Australian Meteorological & Oceanographic Society



Book of Abstracts

AMOS 19th National Conference

Sense and Sensitivity:

Understanding our changing weather and climate

MCEC, Melbourne, 11-13 February 2013

Welcome

19th Annual National Conference of the Australian Meteorological and Oceanographic Society

Melbourne Convention and Exhibition Centre, Melbourne, Victoria

On behalf of the local organizing committee, welcome to Melbourne and to the 19th Annual National Conference of the Australian Meteorological and Oceanographic Society. Our theme for this conference is 'Sense and Sensitivity: Understanding our Changing Weather and Climate', as we will focus attention on understanding the variability and underlying physical processes of the atmosphere and the ocean across a range of timescales.

Following on from the success of last year's AMOS conference in Sydney we have been pleased that this meeting has received similar strong support by the Australian scientific community. This year we have received over 400 abstract submissions across a range of special topics including Weather and Climate Extremes, Past and Future Climates, Stratospheric Processes, Model Development and Renewable Energy.

We are privileged to have a number of prominent local and international guest speakers presenting during the meeting. We welcome Dr. Julia Cole from the University of Arizona who will be presenting the R. H. Clarke Lecture on the topic of narrowing the gap between paleoclimate data and shorter time scales of climate variability. Other plenary talks will be given by Dr. Isla Simpson (Columbia University), Dr. Jean-Baptiste Sallée (British Antarctic Survey), Dr. Savin Chand (winner of the Uwe Radok Award for most outstanding PhD thesis), Dr. Greg Wilson (founder of Software Carpentry), and Prof. Ann Henderson-Sellers (Macquarie University) who will be presented with the AMOS Medal for her many years of excellence in research and leadership.

We would like to thank all the sponsors of this event. Our principal sponsors, the ARC Centre of Excellence for Climate System Science, and SPARC, a core project of the World Climate Research Programme, have facilitated the attendance of many international visitors to this meeting. Silver sponsorship was received from CSIRO and Bronze sponsorship was received from the Melbourne Energy Institute and the CRC for Greenhouse Gas Technologies. Last but not least, thanks to the local organizing committee and to the science committee for all your time and effort, without your help an event like this would not be possible.

Whilst here, please take time to explore the many walks, gardens and laneway cafés around Melbourne. We trust that you will find this year's programme engaging and hope that you will enjoy participating in the meeting.



Dr. Vaughan Barras
Convener, AMOS 2013 National Conference

Sponsors

Australian Research Council's Centre of Excellence for Climate System Science

The Centre of Excellence for Climate System Science is a major initiative funded by the Australian Research Council. The Centre is an international research consortium of five Australian universities and a suite of outstanding national and international Partner Organizations. It will build on and improve existing understanding of the modeling of regional climates to enable enhanced adaptation to and management of climate change, particularly in the Australian region. Z

http://www.climatescience.org.au

SPARC - Stratospheric Processes And their Role in Climate

A core project of the World Climate Research Programme which coordinates international efforts to bring knowledge of the stratosphere to bear on relevant issues in climate variability and prediction. SPARC themes and activities address areas of societal concern such as: climate variability and change, ozone, atmospheric chemistry and aerosols and polar processes.

http://www.sparc-climate.org

Commonwealth Scientific and Industrial Research Organisation

CSIRO Marine and Atmospheric Research (CMAR) aims to advance Australian atmospheric, climate, marine, and earth systems science. We focus on major science challenges affecting Australia, our region, and the world. CMAR capability is built on expertise in marine and atmospheric sciences, with a strong commitment to the science of systems and integration across components of the earth system supplemented with strategic investment in the social and economic components of the coupled social-ecological system. CMAR has particular strengths in understanding, quantifying, and simulating the bio-physical earth systems to assist in informed decision making on sustainable development in the context of human use and change.

www.csiro.au

CRC for Greenhouse Gas Technologies

CO2CRC is a joint venture comprising participants from Australian and global industry, universities and other research bodies from Australia and New Zealand, focused on carbon dioxide capture and geological sequestration.

http://www.co2crc.com.au

Melbourne Energy Institute

The Melbourne Energy Institute is an access point for industry, government and community groups seeking to work with leading researchers on innovative solutions in the following areas: new energy resources; developing new ways to harness renewable energy; more efficient ways to use energy; secure energy waste and frame optimal laws and regulation to achieve energy outcomes.

http://energy.unimelb.edu.au

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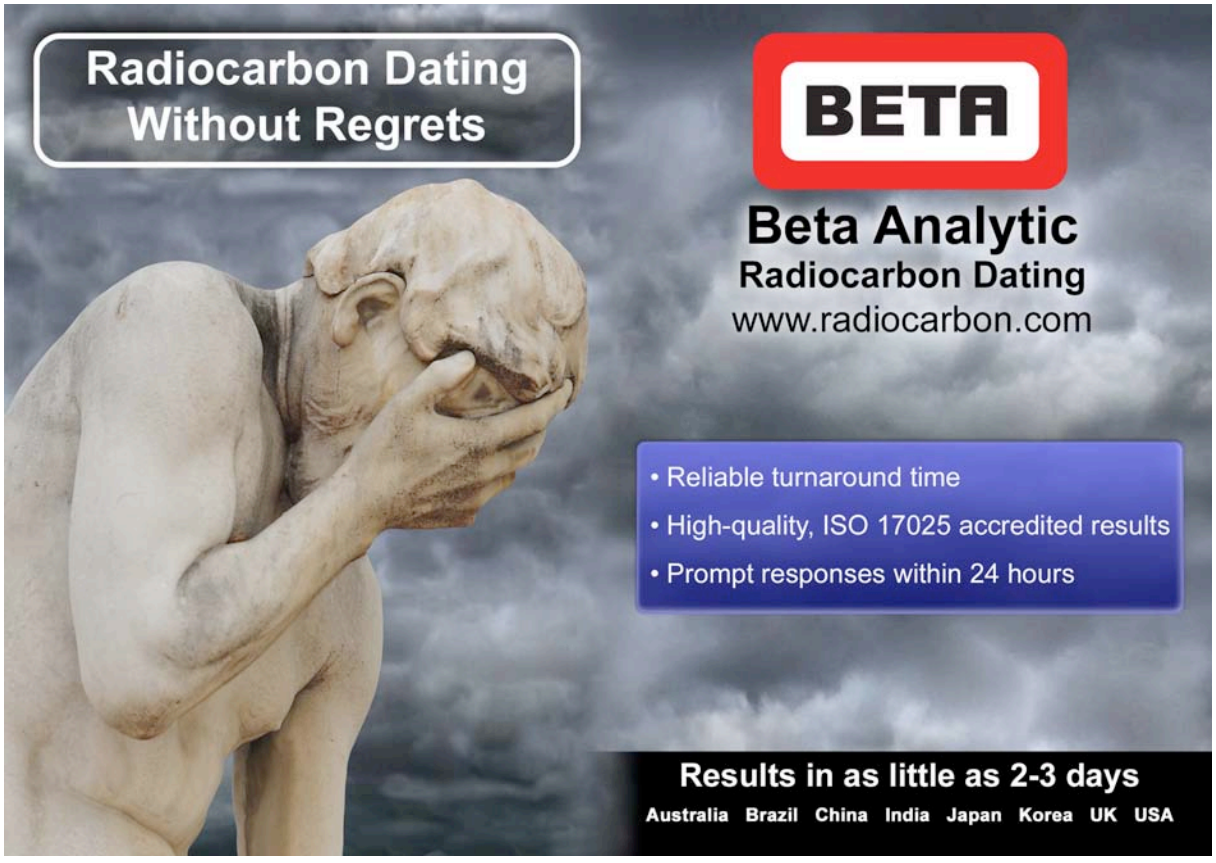
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General programme

	Monday, 11 Feb	Tuesday, 12 Feb	Wednesday, 13 Feb	Thursday (14 Feb)	Friday (15 Feb)
8:00 8:15 8:30	Registration	Registration	Registration	Software Bootcamp	Software Bootcamp
8:45	Opening address (15 min)				
9:00 9:15 9:30	Clarke Lecture (45 min) Julia Cole	Uwe Radok Award winner (30 min) Savin Chand	Plenary (30 min) Isla Simpson		
9:45 10:00 10:15 10:30	Break-out sessions 1 (60 min)	Break-out sessions 5 (75 min)	Break-out sessions 8 (75 min)		
10:45 11:00	Morning Tea Break (10:45 - 11:15)			Software Bootcamp	Software Bootcamp
11:15 11:30 11:45 12:00 12:15 12:30	Break-out sessions 2 (90 min)	Poster Session 1 (90 mins +)	Poster Session 2 (90 mins +)		
12:45 13:00 13:15 13:30	Lunchtime Presentation "RV Investigator" (13:00 - 13:30)	AMOS National AGM (13:00 - 13:30)			
13:45 14:00 14:15	Plenary (30 min) Jean-Baptiste Sallee	AMOS Medal winner (30 min) Ann Henderson-Sellers	Plenary (30 min) Greg Wilson	Software Bootcamp	Software Bootcamp
14:30 14:45 15:00 15:15 15:30	Break-out sessions 3 (90 min)	Break-out sessions 6 (90 min)	Break-out sessions 9 (90 min)		
15:45 16:00	Afternoon Tea Break (15:45 - 16:15)				
16:15 16:30 16:45 17:00 17:15	Break-out sessions 4 (75 min)	Break-out sessions 7 (75 min)	Break-out sessions 10 (75 min)	Software Bootcamp	Software Bootcamp
17:30 17:45 18:00 18:15 18:30 18:45 19:00 19:15	Ice breaker (2 hrs) Boat Builders' Yard, Sth Wharf (18:00 - 20:00)				
19:30 19:45 20:00 20:15 20:30 20:45 21:00 21:15 21:30 21:45 22:00	Evening Dinner Events - Postdoc Social Event - AMOS Fellows' Dinner	AMOS Conference Dinner ZINC - Federation Square Speaker: Tim Costello			

Full Programme

	Monday, 11 February 2013			
	Room 1	**Room 2**	**Room 3**	**Room 4**
8:45	Welcome and Opening address **Blair Trewin** (AMOS National President)			
9:00	Clarke Lecture **Julia Cole*** (Univ. Arizona)			
	Extremes (1)	**CMIP5 (1)**	**General Ocean (1)**	**General Atmosphere (1)**
9:45	**Sally Lavender** Closed Low Pressure Systems and Australian Rainfall	**Tony Hirst** The Australian Community Climate and Earth System Simulator (ACCESS) - Contribution to CMIP5	**Anya Waite** Formation of shallow high-nitrate low-oxygen layers in the eastern Indian Ocean supported by surface nitrogen fixation	**Duncan Ackerley** Processes Leading to Summertime North-West Australian Rainfall in ACCESS1.3
10:00	**Julie Arblaster** ENSO and maximum temperature extremes	**Dave Bi** ACCESS-CM CMIP5 Experiments and Extensions	**Xuerong Qin** Sensitivity of Lagrangian Trajectories to Smoothed Velocity Fields	**Michael Reeder** Wave-Cloud Lines over Northwest Australia
10:15	**Andrew King** Investigating the response of Eastern Australia extreme rainfall to Pacific variability: a statistical and dynamical approach	**Harun Rashid** Intensification of Simulated El Nino-Southern Oscillation in ACCESS Coupled Models under Increased Radiative Forcings	**Nicola Maher** Ocean heat uptake during surface warming hiatus periods	**Rick Millane** Mountain wave 3D wind fields from sailplane flight data
10:30	**Matthew Wheeler** Impacts of the Madden-Julian Oscillation on Australian Maximum and Minimum Temperature and Extremes	**Tim Pugh** Overview of the Climate and Weather Research Services	**Ben McNeil** A Paradigm Shift in the Ocean: Detecting the new Non-Steady-State CO_2 Outgassing Signal	**Colin Simpson** WRF Simulation of a Strong Foehn Wind Event in New Zealand on 6 February 2011
	Morning Tea Break ***(10:45 - 11:15)***			

	Monday, 11 February 2013 (cont)			
	Room 1	**Room 2**	**Room 3**	**Room 4**
	Extremes (2)	**CMIP5 (2)**	**General Ocean (2)**	**General Atmosphere (2)**
11:15	**Eunpa Lim** Dynamical forecast of extreme climate conditions in 2010 spring	**Ben Evans** NCI - Using Australia's Peak Computing Infrastructure for Modelling, Simulation and Data Analysis	**Robin Robertson** Critical latitude effects on internal tides, internal waves and mixing	**Peter MacIntosh** Rossby wave teleconnections to Australian weather in observations and models
11:30	**Louise Wilson** Influence of model bias on projections of Australian and Pacific extreme rainfall and temperatures	**Tim Pugh** Web-based Services of the Climate and Weather Science Laboratory	**Sjoerd Groeskamp** The Thermohaline Streamfunction and Diffusion Coefficients: Estimated From Using Surface Heat and Freshwater Fluxes Together With Ocean Hydrography	**Gareth Berry** The role of continents in determining the mean sea level pressure distribution
11:45	**Tony Rafter** Projections of Australian Region Extreme Precipitation Using Bayesian Spatial Modelling	**Martin Dix** The ACCESS Simulation and Modelling Service	**Shane Keating** Horizontal and Vertical Mixing by Surface-trapped Ocean Eddies	**Jennifer Catto** Fronts and Precipitation in Observations and Climate Models
12:00	**Eric Oliver** Projected ocean warming and extremes off southeast Australia in the 21st century	**Ric Pascual** Progress Report on the Model Analysis Service for the NeCTAR Climate and Weather Science Laboratory	**Andrew Kiss** Eddy/Boundary Interactions and the East Australian Current	**Irina Rudeva** Atmospheric fronts and their associations with precipitation in the Southern Hemisphere
12:15	**Alexander Babanin** Regional and Seasonal Patterns of Changes to Extreme Wind Speeds	**Tom Beer** CMIP5 Coordination Discussion	**Maxim Nikurashim** Water-Mass Transformation by Internal Wave Driven Mixing in the Deep Ocean	**Erica Madonna** Warm Conveyor Belts: significance, climatology and forecast verification
12:30	**Markus Donat** Trends in temperature and precipitation extremes analysed from global observational datasets in comparison to reanalyses and climate model data	**Kevin Keay** Projected changes in Australian region cold fronts and their influence on precipitation	**Gary Brassington** Constructing the Best Estimate from the Ocean Model, Analysis and Prediction System	**Lee Wellhouse** Antarctic Automatic Weather Station Program: Capturing the Meteorology and Climate of Antarctica
	Lunch Break ***(12:45 - 13:45)*** **Lunch presentation**: ***'RV Investigator'*** **(13:00 - 13:30)**			

	Monday, 11 February 2013 (cont)			
	Room 1	**Room 2**	**Room 3**	**Room 4**
13:45	Plenary Session **Jean Baptiste Sallee*** (British Antarctic Survey)			
	Extremes (3)	**CMIP5 (3)**	**Southern Ocean (1)**	**General Atmosphere (3)**
14:15	**Sarah Perkins** Closing the Gap on Heat Wave Measurement	**Aurel Moise** CMIP5 data analysis at NCI - Tools and Experiences	**Peter Strutton** The impact of the Southern Annular Mode on Southern Ocean physics and biogeochemistry	**Tom Keenan** The role of the Centre for Australian Weather and Climate Research (CAWCR) in Changing the Landscape of Australian Earth Systems Science
14:30	**Ruth Lorenz** How important are phenological feedbacks for European climate and heat waves?	**Mark Collier** Australia's CMIP5 data submission and publication report card	**Jennifer Ayers** Nutrient Variability in Subantarctic Mode Waters	**Alan Seed** On the use of radar rainfall estimates and nowcasts for a heavy rainfall warning service
14:45	**Heping Zuo** Assessment of Future Extreme Drought Projections for Different River Basins of New South Wales	**Mike Rezny** Experiences within the ARC CoECSS in generating, storing, publishing, retrieving and analyzing CMIP5 data	**Christopher Roach** The Relationship Between Wind Stress And Ekman Currents In The Antarctic Circumpolar Current: A Spectral Perspective	**Loris Foresti** On the spatial distribution of rainfall nowcast errors
15:00	**Milton Speer** Dust storm frequency and impact over eastern Australia is determined by the state of the Pacific climate system	**Jason Evans** CORDEX-AustralAsia	**David Hutchinson** Interhemispheric Asymmetry in Transient Global Warming: Influence of the Antarctic Circumpolar Current	**James Gilmore** Precipitation extremes on the sub-hourly time scale: Temperature dependence in idealized simulations
15:15	**Melanie Webb** An Analysis of Extreme Rainfall in northern Tasmania, 12-14 January 2011	**Mehera Kidston** Evaluation of Marine Biogeochemistry in the CMIP5 Earth System Models	**Adele Morrison** The transient response of the Southern Ocean to climate change	**James Taylor** Exceptional Rainfall at Wilsons Promontory 22nd-23rd March 2011
15:30	**Teresa Parker** The Connection Between Tropical Convection and Heatwaves in Southeastern Australia	**Ian Watterson** Are climate models more skillful in their home continent?	**Erik Van Sebille** The formation and pathways of Antarctic Bottom Water in the SOSE fine resolution ocean model	**Yi (Vivian) Huang** Evaluation of WRF Simulations of Clouds over the Southern Ocean with A-Train Observations
	Afternoon Tea Break ***(15:45 - 16:15)***			

	Monday, 11 February 2013 (cont)			
	Room 1	**Room 2**	**Room 3**	**Room 4**
	Extremes (4)	**CMIP5 (4)**	**Southern Ocean (2)**	**General Atmosphere (4)**
16:15	**Agata Imielska** Trends in rainfall and temperature extremes in the Pacific	**Jonas Bhend** Evaluation of recent Australian rainfall and temperature change in CMIP5	**Robin Robertson*** Tidal Effects on Ice Shelf Melting and Mixing in the Amundsen Sea	**Jeff Kepert** Why is the tropical cyclone boundary layer not well-mixed?
16:30	**Simon McGree** Trends in total and extreme rainfall in the Western Pacific	**Francois Delage** Statistically-adjusted precipitation projections for the 21st century	**Maria Tsukernik** High accumulation events in the East Antarctica: a closer look at the atmospheric rivers across the Southern Ocean	**Michael Hewson** Exploring Aerosol Effects on Rainfall for Brisbane, Australia
16:45	**Elaine Miles** Seasonal Prediction of Sea-Level Anomalies in the Western Pacific	**Jing-Jia Luo** Longitudinal Biases in the Seychelles Dome Simulated by 35 Ocean-Atmosphere Coupled General Circulation Models	**Ruhi Humphries** Atmospheric Measurements over East Antarctic melting spring sea ice during SIPEX II	**Yinjun Chen** Evaluation of TRMM Estimates of Tropical Cyclone Landfall Rainfall over Australia
17:00	**Ron Hoeke** An Extreme Sea Level Climatology of Oceania	**Clothilde Langlais** Structure and ENSO variability of the edge of the Western Pacific Warm Pool under Climate Change	**Isabella Rosso** The Vertical Transport of Tracers due to Meso and Sub-mesoscales: Impacts in the Kerguelen Region	**Guoping Zhang** Roles of Mesoscale and Convective-scale Systems During the Formation and Early Development of Typhoon Ketsana (2003) in the Western North Pacific
17:15	**Joanna Burson** Real-time numerical modeling of storm surge using high-performance computing for emergency planning purposes for Queensland	**Andrea Taschetto** Assessing two types of ENSO in CMIP5 models	**Stephanie Waterman** Internal waves and turbulence in the Antarctic Circumpolar Current - thought provoking results from the Southern Ocean FINEstructure project	**Alain Protat** Reconciling the Ground-Based and Space-Based Estimates of the Frequency of Occurrence and Radiative Effect of Clouds
	Ice Breaker ***The Boat Builders' Yard - South Wharf*** ***(18:00 - 20:00)***			

	Tuesday, 12 February 2013			
	Room 1	**Room 2**	**Room 3**	**Room 4**
9:00	Uwe Radok Award Winner **Savin Chand*** (Bureau of Meteorology)			
	Extremes (5)	**Regional Climate (1)**	**General Climate (1)**	**IMOS (1)**
9:30	**Andrew Charles** Prediction of environmental parameters associated with Tropical Cyclone risk with dynamical climate models on seasonal timescales	**Penny Whetton** Climate Change Projections to support Natural Resource Management Planning	**Blair Trewin** Global climate in 2012	**Mark Baird*** The Southward Transport of Sub-mesoscale Lenses of Bass Strait Water in the centre of Anti-cyclonic Mesoscale Eddies
9:45	**James Done** Assessing Tropical Cyclone Damage	**Michael Grose** Downscaling adds value to climate projections for Australia: principles and examples for next CSIRO projections release	**Caroline Ummenhofer** Impact of surface forcing on atmospheric blocking in the Australian sector of the Southern Hemisphere	**Helen Beggs** A Study of Diurnal Warming in the Tropical Warm Pool using Sea Surface Temperature from Multiple Satellites
10:00	**Lam Hoang** The Connection Between Coherent Potential Vorticity Anomalies and Heavy Rainfall in the Tropics	**Jason Evans** NSW / ACT Regional Climate Modelling project (NARCliM)	**Mike Pook** A synoptic climatology of heavy rain events in the Lake Eyre and Lake Frome catchments	**Jennifer Penton** The effects of wind forcing on surface currents on the continental shelf surrounding Rottnest Island
10:15	**Hamish Ramsay** The effect of imposed stratospheric cooling on the maximum intensity of tropical cyclones in axisymmetric simulations	**Aurel Moise** Overview of CMIP5 Model Evaluation for Australian Climate and its Drivers	**Linden Ashcroft** Southeastern Australia temperature, pressure and rainfall variations from 1860-1910 using historical data	**Amandine Schaeffer** Understanding the complex roles of alongshore current and wind forcing in driving upwelling in the East Australian Current
10:30	**Greg Holland** Severe Weather Response to Climate Change: A Transient Increase and then Saturation?	**Cindy Bruyere** Evaluating Sources of Uncertainty in Regional Climate Models	**Ailie Gallant** Non-stationary Australasian teleconnections and implications for paleoclimate reconstructions	**Mal Heron** Turbulent Mixing Mapped in Shallow Water Using HF and VHF Ocean Radar
	Morning Tea Break ***(10:45 - 11:15)***			

	POSTER SESSION (1) ***Main Foyer*** ***(11:15 - 12:45)***
	Posters presented during this session: 01. General Atmosphere - global and synoptic scale 02. General Atmosphere - mesoscale and microscale 03. General Atmosphere - forecasting and model development 04. General Oceanography 08. Weather and Climate Extremes: Observations, Processes and Modelling 10. CMIP5 14. The Southern Ocean and its Role in Climate 16. Insights from the Integrated Marine Observing System (IMOS)
	Lunch Break ***(12:45 - 13:45)*** **AMOS National AGM (13:00 - 13:30)**

Tuesday, 12 February 2013 (cont)

	Room 1	Room 2	Room 3	Room 4
13:45	AMOS Medal Winner **Ann Henderson-Sellers*** (Macquarie University)			
	Past Climate	**Regional Climate (2)**	**General Climate (2)**	**NWP (1)**
14:15	**Jonathan Overpeck*** The Importance of High-Resolution Paleoclimate Records for Assessing Future Drought Risk	**Jack Katzfey** Downscale simulations over Southeast Asia	**Claudia Frauen** Analysis of the nonlinearity of ENSO teleconnections	**Kamal Puri** The Australian Community Climate and Earth System Simulator, ACCESS: Current status and future plans
14:30		**Peter Hoffmann** The derivation of downscaling SSTs corrected for both bias and variance	**Terrance O'Kane** An internal South Pacific Ocean ENSO mechanism	
14:45	**Claire Krause** Spatial and Temporal changes in the Intertropical Convergence Zone: A Continuous Stalagmite Palaeomonsoon Record for South-Central Indonesia	**Yang Wang** Delivering Downslcaed Climate Change Projections Using the CMIP5 Dataset - First Step toward National Projections for NRM Groups	**Claire Radley** Cloud and radiation variability associated with El Nino	**Michael Naughton** ACCESS Global and Regional Ensemble Prediction System
15:00	**Cathy Trudinger** The Global Carbon Cycle over the Last Millennium Inferred from a High Resolution CO_2 and $\delta^{13}CO_2$ Ice Core Record	**Surendra Rauniyar** Improvement to a Statistical Downscaling Technique to Capture Extreme Temperature	**Leon Rotstayn** Have anthropogenic aerosols weakened the Southern Hemisphere subtropical jet?	**Annette Hirsch** Impact of Realistic Land Surface Initialization on Sub-seasonal Forecast Skill: Preliminary Results from WRF-LIS-CABLE GLACE-2 Experiments
15:15	**Shayne McGregor** Inferred changes in El Niño-Southern Oscillation variance over the past six centuries	**Markus Thatcher** Current progress and future plans for the ACCESS regional climate model	**Laura O'Brien** The effect of Rossby waves on low-frequency variability of the Southern Hemisphere jet stream	**Georg Gottwald** Controlling balance in ensemble data assimilation
15:30	**Sophie Lewis** Modelled water isotope expressions of ENSO-like variability in tropical precipitation	**Lorenzo de la Fuente** Cluster analysis of SLP-rainfall linked regimes: ERA-I control simulations versus CCSM2 projections downscaled using WRF	**Carsten Frederiksen** Assessment and projected changes in the annual cycle of Southern Hemisphere baroclinicity for storm formation in CMIP5 models	**Christian Werner** Severe Weather Forecasting using 4D RADAR Data Assimilation and NWP modelling to mitigate exposure to hail-storm damage for the Australian region
	Afternoon Tea Break ***(15:45 - 16:15)***			

Tuesday, 12 February 2013 (cont)

	Room 1	Room 2	Room 3	Room 4
	General Ocean (3)	**Regional Climate (3)**	**General Climate (3)**	**NWP (2)**
16:15	**Diana Greenslade** The Evaluation of Tsunami Warning Thresholds	**Ian Macadam** Climate Model Downscaling Data for Impacts Research: An ANDS Initiative	**Xiaobing Zhou** The role of Karimata Strait Throughflow and Makassar Strait Throughflow on Indo-Pacific climate in a global ocean model	**Peter Steinle** What Could a Mesoscale NWP System Deliver for Australia?
16:30	**Stewart Allen** The feasibility of operational tsunami inundation modeling	**Pandora Hope** Will south-west Australia see some types of weather systems disappear in the future?	**Josephine Brown** The South Pacific Convergence Zone in CMIP5 simulations of historical and future climate	**Susan Rennie** Doppler Radar Assimilation in High-Resolution NWP
16:45	**Lawrence Hughes** Whispers from a Forgotten Shoreline	**Kevin Tory** Changes in Tropical Cyclone Frequency by the late Twenty-First Century as Simulated by CMIP5 Models	**Christine Chung** Nonlinear rainfall response to El Nino and global warming in the Indo-Pacific	**Lawrie Rikus** Using Synthetic Satellite Imagery to Assess Numerical Weather Prediction
17:00	**Dajiro Kobashi** Internal tides associated with a western boundary current and a possible sediment transport dynamics on the inner continental shelf, East Australia	**Doerte Jakob** Validation of Space-time Characteristics of Downscaled Rainfall Extremes for the Sydney Region	**Brad Murphy** The impact of variations in the strength and structure of El Nino events on Pacific island rainfall: insights from CMIP3 and CMIP5 models	**John LeMarshall** Earth Observation from Space - Significant Recent Advances
17:15	**Julian O'Grady** Drivers of Sediment Transport Across the Entrance to the Gippsland Lakes, Australia	**Hamish Clarke** Net primary productivity and bush fire fuel load: testing parameterisations in a land surface model	**Jason Smith** Using climate information to improve risk management in climate sensitive industries across the Pacific	**Vinod Kumar** 4D-Var Assimilation of SSMIS Radiances in ACCESS
	2013 AMOS Conference Dinner ***ZINC, Federation Square*** ***(18:30 - 22:30)***			

	Wednesday, 13 February 2013			
	Room 1	**Room 2**	**Room 3**	**Room 4**
9:00	Plenary Session **Isla Simpson*** (Columbia University)			
	SPARC (1)	**Tropical Processes (1)**	**General Climate (4)**	**Renewable Energy (1)**
9:30	**Greg Roff** Top-down and Bottom-up impacts on the ACCESS Ensemble Model	**Peter May*** Observations of cloud properties in a monsoon environment – challenges for understanding and modelling	**Chris Lucas** A critcial comparison of metrics for tropical expansion	**Jing Huang** Predicting a daily variability index of solar radiation from ERA-Interim reanalysis
9:45	**Damian Murphy** Parameterization of Gravity Wave Drag in Models and the Impact on Predictions of the Southern Hemisphere Stratosphere		**Simon Grainger** Assessment and projected changes of the modes of interannual variability of Southern Hemisphere atmospheric circulation in CMIP5 models	**Nicholas Engerer** Meteorological Observations and Collective Rooftop Photovoltaic Power Output in Canberra
10:00	**Ariaan Purich** Weather from Ozone Hole Variations	**Vikal Kumar** A view of tropical cumulus congestus clouds from Polarimetric C-band radar	**Ian Simmonds** The Vertical and Seasonal Profile of Temperature Changes over the Antarctic in the 'new' generation Reanalyses, and their Radiosonde Ground-Truthing	**Paul Gregory** Testing the ability of the Bureau of Meteorology's Numerical Weather Prediction systems to support prediction of solar energy production
10:15	**Andrew Klekociuk** Trends in the Distribution of Antarctic Stratospheric Ozone: Relationships with Circulation Changes	**Jackson Tan** Perspectives on Tropical Convection Using a New Dataset of Cloud Regimes with High Time-Resolution	**Andrew McRobert** City and country scale CO2 fossil fuel trends from a very high resolution global dataset	**Armin Dehghan** Forecasting Radiation for Solar Energy Systems
10:30	**Olaf Morgenstern** Coupled atmosphere-ocean climate modelling with whole-atmosphere chemistry: First results	**Karsten Peters** Applying a stochastic multicloud model to simulate observed tropical convection	**Omid Alizadeh Choobari** Simulation of the spatial distribution of mineral dust and its direct radiative forcing over Australia	**Robert Davy** Empirical modelling of sub-hourly variability in solar irradiance
	Morning Tea Break ***(10:45 - 11:15)***			

	POSTER SESSION (2) ***Main Foyer*** ***(11:15 - 12:45)***
	Posters presented during this session:
	05. General Climate - Variability of the Climate System 06. General Climate - Detection and Monitoring of Climate Change 07. General Climate - Developments in Climate Modelling 09. High-Resolution Records of Past Climate 11. Stratospheric Processes and their Role in Climate 12. Tropical Processes in Observations and Models 13. Regional Climate Projections 15. Renewable Energy 17. Development in Numerical Weather Prediction and Data Assimilation
	Lunch Break ***(12:45 - 13:45)***

	Wednesday, 13 February 2013 (cont)			
	Room 1	**Room 2**	**Room 3**	**Room 4**
13:45	Plenary Session **Greg Wilson*** (Founder - Software Bootcamp)			
	SPARC (2)	**Tropical Processes (2)**	**General Climate (5)**	**Renewables (2)**
14:15	**Stephan Fueglistaler*** The relation between atmospheric humidity and temperature trends for stratospheric water	**Rachel Stratton*** Can analysis of high resolution (~1.5 km) simulations of tropical convection help improve convective parametrization?	**Tilo Ziehn** Carbon Cycle modelling in ACCESS	**Robert Huva** Optimising the Deployment of Renewable Energy Infrastructure in Australia: Results Utilising the ACCESS-A Model
14:30			**Peter Uhe** Development and evaluation of nudging in the ACCESS model	**Merlinde Kay** Investigating Synergies between Solar and Wind Energy using Satellite Data and TAPM
14:45	**Simon Alexander** High resolution VHF radar measurements of tropopause structure and variability at Davis, Antarctica (69°S, 78°E)	**Daniel Hernandez Deckers** Deep Convection Initiation in Cloud Resolving Simulations	**Wataru Sasaki** Role of Vertical Mixing Originating from Small Vertical Scale Structures above and within the Equatorial Thermocline in an OGCM	**Roger Dargaville** Analysing the Impact of Weather Variability on Recent Declines in Electricity Demand in the Australian National Electricity Market
15:00	**Laura Revell** Splicing SAGE-II and GOMOS measurements to create a long-term stratospheric ozone climate data record	**Andrew Ballinger** The frequency of Tropical Cylones in HiRAM aquaplanet simulations	**Seon Tae Kim** Two Types of ENSO and their Future Projections in the CMIP5 Models	**Melissa Hart** Developing Typical Meteorological Year (TMY) Data Sets for Predicting Future Building Energy Consumption within a City
15:15	**Kane Stone** An Updated Retrieval of Australian Dobson Data to Produce Higher Resolved Ozone Profiles	**Rachel Badlan** Multiscale analysis of convective momentum transport in convection-permitting model simulations	**Mitchell Black** Australian precipitation modelled using the weather@home.net Citizen Science Experiment	
15:30	**Greg Bodeker** Measurement programme design for the detection of trends in stratospheric temperatures and water vapour	**Wojchiech Grabowski** Aerosol effects on deep convection	**Vassili Kitsios** Subgrid parameterization of eddy-eddy and eddy-meanfield interactions in simulations of the ocean	
	Afternoon Tea Break ***(15:45 - 16:15)***			

	Wednesday, 13 February 2013 (cont)			
	Room 1	**Room 2**	**Room 3**	**Room 4**
	General Atmosphere (5)	**Tropical Processes (3)**	**General Climate (6)**	
16:15	**Cacilia Ewenz** Seasonal Changes to the Urban Heat Island Effect	**Hanh Nguyen** Attribution and impact of the recent Hadley Circulation expansion	**Michael Hutchinson** A new anomaly-based approach to topographic dependent interpolation of daily and monthly precipitation	
16:30	**Harvey Stern** Weather predictability at 8 to 14 day lead times	**Juliane Schwendike** Local Changes in the Hadley and Walker Circulations in the last 30 Years	**Peter Baines** Factors affecting the interannual variability of global land-based rainfall	
16:45	**Jenny Fisher** Identifying Sources and Transport Pathways of Atmospheric Pollutants over Australasia using a Model Constrained by Surface-Based and Satellite Data	**Joseph Anderson** Zonal Asymmetries in the Widening of the Tropics Under Climate Change	**Daniel Arguesso** Precipitation bias correction of very high resolution regional models	
17:00	**Will Thurston** Idealised numerical modelling of bushfire plumes	**Muhammad Hassim** Diurnal rainfall features over New Guinea: The early morning offshore maximum	**Gab Abramowitz** Multi-model ensemble interpretation paradigms	
17:15	**Belinda Roux** Automated Synoptic Classification for Fog Forecasting at Perth Airport	**Penelope Maher** Can an Adapted Betts-Miller Scheme Improve the Representation of Atmospheric Variability?	**Anthony Kiem** Assisting Australian grain growers in understanding, quantifying and managing the variability of the climate system	
	Conference close			

Poster Programme

01. General Atmosphere - global and synoptic scale

01.	**1**	A Global Experiment to Improve Observations of Snow: The World Meteorological Organization Solid Precipitation Intercomparison Experiment (WMO-SPICE)	Shane	Bilish
01.	**2**	Making sense of sensitivity: Understanding how global climate feedbacks differ across timescales	Robert	Colman
01.	**3**	Wind Profiler Observations of a High Frequency Boundary Layer Wave at Ceduna: Part 1 Investigation	Bronwyn	Dolman
01.	**4**	Wind Profiler Observations of a High Frequency Boundary Layer Wave at Ceduna: Part 2 Meteorological Implications	Alison	Cook
01.	**5**	The Distribution and Long Term Trends in Ozone in the Southern Hemisphere Extra-tropical Boundary Layer and Free Troposphere	Ian	Galbally
01.	**6**	Characteristing the thermodynamics and microphysics of mid-topped cloud regimes in the Southern Ocean	Shannon	Mason
01.	**7**	Contrasting a High Density Spatial Precipitation Product with Supercooled Liquid Water and Synoptic Type over the Snowy Mountains	Luke	Osburn
01.	**8**	An Objective Analysis of Volcanic Cloud Height and Thickness for Puyehue-Cordon Caulle using Satellite Data	Andrew	Prata
01.	**9**	The Behavior of Westerly Jets in Global Reanalyses	Lawrie	Rikus
01.	**10**	Climatology and characteristics of cutoff lows in the Southern Hemisphere	James	Risbey
01.	**11**	An Analysis of the Low-elevation Clouds over the Southern Ocean with A-Train Observations	Steve	Siems

02. General Atmosphere - mesoscale and microscale

02.	**1**	Does aerosol pollution of orographic clouds result in precipitation suppression in the Australian Snowy Mountains?	Thomas	Chubb
02.	**2**	Meteorological Aspects of the Margaret River Fires on 23 November 2011	Robert	Fawcett
02.	**3**	Properties of High-Frequency Convectively-Generated Gravity Waves Simulated during TWP-ICE	Chi Mai N.	Hankinson

02.	**4**	Quantifying the Urban Heat Island (UHI) in Hong Kong	Melissa	Hart
02.	**5**	Wind Climate in the Southern GBR - Local Observations vs Satellites and MesoLAPS	Jasmine	Jaffres
02.	**6**	How does the boundary layer contribute to secondary eyewall formation in axisymmetric tropical cyclones?	Jeffrey	Kepert
02.	**7**	Dynamics and Predictability of a Springtime Precipitation Event in the Australian Alps	Todd	Lane
02.	**8**	Gravity Waves in the Upper-Tropospheric Jet Exit: High Resolution Modelling and Dynamics	Adam	Morgan
02.	**9**	Precipitation and Extreme Events in the "Wet Tropics" region of Queensland	Michael	Murphy
02.	**10**	Using Observations to Improve Mass-Diameter Relationships of Ice Crystals for use in Climate Models	Justin	Peter
02.	**11**	Analysis of a severe multicell/supercell hybrid storm in Brisbane, Australia	Harald	Richter
02.	**12**	An Observation-based Climatology of the Precipitation over the Macquarie Island	Zhan	Wang

03. General Atmosphere - forecasting and model development

03.	**1**	Towards Seamless Rainfall Forecasts for 0-10 Days	Shaun	Cooper
03.	**2**	Probabilistic Rainfall Forecasting in Northern Australia	Michael	Foley
03.	**3**	Novel Computational Techniques to Produce High Resolution Forecast Guidance: Application to the Bureau of Meteorology's Gridded OCF System	Timothy	Hume
03.	**4**	Prediction of Tasmanian Climatic Pattern by Using Singular Spectrum Analysis	Md Atikur Rahman	Khan
03.	**5**	Simulation of the meteorological effects of the S Fornacis superflare on Earth	Tammas	Loughran
03.	**6**	Probabilistic Rainfall Forecasts from Deterministic Numerical Weather Prediction Model Output	Philip	Riley
03.	**7**	Progress towards GA5 the next version of the global Unified Model for NWP and climate use at the Met Office.	Rachel	Stratton

04. General Oceanography

04.	**1**	Temporal Decomposition of Satellite Ocean Chlorophyll Data	Julia	Brandenberg
04.	**2**	Storm Wave Projections for Eastern Australia	Andrew	Dowdy
04.	**3**	A 30-Year Global Wave Hindcast	Tom	Durrant
04.	**4**	Leveraging Open Source Technology for Rapid and Sustainable Development of the Ocean Map Portal	Danielle	Madeley
04.	**5**	Nitrogen Fixation in the Eastern Indian Ocean	Eric	Raes
04.	**6**	Pacific Ocean Map Portal: Informing decision making through high quality visualisation of ocean climate data.	Nicholas	Summons

05. General Climate - variability of the climate system

05.	**1**	"An indefatigable pioneer of civilisation and science": the weather records of W.B. Clarke, 1840-1850	Linden	Ashcroft
05.	**2**	Building Climate Services capacity in Pacific Island Countries	Grant	Beard
05.	**3**	A simple diagnostic for eastern Australian summertime rainfall	Mitchell	Black
05.	**4**	A fresh look at the relationships between Australian Rainfall and the El Nino Southern Oscillation	Belinda	Campbell
05.	**5**	The Link Between ENSO and North Australian SSTs and its Impacts on Projections of Australian Climate	Jennifer	Catto
05.	**6**	A Conceptual Architecture for Developing Seasonal Forecast Systems for Pacific Island Countries using Traditional Ecological Knowledge and Modern Science	Savin	Chand
05.	**7**	Impact of different ENSO regimes on southwest Pacific tropical cyclones	Savin	Chand
05.	**8**	The different impact of positive-neutral and negative-neutral ENSO regimes on Australian tropical cyclones and rainfall	Savin	Chand
05.	**9**	Diagnosing the Impact of Groundwater on the Land-Atmosphere Coupling Strength in Northern Australia	Mark	Decker
05.	**10**	POAMA Forecasts of Intra-seasonal Variability over Northern Australia	Wasyl	Drosdowsky

05.	**11**	Internal Variability and External Forcing of Interannual Kuroshio Path Changes	Leela	Frankcombe
05.	**12**	Australian Climate in 2012 - a Return to Drier Conditions	Catherine	Ganter
05.	**13**	Australia's Integrated Marine Observing System: Monitoring Climate Variability and Weather Extremes.	Katy	Hill
05.	**14**	ENSO Modoki, the Pacific South-American Pattern and Antarctica	Damien	Irving
05.	**15**	Estimating Tropical Cyclone Structure in the Australian Region	Charlie	Lok
05.	**16**	Unravelling Eastern Pacific and Central Pacific ENSO contributions in South Pacific chlorophyll-a variability	Angela	Maharaj
05.	**17**	The relationship between El Nino-Southern Oscillation, wind patterns, and rainfall on the Eastern Seaboard of Australia	Acacia	Pepler
05.	**18**	An objective database of East Coast Low events: Development and verification	Acacia	Pepler
05.	**19**	The Connection between ENSO and Fire Weather Day Frequency in Melbourne, Victoria, 1951-2012	Robert	Rizzo
05.	**20**	Impact of Climate Variability on the Large-scale Atmospheric Waves in the Southern Hemisphere	Sergei	Soldatenko
05.	**21**	Changes in the variability of global land precipitation in observations and in models	Fubao	Sun
05.	**22**	How "Nature's Limit" Changes Over Time - A South Australian Perspective	Carly	Tozer
05.	**23**	Influence of Oceans on Land Surface Temperature Variability	Nicholas	Tyrrell
05.	**24**	Attribution of interdecadal changes in mean circulation and variability using inverse modelling	Meelis	Zidikheri

06. General Climate - detection and monitoring of climate change

06.	**1**	Estimating Temperature and Moisture fields using GNSS Satellites in the Australian Region	Birtukan	Biadglgne
06.	**2**	Rainfall reductions over Southern Hemisphere semi-arid regions: the role of Subtropical Dry Zone Expansion	Tim	Cowan
06.	**3**	Extending the long term temperature records for Canberra Airport	Clem	Davis

06.	**4**	Comparison of the Canberra Airport Observation Sites 2006-2010	Clem	Davis
06.	**5**	Human-induced global ocean warming on multidecadal timescales	Catia	Domingues
06.	**6**	On the changing nature of Australian monthly and daily temperature anomalies	Robert	Fawcett
06.	**7**	Homogenised Monthly Upper-air Temperature and Humidity Datasets for Australia	Branislava	Jovanovic
06.	**8**	ENSO and global ocean chlorophyll in a changing climate	Angela	Maharaj
06.	**9**	The distribution of climate zones across Australia: identifying and explaining changes during the past century	Harvey	Stern
06.	**10**	Changes in extreme temperatures in Australia, 1910 to 2011	Blair	Trewin
06.	**11**	Rainfall Trends from Stations, Merged Analyses, Reanalyses and GCMs over the Tropical Pacific	Guomin	Wang
06.	**12**	Near-term and long-term future trends in Australian climate	Ian	Watterson

07. General Climate - developments in climate modelling

07.	**1**	Towards the implementation of wind-wave physics into climate models	Elodie	Charles
07.	**2**	Verification Study of Seasonal Forecasts in the Pacific Region using the POAMA and SCOPIC models.	Andrew	Cottrill
07.	**3**	Offsetting Methane Emissions - An Alternative to GWPs	Ian	Enting
07.	**4**	Evaluation of clouds and precipitation in ACCESS using satellite simulators	Charmaine	Franklin
07.	**5**	Climate Model Ensemble Generation and Model Dependence	Ned	Haughton
07.	**6**	The Community Atmosphere Biosphere Land Exchange (CABLE) model, Version 2.0.	Rachel	Law
07.	**7**	20th Century Climate of the ACCESS Ocean Model Under Co-ordinated Ocean-Ice Reference Experiments	Simon	Marsland
07.	**8**	Methods of Ensemble Prediction for Seasonal Forecasts with a Coupled Ocean-Atmosphere Model	Stacey	Osbrough
07.	**9**	Sensitivity of an Atmosphere-Ocean System to Coupling Strength	Sergei	Soldatenko

07.	**10**	Verifying the accuracy of seasonal climate outlooks: an update	Harvey	Stern

08. Weather and Climate Extremes: Observations, Processes and Modelling

08.	**1**	Synoptic Typing of Sub-Daily Extreme Rainfall Events in Queensland	Adam	Blazak
08.	**2**	A thunderstorm at Casey Station, East Antarctica	Scott	Carpentier
08.	**3**	Upper ocean temperatures and the distribution of thunderstorms during east-coast lows	Chris	Chambers
08.	**4**	Effects of non-linear tidal-surge interaction on present and future storm surges along the Australian coastline	Frank	Colberg
08.	**5**	An Investigation of Springtime Frost Frequencies in Relation with Precipitation in a Changing Climate	Andrea	Dittus
08.	**6**	An Objective Definition of Extratropical Cyclones	Andrew	Dowdy
08.	**7**	Extreme Snowfall and Snow Melt in Alpine Australia	Sonya	Fiddes
08.	**8**	Estimating TC Wind Probabilities in the Australian Region	Michael	Foley
08.	**9**	Rapid Increases in Fire Danger during Already Dangerous Fire Weather Events - Some Meteorological Aspects.	Paul	Fox-Hughes
08.	**10**	Evaluating the three-dimensional distribution of clouds around Southern Hemisphere extratropical cyclones in the ACCESS model	Pallavi	Govekar
08.	**11**	Modelling Runs of Extremes in a Daily Variable.	Warwick	Grace
08.	**12**	Seasonal Prediction of SST and Coral Bleaching Risk in the Western Pacific	Aurel	Griesser
08.	**13**	Assessing Daily Rainfall Extremes Using a Simple Physically-based Statistical Model	Michael	Hutchinson
08.	**14**	Trends in extreme rainfall on the eastern seaboard of Australia	Agata	Imielska
08.	**15**	A new Bio-comfort Perspective for Melbourne based on Heat Stress, Air Pollution and Pollen	Stephanie	Jacobs
08.	**16**	Consistent Trends in a Modified Climate Extremes Index in the U.S.A., Europe and Australia	David	Karoly
08.	**17**	Investigating the ability of AWAP to capture extreme rainfall characteristics	Andrew	King

08.	**18**	Tropical Cyclone Data Portal for the Western Pacific	Yuriy	Kuleshov
08.	**19**	Weather and Climate Extremes in Samoa and Vanuatu: Impact of Tropical Cyclones, Floods and Droughts	Yuriy	Kuleshov
08.	**20**	Climate Change Impact on Natural Environment in Vanuatu and Samoa	Yuriy	Kuleshov
08.	**21**	Prospects of studying tropical cyclones and tropical waves in the Pacific and Indian Oceans using radiosonde and GPS radio occultation data	Yuriy	Kuleshov
08.	**22**	Seasonal-scale Australian temperature and rainfall extremes in CMIP5 historical simulations	Sophie	Lewis
08.	**23**	Dynamic Trio: Internal, Natural and Anthropogenic Forcings Drive Temperature Extremes in Australia	Tanya	Lippmann
08.	**24**	Development of a Network of Portable Anemometers For Measuring Landfalling Tropical Cyclones	Matthew	Mason
08.	**25**	Projections of drought from CMIP5 for Australia and the Pacific	Sugata	Narsey
08.	**26**	Was the Arctic sea ice anomaly in 2012 influenced by the August storm?	Irina	Rudeva
08.	**27**	Heat waves in Melbourne and the influence of Tasman Sea blocking and sea surface temperatures	Katherine	Sadler
08.	**28**	Tropical Cyclone Frequency Changes if CO2 Doubles in a High-Resolution Coupled General Circulation Model	Wataru	Sasaki
08.	**29**	Dynamical Seasonal Tropical Cyclone Predictions for the Australian and South Pacific Regions	Kay	Shelton
08.	**30**	Laser ceilometer measurements of Australian dust storm highlight need for reassessment of atmospheric dust plume loads	Joshua	Soderholm
08.	**31**	ROAMES Australian thunderstorm climatology and visualisation project	Joshua	Soderholm
08.	**32**	Documentation and verification of the world extreme wind gust record: 113.3 m s-1 on Barrow Island, Australia, during passage of Tropical Cyclone Olivia	Blair	Trewin
08.	**33**	Heat Waves in Southern Australia: A Synoptic Climatology	Peter	van Rensch
08.	**34**	Homogenisation of Daily Temperature Data and Analysis of Climate Extremes in Pacific Island Countries	Kirien	Whan
08.	**35**	Seasonal-scale drivers of heat extremes over Australia for intra-seasonal prediction	Christopher	White

09. High-resolution records of past climate

09.	**1**	Sea-surface temperature changes spanning the last 300 years in the Tasman Sea and offshore southern Australia	Patrick	De Deckker
09.	**2**	A 500-year Streamflow Reconstruction from Tasmania's Central Plateau Derived from Tree Rings	Michael	Goddard
09.	**3**	A Novel Method for Targeting Locations with Paleoclimate Information for Inferring Long-Term Hydroclimatic Variability in Regions Lacking In Situ Proxy	Michelle	Ho
09.	**4**	Changes in the Australian-Indonesian Summer Monsoon System throughout Glacial Terminations III and II	Alena	Kimbrough
09.	**5**	A high-resolution mid-Holocene window on tropical Queensland hydrological variability from coral luminescence	Janice	Lough
09.	**6**	A 1,500 year SE Australian rainfall record based on speleothem hydrological proxies	Janece	McDonald
09.	**7**	Synthesis of Indirect Archives of Environmental Change using Stacked Ordinations: Preliminary Application using 1000 year Lake Sediment Records from Victoria	Jonathan	Tyler

10. CMIP5

10.	**1**	Using simple climate indices to evaluate global climate responses to different forcings	Frank	Drost
10.	**2**	Assessment of polar atmospheric characteristics in Australian CMIP5 models	Andrew	Klekociuk
10.	**3**	Climate Model Drift in CMIP3 and CMIP5	Alexander	Sen Gupta
10.	**4**	Future Changes to the Equatorial Pacific Circulation	Alexander	Sen Gupta
10.	**5**	Comparison of the Simulated Surface Climatology by the ACCESS Model with Two Land Surface Schemes.	Lauren	Stevens

11. Stratospheric Processes and their Role in Climate (SPARC)

11.	**1**	Quantifying the role of orographic gravity waves in increasing polar stratospheric cloud occurrence	Simon	Alexander

11.	**2**	Stratospheric ozone and climate change in CMIP5	Julie	Arblaster
11.	**3**	Analysis of Polar Stratospheric Cloud Occurrence	Fraser	Dennison
11.	**4**	The relation between atmospheric humidity and temperature trends for stratospheric water	Stephan	Fueglistaler
11.	**5**	Price and preference: Developing network design criteria for a stratosphere-troposphere climate monitoring network	Karin	Kreher
11.	**6**	How does tropospheric OH variability influence the transport of SO2 and COS from the surface to the stratosphere? A conceptual study	Stefanie	Kremser
11.	**7**	Modelling tropical tropopause layer convection processes driving stratospheric composition	Robyn	Schofield
11.	**8**	Reprocessing of the Broadmeadows and Macquarie Island Ozonesonde Record as part of the SI2N Past Changes in the Vertical Distribution of Ozone Initiation	Matt	Tully

12. Tropical processes in observations and models

12.	**1**	Variations in the Moist Static Energy Budget of the MJO observed in SP-CAM for Variations in the Imposed SST and for a realistic SP-CAM integration	Joseph	Andersen
12.	**2**	A stability analysis of ENSO over multi-decadal time-scales in a 1000-yr coupled general circulation model simulation	Simon	Borlace
12.	**3**	Interannual Variability and Predictability of the Indian Summer Monsoon - ENSO System	Ghyslaine	Boschat
12.	**4**	More extreme swings of the South Pacific Convergence Zone due to greenhouse warming	Wenju	Cai
12.	**5**	The Tropospheric Land-Sea Warming Contrast as the Driver of Tropical Sea Level Pressure Changes	Dietmar	Dommenget
12.	**6**	Rapid Intensification of Hurricane Opal (1995) revisited: Distant Trough Interaction or Down-Stream Development?	Chi Mai N.	Hankinson
12.	**7**	The Indo-Australian monsoon and IOD-ENSO interactions in the CMIP models	Nicolas C.	Jourdain
12.	**8**	The eastward zonal current events and the generation of strong El Nino	WonMoo	Kim
12.	**9**	Evaluation of Monsoon Seasonality and the Tropospheric Biennial Oscillation Transitions in the CMIP Models	Yue	Li

12.	**10**	Forcing factors behind southern hemisphere tropical expansion	Chris	Lucas
12.	**11**	Indian Ocean warming modulates Pacific climate change	Jing-Jia	Luo
12.	**12**	Ocean salinity stratification near the eastern edge of the Pacific warm pool: a tentative review	Christophe	Maes
12.	**14**	Changes in tropical cyclone activities over Northwest Western Australia	Diandong	Ren
12.	**15**	Observations of the Pacific and Indian Ocean exchange: initial results	Bernadette	Sloyan
12.	**16**	Deformation: a new diagnostic for the evolution of large scale flow	Clemens	Spensberger
12.	**17**	Eastern-Pacific and Central-Pacific ENSO Indices	Arnold	Sullivan
12.	**18**	Intraseasonal moisture budget in ACCESS Model	Hongyan	Zhu

13. Regional climate projections

13.	**1**	What can we learn from recent regional climate change about future expected change?	Jonas	Bhend
13.	**2**	The COordinated Regional climate Downscaling EXperiment (CORDEX)	Jason	Evans
13.	**3**	NARCliM: Exploring new observational data-sets to validate regional climate simulations. An example with radio-soundings	Lluis	Fita
13.	**4**	Fire Danger Projections for Tasmania during the Twenty First Century	Paul	Fox-Hughes
13.	**5**	Adding value to ecological studies using dynamically downscaled regional climate projections	Rebecca	Harris
13.	**6**	Towards New National Climate Projections for Australia: First Impressions of CMIP5	Damien	Irving
13.	**7**	Decadal variability of the Australian monsoon and future projections as represented in CMIP5 models	Aurel	Moise
13.	**8**	Development of an in-line ocean model for improving regional climate simulations with the Conformal Cubic Atmospheric Model	Marcus	Thatcher
13.	**9**	Multimodel Assessment of Temperature over Nepal region using high-resolution regional climate models: a Bayesian statistics approach	Vidyunmala	Veldore

13.	**10**	Impacts of Large-scale Reforestation Programs on Regional Climate Change: A Regional Climate Modeling Study on Loess Plateau, China	Lang	Wang

14. The Southern Ocean and its role in climate

14.	**1**	Jet Jumping: Variability in the Southern Ocean	Christopher	Chapman
14.	**2**	Southern ocean subduction in an eddy-resolving model	Clothilde	Langlais
14.	**3**	Predictability of the Subtropical Dipole Modes in a Coupled Ocean-Atmosphere Model	Jing-Jia	Luo
14.	**4**	Modelling Antarctic Bottom Water (AABW) Overflow in Global Climate Models	Kate	Snow
14.	**5**	Projections of Antarctic Bottom Water formation in response to an increased Southern Annular Mode	Paul	Spence

15. Renewable energy

15.	**1**	One minute solar data: presenting a new public resource	Belinda	Campbell
15.	**2**	Impact of large solar farms on local climate	Kim	Nguyen

16. Insights from the Integrated Marine Observing System (IMOS)

16.	**1**	Internal Tides and Waves off the NSW coast as Observed in IMOS Mooring Data	Matthew	Bell
16.	**2**	ReefTemp Next Generation: A New Operational System for Monitoring Reef Thermal Stress	Luke	Garde
16.	**3**	Australia's Integrated Marine Observing System: monitoring major boundary currents and inter-basin flows	Katy	Hill
16.	**4**	Influence of the complex topography on particle dispersion in the southern Great Barrier Reef	Alessandra	Mantovanelli
16.	**5**	Lagrangian dynamics in the Solitary Islands Marine Park (SIMP)	Alessandra	Mantovanelli
16.	**6**	Opportunities for Marine and Climate Data Discovery	Roger	Proctor
16.	**7**	IMOS Glider Observations of Internal Tides and Waves off the NSW Coast	Robin	Robertson

16.	**8**	Designing an integrated monitoring system for Tasman leakage	Erik	van Sebille
16.	**9**	Explaining variability on the continental shelf upstream and downstream of a western boundary current's separation zone	Julie	Wood
16.	**10**	Averaging requirements and other data quality issues for HF radar wave and wind direction measurement	Lucy	Wyatt

17. Development in Numerical Weather Prediction and Data Assimilation

17.	**1**	Testing the sensitivity of the parameterization of the stable boundary layer in the ACCESS-CABLE coupled climate model	Vaughan	Barras
17.	**2**	Revised Data Assimilation for Better Representation of Regional Events in Global NWP Models	Iliana	Genkova
17.	**3**	Comparison of VAP-like Methods for Horizontal Wind Retrieval from Single Doppler Radar Data	Xingyou	Huang
17.	**4**	Modelling the Effects of Land-sea Contrast on Tropical Cyclone Precipitation	Yubin	Li
17.	**5**	Air-sea fluxes in numerical modelling of Tropical Cyclones: effects of surface drag and spray route on storm track, intensity and rapid intensification	Yimin	Ma
17.	**6**	A Bayesian Classifier for Detecting Anomalous Propagation in Radar Reflectivity Observations	Justin	Peter
17.	**7**	The Australian National Thunderstorm Forecast Guidance System: Current Design, Verification and Future Plans	Harald	Richter
17.	**8**	WRF sensitivity to Cumulus Parameterisation: Implications for forecasting of Hurricane Tracks and Intensity.	Tristan	Shepherd
17.	**9**	Forecast Sensitivity to Observations in the ACCESS G Model	Sergei	Soldatenko

AMOS 2013 Session Chairs

General Atmosphere	**1.** Irina Rudeva **2.** Frank Drost **3.** Jennifer Catto **4.** Muhammad Hassim **5.** Vaughan Barras
General Ocean	**1.** Diana Greenslade **2.** Bernadette Sloyan **3.** Gary Brassington
General Climate	**1.** Damien Irving **2.** Damien Irving **3.** Sarah Perkins **4.** Pandora Hope **5.** Sarah Perkins **6.** Irina Rudeva
Extremes	**1.** David Karoly **2.** Greg Holland **3.** Mike Hutchinson **4.** Blair Trewin **5.** Lisa Alexander
Past Climates	**1.** Joelle Gergis
CMIP5	**1.** Ben Evans **2.** Tony Hirst **3.** Tom Beer **4.** Mike Rezny
SPARC	**1.** Julie Arblaster **2.** Robyn Schofield
Tropical Processes	**1.** Christian Jakob **2.** Todd Lane **3.** Steven Sherwood
Regional Climates	**1.** Jack Katzfey **2.** Bertrand Timbal **3.** Jason Evans
Sthn Ocean	**1.** Matt England **2.** Erik van Sebille
Renewables	**1.** Roger Dargaville **2.** Robert Davy
IMOS	**1.** Robin Robertson
NWP and DA	**1.** Lawrie Rikus **2.** Kamal Puri



The Bureau of Meteorology has developed a publicly accessible online system for the delivery of one minute solar data recorded at its ground solar network stations.

You may find the one minute solar data useful if you are involved in developing photovoltaic or concentrating solar power plants as it can help you:

- understand the solar resource and the likely power plant output at prospective sites
- optimise plant design
- build a stronger case for project finance
- study the effect of the power plant on the grid
- minimise the amount of expensive and time-consuming measurements undertaken at the site of planned developments.

What data are included?
The data contain historical and recent solar statistics. These are supported with information such as the station number, date and time of observation, date of last update of data and solar zenith angle at the time of observation.

What are the solar parameters?
The solar parameters include:

- global irradiance
- direct normal irradiance
- direct irradiance on a horizontal plane
- diffuse irradiance
- terrestrial irradiance
- sunshine duration.

For each quantity and each minute the average, minimum, maximum, standard deviation, and an estimate of the uncertainty are available.

Where do the data come from?
The data are drawn from more than 27 past and present observation stations, including eight stations established in 2012 and funded for two years by the Australian Government through Geoscience Australia. The resource leverages long-term solar exposure data along with infrastructure and topographic data provided by the Bureau of Meteorology and Geoscience Australia.

How do I access the data?
To access the data, please register for a user name and password at **www.bom.gov.au/climate/data/oneminsolar/about-IDCJAC0022.shtml**

Each file available for download contains one month of data, for one station. The entire data set is available (at a cost recovery charge) on a USB drive, together with the corresponding available one minute weather data (for example, temperature and wind speed).

The USB drive can be requested via the climate data feedback form also available on the Bureau's website.

How do I provide feedback?
The team from the Bureau has developed a survey to collect valuable information about the current and emerging requirements for these and related data.

Please complete the survey at **http://www.bom.gov.au/climate/data/oneminsolar/survey-solar-2012.shtml** to help inform the development of this and other data products.

Images (left to right): Bureau of Meteorology technician Paul Freeman inspecting solar radiation monitoring equipment in Learmont West Australia; Solar halo caused by refraction of sunlight through ice crystals at Casey Station, Antarctica; Solar halo over Kangaroo Island, South Australia.

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PLENARY SESSIONS

Session: RHC Clarke Lecture - Mon 11 February, 9:00am

R.H. CLARKE LECTURE

Prof. Julia Cole
University of Arizona

Past climate change and future uncertainty: the case of the tropical Pacific

Anticipating and preparing for climate change requires that we know the natural as well as human-caused dimensions of change. One of the largest uncertainties in future climate projections is the behavior of the El Niño/Southern Oscillation (ENSO) phenomenon and its associated global impacts. The instrumental record of this system is notably brief and spatially incomplete. Paleoclimate records of ENSO suggest that its behavior can differ substantially from that observed in modern instrumental data. For example, coral records indicate that during the 19th century, ENSO variability assumed a longer time scale relative to more recent decades. In the frequency domain, ENSO-related paleoclimate records exhibit greater long-term variability than expected from long climate model simulations. We also observe that paleoclimate records of drought in the western US, where ENSO's influence is strong, show long-term variability ("megadrought") that is not well captured in these same models. Without a robust representation of low-frequency climate variability, climate models will underestimate projections of climate risk for many parts of the world. A better understanding of low-frequency variations in the tropical Pacific will improve estimates of future climate extremes.

Biography:

Prof. Cole's research centers on expanding our view of recent climate variability, using geological and biological proxies for climate along with instrumental records and climate models. Common themes include the development of geochemical records from long-lived corals and sediments, the variability and impacts of large-scale climate systems throughout the tropical oceans, and stable isotopes in the hydrologic cycle.

Session: PLENARY - Mon 11 February, 13:45pm
Presenting Author: JB Sallée

PLENARY

Dr. Jean-Baptiste Sallée

British Antarctic Survey

Surface-layer dynamics impact on vertical iron supply and subduction of anthropogenic carbon dioxide in the Southern Hemisphere oceans

JB Sallée* [1] R. Matear [2] S. Rintoul [2] A. Lenton [2] A. Tagliabue [3]

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The oceans slow the rate of climate change by absorbing about 25% of the CO_2 released to the atmosphere by human activities. The Southern Ocean makes a substantial contribution to this oceanic sink: more than 40% of the global oceanic inventory of anthropogenic CO_2 has entered the ocean south of 40S. Both biological and physical mechanisms play an important role in the surface absorption of carbon and its transfer from the surface layer into the interior. In this study, we quantify the importance of surface layer dynamics on two key processes impacting surface biological activity and surface to interior export of carbon. First, we show that winter entrainment of iron, which is a key regulator of primary productivity in the Southern Ocean, is the dominant supply mechanism and the only one able to match recent estimates of local demand. Second, we quantify the transport of anthropogenic CO_2 from the surface layer to the ocean interior by combining carbon observations with new estimates of the subduction of surface waters. Our results highlight the dependence of surface layer iron supply and carbon sequestration on physical properties sensitive to climate variability and change, including winter mixed layer depth, ocean currents, wind and eddies.

Biography:

Dr. Sallée graduated with a PhD on the study of mode waters of the Southern Ocean from Toulouse University and Florida State University (USA). Dr Sallée's research has been structured around the study of Southern Ocean surface mixing and its impact on the upper limb of the meridional overturning circulation. Specifically his research has focused on the observational connection between the ocean surface and the ocean interior, with particular emphasises on heat, salt and anthropogenic carbon sequestration in the Southern Ocean.

Session: Uwe Radok Award - Tues 12 February, 9:00am

UWE RADOK AWARD

Dr. Savin Chand
Bureau of Meteorology

Tropical cyclones and climate change: current perspective

How tropical cyclone characteristics will change due to global warming is a subject of considerable investigation. Studies based on theory and dynamical modeling consistently indicate that the greenhouse warming will cause the global numbers of tropical cyclones to decrease by the late 21st century, and leading towards more intense systems. In this talk, I will give a current state of knowledge of how anthropogenically induced climate change will impact tropical cyclones. Some new results will be presented on changes in tropical cyclone frequency as simulated by CMIP5 models.

Biography:

Dr. Chand completed his PhD at Melbourne University. His research has focused on tropical cyclones and natural climate variability. From 2011 to mid 2012, he worked in the High Impact Weather Team at the Australian Bureau of Meteorology on a project that emphasised changes in tropical cyclone characteristics due to climate change in the Pacific. Presently, he is working on a project for the Climate and Ocean Support Program in the Pacific (COSPPac) investigating methods of integrating Traditional and Scientific approaches of seasonal weather forecasts.

Session: AMOS Medal - Tues 12 February, 13:45pm

AMOS MEDAL

Prof. Ann Henderson-Sellers
Macquarie University

Blockbuster Climate Change

'*When you think about art, you think about film. And you can use it as an agent for change*.' Robert Redford, Sundance Film Festival 18 Jan 2013.

We demonstrate that climate change depiction in blockbuster movies is of good quality and constitutes effective communication. Our hypothesis is that 'block buster' movies, as opposed to those with clear educative intent such as 'An Inconvenient Truth' (2006), deliver unnoticed climate messaging. To investigate this proposition 'disaster movies' (i.e. films like '2012') are examined. In other words we are interested in the successful communication of a climate change message that is subversively portrayed in the guise of mass entertainment. We tackle the question, "can people be motivated to make Earth's future less frightening by enjoying dramas depicting terrifying climatic consequences?

Biography:

Until 2007, Professor Ann Henderson-Sellers was the Director of the United Nations' World Climate Research Programme http://wcrp.wmo.int (WCRP) based in Geneva at the headquarters of the World Meteorological Organisation. Henderson-Sellers is an international leader in climate science. She has championed the scientific need for action to mitigate and adapt to climate change for over 35 years. Professor Henderson-Sellers now holds an Australian Research Council Professorial Fellowship in the Department of Physical Geography of Macquarie University. Professor Henderson-Sellers has been an Earth Systems scientist all her life spearheading the description and prediction of the influence of land-cover and landuse change on climate and human systems. She has a BSc in mathematics, undertook her PhD in collaboration with the U.K. Meteorological Office and earned a D.Sc. in climate science in 1999. She is an elected Fellow of Australia's Academy of Technological Sciences and Engineering and was awarded the Centenary Medal of Australia for Service to Australian Society in Meteorology in 2003. Ann is an ISI "most highly cited" author of over 500 publications, including 14 books and an elected Fellow of America's Geophysical Union and the American Meteorological Society.

Session: PLENARY - Wed 13 February, 9:00am

PLENARY

Dr. Isla Simpson

Columbia University

Understanding climate model biases in southern hemisphere mid-latitude variability.

Isla R. Simpson* [1], Peter Hitchcock [2], Theodore G Shepherd [3], John F Scinocca [4]

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[2] Department of Applied Maths and Theoretical Physics, University of Cambridge, UK

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The Southern Annular Mode (SAM) represents a latitudinal shifting of the Southern Hemisphere (SH) jet stream and is the dominant mode of variability in the SH mid-latitude circulation. A common bias among global climate models is that they tend to exhibit SAM variability that is much too persistent, particularly in the summer season. Many climate forcings such as ozone depletion/recovery and increasing greenhouse gas concentrations result in tropospheric circulation changes that project strongly onto the SAM and therefore the inability of models to simulate natural SAM variability correctly is of concern for the ability of such models to accurately predict future circulation changes.

Here, specifically targetted experiments with one global climate model, the Canadian Middle Atmosphere Model (CMAM), will be used to investigate the cause of this bias in SAM variability. The role of biases in stratospheric variability and climatological tropospheric jet structure will be assessed. It is found that even in the absence of stratospheric variability the SAM timescales are biased long relative to the observations, suggesting a role for a bias in internal tropospheric dynamics. Furthermore, it is found that this bias is not alleviated when the climatological tropospheric jet structure is improved in an artificial way. An analysis of eddy-mean flow feedbacks reveals that the strength of planetary scale wave feedbacks differ between the model and observations leading to the enhanced SAM persistence.

Biography

Dr. Simpson research interests are climate modelling and atmospheric dynamics, in particular understanding the dynamics of variability and change in the mid-latitude jet streams. She is also interested in the ability of GCM's to simulate these dynamics as well as stratosphere-troposphere coupling.

Session: PLENARY - Wed 13 February, 13:45pm

PLENARY

Dr. Greg Wilson
Founder – Software Carpentry

'Are some programming languages better than others? New approaches in software engineering'

Do vaccines cause autism? Does violence on TV make children more violent? Are some programming languages better than others? Every serious attempt to answer the first two questions relies on the scientific method, but until recently, only a few people have tried to apply it to the third. In programming, it often seems that a couple glasses of beer and an anecdote about a friend's startup are all the 'evidence' most people expect. That is now changing. Drawing on fields as diverse as data mining, cognitive psychology, and sociology, a diverse group of researchers are taking an evidence-based approach to software engineering. In doing so, they are shedding new light onto some vexing questions of software development. What do most programmers get wrong in their first job? Does test-driven development lead to better code? What about pair programming, or code reviews? Is it possible to predict the likely number of bugs in a piece of code before it's released? If so, how? This talk will present some of their findings, and explain why the jury is still out on other questions.

Biography:

Dr Greg Wilson from Software Carpentry will be flying out from Canada to speak at the AMOS conference and to host the boot camp. Greg has previously worked on high-performance scientific computing, data visualization, and computer security, and has a PhD in Computer Science from the University of Edinburgh. He has written and edited several books, including the Jolt Award winner Beautiful Code (O'Reilly, 2007), and was named ComputerWorld Canada's IT Educator of the Year for 2010.

ORAL PRESENTATIONS

Session: General Atmosphere (1)
Presenting Author: Duncan Ackerley

Processes leading to summertime north-west Australian rainfall in ACCESS1.3

Duncan Ackerley* [1], Gareth Berry [1], Christian Jakob [2] and Michael Reeder [1]
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Australian summertime rainfall has been shown to be increasing in the north-west of the continent. Despite this well-documented increase in rainfall, there are still several competing hypotheses as to the cause of the increase with no overall consensus. Modelling work has been undertaken to explore the current (and potential future) trend in rainfall in north-west Australia but a detailed assessment of the rainfall generation processes on daily to sub-daily time scales has not been undertaken. These daily to sub-daily time scales have been shown to be important when considering the rainfall generation mechanisms over north-west Australia. The work presented in this paper draws upon methods derived in previous studies to provide a model-assessment framework for the rainfall formation processes over north-west Australia, which could be applied to any atmosphere model. In this study we assess one model, the Australian Community Climate and Earth System Simulator (ACCESS) model and find that while some aspects of the rainfall generation processes are represented, key elements are misrepresented by ACCESS. We therefore conclude that before we can fully understand the cause of the recent (and future) rainfall trends through using such a model that the misrepresented processes must be addressed and corrected.

Session: General Atmosphere (1)
Presenting Author: Michael Reeder

Wave-cloud lines over northwest Australia

Michael J. Reeder* [1] and Cathryn E. Birch [2]
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Prior to this study, very little was known about the frequency of occurrence and formation mechanisms of wave-cloud lines off the northwest coast of Australia. Apart from being spectacular atmospheric phenomenon in their own right, these wave-clouds can have a role in the secondary initiation of convection. A climatology of wave-clouds, based on visible satellite imagery, suggests two main types of cloud lines form over northwest Australia. The first are bore-like waves, similar in structure to the morning glory of northeast Australia, and occur at least 2-3 times per month throughout the entire year. The second type are convectively-generated cloud lines, which are more circular in shape, appear to originate from convective storms and occur at least 0.5-1.5 times per month during the wet season. Examples of each type of wave cloud are analysed in two high-resolution, nested simulations with the Met Office Unified Model. The bore-like waves occurred in synoptic-scale, low-level southeasterly flow with a heat low along the northwest coast of Australia. At night, the offshore southeasterlies accelerate into the heat low and collide with the onshore sea breeze. The southeasterlies override the sea breeze, much like an intrusive gravity current, and the wave-cloud lines form at the leading edge of this front. The convectively generated waves occur as compensating subsidence for the updrafts in convective storms. These waves take the form of n=2 mode wave-fronts, spanning the depth of the troposphere.

Session: General Atmosphere (1)
Presenting Author: Rick Millane

Mountain wave 3D wind fields from sailplane flight data

Ni Zhang [1], Rick Millane* [1], Einar Enevoldson [2] and James Murray [2]
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Mountain lee waves are trapped gravity waves generated by flow over mountainous terrain under appropriate conditions of the vertical distribution of wind speed and stability. They can produce drag that affects the general circulation, windstorms, clear-air turbulence and can influence ozone abundance. Wind fields in high-altitude mountain waves, particularly the vertical component, are not particularly easily measured using conventional techniques such as radiosondes and Doppler radar. Research aircraft have been used for this purpose but are expensive. Sailplane pilots make extensive use of mountain waves to climb and many flights are conducted that cover considerable distances and altitudes, and it is common these days for basic flight data to be logged. There is potential therefore to use these flights as "sensors of opportunity" to study mountain waves. We have developed methods to use data from sailplane flights to estimate three-dimensional wind fields in high-altitude mountain waves (Millane et al. 2010). Here we describe results from using this method to analyse data from four high-altitude Perlan Project sailplane flights, one in the Sierra Nevada wave system, two in the lee of the Andes, and one in the Southern Alps. One of the Argentina flights reached an altitude over 15,000 m, well into the stratosphere. The results allow the parts of the wave system to be mapped out relative to the topography, estimation of wave strength and wavelengths, and comparison with the Scorer parameter and other observational data. Overall, the results illustrate the potential utility and limitations of this approach.
Reference:

R.P. Millane, G.D. Stirling, R.G. Brown, N. Zhang, V.L. Lo, E. Enevoldson and J.E. Murray. Estimating wind velocities in mountain lee waves using sailplane flight data. J. Atmos. Oceanic Technology, 27, 147-158 (2010).

Session: General Atmosphere (1)
Presenting Author: Colin Simpson

WRF simulation of a strong Foehn wind event in New Zealand on 6 February 2011

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The Canterbury Nor'wester of New Zealand's South Island is a classic example of the Foehn effect. On 6 February 2011, the South Island experienced a strong foehn wind event associated with an atmospheric pressure difference of around 5 hPa per 100 km between the west and east coasts. The synoptic conditions leading to this foehn wind event were related to Cyclone Yasi, which made landfall in Australia three days earlier. This foehn wind event led to near-record breaking air temperatures across much of Canterbury. The Weather Research and Forecasting (WRF) numerical weather prediction model was used to simulate this event across the South Island using a horizontal grid spacing of 3 km. The general characteristics of this foehn wind event were found to be similar to those expected from foehn wind events in other countries. As expected, the air temperature, dew point depression and wind speed all increased rapidly at the onset of the foehn wind event, which lasted for approximately one day. This event was then interrupted in a typical fashion by the passage of a cold front over the South Island from the southwest. This cold front passage was found to eliminate the pre-existing gravity wave activity and led to a rapid decrease in the air temperature, dew point depression, and wind speed along with a change in wind direction across much of the island. The impact of this foehn wind event on fire weather severity across the South Island was investigated through consideration of the Fire Weather Index and Continuous Haines Index. The behaviour of these indices implied that this was the most extreme fire weather day during the 2011/12 wildland fire season in New Zealand, due to a combination of high air temperatures, dew point depressions and wind speeds.

Session: General Atmosphere (2)
Presenting Author: Peter McIntosh

Rossby wave teleconnections to Australian weather in observations and models

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Atmospheric Rossby waves provide an important teleconnection between equatorial convection and mid-latitude weather systems. Both ENSO and the IOD influence southern Australian weather in winter and spring via Rossby waves originating in the Indian Ocean. The classical mechanism involves equatorial heating generating stationary Rossby waves that propagate energy eastwards and polewards, altering the geopotential height in mid-latitudes. However, there is a 'no-go zone' for Rossby waves in the southern Australian region due to the adverse vorticity gradient associated with the southern flank of the sub-tropical jet. The teleconnection mechanism is therefore more complicated, involving an eddy/mean flow interaction on weather timescales that changes the mean geopotential height field in the Rossby wave no-go zone. The ability of climate models, including POAMA, to represent the no-go zone and teleconnection mechanism is examined.

Session: General Atmosphere (2)
Presenting Author: Gareth Berry

The role of continents in determining the mean sea level pressure distribution

Gareth Berry* [1] Michael Reeder [1] and Christian Jakob [2]

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Time mean asymmetries in the global distribution of mean sea level pressure are often attributed to troposphere deep circulations connected with the Hadley and Walker circulations and the mid-latitude storm tracks. The geographical location of these circulations is often thought to be related to the shape and orientation of the world's continents. In this study, we conduct a series of idealised experiments with the Australian Community Climate and Earth System Simulator (ACCESS) to investigate and quantify the impact that each of the world's continents has on the mean sea level pressure distribution. It will be shown to what extent the observed mean sea pressure distribution can be reconstructed using the superposition of each continent's impact and if a linear 'building block' view of the global mean sea level pressure distribution is valid.

Session: General Atmosphere (2)
Presenting Author: Jennifer Catto

Fronts and precipitation in observations and climate models

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Atmospheric fronts are important for the day-to-day variability of weather in the midlatitudes, particularly during winter when extratropical storm-tracks are at their maximum intensity. Fronts are often associated with heavy rain, and strongly affect the local space-time distribution of rainfall. Although global climate models should be expected to represent the baroclinic systems within which the fronts are embedded, the fronts themselves and precipitation processes within them are of much smaller scale. As a consequence, models with the typical horizontal resolution of contemporary climate models do not necessarily accurately capture these features.

A recently developed objective front identification method applied to reanalysis data is combined with global rainfall data to investigate how precipitation and extremes of precipitation around the globe are associated with atmospheric fronts. Having established the observed distribution of fronts and their role in producing precipitation and extremes, the occurrence of fronts and the associated precipitation can then be evaluated in state-of-the-art climate models. This provides a process-oriented method of model evaluation where the errors in the model can be decomposed into contributions from errors in front frequency and errors in frontal and non-frontal precipitation intensity. Finally, how fronts and their associated precipitation, especially the extremes, may change in the future can be investigated using a similar decomposition.

Session: General Atmosphere (2)
Presenting Author: Irina Rudeva

Atmospheric fronts and their associations with precipitation in the Southern Hemisphere

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Atmospheric fronts have always been one of the key factors that determine weather in the mid-latitudes. However, the most of recent research has been focused on the atmospheric cyclones rather than fronts due, in part, to a greater complexity associated with the identification and tracking of frontal systems. Advances in the spatial resolution and the quality of data available in the modern reanalyses made it possible to conduct research on smaller scales. Accordingly, during the last couple of years some papers on the climatology of objectively identified fronts have been published (Simmonds et al. 2011, Berry et al. 2011). Objective frontal analysis is now being used to explore the relationship between fronts and precipitation, high winds, evaporation, etc. Catto et al. (2012) showed that a large proportion of rainfall in the major stormtrack regions is associated with fronts. However, they only matched GPCP precipitation events with fronts without taking into account real cyclones.

In this presentation we will show the climatology of atmospheric fronts identified in the MERRA reanalysis using the method of Simmonds et al. (2011). In contrast with the approach of Berry et al. (2011) this method does not produce artificial 'fronts' around the Antarctic coast line or in other parts of the Southern Hemisphere. Another distinctive feature of this method is that it is possible to track fronts which provide valuable information on the frontal lifecycle.

One of the novel results of our research is the attribution of areas of intense precipitation (>75th percentile) to the fronts and cyclones. We will show that significant amount of intense precipitation falls outside cyclones along fronts. In high latitudes in the SH up to 80% of precipitation falls within cyclones while in the mid-latitudes from 30 to 70% of intense precipitation occur within frontal areas but outside cyclones.

Catto, J. L., C. Jakob, G. Berry, and N. Nicholls, 2012: Relating global precipitation to atmospheric fronts, Geophys. Res. Lett., 39, L10805, doi:10.1029/2012GL051736.

Berry, G., M. J. Reeder, and C. Jakob (2011), A global climatology of atmospheric fronts, Geophys. Res. Lett., 38, L04809, doi:10.1029/2010GL046451.

Simmonds, I., K. Keay, and J.A. T. Bye (2011), Identification and climatology of Southern Hemisphere mobile fronts in a modern reanalysis, J. Clim., 25, 1945–1962.

Session: General Atmosphere (2)
Presenting Author: Erica Madonna

Warm Conveyor Belts: significance, climatology and forecast verification

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During their intensification and in the mature stage, extratropical cyclones are typically associated with three coherent major airstreams – the dry intrusion, the cold conveyor belt and the warm conveyor belt, respectively. These airstreams are important for the dynamics of the cyclone evolution, and potentially also for the rapid long-range transport of atmospheric constituents. Warm Conveyor Belts (WCBs) are strongly ascending cloud-producing flows. During their rapid ascent from the boundary layer to the upper troposphere in about 1–2 days, they transport a large quantity of sensible and latent heat poleward and upwards, which leads to cloud formation and the release of latent heat. Through diabatic processes the tropospheric potential vorticity (PV) is modified in a significant way, where WCBs reach the tropopause level with low absolute PV values (∼–0.5 pvu in the Southern Hemisphere) and can potentially amplify the upper-level Rossby waves and contribute to the formation of PV streamers. These in turn can act as precursors of extreme weather events. Furthermore, with respect to the quality of numerical weather prediction, an underestimation of the frequency and/or intensity of WCBs can lead to an underprediction of the intensity of upper-level ridges and in turn develop into a poor-quality medium-range weather forecast. In this study, first a detailed global climatology of WCBs for the 32-year time period of the ERAinterim reanalysis (1979–2010) is presented, with a focus on the Southern Hemisphere. WCBs are identified from comprehensive trajectory calculations that select air parcels in the vicinity of cyclones with a minimum ascent of 600 hPa in 48 hours. Secondly, using the feature-based verification technique SAL, the representation of WCBs in the operational deterministic ECMWF forecasts is investigated for three winters with a particular focus on periods with poor-quality forecasts.

Session: General Atmosphere (2)
Presenting Author: Lee Welhouse

Antarctic Automatic Weather Station Program: capturing the meteorology and climate of Antarctica

Matthew Lazzara [1], Lee Welhouse* [1], Linda Keller [1], [2], Jonathan Thom [1], David Mikolajczyk [1], Maria (Masha) Tsukernik [3], and John Cassano [4]

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For the past 33 years, the University of Wisconsin-Madison has operated a network of automatic weather stations (AWS) across the Antarctic. The aim of the network is to capture the surface meteorology of the Antarctic, including but not limited to katabatic winds, barrier winds, kernlose or coreless winter, Ross Ice Shelf Air stream, polar lows and other phenomena. The network has been used historically to diagnose Antarctic key climate features, and later evolved into an invaluable resource for Antarctic operational forecasting services, as well as research and educational resource. Today, over half of all Antarctic AWS belong to the Wisconsin network.

We review the history of the network, including both the meteorological equipment employed to make the observations along with evolving applications of the observations. We discuss the on-going Antarctic research, such as wind studies in the Ross Ice Shelf region, employing the Wisconsin AWS network. Additionally, we review the results of an on-going project evaluating the Antarctic surface climatology – made possible with over 30 years of surface observations.

We address the value of modern day Wisconsin network in the context of other AWS networks across the continent. Maintaining such a relatively large network across vast portions of the remote continent present challenges. Without question, the observations provided by the network have played an important role in shaping our current understanding of Antarctic meteorology, and will be needed to evaluate the uncertain future of Antarctic climate. We discuss the future of the network including the trials the network faces.

Session: General Atmosphere (3)
Presenting Author: Tom Keenan

The role of the Centre for Australian Weather and Climate Research (CAWCR) in changing the landscape of Australian earth systems science

T. Keenan*, H. Cleugh, P. May, K. Puri, T. Beer, P. Craig, E. Ebert, and J. LeMarshall
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The Centre for Australian Weather and Climate Research (CAWCR) was established in 2007 predicated upon the proposition that enhanced collaboration will provide 'critical mass' in the areas of weather, climate and Earth systems science. The 'Earth systems science' approach was seen as the way forward, providing the framework to address the scope of related challenges, across a range of time and space scales that impact the safety, well-being and resilience of the Australian community. The Centre's approach is aligned with the strategic objectives of both the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (the Bureau). This is crucial and is the means by which CAWCR is able to support and build the outputs from both organisations. CAWCR now represents by far the largest national climate and weather research capability house in Australia with significant national and international links. The operation and performance of CAWCR over the last five years will be reviewed with major accomplishments highlighted. With the CAWCR relationship now starting a second five year term, evolving science activities will be discussed in the context of the international, national and partner priorities.

Session: General Atmosphere (3)
Presenting Author: Alan Seed

On the use of radar rainfall estimates and nowcasts for a heavy rainfall warning service

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The Australian Bureau of Meteorology weather radar network provides good quality radar reflectivity observations in the major cities which, together with dense networks of real-time rain gauges, can be used to support a heavy rainfall warning service that is based on radar rainfall estimates and nowcasts. The Australian climate varies from tropical in the north to oceanic in the south, so it is necessary to express the rainfall in a way that reflects the impact of the rainfall rather than simply the amount. The design standard for minor hydraulic works in most Australian cities is the storm with an annual exceedance probability (AEP) of 10% (once in 10 years). The Bureau provides a warning to the public when the rainfall accumulation at a point is expected to exceed the 10% AEP depth since this will have approximately the same impact on a city independent of the climate.

The use of radar rainfall estimates and forecasts to provide guidance for a heavy rainfall warning service at the Bureau of Meteorology is presented. The paper first describes the main attributes of the quantitative precipitation estimation system (rainfields, Seed et al. 2007) and the Short Term Ensemble Prediction System (STEPS, Bowler et al. 2006) that is used to generate the nowcasts, and thereafter discusses how these products are used to provide guidance in a heavy rainfall warning service.

Reference:

Bowler, N. E., Pierce, C. E. and Seed, A. W. (2006), STEPS: A probabilistic precipitation forecasting scheme which merges an extrapolated nowcast with downscaled NWP, Q. J. R. Meteorol. Soc., 132, 2127–2155.

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Session: General Atmosphere (3)
Presenting Author: Loris Foresti

On the spatial distribution of rainfall nowcast errors

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This research studies the spatial distribution of the errors in nowcasts of rainfall of STEPS (Bowler et al. 2006), which is important to design regime dependent bias correction schemes and drive future model developments. STEPS is a short-term ensemble prediction system that exploits the persistence of rainfall in Lagrangian coordinates to extrapolate weather radar images using an estimated velocity field. Radar rainfall fields are decomposed into a multiscale cascade which stochastically evolves in time to represent the forecast uncertainty due to rainfall evolution.

Stochastic simulations are performed by assuming stationarity of the field, i.e. no trend in growth or decay of rainfall is accounted for in the spatial domain. However, it is known that the presence of orographic features and land-sea interactions can have a major control on rainfall evolution mechanisms. A characteristic example is the rainfall enhancement and convective initiation on the upwind side of mountain barriers and the consequent decay on the leeward side. These effects can be analysed by looking at the spatial distribution of forecast performance under different rainfall regimes.

Data from the weather radar composite of eastern Victoria (Melbourne, Yarrawonga and Bairnsdale C-band radars) were used to verify STEPS forecasts during the period 2008-2012. The k-means clustering algorithm was applied to classify the different rainfall regimes and stratify the obtained verification fields. Significant forecast biases were detected in the regions with persistent rainfall growth and decay, in particular in the areas surrounding the Macedon ranges (Northwest of Melbourne) and the first slopes of the Alpine chain. The conditioning of verification fields on given rainfall regimes/classes could be exploited to design advanced non-stationary stochastic simulation schemes accounting for orographic rainfall enhancement and decay.

Reference:

Bowler NE., Pierce CE., Seed AW., 2006: STEPS: A probabilistic precipitation forecasting scheme which merges an extrapolation nowcast with downscaled NWP. Q. J. R. Meteorol. Soc., 132:2127-2155.

Session: General Atmosphere (3)
Presenting Author: James Gilmore

Precipitation extremes on the sub-hourly time scale: temperature dependence in idealised simulations

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Extreme precipitation and its dependence on climatic variables has received significant attention over the last few years. Currently, it is poorly understood how precipitation extremes for sub-hourly accumulations depend on atmospheric temperature. Observations from a number of groups indicate that precipitation extremes for hourly accumulations or less are correlated with surface temperature; however, whether the effect is a direct result of surface temperature changes or temperature gradients in the lower troposphere is unknown (Hardwick Jones et al. 2010; Mishra et al. 2012). This question is investigated by studying idealised simulations of the atmosphere as a function of temperature. The Weather Research and Forecasting model is used and configured at a cloud resolving resolution of 400m and a coarser 2km, with the simulations employing a wind-only forcing with periodic boundary conditions, run to equilibrium (Muller et al. 2011). We discuss how the observed distribution of sub-daily precipitation depends on surface temperature, and show that so-called super Clausius–Clapeyron can be obtained. We also show that sub-hourly extreme accumulations are more sensitive to temperature changes than hourly or daily accumulations.

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Session: General Atmosphere (3)
Presenting Author: James Taylor

Exceptional rainfall at Wilsons Promontory 22nd–23rd March 2011

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On Tuesday morning the 22nd of March 2011 a broad trough extended from a low over western Bass Strait, through central and northeastern Victoria to the southern NSW coast. By late on Tuesday a secondary low centre had developed over Eastern Bass Strait approximately 70km south of Lakes Entrance. This low tracked to the south of Wilsons Promontory early on Wednesday morning the 23rd of March. Vigorous and deep moist easterly flow was incident on Wilsons Promontory's steep terrain for most of this period until the low tracked to the south.

Resultant rainfall of 377.4 mm from midnight on the 21st to 5am on the 23rd was recorded by a Davis Weather Station (DWS) rain gauge mounted on the roof of the Tidal River National Parks Offices. Daily rainfall (measured from 9am on the 22nd to 9am on the 23rd) of 360.2mm was recorded, and is close to Victoria's official highest ever daily rainfall of 375.0 mm recorded at Tanybryn in the Otway Ranges on the 22nd of March 1983. There were three separate three hourly periods where close to 100mm of rain was recorded by the Davis Weather Station. The Average Recurrence Interval for this event is calculated as 30000 years, although there is a high level of uncertainty in such a figure.

This extreme rainfall resulted in widespread devastation over a central swath of Wilsons Promontory extending from the east to western coasts. Multiple huge landslides extended from some of the Promontory's highest peaks to sea level, some of which destroyed roads and walking tracks. Flooding in Tidal River resulted in the rebuilding and refurbishment of 25 accommodation, administration and utility buildings. The destruction of a bridge over Darby River on the northern side of the Promontory resulted in the stranding and eventual airlifting of around 500 campers and staff from the region.

Session: General Atmosphere (3)
Presenting Author: Yi Huang

An evaluation of the WRF simulations of the clouds over the Southern Ocean with A-Train observations

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The radiative budget over the Southern Ocean (SO) strongly depends upon the thermodynamic phase of the ubiquitous low-altitude clouds observed over the region (Mace et al. 2010). This budget has been found to be poorly represented in both state-of-the-art reanalysis and coupled global climate models (Trenberth and Fasullo, 2010). The A-Train satellite constellation, presenting an unprecedented view into the vertical distribution of the cloud microphysical and radiative properties, has been used to evaluate the simulation of clouds over the SO with the Weather Research and Forecasting Model (WRFV3.3.1).

Common cloud regimes associated with two frontal passages over the SO and Tasmania have been investigated. The simulated cloud structure, radar reflectivity, thermodynamic phase and cloud integrated properties are compared against the along-track A-Train observations. The statistics of cloud-top phase composition and the associated radiative implication are explored in comparison with the observed climatology constructed with MODIS and the A-Train merged product DARDAR-MASK. Experiments have also been undertaken to examine the sensitivity of model resolution, microphysics scheme, boundary layer scheme and CCN number concentration.

Results of the study show that WRF is capable of capturing the overall structure and phase composition of the convective clouds associated with frontal passages, despite the simulated radar reflectivity being systematically underestimated. The supercooled water cloud fields within the postfrontal air mass can be reproduced but are sensitive to the microphysics scheme employed. The simulation of cloud-top phase population depends strongly upon both the microphysics schemes and vertical resolution. The vertical resolution, particularly within the boundary layer, has a significant impact on the simulated cloud water path. The simulations, however, have greater difficulty capturing the widespread low-elevation clouds that are not immediately associated with the frontal passage, even at high resolution. The evaluated scenarios are only found to be marginally sensitive to the boundary layer schemes.

Reference:

Trenberth, K. E. and Fasullo, J. T., 2010. Simulation of Present-Day and Twenty-First-Century Energy Budgets of the Southern Oceans. Journal of Climate, 23, 440–454, doi: 10.1175/2009JCLI3152.1.

Session: General Atmosphere (4)
Presenting Author: Jeff Kepert

Why is the tropical cyclone boundary layer not well-mixed?

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Plausible definitions for the tropical cyclone boundary layer include (i) the inflow layer and (ii) the layer over which potential temperature is approximately constant. Observations show that these two candidate definitions give markedly different results in practice, with the inflow layer being roughly twice the depth of the well-mixed layer. This discrepancy is a hindrance to understanding, and has a potentially large impact on those boundary layer parameterisations that rely on the diagnosis of the boundary layer depth, including that in ACCESS. Here, we will present an analysis of the thermodynamics of the tropical cyclone boundary layer derived from an idealised model, and demonstrate why the two depths are different. The results will be compared with dropsonde and other observations, and implications for boundary layer parameterisation will be discussed.

Session: General Atmosphere (4)
Presenting Author: Michael Hewson

Exploring aerosol effects on rainfall for Brisbane, Australia

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The second indirect aerosol effect where anthropogenic aerosol may inhibit stratiform rainfall, has been the subject of studies in Australia during the late 1960s (Warner 1968) and in the year 2000 (Rosenfeld 2000). In a 2008 study examining the spatial distribution of long-term rainfall datasets around Brisbane, Bigg (2008) indicated that a possible aerosol effect on rainfall should be further examined.

To date, the majority of such studies has used long term remotely sensed atmospheric properties, or long term climate modelling, to examine the question on a climatological basis. The very limited short term, rain event scale investigations have used either weather models or satellite image band manipulation separately – and have not compared observations of co-located aerosol, cloud and rain parameters during a rain event. While interim results were presented at the International Conference of Clouds and Precipitation at Leipzig in August 2012, this paper presents the final results from a study which explores the spatial correlation between aerosol size distribution, cloud properties and rain rate on a rain event, cloud resolving scale.

Because optically based, areal remote sensing of aerosol is not possible during co-located rainfall, the chemistry transport version of the Weather Research and Forecasting model (WRF-Chem) is used to provide maps of aerosol properties to the time of a rain event from an inventory of aerosol emissions. The project leverages the fact that anthropogenic aerosol is principally found in the fine mode of the aerosol size distribution. Geo-statistics, particularly cross-variograms, were used to examine the spatial correlation of Angstrom exponent (a proxy for aerosol size) and sulphur dioxide emissions with rain intensity and cloud droplet size. The cross-variograms were produced for stratiform and cumuliform rain bearing structures and a Geographic information System was used for data processing.

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Warner, J. (1968). "A Reduction in Rainfall Associated with Smoke from Suger-Cane Fires - An Inadvertent Weather Modification?" Journal of Applied Meteorology 7: 247-251.

Rosenfeld, D. (2000). "Suppression of Rain and Snow by Urban and Industrial Air Pollution." Science 287(5459): 1793-1796.

Bigg, E. K. (2008). "Trends in rainfall associated with sources of air pollution." Environmental Chemistry 5(3): 184-193.

Session: General Atmosphere (4)
Presenting Author: Yingjun Chen

Evaluation of TRMM estimates of Tropical Cyclone landfall rainfall over Australia

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Torrential rainfall at Tropical Cyclone (TC) landfall is an important element of a TC forecast, and its estimation remains quite uncertain especially in Australian tropical regions. In this study we evaluate the latest release of TRMM 3B42 version 7 estimates of rainfall in landfalling TCs over Australia. A high quality gridded rainfall product from the Australian Water Availability Project (AWAP), based on an extensive network of rain gauges, is utilised as reference data. The overall quality of TRMM estimates is measured by mean rain rate, correlation coefficient, relative biases, relative root-mean-square-error, probability distribution function (PDF) and cumulative distribution function (CDF) of rain rate, and empirical orthogonal function (EOF) analysis on both AWAP and TRMM. These comparisons show high correlation over space and time between TRMM estimates and AWAP analysis for rainfall at TC landfall over Australia.

We have also sought correlations between the relative bias of TRMM estimates and the AWAP rainfall amount. TRMM generally overestimates TC rain at low rain range but underestimates TC rain at high rain range. Within the radii of 500 km to the TC centres, TRMM agrees well with AWAP for moderate and strong TCs (CAT 3–5) but significantly underestimates TC rain within 250km of the TC center for weak TCs (CAT 1–2). The equitable threat score, a measure of detection skill, further confirms that TRMM is more skilful during intense TCs (CAT 3–5) than weaker cases. Finally, a case study for Yasi (2011) is chosen to illustrate TRMM's ability to estimate TC landfall rainfall over Australia.

This study is important because it gives researchers confidence and expected error characteristics for using TRMM estimates for future Australian TC landfall rainfall studies. The benefit of a combined usage of TRMM estimates with rain gauge observations for Australian TC landfall rainfall studies will also be discussed.

Session: General Atmosphere (4)
Presenting Author: Guoping Zhang

Roles of mesoscale and convective-scale systems during the formation and early development of Typhoon Ketsana (2003) in the western north Pacific

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Lu et al. (2012) simulated the formation of Typhoon Ketsana (2003) in the western North Pacific using the Weather, Research and Forecasting (WRF) model. In particular, the mesoscale dynamics associated with the generation of mesoscale convective vortices (MCVs) and the roles of mesoscale convective systems (MCSs) during the formation process were investigated. Lu et al. concluded that with the successive occurrence of MCSs, midlevel average relative vorticity was strengthened through generation of MCVs via mechanisms such as vertical stretching and eddy fluxes. Through sensitivity experiments to modify the vertical humidity profile in each MCS, it was found that the development of a MCS depends substantially on that of the prior ones through remoistening of the midtroposphere, and thus leading to different scenarios of system intensification during the typhoon formation. This study further analyses the formation mechanisms of this typhoon case by examining contribution from the convective-scale vertical hot towers or in general convectively induced vorticity anomalies (CVAs). Scale separation showed that the activity of the CVA-type vortices correlated well with the development of the MCSs. These CVAs have large values of positive relative vorticity induced by intense low-level convergence. A quantitative comparison between the relative contributions from these CVAs and the MCSs to the typhoon formation will be performed, and mechanisms by which the CVAs can get organised to form the system-scale surface vortex will be identified. Further, how the mesoscale and convective-scale heating contribute to the establishment of secondary circulation and warm-core structure during the early development of the typhoon will be investigated and present in the conference.

Reference:

Lu, Xinyan, Kevin K. W. Cheung, Yihong Duan, 2012: Numerical Study on the Formation of Typhoon Ketsana (2003). Part I: Roles of the Mesoscale Convective Systems. Mon. Wea. Rev., 140, 100–120. doi: http://dx.doi.org/10.1175/2011MWR3649.1

Session: General Atmosphere (4)
Presenting Author: Alain Protat

Reconciling the ground-based and space-based estimates of the frequency of occurrence and radiative effect of clouds

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The CloudSat-CALIPSO radar-lidar combination is currently the only way to characterise the vertical distribution of hydrometeor frequency of occurrence and radiative effect of clouds on a global scale. Nevertheless, some characteristics of the instruments onboard those satellites imply that probably not all clouds are sampled by this combination. One particularly difficult situation is that of low-level clouds near the oceanic or continental surface. Our recent investigations also showed that the ground-based radar-lidar sites that do not include a high-power lidar also miss a significant fraction of thin cirrus clouds. Both effects presumably have a large impact on the estimate of the radiative effect of clouds in some critical climatic regions, such as the Tropics and the Southern Ocean. The objective of this study is to better characterize the errors associated with these space-based and ground-based instrumental limitations on the vertical distribution of hydrometeor frequency of occurrence and radiative effect of clouds. In order to quantify these errors, we compare the mean vertical profiles of hydrometeor frequency of occurrence, radiative fluxes, and the surface and top-of-atmosphere cloud radiative effect, as derived over cloud radar – lidar sites over Darwin, Australia with the same profiles derived from extractions of CloudSat-CALIPSO products within 200 km range from these sites.

Session: General Atmosphere (5)
Presenting Author: Caecilia Ewenz

Seasonal changes to the urban heat island effect

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The increasing urbanisation world-wide requires accounting for the anthropogenic urban heat island (UHI) effect by urban planning. Mitigation of the UHI effect is generally achieved through green areas, open spaces and parkland.

Adelaide provides a unique setting for studying the effect of green spaces such as parkland on the UHI. The Central Business District (CBD), 2km by 2km square, is surrounded by a 500m wide parkland-strip, covered with grass and sparse trees. The parkland can mitigate the UHI. The work reported here is an attempt to quantify their effect.

The study used a network of low-cost temperature sensors to evaluate the spatial and temporal structure of the thermal climate. 39 sensors, deployed in CBD, parkland and suburbs, the first set of 17 sensors in CBD and parkland run since June 2010 the remaining sensors were installed during October 2010. Traverses in 2011, measuring atmospheric parameters, achieved a greater temporal and spatial resolution.

The urban heat island effect varies seasonally. Winter is generally the time when the UHI effect is more prominent and the differences between green spaces (eg. parkland) are largest. Quantifying the UHI under different synoptic conditions has shown the average intensity of the nocturnal UHI in winter 2010 was 3 to 4°C with a maximum intensity compared to the surrounding parkland of up to 5°C.

The nocturnal UHI was most pronounced during clear and calm conditions. The parkland cooled faster and more than the urban area. The UHI intensity shows a minimum difference midday to early afternoon and a maximum six to eight hours after sunset. The parkland surrounding the CBD had an air temperature comparable to rural sites, namely cooler than the CBD. The parkland appeared to play an ameliorating role in limiting the magnitude of the nocturnal UHI by exchanging warmer and cooler air between regions.

Session: General Atmosphere (5)
Presenting Author: Harvey Stern

Weather predictability at 8 to 14 day lead times

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Various papers have addressed how new technologies might be harnessed to integrate material from sources on the web to generate new products (Stern, 2012). The present paper provides an update on this earlier work. It specifically examines the generation of experimental day-to-day weather forecasts at the 'outer limit' of potential forecast capability, namely, for days 8–14, with the aim of comparing the broad scale circulation in association with weather and climate regimes that are particularly predictable, with those that are less so. A 'real time' trial of a methodology utilised to generate Day-1 to Day-7 forecasts for Melbourne, by mechanically integrating (that is, combining) judgmental (human) and automated predictions, has been ongoing since 20 August 2005. Since 20 August 2006, forecasts have also been generated for beyond Day-7 (out to Day–10). Since 18 January 2009, forecasts have also been generated out to Day-14. Average correlation coefficients between forecast and observed precipitation probability, precipitation amount, minimum temperature and maximum temperature, were calculated in regard to the Day-8 to Day-14 forecasts. They were positive for all lead times and for all elements, suggesting the existence of some skill. The highest correlation coefficients (reflecting the most skilful forecasts) were those for maximum temperature. The lowest correlation coefficients (reflecting the least skilful forecasts) were those for precipitation amount. Significance tests applied to the correlation coefficients indicated that one could be confident that, at least for the Day-8 to Day-10 predictions, it was highly unlikely that the skill suggested arose by chance. 12-month 'running mean' correlation coefficients for the four elements dipped slightly in association with the recent (2010-2011) La Niña event, before recovering to earlier values once the event was over, suggesting that some weather and climate regimes are more predictable at 8 to 14 day lead times than others.

Reference:

Stern, H., 2012: Computer programs with the capacity to read and manipulate data within web documents as a vehicle for the automatic generation of more accurate weather and climate forecasts. 10th Conference on Artificial Intelligence and its Applications to the Environmental Sciences, 22–26 January 2012, New Orleans LA (available at https://ams.confex.com/ams/92Annual/webprogram/Paper192615.html).

Session: General Atmosphere (5)
Presenting Author: Jenny Fisher

Identifying sources and transport pathways of atmospheric pollutants over Australasia using a model constrained by surface-based and satellite data

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Short-lived trace gas pollutants in the atmosphere play a critical role in regulating atmospheric composition, air quality, and climate forcing. Over Australasia, concentrations of these gases are affected by anthropogenic and wildfire emissions from both local and distant sources, including Africa, South America, and the Northern Hemisphere. Here, we use a global chemical transport model (GEOS-Chem) to identify the sources and transport pathways of pollution over Australia and New Zealand. The model is constrained by multi-year observations from satellites (MOPITT, IASI, SCIAMACHY) and surface-based remote sensing spectrometers at Darwin (Australia), Wollongong (Australia), and Lauder (New Zealand). Using the model, we quantify the relative contributions of emissions from different regions and source types (fossil fuel combustion, wildfires) to pollution levels, seasonality, and interannual variability. Case study analyses of individual pollution events using the ground-based data, satellite data, and model simulations are used to identify pathways of pollution transport. The likely synoptic drivers of these transport events and their implications for pollution variability over Australasia will be discussed.

Session: General Atmosphere (5)
Presenting Author: William Thurston

Idealised numerical modelling of bushfire plumes

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The lofting of firebrands from bushfires into a background flow leads to spotting downwind of the fire front. Firebrands can travel a considerable distance under suitable conditions, so lofting and spotting make a significant contribution to the spread of fires. A thorough knowledge of the potential for lofting from a fire is therefore desirable in order to accurately predict the fire's rate of spread and coverage. The potential for the lofting of firebrands is determined by interaction between the atmospheric boundary layer, topography and the fire convective column. Here we use high resolution, idealised numerical simulations to investigate the behaviour of bushfire plumes, with reference to the potential for vertical transport of firebrands. In particular, we explore the sensitivity of the updraft to the background thermodynamic and wind profiles, and the intensity of the fire.

Session: General Atmosphere (5)
Presenting Author: Belinda Roux

Automated synoptic classification for fog forecasting at Perth Airport

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Accurate forecasting of fog at airports is important to the aviation industry for reasons of safety and economics. The Bureau of Meteorology provides terminal aerodrome forecasts for Perth Airport and there has been recent work to improve the forecasting of fog that includes improved forecast guidance and the development of a more structured forecast process. When assessing the risk of fog at Perth Airport forecasters consider the synoptic situation and whether it is conducive to fog based on a database of favourable situations developed over a long period. Although extensive forecaster knowledge and historical data analysis have contributed to compiling the database, it is not exhaustive and classification of the synoptic situation and the associated probability of fog are subjective. A project was therefore initiated to investigate the possibility of providing an objective classification system using Synoptic Typer Tools (STT). The original Synoptic Typer was developed in the Bureau of Meteorology more than a decade ago with significant improvements made by scientists in Canada in collaboration with the Bureau over recent years. STT provides an objective way of classifying synoptic patterns for any region of interest using principle components and cluster analysis. The suitability of the objective synoptic classification for the specific purpose of forecasting fog at Perth Airport has been investigated, looking particularly at the ability of the system to discriminate between fog and no-fog events. A synoptic catalogue has been developed with STT using the ERA Interim Reanalysis data for 1979–2011 and independent classification is done using the Bureau's ACCESS model. A near real-time system has been developed to automatically produce fog probability guidance based on the objective classification. Results from the investigation into automated synoptic classification and the development of the near-real time system are presented in this paper.

Session: General Ocean (1)
Presenting Author: Anya M. Waite

Formation of shallow high-nitrate low-oxygen layers in the eastern Indian Ocean supported by surface nitrogen fixation

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In the Eastern Indian Ocean off Australia, interleaving water masses coalesce to form the poleward-flowing Leeuwin Current, impacting the ecological function of Ningaloo Reef (UNESCO World Heritage Site) and other iconic coastal habitats downstream. We suggest that Low Dissolved Oxygen High Nitrate (LDOHN) layers forming at relatively shallow depths (100–200 m) contribute to localised wind-driven productivity events on the continental shelf in the region, which is otherwise largely oligotrophic. The formation of LDOHN layers at density anomalies is supported by the accumulation of biogenic particles, whose biodegradation results in depletion of dissolved oxygen and shallow regeneration of nitrate. Injection of CO_2 in these layers also lowers the pH by 0.04 units, forming an important backdrop for ocean acidification. Using isotopic $d^{15}N$ and $d^{18}O$ of dissolved NO_3, we estimate that off Ningaloo Reef, ~85% of the nitrate in the LDOHN layers originates from nitrogen fixation. We compare these values with estimates to the south and the remote northern Kimberley Region. These are the first measurements of their kind in this region.

Session: General Ocean (1)
Presenting Author: Nicola Maher

Ocean heat uptake during surface warming hiatus periods

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The anthropogenic increase in greenhouse gases in the atmosphere results in a radiative imbalance at the top of the atmosphere, which subsequently causes a non-linear increase in both land and sea surface temperatures. However, the observational record of surface air temperature reveals decadal periods with no significant change or in some cases a decrease in the global mean. These decades have been termed 'hiatus' periods. During these hiatus periods, there is still a net increase in the input of radiation at the top of the atmosphere, and so the energy surplus must be modifying other components of the climate system. Here we examine what happens to this extra energy during hiatus periods.

We have undertaken an analysis of CMIP5 models, with a focus on the ACCESS model. Decadal long hiatus periods are identified within the models and assessed to test the hypothesis that the 'missing' energy is being used to heat the oceans below the sea surface. We investigate how and where deep ocean heat content anomalies penetrate the interior on decadal timescales. Where possible, comparisons with the observational record are made.

The mechanisms causing decadal changes in ocean heat content are also examined regionally, using the CMIP5 models as well as observations. In particular we examine the role of El Niño-Southern Oscillation variability in modulating global ocean heat content and surface air temperatures over interannual to decadal time-scales. We also examine the model's hiatus decades with regard to ocean heat content variations due to deep-water formation, both in the Antarctic and North Atlantic regions. Finally, time permitting, we will examine mode water variability.

Session: General Ocean (1)
Presenting Author: Ben McNeil

A paradigm shift in the ocean: detecting the new non-steady-state CO2 outgassing signal

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The ocean's role has been pivotal in modulating rising atmospheric CO_2 levels since the industrial revolution, sequestering over a quarter of all fossil-fuel derived CO_2 emissions. Net oceanic uptake of CO_2 has roughly doubled between the 1960's (~1PgC/yr) and 2000's (~2PgC/yr), with expectations it will continue to absorb even more CO_2 with rising future atmospheric CO_2 levels. However, recent CO_2 observational analyses along with numerous model predictions suggest the rate of oceanic CO_2 uptake is already slowing, largely as a result of a natural decadal-scale outgassing signal. This recent and unexpected CO_2 outgassing signal represents a paradigm-shift in our understanding of the oceans role in modulating atmospheric CO_2. Current tracer-based estimates for the ocean storage of anthropogenic CO_2 assume the ocean circulation and biology is in steady state, thereby missing the new and potentially important 'non-steady-state' CO_2 outgassing signal. By combining data-based techniques that assume the ocean is in steady-state, with techniques that constrain the net oceanic CO_2 uptake signal, we show how to extract the non-steady-state CO_2 signal from observations. Over the entire industrial era, the non-steady-state CO_2 outgassing signal (~13±10 PgC) is estimated to represent about 9% of the total net CO_2 inventory change (~142 PgC). However between 1989 and 2007, the non-steady-state CO_2 outgassing signal (~6.3 PgC) has likely increased to be ~18% of net oceanic CO_2 storage over that period (~36 PgC), a level which cannot be ignored.

Session: General Ocean (2)
Presenting Author: Robin Robertson

Critical latitude effects on internal tides, internal waves, and mixing

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Vertical mixing in the ocean is one of the most prominent problems in physical oceanography and climate modelling today and it is poorly represented in models. Internal tides contribute 1 TW (1TW=1012 W) of energy to mixing. Present parameterizations of vertical mixing in ocean and climate models ignore critical latitude effects for their tidally parameterised mixing. Critical latitude is the latitude where the inertial frequency equals the tidal frequency and one exists for each tidal constituent. The critical latitude strongly influences generation and propagation of internal tides and is the turning latitude for Poincaré waves. Additionally, near the critical latitude, the boundary layer thickens and resonant effects come into play, both of which affect mixing. Using a model, critical latitude effects were examined over a seamount. The critical latitude was found to strongly influence the generation of internal waves, the spectral content of the internal wave field, mean flows, and the boundary layer thickness. Critical latitude effects were strongest within 1º of latitude of the critical latitude; however, some effects extended 2-3º poleward of critical latitude.

Session: General Ocean (2)
Presenting Author: Sjoerd Groeskamp

The thermohaline streamfunction and diffusion coefficients: estimated from using surface heat and freshwater fluxes together with ocean hydrography

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The flow through the global interconnected ocean, often referred to as the 'Thermohaline Circulation', has strong influence on the ocean's stratification, distribution of water masses, heat transport and cycling and storage of chemical species (e.g. carbon dioxide). This Thermohaline Circulation is a key player in the Earths climate system. Understanding of the underlying physical processes that drive the Thermohaline Circulation and quantifying its different branches is of great importance for Climate Science purposes and is an intensively studied subject.

Different approaches like tracer tracking, lagrangian trajectories, inverse methods and various overturning stream-functions, have been used to study the Thermohaline Circulation. We study the Thermohaline Circulation in temperature and salinity coordinates by applying an inverse method to observed air-sea heat and freshwater fluxes in combination with the ocean's interior hydrography to obtain a thermodynamic model of the Thermohaline Circulation. It allows us to estimate the thermohaline streamfunction, interior diapycnal transports, interior isopycnal and diapycnal mixing coefficients and overturning timescales. With this method we hope to gain new insight in the physics underlying the thermohaline circulation; this view is essentially a thermodynamic take on the global conveyer.

Session: General Ocean (2)
Presenting Author: Shane R. Keating

Horizontal and vertical mixing by surface-trapped ocean eddies

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Mesoscale eddies in the ocean, which are primarily driven by baroclinic instability of the mean shear and stratification profiles, dominate the ocean kinetic energy and play a crucial role in the transport of heat, carbon, and nutrients, with important implications for biogeochemical processes and climate change. However, no well-accepted scaling theory for baroclinic eddies exists, in part because of the complexity of the full nonlinear instability problem for realistic mean states, and this remains a critical limitation in efforts to develop mesoscale eddy parameterizations.

In this study, we exploit the observation that the potential vorticity (PV) inversion problem for a general mean state can be decomposed into a part forced by surface boundary conditions and a part forced by the interior PV distribution. This allows for a convenient categorization of the mean state into Charney-type — in which surface-intensified modes interact with a background meridional PV gradient — or Phillips-type, which is unstable when there is an inflection point in the mean PV profile. Within this framework, we examine idealised Charney, Phillips, and mixed mean states in high-resolution quasigeostrophic simulations with the goal of elucidating the equilibration, vertical structure, and transport properties of the resulting baroclinic eddies.

Session: General Ocean (2)
Presenting Author: Andrew Kiss

Eddy/boundary interactions and the East Australian Current

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Mesoscale eddies tend to propagate westward, and western boundaries have recently been proposed as a 'hotspot' for the dissipation of their energy (Zhai et al. 2010); the behaviour of eddies at western boundaries is therefore of interest. I will present results from quasigeostrophic and isopycnal-coordinate process modelling studies of eddy/boundary interactions. The beta effect and image effect each tend to induce longshore eddy propagation, but in opposite directions which also depend on the sign of the eddy (Shi & Nof 1994); interaction with topography and with mean currents can also have profound effects on longshore eddy propagation, as can the choice of lateral boundary condition. In some situations eddies propagate rapidly along the western boundary, crossing a wide range of latitudes as they dissipate; this can result in a retroflecting mean current. I will attempt to relate the dynamics identified in these process models to eddy motion observed in the East Australian Current separation region in the BLUElink Reanalyses (BRAN; e.g. Oke et al. 2011) and satellite altimetry (Chelton et al. 2011).

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Session: General Ocean (2)
Presenting Author: Maxim Nikurashin

Water-mass transformation by internal wave driven mixing in the deep ocean

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Direct observations show that small-scale turbulent mixing is enhanced in the deep ocean in regions of rough topography. Theoretical and numerical studies suggest that the enhanced mixing is sustained by breaking of internal gravity waves generated by the deep tidal and geostrophic motions flowing over rough small-scale topography. Internal wave driven mixing modifies density of the stratified ocean interior and thus results in the transformation of the oceanic water masses. In this study, we diagnose the global water-mass transformation rates using recent estimates of the energy conversion from tidal and geostrophic motions into internal waves, combined with a mixing parameterization used in state-of-the-art climate models. The results show that internal wave driven mixing in the deep ocean can sustain up to 25 Sv of the water-mass transformation. The bulk of this transformation is in the abyssal ocean near the interface between the Circumpolar Deep Water and the Antarctic Bottom Water masses. One third of the water-mass transformation is attributed to internal waves generated by geostrophic motions flowing over rough topography, a process which is dominated by the Southern Ocean and is absent from current ocean and climate models.

Session: General Ocean (2)
Presenting Author: Gary Brassington

Constructing the best estimate from the Ocean Model, Analysis and Prediction System

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The BLUElink Ocean ReANalysis is used extensively in ocean research as the best reconstruction of the past ocean state and circulation at the mesoscale for the Australian region. BRAN however is performed as close to real-time but is limited by the availability of delayed quality controlled observations and reanalysis atmospheric forcing. Typically BRAN is updated every 2 years and within one year of real-time. Frequently, researchers are analysing observations from GOOS and IMOS that are available in near real-time and are using analyses from the Bureau of Meteorology's Ocean Model, Analysis and Prediction system (OceanMAPS). The question arises what is the best estimate from OceanMAPS for research applications.

OceanMAPS uses a four-cycle approach to achieve a daily forecast. Each cycle is repeated every fourth day and the four cycles are performed sequentially over four consecutive days. Each forecast cycle includes a hindcast cycle to estimate the true state through data assimilation. The best analysis is performed 9 days behind real-time to account for both the 3-day latency as well as the period to complete a full cycle of the Jason-class altimeters. This strategy provides a symmetric analysis, the closest approximation to BRAN, but is based on the assimilation of realtime quality controlled observations and is forced by surface fluxes from the Bureau's operational numerical weather prediction system. However, unlike BRAN, which is based on a single cycle, OceanMAPS offers four BRAN-like hindcast analyses. This provides the opportunity to both optimise the fit to observations as well as provide a smoother time series. We present the potential strategies, properties and performance of these analysis products.

Session: General Ocean (3)
Presenting Author: Diana Greenslade

The evaluation of tsunami warning thresholds

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Tsunami warnings issued by the Joint Australian Tsunami Warning Centre (JATWC) are derived from a database (T2) consisting of more than two thousand pre-computed tsunami scenarios. Following any potentially tsunamigenic earthquake, warnings are issued for individual coastal zones with three different levels of threat: marine, land or no threat. The decision is based on wave amplitudes of the relevant T2 scenario within defined coastal zones. Threshold amplitude values have been derived through analysis of observed impacts for recent events. Given that historical records are available for only a short time period and no observations for which a land threat would have been issued for Australia exist, it has been difficult to determine the appropriate threshold for a land threat and this is currently set at a relatively conservative value.

A recent probabilistic tsunami hazard assessment study for New South Wales investigated potential tsunamis triggered from mega earthquakes on known subduction zones and computed inundation distances using the Delft3D model nested within T2 scenarios. These modelling results are used to evaluate the threshold values for the JATWC tsunami warnings. It is confirmed that in general, the thresholds have been set conservatively. The results also indicate the potential for improving the JATWC warnings by developing “tailored” threshold levels for each coastal zone or by incorporating real-time inundation modelling in the forecast system.

Session: General Ocean (3)
Presenting Author: Stewart Allen

The feasibility of operational tsunami inundation modelling

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The Australian Tsunami Warning System (ATWS) currently utilises the T2 tsunami scenario database to evaluate tsunami threat when a potentially tsunamigenic earthquake has occurred. The T2 database consists of many pre-computed simulations of deep-water tsunami propagation, up to a depth of 20 metres. An empirical technique was developed that allows warnings to be generated from these scenarios, assuming that wave amplitudes predicted by T2 can serve as a proxy for impacts at the coastline.

A more accurate assessment of tsunami threat and coastal impact can be obtained using high-resolution inundation modelling for near-shore regions. Other warning centres, such as the NOAA Center for Tsunami Research have successfully developed systems that use such modelling, with boundary forcing provided by tsunami propagation modelling.

This presentation will discuss what techniques have been implemented elsewhere, and how they might spur development of similar techniques for the ATWS. It will outline the technical obstacles faced and how they might be overcome. This work is part of a larger study assessing whether it is feasible to develop high-resolution tsunami inundation models for key Australian coastal communities for use in providing operational tsunami warning guidance.

Session: General Ocean (3)
Presenting Author: Lawrence Hughes

Whispers from a forgotten shoreline

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This presentation describes the evolution of the coastal and marine geomorphology off the east coast of Australia from the early Pleistocene to the Anthropocene (a proposed term for the geological time scale dating from the industrial revolution to the present). Local weather, oceanographic, shelf and coastal processes are introduced with a particular emphasis on sediment transport and the subsequent beach management of the Gold Coast region.

Field measurements are presented taken from six years of offshore observations undertaken during three principal data collection campaigns, a two year baseline survey for a desalination plant, a one month inshore data collection campaign defining flood model boundary conditions and thirdly a two year study collecting baseline meteorological and oceanographic data for a proposed dive site attraction. The methodologies of the different campaigns highlight value adding innovations and introduce the convergence of a multi-disciplinary approach to data collection.

Results appear to show the ocean systems in the area are complex relationships between understood mechanisms and yet to be determined inter-relationships. Dominated by a south east wind and swell, sediment transport is generally northward, infilling the creeks and rivers necessitating (in recent times) constant dredging and sand nourishment of the beaches. However, even with a small tidal range, high energy events have been identified between EAC sub-mesoscale eddies, baroclinic internal tides and shoaling internal waves that appear to affect turbidity and adversely affect water quality. These transitional and seasonal phenomena imply temperature stratification is a factor. Future studies hope to further illuminate the effect of these complex systems on water quality, sediment transport and coastal ecosystems enabling best management policies to be implemented.

Session: General Ocean (3)
Presenting Author: Daijiro Kobashi

Internal tides associated with a western boundary current and a possible sediment transport dynamics on the inner continental shelf, East Australia

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Internal waves play a significant role in ocean mixing and occur almost ubiquitously in the stratified ocean, particularly near abrupt topographic changes. Areas of intense internal wave activity are known as mixing hotspots. These mixing hotspots are critical for maintaining the vertical stratification of the ocean and affect nutrient concentrations, heavily influencing marine ecosystems. *In-situ* data were measured by a bottom-mounted instrument system off the Southern Gold Coast in 2007–2008 and were analysed. Sharp temperature gradients with periodic oscillations near the bottom were captured inferring existence of internal waves.

Another set of measurements with additional instruments was conducted in 2011-2012 in 30 m of water off the Gold Coast (two locations). The in-situ data were then analysed to examine links between internal waves and the East Australia Current (EAC), and a possible sediment transport mechanism.

Results demonstrate the existence of baroclinic internal waves with a peak at semi-diurnal and diurnal periods. Despite in shallow water where ocean is typically well-mixed, internal tides exist and are evident in particular in Austral summer when temperature gradients become strongest. These internal tides correspond to the EAC meandering and passages of cold core eddies, bringing cold water to the inner shelf and intensifying thermal stratification in part triggering internal tide generation. Passages of internal tides are in general agreement with significant reduction in light intensity. The results from the 2007–2008 measurements indicate high bottom shear stress during a similar event. We hypothesise this reduction in light intensity would be due to sediment re-suspension driven by internal tides (possibly breaking).

The presentation will include outcomes of in-situ data analyses. The focus of the presentation will be to quantify links between internal waves and the EAC and low light intensity near the bottom during eddy incursion based on in-situ data and Bluelink Ocean Reanalysis outputs.

Session: General Ocean (3)
Presenting Author: Julian O'Grady

Drivers of sediment transport across the entrance to the Gippsland Lakes, Australia.

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Lakes Entrance, a township located in south-eastern Australia, is the largest fishing port in Victoria and is situated at the entrance to a man-made channel connecting the Gippsland Lakes to Bass Strait. The channel was first opened in 1889 and requires ongoing dredging to maintain the passage of fishing vessels. The channel sits at the northern end of a 151km high energy beach 'Ninety Mile Beach' where the region is subject to large fluctuations in the sediment budget.

The climate of significant wave height over the southern ocean has been found to be increasing (e.g. Young et al. 2011) in conjunction with an increasing Southern Annular Mode, which is associated with sea level pressure reductions over the pole and a general poleward shift of the mid-latitude storm tracks. Furthermore, a significant proportion of the ensemble of GCM projections from the IPCC fourth assessment report suggest this trend will continue in the future (Meehl et al. 2007) and that the subtropical ridge, which affects wind and weather regimes in the study region, will also undergo a southerly shift, (e.g. McInnes et al. 2011). Such a change could lead to a regime shift in sediment movement along this coast. This talk will discuss a project aimed towards understanding changes in sediment transport budgets that may influence this region in the future.

The suite of TELEMAC models are used to investigate the movement of sediments in the nearshore region of the Gippsland Lakes. Reasonable validation of the modelled wind and waves on the ocean side of the domain is achieved in this study, however improved hydrodynamic modelling requires improved bathymetry within the Gippsland Lakes system. Three simulations testing different components of the hydrodynamics highlight the sensitivity of the model setup to move sediments offshore during stormy conditions.

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Session: General Climate (1)
Presenting Author: Blair Trewin

Global climate in 2012

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Global temperatures in 2012 were again well above the long-term average. Mean global temperatures for the year were approximately 0.45°C above the 1961–1990 average, ranking 2012 in the ten warmest years on record. Relatively cool conditions between January and March, associated with a declining La Niña event, reverted to warm conditions from April onwards.

The Northern Hemisphere was especially warm. The four months from April to July were each warmest on record for Northern Hemisphere land areas. The most exceptional warmth has been in the continental United States (US). Year to date US temperatures have been more than 2°C above normal and 0.6°C warmer than the previous hottest year on record. July was the hottest month on record for the continental US. As of early September, 63 per cent of the US was also affected by moderate to exceptional drought, the nation's most extensive drought since the mid-1950s. It was also a notably hot summer over central and western Russia, southern and eastern Europe, the Middle East and North Africa, while in the Arctic, sea ice extent has declined to its lowest level on record.

Significant flooding affected numerous parts of the world in 2012, including the Philippines, the Korean Peninsula, and parts of western and central Africa. The latter occurred during one of the wettest rainy seasons in the Sahel since the 1970s, while drought conditions have also eased in east Africa. The monsoon season was late in starting in the Indian subcontinent but total seasonal rainfall later recovered to near-normal levels.

Global tropical cyclone activity in 2012 has been near normal, and higher than the two inactive years of 2010–2011, with activity above normal in the North Atlantic and below normal in most Southern Hemisphere basins.

Session: General Climate (1)
Presenting Author: Caroline Ummenhofer

Impact of surface forcing on atmospheric blocking in the Australasian sector of the Southern Hemisphere

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Characteristics of atmospheric blocking in the Southern Hemisphere (SH), with a particular focus on the Australia-New Zealand sector, are explored in atmospheric general circulation model (AGCM) simulations with the Community Atmosphere Model, version 3. Preferred locations of blocking in SH observations and the associated seasonal cycle are well represented in the AGCM simulations. However, the model underestimates the observed magnitude of blocking. This is related to overly zonal flow due to an enhanced meridional pressure gradient in the model, which results in a decreased amplitude of the long-wave trough/ridge pattern.

A range of AGCM sensitivity experiments are conducted to explore the role of local and remote sea surface temperatures (SST) and land-sea temperature gradients for their effect on SH blocking, both separately and in combination. In particular, we assess the role of extratropical SST gradients, in conjunction with an enhanced seasonal land-sea temperature contrast created by the Australian continent during austral winter, for modifying blocking characteristics in the Australia-New Zealand sector. Furthermore, Rossby wave-train propagation forced by tropical heating in the Indo-Pacific region is linked to atmospheric blocking in the SH extratropics. The combined effects of tropical heating and extratropical temperature gradients are explored in a configuration that is favourable (unfavourable) for blocking in the Australia-New Zealand sector with warm (cold) SST anomalies to the north of Australia, cold/warm (warm/cold) to the southeast/southwest of Australia and cool (warm) Australian land temperatures, respectively. The blocking-favourable configuration indicates a significant strengthening of the subtropical jet and reduction in mid-latitude flow, while the reverse is seen for the unfavourable configuration. The relative contributions of tropical and extratropical factors to blocking are quantified, as related to the zonal flow structure over the Australian region.

Session: General Climate (1)
Presenting Author: Michael Pook

A synoptic climatology of heavy rain events in the Lake Eyre and Lake Frome catchments

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The filling of Lake Eyre by major rain events excites great interest and mainly reflects tropical and subtropical rainfall influences. The filling of Lake Frome has less impact and more specifically relates to southern rain systems. Knowledge of the historical peaks of water levels in both lakes provides important information about past climate. Here, the dominant synoptic systems responsible for recent heavy rainfall over the catchments of Lake Eyre and Lake Frome are compared and contrasted.

'Heavy rain events' are defined here as those where the mean catchment rainfall for 24 hours was 20 mm or more (AWAP data). Between 1950 and 2011, there were 30 such events at Lake Eyre and 24 in the Lake Frome catchment. The monsoon trough was found to be responsible for 43% (13 events) of the heavy rain events affecting Lake Eyre with an upper trough also present on 10 of these occasions. Troughs in the easterlies, not assessed as monsoon troughs, produced a further 11 heavy rainfall events, 10 of which were associated with troughs in the middle and upper atmosphere. The cutoff low was the next most important synoptic system in the Lake Eyre catchment (9 events).

The more southerly latitude of Lake Frome largely excludes its catchment from the main tropical activity in the monsoon season. Nevertheless, there were six days in the analysis when a mean rainfall of 20 or more mm was recorded in both catchments concurrently. Cutoff lows were the dominant cause of heavy rainfall events in the Frome catchment, closely followed by easterly troughs with upper trough support. Complex frontal systems also contributed to the Lake Frome heavy rain events.

The important conclusion of this study is that mean sea level pressure analyses alone do not adequately capture the complexity of the heavy rainfall events leading to lake filling in both cases.

Session: General Climate (1)
Presenting Author: Linden Ashcroft

Southeastern Australia temperature, pressure and rainfall variations from 1860–1910 using historical data

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Newly developed observational datasets of temperature, pressure and rainfall are used to explore interannual climate variability in southeastern Australia (SEA) during 1860–1910.

Pressure, temperature and rainfall in SEA are known to covary, not only with each other but also with large-scale circulation features such as El Niño–Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD) and changes in regional mean sea level pressure (MSLP). To examine how these links have changed over time, a path analysis process—employing partial and semi partial correlations to determine independent relationships between variables—is applied.

The historical datasets reveal several relatively unknown periods of SEA climate variation, including cool, wet conditions in the early 1870s and early 1890s, dry conditions in the early 1880s, and high interannual variability from 1885–1890. Changes in MSLP are closely linked with rainfall, and are highly correlated with the intensity of the sub-tropical ridge (STR). Independent verification using 20th Century Reanalysis data supports these findings.

Path analysis identifies changes in the relationships between ENSO and the IOD and SEA pressure, temperature and rainfall across the 1860–2009 period. By isolating the independent influence of each large-scale circulation feature on the SEA climate, we find dynamic changes in the way that ENSO and the IOD affect rainfall variation in SEA, particularly during 1920–1950 when ENSO variability is low. We also discuss whether or not the relationships since 1950, in the presence of anthropogenic warming, are outside the range of natural variability over the last 150 years.

Session: General Climate (1)
Presenting Author: Ailie Gallant

Non-stationary Australasian teleconnections and implications for paleoclimate reconstructions

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The stationarity of relationships between local and remote climates is a necessary, yet implicit, assumption underlying many palaeoclimate reconstructions. However, the assumption is tenuous for many seasonal relationships between interannual variations in the El Niño–Southern Oscillation (ENSO) and the Southern Annular Mode (SAM), and Australasian precipitation and temperatures. Non-stationary statistical relationships between local and remote climates are detected on near-centennial time scales from instrumental data, climate model simulations and paleoclimate proxies.

The relationship between ENSO and precipitation is non-stationary at many Australian stations from 1900–2009. Three climate models skillfully simulate the strength of most relationships between ENSO, SAM and the Australasian climate, but have less skill over New Zealand. Model-based relationships are non-stationary over a large proportion of the domain. A comparison of two Australasian proxy time series with remote ENSO proxies reveals non-stationary relationships consistent with instrumental and model results.

Instrumental records provide the only means of calibrating and evaluating regional paleoclimate reconstructions. However, the length of Australasian instrumental observations may be too short to identify any non-stationary local-remote climate relationships, potentially compromising these reconstructions. Regardless, the uncertainty surrounding non-stationary teleconnections must be acknowledged and quantified. Possible solutions include calibrating against multiple instrumental periods and utilising climate modelling to improve understanding of the dynamics underlying non-stationary local-remote climate relationships.

Session: General Climate (2)
Presenting Author: Claudia Frauen

Analysis of the nonlinearity of El Niño–Southern Oscillation teleconnections

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The El Niño–Southern Oscillation (ENSO) mode is the leading mode of climate variability on interannual time scales. It has its origins in the interactions of the tropical Pacific Ocean and the atmosphere but its teleconnections reach far beyond the tropical Pacific. One important characteristic of ENSO is the amplitude asymmetry between positive (El Niño) and negative (La Niña) events. Recent studies have shown that ENSO is not only nonlinear in the amplitude of its events but also in the spatial pattern and time evolution. In this study we are demonstrating that nonlinearities are also found in the global ENSO teleconnections.

By using a low resolution version of the ACCESS model forced with normalised El Niño and La Niña SST pattern of different signs and amplitudes we show that significant nonlinearities exist in the ENSO teleconnections between positive vs. negative and strong vs. weak events. These nonlinear teleconnections also have a strong impact on the atmospheric circulation and precipitation over Australia.

Session: General Climate (2)
Presenting Author: Terry O'Kane

An internal South Pacific ocean mechanism to establish thermocline regimes and modulate ENSO decadal variability

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Routine monitoring of the Southern Oscillation Index (SOI) has shown that the El Niño–Southern Oscillation (ENSO) underwent a regime transition in the late 1970s with the period (1978–2008) one of unprecedented El Nino dominance. Using ocean observations and a numerical ocean model configuration forced by reanalysed atmospheric forcing, we show that this transition was coincident with the arrival of a large--scale cold fresh salinity anomaly that had taken about a decade to propagate from the Chilean coast via an internal ocean pathway. We show not only how these disturbances are generated in the region where the Antarctic Circumpolar Current passes through Drakes Passage but quantify the roles of stochastic weather noise, mid-latitude synoptic weather patterns and inter-annual atmospheric forcing in amplifying this mode. This pathway provides a plausible mechanism for modulating ENSO variability on decadal timescales.

Session: General Climate (2)
Presenting Author: Claire Radley

Cloud and radiation variability associated with El Niño

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The El Niño–Southern Oscillation (ENSO) is the dominant form of variability in the tropics, causing both local and global variations in radiation, clouds, and precipitation. In this study we examine the response of the atmosphere, during El Niño events, in both observations and GFDL's atmosphere-only models: AM2, AM3 and HiRAM. Locally, both shortwave and longwave top-of-atmosphere (TOA) fluxes show strong correlation with ENSO, but in the tropical and global mean the correlation is strong only for the longwave. This implies strong cancellation of induced geographical shifts in cloud distributions. All models reasonably reproduce longwave TOA, but show large deficiencies for shortwave fluxes in the tropical/global average. We show that biases in cloud amount in the models mean state translate linearly to biases in anomalies. The same scaling argument works for precipitation but not TOA radiation fluxes. Implications of these results are discussed.

Session: General Climate (2)
Presenting Author: Leon Rotstayn

Have anthropogenic aerosols weakened the Southern Hemisphere subtropical jet?

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Single-forcing historical simulations with a coupled atmosphere-ocean global climate model are used to compare the effects of anthropogenic aerosols (AAs) and increasing long-lived greenhouse gases (GHGs) on winter circulation in the Southern Hemisphere. The primary focus is on the subtropical jet, which is an important source of baroclinic instability, especially in the Australasian region, where the speed of the jet is largest. During 1950 to 2005, AAs weaken the jet, whereas increasing GHGs strengthen the jet. The different responses are explained in terms of thermal wind balance: increasing GHGs preferentially warm the mid- and upper tropical troposphere, whereas AAs have a similar effect of opposite sign. This means that GHGs (AAs) increase (decrease) the temperature gradient between the tropics and the Southern Hemisphere midlatitudes. In the mid-troposphere, the warming (cooling) effect of GHGs (AAs) is maximal between 20°S and 30°S, because this latitude coincides with the descending branch of the Hadley circulation. The strongest effects are seen at longitudes where the southward branches of the Hadley circulation in the upper troposphere are strongest, notably at those that correspond to Asia and the western Pacific warm pool. The results suggest that AAs may have been a substantial driver of recent winter circulation changes in the SH. Understanding these effects is important, as GHGs are expected to increase, while AAs are projected to decrease during the next few decades. Further research is needed to systematically explore these effects, and the implications for future climate change.

Session: General Climate (2)
Presenting Author: Laura O'Brien

The effect of Rossby waves on the low-frequency variability of the Southern Hemisphere jet stream

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Large amplitude Rossby waves (RWs) stir potential vorticity (PV) and this redistribution is thought to play an essential role in the dynamics of the general circulation. This redistribution of PV probably controls both extratropical cyclogenesis and the low frequency variability of the jet stream (and storm track). In particular, large amplitude RWs sometimes break, producing isolated PV streamers and isolated anomalies which are key ingredients for further extratropical cyclogenesis. Furthermore, the processes that underpin the modulation of the Southern Annular Mode (SAM) are probably controlled by the strength and frequency of RW breaking. To explain the predicted changes in the general circulation in a warmer world, it is, therefore, important to understand the effect of RWs on climate modes such as SAM. In this study we examine different ways to characterise RW breaking and present a climatology of the seasonal variability of these events in the Southern Hemisphere. This analysis is then extended to include variability associated with different climate modes such as SAM, El Niño–Southern Oscillation (ENSO) and Madden-Julian Oscillation (MJO).

Session: General Climate (2)
Presenting Author: Carsten Frederiksen

Assessment and projected changes in the annual cycle of Southern Hemisphere baroclinicity for storm formation in CMIP5 models

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Recent studies have shown that over the last sixty years, there have been dramatic changes in the properties of mid-latitude storms which have impacted on southern Australian rainfall. In particular, during winter there have been large reductions and negative trends in rainfall over this period, associated with similar reductions in the growth rates of storm track modes and a preference for some storms to develop further south of the Australian continent. Similar changes in storm formation and rainfall have been observed in all months. These changes in the storm track modes have been shown to be related to highly significant negative trends in the baroclinic instability of the mid-latitude atmospheric circulation resulting in a reduction in storm formation at these latitudes, and increases in baroclinicity further poleward associated with increased storm formation.

In this paper, models from the Coupled Model Intercomparison Project Phase 5 (CMIP5) dataset are assessed for their ability to simulate these observed trends in baroclinicity in all months. For this purpose, we employ the Phillips criterion as a useful diagnostic of storm development related to baroclinic instability. How well the models capture the changes in the Phillips criterion and implied hemispheric changes in storm formation and rainfall in all months during the 20th century is discussed. Finally, projected changes in baroclinicity and rainfall in the 21st century are investigated using ensembles of models that best reproduce the 20th century observed changes. Our results indicate that projected changes in baroclinicity during the 21st century show similar patterns of negative and positive trends in the mid-latitudes and high latitudes to those observed and simulated in the 20th century, with increasing anthropogenic greenhouse gas forcing.

Session: General Climate (3)
Presenting Author: Xiaobing Zhou

The role of Karimata Strait Throughflow and Makassar Strait Throughflow on Indo-Pacific climate in a global ocean model

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How the Karimata Strait throughflow (KSTF) and Makassar Strait throughflow (MSTF) affect the Indo-Pacific oceanic climate individually has been investigated in a global ocean model. Four 100-yr experiments forced with climatological forcing have been conducted. Two of them are to open or close Indonesian throughflow (ITF) completely like previous work, but the other two runs only open a part of ITF. Namely, Java Sea is open only but a blockage of MSTF or vice versa. Although the MSTF makes a major contribution to the whole ITF system, the KSTF which is a part of the South China Sea throughflow has a pronounced impact on the climate of the Indian Ocean as well. Compared to the run without ITF, opening KSTF can increase 2°C in temperature and reduce 0.7 psu in salinity in the subsurface of the South Indian Ocean. Opening MSKF and whole ITF can make 3°C increase and 0.7 psu reduction in salinity in the same region. The ITF has also a large effect on the subsurface of the North Indian Ocean. Permitting KSTF or MSTF individually induces an increase of 3°C or 5°C in temperature, 0.9 psu or 1.2 psu in salinity at around 300-m depth in contrast to the run of no ITF. The fresh sea water via the ITF from the western Pacific and South China Sea will make sea water fresher near sea surface but saltier below 300 m in the Indian Ocean.

Session: General Climate (3)
Presenting Author: Josephine Brown

The South Pacific Convergence Zone in CMIP5 simulations of historical and future climate

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The South Pacific Convergence Zone (SPCZ) is a band of precipitation and surface wind convergence extending diagonally from the equatorial western Pacific to the south-east. The SPCZ is a major feature of the climate of the South Pacific, with variability on seasonal and interannual time scales that influences many Pacific island nations.

The ability of Coupled Model Intercomparison Project Phase 5 (CMIP5) models to simulate the SPCZ is evaluated and compared with previous generation CMIP3 models. A subset of CMIP5 models are able to simulate a distinct SPCZ in the December to February (DJF) austral summer in historical simulations, although the position of the SPCZ in these models is too zonal compared with observations. The spatial pattern of SPCZ precipitation is improved in CMIP5 models relative to CMIP3 models, although the spurious double ITCZ precipitation band in the eastern Pacific is intensified in many CMIP5 models. All CMIP5 models examined capture some interannual variability of SPCZ latitude and the majority of models simulate a realistic correlation with El Niño-Southern Oscillation.

In simulations of the 21st century under the RCP8.5 emission scenario, no consistent shift in the mean position of the DJF SPCZ is identified. Several models simulate significant shifts northward, and a similar number of models simulate significant southward shifts. The majority of CMIP5 models simulate an increase in mean DJF SPCZ precipitation, and there is an intensification of the eastern Pacific double ITCZ precipitation band in many models. Most models simulate regions of increased precipitation in the western part of the SPCZ and near the equator, and regions of decreased precipitation at the eastern edge of the SPCZ. Decomposition of SPCZ precipitation changes into dynamic and thermodynamic components reveals predominantly increased precipitation due to thermodynamic changes, while dynamic changes lead to regions of both positive and negative precipitation anomalies.

Session: General Climate (3)
Presenting Author: Christine Chung

Nonlinear rainfall response to El Niño and global warming in the Indo-Pacific

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Rainfall changes over the IndoPacific during El Niño events are studied using an Atmospheric General Circulation Model forced with sea-surface temperature (SST) anomalies and changes in atmospheric CO_2 concentrations. Linear increases in the amplitude of the El Niño SST anomaly pattern trigger nonlinear changes in precipitation amounts, resulting in shifts in the location and orientation of equatorial Pacific rainfall, the Intertropical Convergence Zone (ITCZ) and the South Pacific Convergence Zone (SPCZ). In particular, the ITCZ and SPCZ shift eastwards, the ITCZ shifts south towards the equator, and the SPCZ becomes more zonal. The effect of increasing CO_2 levels and warming SSTs is also investigated.

The precipitation response over the ocean is dominated by SST changes. Global warming generally enhances the tropical Pacific rainfall response to El Niño. For example, El Niño-driven precipitation increases in the equatorial Pacific are enhanced and El Niño-driven drying in the tropical west Pacific is intensified. While the dependence of projected climate change impacts on seasonal variability is well-established, this study reveals that the impact of global warming on Pacific rainfall also depends strongly on the magnitude of the El Niño event. For example, the centre of the global warming-driven precipitation increase in the equatorial Pacific moves east as the magnitude of the El Niño event increases. The magnitude and structure of the precipitation changes are also sensitive to the spatial structure of the global warming SST pattern.

Session: General Climate (3)
Presenting Author: Brad Murphy

The impact of variations in the strength and structure of El Niño events on Pacific island rainfall: insights from CMIP3 and CMIP5 models

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El Niño – Southern Oscillation (ENSO) plays a dominant role in interannual climate variability in Pacific island countries. In some countries as much as 60% of this variability can be attributed to ENSO and so ENSO directly affects the lives of people inhabiting these countries. Many countries show different rainfall responses depending on the sea surface temperature structure of different types of El Niño events. Some even display opposite rainfall anomalies for El Niño events with strongest SST changes in the eastern equatorial Pacific as opposed to those centered in the western part of the basin. However, the strength of the SST anomalies can also shift the rainfall teleconnections significantly even with no change in the SST anomaly pattern.

We take advantage of a tendency of CMIP3 and CMIP5 models to produce El Niño events with SST anomalies extending too far to the west. Due to this bias some models simulate western Pacific El Niño events with SST anomalies much stronger and with a larger range between events than observed. We firstly show the range of El Niño events in these modelling archives and how well the models reproduce observed rainfall teleconnections in the Pacific. We then investigate the teleconnections across the basin and over individual island countries in the region and how these are related to the strength and the structure of SST anomalies during El Niño events.

Session: General Climate (3)
Presenting Author: Mr. Jason A. Smith

Using climate information to improve risk management in climate sensitive industries across the Pacific

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The Climate and Oceans Support Program in the Pacific (COSPPac) is a major component of Australia's contribution to minimising the impacts of climate variability and climate change in the Pacific. A key component of the Climate and Ocean Monitoring and Prediction (COMP) component of COSPPac is the development of a set of climate application projects (CAPs) demonstrating the utility of seasonal forecasts in sectors vulnerable to climate variability such as health, agriculture, water management and renewable energy.

The primary goal of the CAPs will be the establishment of prototype operational climate risk management systems in partner countries. Particular emphasis will be focussed on developing a set of customised software tools which can be utilised by partner countries to maintain and further develop these operational climate systems in a sustainable manner. The implementation and sustained operation of these risk management systems will require close coordination between the Bureau of Meteorology, the National Meteorological Services of partner countries and the primary stakeholder agencies for each project. In order to foster these relationships and build capacity in the application of climate science to specific industry sectors, in-country workshops and discussions will form an important part of the CAPs program.

CAPs are currently being implemented in a number of COSPPac partner countries across the Pacific. Of particular note is the development of a malaria early warning system in the Solomon Islands, the use of groundwater forecasting tools to mitigate the impacts of drought in Kiribati, and the application of hydrological modelling techniques to hydropower and water management at both the Afulilo Dam in Samoa and the Vaturu Dam in Fiji respectively. The CAPs program is expected to deliver prototype climate risk management systems being established in a number of partner countries thereby assisting them to better manage the risks of climate variability and climate change.

Session: General Climate (4)
Presenting Author: Chris Lucas

A critcial comparison of metrics for tropical expansion

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Numerous papers have reported an expansion of the global tropical atmosphere using a variety of metrics and data sources to define the tropical edge. While the results are qualitatively consistent across these different measures, significant uncertainties remain amongst the results produced from different methodologies, including the rate of expansion and the degree of asymmetry between the hemispheres. These uncertainties limit our understanding of the causes and impacts of tropical expansion both now and into the future.

Here we compare and contrast the position and temporal trends of the tropical edge as defined from several different metrics, including definitions based on outgoing longwave radiation (OLR), radiosonde- and reanalysis-defined tropopause heights (ZT) and the subtropical edge of the Hadley cell. Estimates from both the Northern (NH) and Southern hemisphere (SH) are examined. The objective is to identify the source(s) of the differences of the results from the different methodologies. This knowledge helps to build a comprehensive and coherent picture of tropical expansion.

Preliminary analysis indicates that many of the observed discrepancies are related to shortcomings in the underlying data sources. For example, expansion estimates based on OLR, which indicate greater expansion in the NH, are likely flawed due to equatorial crossing time biases in the satellite data, an issue particularly relevant to the NH. In the SH, time series of the Hadley cell-based tropical edge from the majority of reanalyses show significant breakpoints in 1990 and 1998, suggestive of inhomogeneities in some of the reanalysis products. The possibility of artificial inhomogeneities in reanalysis products was also noted in the SH ZT-based tropical expansion results from Lucas et al. (2012).

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Session: General Climate (4)
Presenting Author: Ian Simmonds

The vertical and seasonal profile of temperature changes over the Antarctic in the 'new' generation reanalyses, and their radiosonde ground-truthing

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The nature of temperature trends over and above Antarctica can potentially tell us a great deal about multi-decadal climate change in the Antarctic, and the role of Antarctica in global climate change. Screen and Simmonds (2012) made use of 'homogenised' Antarctic radiosonde data from the half-century period 1961-2010. They showed a complex spatial pattern of change. However, when averaged across all stations, a robust vertical profile of half-century temperature change emerged, characterised by mid-tropospheric warming and stratospheric cooling. Statistically significant Antarctic-mean 500 hPa warming (0.1 to 0.2oC per decade) is found in all seasons. In the lower stratospheric cooling was diagnosed primarily in spring and summer (-1.0 to -2.0oC per decade). In this presentation we report on the seasonal and vertical structure of temperature trends over the Antarctic continent in the 'new' generation reanalyses, with specific focus on the NCEP Climate Forecast System Reanalysis (CFSR) and the NASA Modern-Era Retrospective Analysis for Research and Applications (MERRA) data sets. The talk will draw attention to the respects in which the signals in these reanalyses are similar to, or differ from, those revealed in the ground-truth provided by the radiosonde data.

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Session: General Climate (4)
Presenting Author: Andrew McRobert

City and country scale CO2 fossil fuel trends from a very high resolution global dataset

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CO_2 emissions from fossil fuels are the main driver of the enhanced greenhouse effect. Considering this, it is surprising how little is understood about when and where the emissions originate at fine resolution. This research aims to describe the global trends in fossil fuel emissions at a resolution of 0.1°. To investigate this, an 18 year (1992-2010) world dataset of yearly averaged CO_2 greenhouse gas emissions was used (rayner et al. 2010). The dataset is derived by combining national energy data, data on individual power-plants, gridded data on population and nighttime lights as measured by satellite. Using a linear least-squares regression model, the most interesting (both positive and negative) trends on the world have been chosen for further investigation. Some very large positive trends were found in vast areas around Beijing and Shanghai, while small negative fossil fuel trends were found in the greener cities of Western Europe. The errors on each individual pixel are relatively large but can be reduced with $14CO_2$ measurements. Better understanding of where and when CO_2 emissions are created could shape the direction of future fossil fuel reduction policies.

References

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Session: General Climate (4)
Presenting Author: Omid Alizadeh Choobari

Simulation of the spatial distribution of mineral dust and its direct radiative forcing over Australia

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Direct radiative forcing by mineral dust is important as it significantly affects the climate system by scattering and absorbing and shortwave and longwave radiation. The Multi-angle Imaging SpectroRadiometer and Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) data are used to observe mineral dust distribution over Australia. These observations are combined with the Weather Research and Forecasting with Chemistry (WRF/Chem) model to estimate shortwave and longwave radiative forcing by mineral dust. At the surface, the model domain clear-sky shortwave and longwave radiative forcing by dust averaged for austral spring and summer was estimated to be -3.80 W m^{-2} and 0.71 W m^{-2} respectively, with a net cooling effect of -3.09 W m^{-2}. The longwave warming effect of dust therefore offsets 18.7% of its shortwave cooling effect. However, over Lake Eyre basin where coarse particles are more frequent, the longwave warming effect of mineral dust offsets 42% of its shortwave cooling effect. At the top of the atmosphere (TOA), the clear-sky upward shortwave and longwave radiative forcing by mineral dust was estimated to be 1.52 W m^{-2} and -0.24 W m^{-2} respectively, with a net warming effect of 1.28 W m^{-2}. Therefore, the longwave cooling effect of dust offsets 15.8% of its shortwave warming effect. Shortwave and longwave radiative forcing by dust is found to experience diurnal variation due to changes in solar zenith angle and in the intensity of longwave radiation emitted from the surface. The effect of dust on shortwave radiation in the atmosphere was simulated to be positive due to absorption of shortwave radiation, but its effect on longwave radiation was negative because absorption of longwave radiation by dust is less than its emission to the surface and the TOA.

Session: General Climate (5)
Presenting Author: Tilo Ziehn

Carbon cycle modelling in ACCESS

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The Australian Community Climate and Earth-System Simulator (ACCESS) has been used in the Coupled Model Intercomparison Project (CMIP5) in two different versions (1.0 and 1.3) making a valuable contribution towards understanding our climate and to providing estimates of future climate change. ACCESS 1.3 includes the Community Atmosphere Biosphere Land Exchange (CABLE) model as its land surface model. CABLE does not simulate the dynamics of carbon pools and therefore the ACCESS 1.3 contribution to CMIP5 did not include the carbon cycle.

CABLE can be coupled to CASA-CNP, which is a biogeochemical model of carbon (C), nitrogen (N) and phosphorus (P) cycles for the terrestrial biosphere (Wang et al. 2010). An initial coupling of CABLE including CASA-CNP with ACCESS 1.3 has shown promising results, but has also highlighted a strong sensitivity to the initial size of the carbon pools. Therefore, it is important to spin up the carbon pools first until they reach equilibrium. A method for doing this has been tested with ACCESS1.3.

Using atmosphere-only simulations of ACCESS 1.3 over the 1979-2005 period, this study explores the sensitivity of simulated land carbon fluxes to a range of model settings. These may include the inclusion of prognostic, rather than prescribed, leaf area index and simulations with and without nutrient limitation (N and P).

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Session: General Climate (5)
Presenting Author: Peter Uhe

Development and evaluation of nudging in the ACCESS model.

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Nudging is a technique used in atmospheric models to perturb dynamical variables towards those of a host model (e.g. reanalysis data). This can help isolate the underlying processes of schemes such as atmospheric chemistry and the carbon cycle, by suppressing effects such as errors in the transport of tracers. Consequently, nudging is an important aid for model evaluation and development. Nudging schemes have many other uses such as helping to create realistic states for model initialisation and to recreate particular significant weather events in regional climate models.

We have been developing the nudging scheme in ACCESS (Australian Community Climate and Earth-Systems Simulator) to improve its reliability for users. Furthermore, we have developed an alternative spectral nudging scheme that applies a Gaussian spectral filter to the perturbation. This nudges the model to represent the large scale features of the host model while preserving the high frequency processes simulated by ACCESS. We analyse the results of nudging ACCESS towards ERA reanalysis data and quantify the performance of the different nudging approaches.

Session: General Climate (5)
Presenting Author: Wataru Sasaki

Role of vertical mixing originating from small vertical scale structures above and within the Equatorial Thermocline in an OGCM

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Recent high vertical resolution measurements show small vertical scale structures (SVSs) are present in the flow above and within the equatorial thermocline and that these structures contribute significantly to ocean mixing. The SVSs are typically unresolved in OGCMs and thus their impact needs to be parameterised. We investigate the impact of the mixing induced by the SVSs on the state of the equatorial Pacific in an ocean general circulation model (OGCM). As a first step to determine the importance of the SVS induced mixing we introduce an enhanced mixing within and above the equatorial thermocline. It is found that this enhanced mixing reduces the stratification above the thermocline, and sharpens the thermocline through the Phillips effect. The sharpened thermocline limits the exchange of heat across the thermocline and traps the surface heating above the thermocline. The reduced stratification leads to less cooling of the mixed layer through entrainment, a reduced annual cycle and an increase in the annual mean of the sea surface temperature (SST) in the eastern equatorial cold tongue. The depth dependency in enhanced SVS mixing is crucial to its impact; when the enhanced mixing is applied throughout the depth of the ocean (as has been done usually in previous studies,) the cold tongue SST is cooled further. In the western equatorial Pacific, where the thermocline is deeper, SVS enhanced mixing induces a colder SST.

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Sasaki, W., K. J. Richards, and J.-J. Luo, Role of vertical mixing originating from small vertical scale structures above and within the equatorial thermocline in an OGCM, doi:10.1016/j.ocemod.2012.09.002, accepted

Session: General Climate (5)
Presenting Author: Seon Tae Kim

Two types of ENSO and their future projections in the CMIP5 models

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In this study, we evaluate the intensity of the Central-Pacific (CP) and Eastern-Pacific (EP) types of El Niño-Southern Oscillation (ENSO) simulated in the pre-industrial, historical, and the Representative Concentration Pathways (RCP) 4.5 experiments of the Coupled Model Intercomparison Project Phase 5 (CMIP5). Compared to the CMIP3 models, the pre-industrial simulations of the CMIP5 models are found to (1) better simulate the observed spatial patterns of the two types of ENSO and (2) have a significantly smaller inter-model diversity in ENSO intensities. The decrease in the CMIP5 model discrepancies is particularly obvious in the simulation of the EP ENSO intensity, although it is still more difficult for the models to reproduce the observed EP ENSO intensity than the observed CP ENSO intensity. Ensemble means of the CMIP5 models indicate that the intensity of the CP ENSO increases steadily from the pre-industrial to the historical and the RCP4.5 simulations, but the intensity of the EP ENSO increases from the pre-industrial to the historical simulations and then decreases in the RCP4.5 projections. The CP-to-EP ENSO intensity ratio, as a result, is almost the same in the pre-industrial and historical simulations but increases in the RCP4.5 simulation.

Session: General Climate (5)
Presenting Author: Mitchell Black

Australian precipitation modelled using the weather@home.net Citizen Science Experiment

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In order to quantify uncertainty in global and regional climate model forecasts, large ensembles of climate model simulations are required. While such ensembles are beyond the capability of conventional supercomputing resources, they may be achieved through the aggregated computing power of distributed computing projects.

Launched in 2010, the weather@home.net experiment runs a moderate-resolution global atmospheric model (HadAM3P) with an embedded regional model (HadRM3P) on personal computers volunteered by the general public. To date, weather@home.net has generated over 641,000 model-years of simulations, a unique modelling resource at this resolution. Regional simulations for Europe, western United States and southern Africa are already being run in the weather@home.net experiment, while an additional Australia-New Zealand domain will be launched in late 2012.

This study presents preliminary results for Australia from the global model simulations run as part of the weather@home.net experiment, providing an evaluation of the performance of the global model in representing rainfall over the Australian region. A control ensemble is used to examine rainfall variability over seven regions of the continent, for the period 1960 to 2010, and is compared against a high quality observational dataset. Model representation of rainfall during El Nino and La Nina years is also explored.

Session: General Climate (5)
Presenting Author: Vassili Kitsios

Subgrid parameterization of eddy-eddy and eddy-meanfield interactions in simulations of the ocean

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In oceanic, and geophysical simulations in general, it is not possible to resolve all of the scales of motion. Instead one must resort to large eddy simulation (LES), where the large eddies are resolved on a computational grid, and the unresolved subgrid interactions are parameterised. There are four types of subgrid interactions: eddy-eddy; eddy-topographic; eddy-meanfield; and meanfield-meanfield. The eddy-eddy interactions are those between the subgrid and resolved transient eddies. These interactions dominate in simulations of the ocean at realistic resolutions, and have recently been parameterised in Kitsios et. al. (2012). The eddy-meanfield interactions are the next most dominant, and are the interactions between the subgrid eddies and the resolved meanfield. As the grid resolution decreases, these interactions become proportionally more significant. The current study will present parameterizations for both the eddy-eddy and eddy-meanfield interactions in climatic simulations of the ocean. Specifically, parameterizations are developed for flows representative of the Antarctic Circumpolar Current. The flow fields are generated using a two-level quasi-geostrophic spectral spherical harmonic code on a global grid with a resolution of half a degree. The parameterization coefficients (eddy viscosities) are calculated from a high resolution reference direct numerical simulation (DNS) truncated back to lower LES resolutions. The eddy viscosities representing the eddy-eddy and eddy-meanfield interactions are determined from the DNS statistics of the subgrid scales. This is repeated for various truncation levels, and the dependence of the eddy viscosities on resolution is determined. The kinetic energy spectra resulting from LESs using these eddy viscosity coefficients replicate the spectra from the reference DNS.

Kitsios, V., Frederiksen, J.S. & Zidikheri, M.J., 2012, Scaling laws for parameterizations of subgrid eddy-eddy interactions in simulations of oceanic circulations, to be submitted, ftp.csiro.au/Kitsios/Kitsios2012.pdf

Session: General Climate (6)
Presenting Author: Michael Hutchinson

A new anomaly-based approach to Topographic dependent interpolation of daily and monthly precipitation

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High resolution spatially extended values of climate variables play a central role in ecosystem modelling, assessment of ecosystem models themselves and in downscaling. Precipitation presents several challenges to effective spatial interpolation at both daily and monthly timescales. These include the innate high degree of spatial and temporal variability of precipitation, in statistical terms it is highly skewed, and, at the daily timescale, there are many zero values. Data errors, particularly false zeroes, also need to be accounted for. Moreover, the data network has uneven density and is quite sparse for large parts of Australia. A new normalised anomaly-based interpolation method has been developed that separately accounts for the strong dependence on topography of the "background field" and the atmospheric convergence processes and associated wet day thresholds that give rise to precipitation. The (approximate) normalising process is to take the square root of the precipitation values and refer these as anomalies with respect to a background field that can be calibrated in terms of two parameters, the mean precipitation and the probability of zero precipitation. This can be done at both monthly and daily timescales for each month of the year. The method is a significant advance over the method described in Hutchinson et al. (2009).

Topographic interpolation of the background field, using tri-variate smoothing splines (Hutchinson 2004) can take near full account of the topographic forcing of precipitation, leaving the normalised daily and monthly anomalies to be interpolated more broadly, as these are largely driven by broad synoptic patterns. Zero precipitation values require special action in calculating sensible anomaly values, and this is always required when interpolating daily precipitation. Enhancements to the methodology for interpolating monthly mean precipitation and the new approach to dealing with zero values are described. A full error assessment of the interpolated values is provided to assist the assessment of applications and in comparing accuracies of existing interpolation products for Australia and elsewhere.

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Session: General Climate (6)
Presenting Author: peter g baines

Factors affecting the interannual variability of global land-based rainfall

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Rainfall is a notoriously variable, even when seasonal means are taken. In part, this may be attributed to the fact that it is influenced by a variety of different dynamical factors. Some of these (such as El Niño/La Niña) are reasonably well known, but others with smaller but significant contributions have received relatively little attention. Here, a study is described of the interannual variability of the observed rainfall based on global land-based observations from 1950, taken from a data set compiled by the University of Delaware (Legates and Willmott 1990, Willmott and Matsuura). Since rainfall is affected by different factors in different seasons, the analysis is seasonal, and a multiple regression analysis based on time series is performed to determine the effects on seasonal rainfall of nine factors that include the following: ENSO, global warming, the quasi-biennial oscillation (QBO), the Pacific Decadal Oscillation, the Atlantic Meridional (or Multi-decadal) Oscillation, the Pacific Gyre Oscillation, the Southern Annular Mode (SAM) and the solar cycle. Patterns of influence of these various factors on rainfall are obtained, which are indicative of the (mostly, so far poorly understood) dynamical processes associated with these variations. Confidence intervals for these effects are presented, together with a variogram analysis of near-neighbour effects in the data. Regions specifically presented include Australia.

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Session: General Climate (6)
Presenting Author: D. Argüeso

Precipitation bias correction of very high resolution regional models

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Regional Climate Model (RCM) simulated precipitation usually need bias-correction, particularly when they are to be used to drive impact models such as hydrological models. Several methods have been proposed to correct precipitation aimed at correcting the mean and higher order moments of the rainfall distribution. However, all these methods impose a condition: the model has to produce the same or a higher number of rain days. RCMs have traditionally met this condition, partly because their resolution is coarser than the observational dataset used to conduct the bias correction. Recently RCM simulations that exceed the spatial resolution of most gridded observational products have become possible due to improvements in computational resources. In this new scenario, RCMs are likely to produce less rain days than the gridded observations and thus the suggested bias-correction methods have to be revised.

The Weather Research and Forecasting (WRF) model was employed to determine the implications of increasing spatial resolution in terms of bias correction. To that purpose, we analysed two RCM simulations at 2- and 10-km spatial resolution over the Sydney area. The model outputs were compared with both gridded and in-situ observational datasets and different methods for precipitation bias correction were examined. Finally, we propose an alternative to correct very high-resolution model outputs towards in-situ observations. An adjustment of the cumulative probability distribution function is selected and modified so that the correction is performed towards a set of stations. The stations are weighted using a combination of inverse squared distance and an objective regionalisation, which removes the spatial scale difference between the stations and the grid-points. It is also likely to remove the issue of the number of rain days so that high resolution will not be an obstacle for bias correction.

Session: General Climate (6)
Presenting Author: Gab Abramowitz

Multi-model ensemble interpretation paradigms

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How closely should a climate model match observations? What is the timescale beyond which observed and model averages should be expected to match? What is the meaning of ensemble spread and how does it relate to prediction uncertainty? While these may seem like somewhat unrelated questions, their answers go to the heart of how we use and evaluate multi-model ensemble predictions. This talk will compare and contrast the so called 'truth-plus-error', 'indistinguishable' and 'replicate Earth' paradigms of ensemble interpretation, using the questions posed above as well as conceptions of model dependence within ensembles as a way of highlighting their differences.

Session: General Climate (6)
Presenting Author: Anthony Kiem

Assisting Australian grain growers in understanding, quantifying and managing the variability of the climate system

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For Australian agriculture much has been made of the problems associated with anthropogenic climate change. However, out to at least 2030, coping with climate variability is of much higher importance than dealing with the projected impacts of anthropogenic climate change. Therefore, perhaps the best way to adapt to future climate change is to improve the ability to cope with existing and historical variability. The better we understand historical climate impacts the more chance there is of being robustly adapted for the future. That is, build resilience based on what we know has happened but make the adaptation strategies flexible so they can be altered if and when needed. Fundamentally, this requires understanding both the causes and magnitudes of historical climate risk and how that risk may change in the future – which in turn requires focusing on more than just changes to average rainfall or temperature conditions.

This study, recently completed for the Grains Research and Development Corporation (GRDC), demonstrates station by station across Australia the variability that is already experienced and needs to be taken into account as part of climate risk management. Importantly, this was done not just on 'primary' climate variables (e.g. rainfall, temperature) but also on derived 'climate products' actually used by grain growers but not directly available (e.g. growing season rainfall totals, flood risk, chance of frost, timing of first and last day over 30°C each year, heatwaves, chance of thunderstorm, etc.).

By collating information on key 'climate products' across Australia the changing nature of climate is put into context at a scale and for variables that are useful for farmers. This is very important as farmers start to appreciate how their local climate could change and how this change needs to be planned for in addition to the immediate issues associated with managing climate variability.

Session: Extremes (1)
Presenting Author: Sally Lavender

Closed low pressure systems and Australian rainfall

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Tropical cyclones and other closed low pressure systems are important synoptic systems that provide a large proportion of Australia's annual and extreme rainfall. Understanding the influence of these synoptic systems on Australian rainfall in the current climate is important in order to understand how Australia's rainfall, and hence water budget, may change in future climates.

Changes in these synoptic systems can partially explain the recent positive rainfall trend in the north of Australia. Similarly, closed low pressure systems, such as cut-off and east coast lows, affect rainfall over south-eastern Australia, and influence the negative trend in rainfall in this region. The contributions of tropical cyclones and other closed low pressure systems to rainfall trends in the north and south-east is found to be predominantly due to changes in the precipitation efficiency. Possible mechanisms for these changes will be discussed here.

The ability of climate models to simulate these Australian closed low pressure systems will be evaluated under the current climate. Projected changes in these synoptic systems under future climate scenarios will also be examined.

Session: Extremes (1)
Presenting Author: Julie Arblaster

ENSO and maximum temperature extremes

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The impact of the El Niño-Southern Oscillation (ENSO) on temperature extremes is examined in both observations and coupled climate model simulations. HadEX2, a recently developed observed gridded dataset of climate extremes indices shows marked contrasts in seasonal composites of the monthly maximum value of daily maximum temperatures during the cold and warm phases of ENSO. Extreme maximum temperatures are significantly cooler over Australia, southern Asia, Canada and South Africa during strong La Niña events compared to El Niño events and significantly warmer over the contiguous United States and southern South America. Two NCAR climate models are contrasted for their ability to capture these relationships given their very different simulations of ENSO; the CCSM3 ENSO has a strong biennial frequency that is too narrowly confined along the equator, while the CCSM4 ENSO is more realistic in both frequency and pattern. While both models capture some aspects of the observed teleconnections, the fidelity of the ENSO simulation appears to be crucial for simulating the magnitude and sign of the extreme maximum temperature relationships. The impact of future climate change on these patterns is also investigated. An amplification of the response of maximum temperature extremes to El Niño over Australia occurs in a single simulation under RCP8.5 which warrants further investigation. Potential mechanisms for this amplification are discussed.

Reference: Arblaster, J.M. and L.V. Alexander (2012), The impact of the El Niño-Southern Oscillation on maximum temperature extremes, *Geophys Res Lett*, in press

Session: Extremes (1)
Presenting Author: Andrew D. King

Investigating the response of Eastern Australia extreme rainfall to Pacific variability: a statistical and dynamical approach

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Variability in the Pacific Ocean affects rainfall in Eastern Australia on inter-annual to multi-decadal timescales. We demonstrate that the El Niño-Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO) exhibit strong teleconnections with extreme rainfall in this region.

An asymmetric relationship is found between indices for ENSO and indices representing the intensity and duration of extreme rainfall. Stronger La Niña years are associated with greater values of extreme rainfall indices than weaker La Niña years are, however, the magnitude of an El Niño event is found to have little effect. This asymmetry is strongly modulated by the IPO, such that in IPO positive (more El Niño-like) periods the relationship breaks down. In IPO negative (more La Niña-like) periods, on the other hand, the relationship is considerably stronger. These results suggest that the IPO modulates the ENSO-extreme rainfall teleconnection.

In order to gain a deeper understanding of the physical mechanisms at work, atmospheric and oceanic patterns associated with extreme rainfall in Eastern Australia are also examined. This is done through the use of fields of sea surface temperature and atmospheric circulation patterns from reanalysis data. The regions where the atmospheric and oceanic conditions have the greatest impact on extreme rainfall are identified and effects on synoptic-scale rain-bearing systems in Eastern Australia are discussed.

Session: Extremes (1)
Presenting Author: Matthew Wheeler

Impacts of the Madden-Julian Oscillation on Australian maximum and minimum temperature and extremes

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Impacts of the Madden-Julian oscillation (MJO) on Australian surface air temperature are examined during all seasons and explained with the help of previously-published impacts on rainfall and circulation. Gridded observations of daily maximum and minimum temperature, derived from station observations, are analysed to determine when and where significant impacts occur. The index of the MJO that is used is the Realtime Multivariate MJO (RMM) index of Wheeler and Hendon. This index has the advantage that the relationships that are obtained using past data may be applied for diagnosis of impacts in real-time. Several temperature metrics are considered, including daily maximum and minimum temperature anomalies, as well as the probability of extremes. Extremes are defined as the occurrence of the daily maximum or minimum temperature anomaly (with respect to a smoothly varying seasonal cycle) in the highest or lowest decile. The largest impact on maximum temperature is warm anomalies over southeast Australia during Phase 3 of the MJO in austral spring. For minimum temperature the largest impact is cold anomalies over Queensland during Phase 7 in winter. Interestingly, both of these temperatures signals correspond to dry conditions as described in our previously-published work on rainfall, indicating that these particular impacts are a result of, or at least supported by, cloudfree skies. During these particular phases the probability of our defined extremes (i.e. in the highest and lowest decile respectively) is approximately doubled compared to the normal probability. During the wet MJO phases in northern Australia in summer (i.e. Phases 5 and 6), when the MJO's signal in tropical convection has a direct influence on Australia, daily maximum temperatures are everywhere cooler than normal and minimum temperatures are little affected. Knowing these impacts is useful for our understanding and prediction of temperature and extremes on the intraseasonal time scale.

Session: Extremes (2)
Presenting Author: Eun-Pa Lim

Dynamical forecast of extreme climate conditions in 2010 spring

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2010 spring host a near-record strong La Nina and a record-breaking positive SAM, which played key roles for extreme wet condition in eastern Australia. In this study, we assess the prediction skill of the Australian Bureau of Meteorology's dynamical seasonal forecast system (POAMA2) for the 2010 spring extraordinary climate conditions.

POAMA2 skilfully predicts the spatial pattern and magnitude of the tropical ocean temperatures associated with the La Niña event at lead times of at least 4 months. Importantly, POAMA2 also predicted the key variations of atmospheric circulation during spring 2010 associated with the positive swing in the Southern Oscillation as well as the strong positive excursions of the SAM out to a lead time of 3-4 months. Consequently, the wet conditions over eastern Australia in 2010 spring were skilfully anticipated from the preceding early winter.

We also conducted model experiments to investigate the forecast sensitivity to atmosphere and land surface initial conditions. The results suggest that the 2010 strong La Niña (ocean initial condition) was a necessary condition for the development of the positive phase of SAM and the high rainfall in eastern Australia, but realistic atmospheric conditions played an important role in predicting the extraordinary strengths of the SAM and the rainfall.

Session: Extremes (2)
Presenting Author: Louise Wilson

Influence of model bias on projections of Australian and Pacific extreme rainfall and temperatures.

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The impact of climate change is likely to be felt more in the extremes than the mean state for many sectors. Studies of observed trends in climate extremes for Australia and the western Pacific report increasing occurrences of high temperature extremes and an increase the number of dry spells interspersed with periods of extreme precipitation (eg. Alexander and Arblaster, 2009). To investigate these observed increases in frequency and intensity we look at changes in return values of extreme precipitation and temperature events under future emissions scenarios.

The average recurrence interval (ARI) of extreme precipitation and temperature events in the CMIP5 models is reported for the Australian and Pacific region. Annual maxima from the CMIP5 models are fitted to generalised extreme value (GEV) distributions, similar to that done for CMIP3 models by Kharin et al. (2007) for historical, mid 21st century and the late 21st century. The distributions are used to investigate the projected changes in magnitude and frequency of extreme events. As the emissions scenarios used as forcings for the CMIP5 models are not identical to those used for CMIP3, direct comparisons between models from these experiments cannot be made, however the direction of change and magnitude of change is qualitatively compared for given return values.

To provide meaningful climate projections a good understanding of model biases and how they affect the variable(s) in question is required. A multi-model study is used to investigate the impact of model biases on the robustness of the response We analyse multiple models to investigate their variability in the response of extreme rainfall events to climate change. Historical observations of extremes are compared with model derived extremes at discrete locations to provide a qualitative statement regarding model performance. The relationship between model biases and projections of extreme events is investigated. This relationship is used to examine whether regional biases in the simulated mean climate state contribute to biases in the projection of precipitation and temperature extremes.

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Session: Extremes (2)
Presenting Author: Tony Rafter

Projections of Australian region extreme precipitation using Bayesian Spatial Modelling

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One anticipated effect of anthropogenic global warming is the amplification of the hydrological cycle, and this is likely to be felt most clearly through changes in the occurrence and/or intensity of its extremes. These changes are not expected to be uniform in space however, and so it is of interest to investigate changes in the patterns and magnitudes of change of precipitation extremes at regional scales. The spatial and temporal scales of GCMs are generally insufficient to reproduce realistic precipitation extremes on these scales, so we analyse output from simulations of higher resolution (65, 14 and 4 km) regional models. We expect these regional models to give an improved representation of extreme rainfall events through better representation of terrain and sub-grid scale processes.

Estimates of long-period Average Recurrence Intervals (ARI) of heavy precipitation are typically calculated by fitting an extreme value distribution to time series data at individual locations or grid points, but obtaining spatially consistent estimates of the parameters of these distributions can be problematic. To help overcome this problem we have employed the Bayesian spatial hierarchical model developed by Schliep et al. (2010), which borrows strength from nearby grid points to obtain spatially coherent parameter estimates and hence fields of return levels. We have performed this spatial modelling on output of our regional models for baseline and future climate periods and produced projected changes in intensity of daily precipitation over Australia from each set of simulations. These projections and the differences between those from the various regional model simulations will be discussed, as well as the ability to connect output of the spatial model to observational extremes.

References:

Schliep, E., et al. (2010). "A comparison study of extreme precipitation from six different regional climate models via spatial hierarchical modelling." Extremes 13(2): 219-239.

Session: Extremes (2)
Presenting Author: Eric Oliver

Projected ocean warming and extremes off southeast Australia in the 21st century

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The ocean off southeast Australia is warming at almost four times the global average rate. Observational and modelling studies suggest that the increased sea surface temperature (SST), and reduced nutrient supply, is largely due to a spin-up of the South Pacific Gyre, and intensification of the East Australian Current (EAC) over recent decades. The extending EAC does not represent a simple change in the mean flow, but rather complex pulse and eddy changes, and is likely to affect higher order statistics such as the frequency of warming or cooling events. Extreme temperature events in particular can have catastrophic impacts on fragile coastal ecosystems. We investigate how the ocean climate in the Tasman Sea is projected to change during the 21st century. Here, we discuss results from a high-resolution (~10 km) ocean circulation model, forced by output from a large-scale climate model simulation, for the southeast Australia region through the 2060s. Model biases are taken into account by evaluating the model representation of SST through the 1990s against satellite remote sensed AVHRR observations. Bias corrections are thus applied to the simulated 2060s period. We present the projected future ocean climate in terms of changes in the mean SST, SST variability, and occurrence of extreme temperature events. By mapping ocean climate changes and extremes, we identified specific regions where the change in climate is expected to be particularly strong. Finally, we discuss the ocean dynamic mechanisms that underpin these high-resolution simulations in light of climate change.

Session: Extremes (2)
Presenting Author: Alexander Babanin

Regional and seasonal patterns of changes to the extreme wind speeds

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Recent analyses of long-term observations, both in situ and by remote sensing means, and of numerical modelling indicate that surface winds have been growing globally. The growth is particularly essential at high percentiles, i.e. for extreme weather events.

In the present paper, global wind trends are studied in space and time at the local scale. The data used were obtained from altimeter and SSM/I satellite records over the period of 1991-2008. The time series were investigated for regional linear trends in particular months. The satellite records indicate that the earlier observed global trend is due to a significant increase in wind speed across the Pacific and Southern Oceans. In those regions, ocean surface winds largely increased in excess of the global average trend during the austral and boreal winter, over six continuous months. The data also showed that in the month of May, one of the largest trends in surface wind speed was found for the North Indian Ocean, which might indicate a shift in onset time of the Indian summer monsoon. Significant shifts of the weather patterns are also observed in the Australian region.

Session: Extremes (2)
Presenting Author: Markus Donat

Trends in temperature and precipitation extremes analysed from global observational datasets in comparison to reanalyses and climate model data

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Based on newly developed global gridded data sets of climate extremes indices, we analyse how temperature and precipitation extremes have changed during the past century. Results are compared across the datasets, as well as to climate extreme indices calculated from global reanalyses data and climate models.

We find consistent and wide-spread warming trends over much of the globe, as reflected by e.g. increasing numbers of warm days and nights and fewer cold days and nights, higher extreme temperature values and longer warm spell durations. Extreme precipitation indices are characterised by a higher variability than extreme temperatures, and changes are spatially more heterogeneous. However, on global average we also find a tendency towards stronger precipitation, and larger areas with significant trends towards wetter conditions than areas with drying trends.

While we find a strong agreement between the different observational datasets, larger differences are found for some of the reanalyses results, particularly during the pre-satellite era. For the NCEP1 reanalysis we document spurious values of maximum temperature which seem to make this dataset unsuitable for the analysis of warm temperature extremes. We conclude that there is high robustness of the observational results since the middle of the 20th century, but reanalyses seem suitable for this kind of global analysis of climate extremes only during the most recent 3 decades when satellite data are used for assimilation. The ensemble of CMIP5 climate simulations generally shows a comparable tendency of changes, however there is also a large inter-model spread.

Session: Extremes (3)
Presenting Author: Sarah Perkins

Closing the gap on heat wave measurement

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The effects of heat waves are felt across many different sectors, and have high monetary, human, and physical impacts over many global regions. Due to this wide interest, the definition of a heat wave remains broad in describing a period of consecutive days where conditions are excessively hotter than normal. This has allowed for the employment of an excess of metrics, which are usually sector-specific, or do not appropriately describe important features of heat wave events.

This talk will present a framework in which heat waves are measured. The indices are calculated from daily maximum, minimum, and average temperature, and are analysed to study multiple components of heat waves that represent heat wave duration, frequency, intensity and timing. The framework has been constructed in order to suitably measure heat waves, and to provide practical information for those effected by such events. Results focus on observed heat waves over Australia using the AWAP gridded dataset, and exploring relationships between event components and low-frequency modes of variability. Key results include increases in heatwave frequency for all indices, with considerable regional detail for all indices and components.

Session: Extremes (3)
Presenting Author: Ruth Lorenz

How important are phenological feedbacks for European climate and heat waves?

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European summer climate, especially extreme events such as heat waves and droughts, is strongly impacted by processes acting at the interface between the land surface and the atmosphere. It has been hypothesised that phenological processes may play an important role, but these effects have not been investigated in detail with dynamical models so far. In this study, we investigate the impacts of inter-annual and extreme phenological variations on European climate using regional climate model simulations. In addition, we assess the relative impact of inter-annual and extreme variations in soil moisture (SM) and phenology on the European climate. We find that the overall effects of phenological anomalies on mean climate are small, in particular with respect to those induced by SM anomalies. However, effects on heat wave persistence are of the same order of magnitude, if we disregard the larger effect on mean climate induced by SM. Generally, late greening and small vegetation activity have amplifying effects on heat waves, and early and strong greening have dampening effects. The experiments suggest that in the extreme hot 2003 (West and Central Europe) and 2007 (South-East Europe) summers the decrease in vegetation activity amplified the heat waves. Especially high temperatures at night were increased by about 0.5°C. In contrast to other studies, our data do not show an anomalous early greening of the vegetation in spring 2003. Hence, our results indicate that vegetation amplified the heat wave in 2003 but was not responsible for its initiation. The amplification due to vegetation feedbacks was even more pronounced in the 2007 case study. In conclusion, phenology can be important for specific extreme events but in contrast to SM, our results do not suggest that it has a pronounced effect on the European mean climate.

Session: Extremes (3)
Presenting Author: Heping Zuo

Assessment of future extreme drought projections for different river basins of New South Wales

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Extreme drought events have been a critical matter for water resource management in New South Wales (NSW), as they affect many water related decisions such as water sharing plans and relevant infrastructure. Climate change is imposing further challenges to industries and community of NSW with exacerbating extreme drought and reduced water availability.

This study aims to assess the future change of severity and length of extreme drought for the Lachlan and Gwydir river systems, which have different rainfall patterns and possibly different rainfall projections for the future. The analysis is based on statistically downscaled rainfall data for the A1B and A2 scenarios for the period of 1900-2098 using the methods reported in Liu and Zuo (2012), including 23 and 18 GCMs. Observed rainfall data is also used in defining baselines. There are similar numbers of models projecting either drier or wetter changes for both basins. However, drought length changes are projected extreme increases by some dry models. Average annual rainfall changes over the drought are not as significant as the length changes.

There is no substantial difference found between A1B and A2, except a few moderate models projected minimal changes but with contrast directions. Projections for Gwydir are slightly less significant than the Lachlan with. The only GCM model projected significant difference between two regions is IPSL, which projects extreme dry changes for the Lachlan but moderate wet changes for the Gwydir. The dry and wet cycles, rainfall trends are also discussed for some GCMs that projected very significant changes in future drought events.

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Session: Extremes (3)
Presenting Author: Milton Speer

Dust storm frequency and impact over eastern Australia is determined by the state of the Pacific climate system

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Dust storms resulting from synoptic scale mid-latitude frontal systems affect inland, eastern Australia predominantly through spring (SON) and summer (DJF) but extend to the east coast only rarely when strong, frontal westerly winds crossing the continent, are sustained over the coast.

It will be shown that extreme westerly wind dust events are anomalous to the more pervasive southerly winds that have shaped the sand dunes over inland eastern Australia. It will also be shown that while antecedent dry conditions are very important, higher SON and DJF dust storm frequencies since 1957 occurred in the dominant La Niña phase until the mid-1970s. This is due to both anomalously strong, southerly winds existing on the western side of a cyclonic anomaly adjacent to the east Australian coast which resulted from the state of the Pacific climate system, and an anticyclonic anomaly at the top of the Great Australian Bight, prior to the mid-1970s.

Synoptic scale frontal systems in the westerlies that result in the transport of dust remained low in frequency throughout the whole period from 1957 to 2011. However, those dust storms in the westerlies that do reach the east coast, while rare, tend to occur during El Niño dominated years. On the other hand, they occur during both negative and positive phases of the southern annular mode (SAM).

This ambiguity with the SAM phase is consistent with the fact that the mid-latitude westerlies and associated frontal systems are usually at their most equatorward position in Australian longitudes in late winter/spring regardless of the SAM phase. This suggests little change is likely in the frequency of westerly frontal system induced dust storms in late winter/spring over central eastern Australia even though the seasonal westerly winds are expected to contract polewards under increased global warming.

However, a complicating factor is that the increasing likelihood of longer dry spells under climate change would imply reduced vegetation for longer periods over the dust prone source region of the of the Lake Eyre basin which could worsen the impact of dust storm events.

Furthermore, longer dry spells throughout the year would increase the risk of more frequent westerly dust storm events in other seasons when strong, westerly frontal systems do occur.

Session: Extremes (3)
Presenting Author: Melanie Webb

An analysis of extreme rainfall in northern Tasmania, 12-14 January 2011

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Australia experienced record-breaking rainfall in 2010–11 during one of the strongest La Niña events on record, with extensive and repeated severe flooding affecting large parts of the country. Intense and extreme rainfall events occurred in Tasmania on 10–11 August 2010, 12–14 January 2011, 23–24 March 2011 and 10–13 April 2011. This presentation will analyse the 12–14 January 2011 episode, when exceptionally heavy rain fell in northern Tasmania with event totals reaching over 300 mm in some parts of the northwest and northeast. Observations will be examined, and ACCESS-A model data used to investigate the mechanisms causing the heavy rain.

It will be shown that the air mass over the state during this event was exceptional with upper temperatures and dew points reaching levels more typically found in the tropics during the wet season and never before recorded over Tasmania. Precipitable water values also reached record high levels and were part of an atmospheric river extending over Tasmania from the tropics. Strong onshore winds in the low-levels interacting with Tasmanian topography, the right-exit and left-entrance regions of upper-level jets and an active trough will be suggested as the triggers to release this moisture.

Session: Extremes (3)
Presenting Author: Tess Parker

The connection between tropical convection and heatwaves in Southeastern Australia

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Heatwaves in summer over Southeastern Australia are invariably associated with strong slow-moving transient anticyclones, which direct warm dry air from the interior in a northerly or northwesterly flow over this region. These events are associated with propagating Rossby waves, which grow in amplitude and eventually overturn. The dynamical link between heatwaves in this region and tropical cyclones or strong tropical convection is investigated using ERA-Interim reanalysis and IBTRaCS named storm data. It is shown that the anticylonic PV anomaly which is generated over the southeastern regions as a result of Rossby wave breaking is intensified or maintained by the injection of low-PV air which is generated by strong convective heating at lower latitudes. The simulation of these events by GCMs is also examined using the ACCESS model.

Session: Extremes (4)
Presenting Author: Agata Imielska

Trends in rainfall and temperature extremes in the Pacific

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Many people living in the Pacific Islands Countries and East Timor report their climate is changing. Despite the high vulnerability that these countries face, there is only very limited scientific information available to these countries about the nature and significance of climate trends. A recent report published by the Pacific Climate Change Science Program (PCCSP) found that collectively, the Pacific region indicates a climate in transition, driven by both natural and human influences, with large nearly monotonic warming, sea level rise and shifts in rainfall patterns. Extreme climatic events can have large impacts, particularly on developing nations that have under-developed infrastructure and lower capacity to react to high impact events. As part of the Pacific-Australia Climate Change Science and Adaptation Program (PACCSAP) analysis of new homogenised datasets (including daily and monthly rainfall, temperature and mean sea-level pressure) has been carried out for countries in the Pacific to further explore climate variability in the western Pacific with a focus on climate extremes. Traditional analysis of trends in climate extremes utilise linear regression techniques and use percentile based definitions of extremes over large areas. This however introduces potential statistical biases in the sampling of data and potentially incorrect assumptions about its distribution. An alternative lies in the use of Extreme Value Analysis (EVA) techniques to define and analyse trends in climate extremes. This research focused on the use of EVA to examine western Pacific trends in climate extremes with preliminary results showing an increase in warm events and a decrease in cool events with a less coherent trend in rainfall extremes.

Session: Extremes (4)
Presenting Author: Simon McGree

Trends in total and extreme rainfall in the Western Pacific

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Climate change poses a major hazard to Pacific Island countries and East Timor. Recognising this vulnerability, the Australian government has supported a program of work called the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) program which seeks to build the scientific understanding of Pacific climate and associated climate change. This program is being delivered in partnership between CSIRO, the Bureau of Meteorology, Australian Universities and Geoscience Australia working closely with National Meteorological Services and other agencies in the Pacific. We will describe the development of homogenous rainfall datasets for the Pacific Islands and East Timor, and associated analysis of these data. Rainfall data clearly show large interannual variability resulting in long-term rainfall trends that are less spatially coherent than those for air temperature. Updated analysis is consistent with previous studies that indicate a general increase in rainfall totals north-east of the South Pacific Convergence Zone (SPCZ) over the past 50 years, with predominant declines to the south. This is consistent with a northeast movement of the SPCZ over this time. However, the 50 year trend appears to have reversed markedly over the past two decades consistent with a shift of the SPCZ back to its climatological position since the late 1990s. The 20-year declines have not yet been sustained long enough to counteract the longer-term trends. We have also analysed a suite of indices defining a range of climate extremes including rainfall, which have been developed by the WMO Expert Team on Climate Change Detection and Indices. In this way the current research fits in to an existing global framework, building on an international effort to improve understanding of extreme climate variability and trends. Preliminary results for extreme rainfall show trend patterns consistent with that for total rainfall (i.e. with SPCZ displacement influence) but not as spatially consistent.

Session: Extremes (4)
Presenting Author: Elaine Miles

Seasonal prediction of sea-level anomalies in the Western Pacific

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In the Western Pacific sea-level rise is four times greater than the global average and is expected to be one of the most profound impacts of climate change for its regional countries. Sea-level related impacts are felt through extreme events, seasonal to inter-annual sea-level changes and long-term sea-level rise. The impacts of sea-level rise include the loss both of amenity (e.g., loss of beaches, erosion and damage to physical assets) and agricultural production due to salt water intrusion and increasing salinity. In recognising that it is through natural variability that the early effects of climate change are most acutely felt, this research seeks to assess the relationships between seasonal variability and regional sea-level affecting Western Pacific Partner Countries within the Pacific-Australia Climate Change Science Adaptation Planning Program (PACCSAP). This presentation demonstrates the first attempt to produce seasonal sea-level predictions from a dynamical multi-model ensemble system. The study uses the Australian Bureau of Meteorology's seasonal prediction system POAMA to predict monthly sea-level anomalies (SLA) over the Western Pacific for up to 9 months into the future. POAMA calculates SLA using a rigid lid ocean model (MOM2) that determines sea surface height based on temperature, salinity and wind gradients. As a dynamical model, POAMA has a distinct advantage over statistical models in being able to predict SLA under unprecedented changes to physical forcings, such as climate change. The skill of POAMA SLA forecasts is assessed using satellite altimeter data over the period 1993–2010 and POAMA's data assimilation scheme PEODAS over the longer 1981-2010 period. Probabilistic skill in forecasting extreme events is also presented. These results have been used to develop prototype seasonal forecast products for Partner Countries and will be available online. They will assist management of seasonal changes in sea-level to increase community resilience under climate change.

Session: Extremes (4)
Presenting Author: Ron Hoeke

An extreme sea level climatology of Oceania

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More frequent and severe inundation events associated with climate-change related sea level rise is often cited as the biggest single threat to coastal communities. Assessing this threat requires a baseline understanding of local extreme sea levels and their drivers, i.e. what combination of astronomic tides, low frequency (annual and interannual) sea level variability, and higher-frequency phenomena such as storm surge, cause particular locations to be at risk? Which of these components dominate and how the latter two may change with a changing climate will at least partially dictate successful adaptation and mitigation strategies to sea level rise.

In this study, we decompose hourly tide gauge data into tidal, seasonal, low frequency and high frequency components over Oceania, which we define to encompass Australasia and the countries and territories of the insular Pacific Ocean. The components from this decomposition are compared with and regressed against gridded global datasets to produce a set of independent derived extreme sea level drivers. The gridded datasets include a global tidal model, satellite altimetry products, a climate reanalysis and a wind-wave model driven by the climate reanalysis. Preliminary results illustrate the usefulness of this approach to produce spatial climatologies. It identifies regions where extremes are (a) primarily tidally driven; (b) driven by interannual variability such as El Nino/Southern Oscillation (ENSO); and (c) where high frequency variability dominates extreme sea levels. We assess how well these gridded extreme sea level drivers are able to predict the largest extreme events, defined as those above the 99% exceedence level measured by the tide gauges and independently by inundation reports issued by disaster management and humanitarian aid agencies. While the predictive capacity of tidal and low frequency components is generally quite robust, shortcomings in the high-frequency component are evident. The potential reasons for these shortcomings are discussed in more detail.

Session: Extremes (4)
Presenting Author: Joanna Burston

Real-time numerical modelling of storm surge using high-performance computing for emergency planning purposes, Queensland.

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Storm surge presents the greatest hazard to life in tropical cyclone (TC) events, and the Queensland (Qld) coastline has particular vulnerability to this hazard. Presently, BOM issues warnings of storm surge inundation using a static look-up table of scenarios associated with forecast track parameters. Griffith has initiated a research project investigating the potential to dynamically model storm surge during tropical cyclone events, in association with Emergency Management Qld. The project aims to improve storm surge forecasts by providing greater detail of the longshore variation in storm surge inundation, possibly a more accurate estimation of peak surge relative to tidal conditions, as well as consideration of wave processes, in order to optimize emergency planning and evacuation strategies.

The storm surge model is built using the MIKE21 hydrodynamic model, and a parallel version of this model has been implemented on Griffith University and QCIF (Qld Cyber Infrastructure Foundations)'s high performance computing facilities by DHI. LiDAR elevation data supplied by Qld DNRM and the best available bathymetry is applied to the model. The model resolution is in the order of 50 m in low-lying populated coastal areas.

Here we present a validation of the model for TC Yasi (2011) against measured water level and survey data supplied by Qld Coastal Sciences Unit (DSITIA). The validation shows that the current operational BOM ACCESS-TC modelled wind fields are of insufficient spatial and temporal resolution to replicate the storm surge event. Application of a modified Holland wind field approach was more successful.

An ensemble approach to TC forecasting is explored in order to gain an understanding of the effects of the spatial, temporal and intensity uncertainties in TC forecasts on the resultant storm surge forecast.

Session: Extremes (5)
Presenting Author: Andrew Charles

Prediction of environmental parameters associated with tropical cyclone risk with dynamical climate models on seasonal timescales

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Statements of seasonal tropical cyclone (TC) risk can be made using empirical schemes relating storm counts in past seasons with indices that measure the state of large-scale climatic influences. However such statistical schemes have proven unreliable in recent years, and may be corrupted by inter-decadal variability and by the influence of climate change driving empirical predictors outside the range for which statistical models were trained.

Physically based coupled ocean-atmosphere general circulation models (GCMs) are able to simulate many of the large-scale processes that determine which locations will be favourable to cyclogenesis. On a seasonal timescale, GCMs provide useful forecasts of sea surface temperature, and to some extent they are able to predict variability in the location of atmospheric climate features such as the South Pacific Convergence Zone.

Previous work has assessed the use of the frequency of tropical cyclone-like disturbances in GCMs as a forecasting tool. By tracking tropical storm-like vortices and regions of environmental favourability for storm development in an ensemble of GCMs, probabilistic forecasts of TC activity over seasonal timescales can be made. Predictions are constrained by coarse model resolution, and by the limited predictability of the environmental fields associated with cyclogenesis.

We report on the assessment of predictability of large-scale environmental parameters favourable to TC development in operational GCMS run by the Australian Bureau of Meteorology and the Japan Meteorological Agency. These models are run in real time, ingesting available observations and simulating the evolution of the ocean-atmosphere system out to several months.

Session: Extremes (5)
Presenting Author: James Done

Assessing tropical cyclone damage

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Landfalling tropical cyclones impact large coastal and inland areas causing direct damage due to winds, storm-surge flooding, tornadoes, and precipitation; as well as causing substantial indirect damage such as electrical outages and business interruption. The likely climate change impact of increased tropical cyclone intensity, combined with increases in exposure, bring the possibility of increased damage in the future.

A considerable amount of research has focused on modelling economic damage due to tropical cyclones, and a series of indices have been developed to assess damages under climate change. We highlight a number of ways this research can be improved through a series of case study analyses. First, historical loss estimates are revisited to properly account for; time, impacted regions, the source of damage by type, and whether the damage was direct/indirect and insured/uninsured. Second, the drivers of loss from both the socio-economic and physical hazard sides are examined. A case is made to move beyond the use of maximum wind speed to more stable metrics and the use of other characteristics of the wind field such as direction, degree of gustiness, and duration is explored. A novel approach presented here is the potential to model losses directly as a function of climate variables such as sea surface temperature, greenhouse gases, and aerosols.

This work is the first stage in the development of a tropical cyclone loss model to enable projections of losses under scenarios of both socio-economic change (such as population migration or altered policy) and physical change (such as shifts in tropical cyclone activity one from basin to another or within the same basin).

Session: Extremes (5)
Presenting Author: Lam Hoang

The connection between coherent potential vorticity anomalies and heavy rainfall in the tropics

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Coherent potential vorticity (PV) anomalies are defined as sufficiently large local maxima in the PV. A climatology of coherent PV anomalies is constructed from the ERA-Interim dataset from the European Center for Medium-range Weather Forecast (ECMWF). The connection between coherent PV anomalies and heavy rainfall is examined using the GPCP daily rainfall data. Of particular interest are (i) the distance between a PV anomaly and maximum rainfall and (ii) the direction of propagation of the PV anomaly relative to the background wind and maximum rainfall. The maps of the mean speed of coherent PV anomalies illustrate the meridional exchange between the tropics and higher latitudes. In general, coherent PV anomalies curve anticyclonically around the mean subtropical ridge, travelling from the midlatitudes to the tropics. Some of these anomalies subsequently intensify into tropical cyclones, one such example being tropical cyclone Larry in 2006. Coherent PV anomalies associated with the genesis of tropical cyclone Larry are simulated with the WRF model.

Session: Extremes (5)
Presenting Author: Hamish Ramsay

The effect of imposed stratospheric cooling on the maximum intensity of tropical cyclones in axisymmetric simulations

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There has been considerable debate over the role of increasing sea surface temperature (SST) on tropical cyclone (TC) intensity globally. However, according to TC potential intensity (PI) theory, SST is only one factor governing the thermodynamic environment of a TC; the other being the temperature of the entropy-weighted outflow layer – the so-called 'outflow temperature'. The extent to which the outflow temperature has contributed to past trends in TC intensity remains unclear, though some recent studies suggest it could be a significant factor. In this study, the effect of lower-stratospheric cooling on PI is quantified using an axisymmetric cloud model run in an idealised mode of radiative-convective equilibrium. Preliminary results indicate a close match between the simulated increase in PI and the trend derived from reanalysis data. The results also suggest that outflow-layer cooling over the past 30 years may have had a stronger influence on PI than SST warming, all else being equal.

Session: Extremes (5)
Presenting Author: Greg Holland

Severe weather response to climate change: A Transient increase and then saturation?

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Holland and Bruyere (2012) have found a substantial contribution of anthropogenic climate change in current proportions of intense tropical cyclones, both globally and regionally. Using an index of climate change they found increases in the proportion of category 4 and 5 hurricanes (using the Saffir_-Simpson scale) of ~25% per °C increase in surface temperatures (in essence a doubling of the proportion of these intense systems over the past 30-40 years). Substantial increases in severe weather systems generally also have been assessed as likely by the IPCC.

This raises the question of what will happen in the future? Obviously the proportion of intense systems cannot keep doubling, as they cannot exceed one. In this presentation we examine this conundrum by way of the following hypothesis:

• Hurricanes respond initially to global warming with a strong transient increase in the

proportion of intense systems and a corresponding reduction in weaker systems;

• A saturation proportion is then reached beyond which there is no further change as the planet warms.

We discuss potential physical reasons and present evidence that for hurricanes, this saturation level has already nearly been reached. We also discuss the implications for severe weather systems generally.

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Holland, G.J. and C. Bruyere, 2012: Recent Intense Hurricane Response to Global Climate Change. *Climate Dynamics., (submitted).*

Session: Past Climate
Presenting Author: Jonathan Overpeck

The Importance of High-Resolution Paleoclimatic Records for Assessing Future Drought Risk

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Increased drought risk is (and will be) arguably one of the most certain and troubling aspects of anthropogenic climate change for many parts of the world. Fortunately, because droughts will still occur for natural reasons as well as anthropogenic, increased drought preparedness is a clear "no-regrets" climate change adaptation strategy.

Annually- to near annually-resolved paleodrought records, e.g., from trees, sediments and speleothems, provide a number of insights that are essential for effective drought planning. Recently generated 1000+ year records from SW North America, sub-Saharan Africa and the Amazon indicated that (1) the full range of drought variability, including "worst-case" scenarios needed by managers, is not captured in instrumental records – in each regional case examined, sustained "megadroughts", unprecedented in the instrumental record, have occurred repeatedly in recent Earth history, (2) natural drought variance is more energetic at lower frequencies than high – in general agreement with instrumental data, but extending to centennial time-scales inaccessible via instrumental data, and (3) tree-ring records produced with widely used standard methods often underestimate drought variability over interdecadal and longer time scales. Comparisons of observed drought variance over interannual to centennial time scales with that simulated using state-of-the-art (e.g., CMIP5) climate models (unforced or forced, including with paleoclimatic forcing) indicate that the models all appear to underestimate the future drought variability over decadal and longer time scales. This means that model-based projections of future severe drought risk are biased low for those regions where they have been evaluated by paleoclimatic observations, and should be considered underestimates in other regions until proven otherwise. Where available, paleoclimatic observations can be used with state-of-the-art climate models to provide bias-corrected estimates of future drought risk that may be the best available until models are shown capable of simulating the full range of drought variability found in nature.

Session: Past Climate
Presenting Author: Claire Krause

Spatial and temporal changes in the Intertropical Convergence Zone: A continuous stalagmite palaeomonsoon record for South-Central Indonesia over the over the last glacial/interglacial cycle

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A number of prominent records of the Asian Monsoon (AM) over the last glacial/interglacial cycle have been published for the Northern Hemisphere, however there remains a large gap in our understanding of the southern counterpart of the AM, referred to here as the Indo-Australian Monsoon. We will present a continuous palaeomonsoon record based on $\delta^{18}O$ analysis of stalagmites from southwest Sulawesi and Flores, Indonesia, spanning 40,000 years ago to the present. These sites are positioned to document changes in austral summer monsoon rainfall and track north-south migrations of the intertropical convergence zone (ITCZ) since the last glacial. Comparison of the new palaeomonsoon record from south-central Indonesia with AM records allows us to develop, for the first time, a 'palaeomonsoon index' that maps the movement of the monsoon system over the last 40,000 years. The pattern of north-south ITCZ migration across the Australasian monsoon domain clearly correlates with summer insolation curves for the northern and southern mid-latitudes, providing corroboration for the importance of insolation in driving the ITCZ and the Australasian monsoon system. The palaeomonsoon index forms the basis for our interpretation of the Sulawesi and Flores $\delta^{18}O$ records within the context of the wider Australasian monsoon system, and for examining the potential role that ITCZ positioning played in the start of the last deglaciation.

Session: Past Climate
Presenting Author: Cathy Trudinger

The global carbon cycle over the last millennium inferred from a high resolution CO2 and d13CO2 ice core record

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We present a revised record of $\delta 13CO_2$ from the Law Dome ice core over the last 1000 years. The Law Dome ice core record has high time resolution due to the high snow accumulation rate. We also present measurements of $\delta 13CO_2$ in air extracted from the low accumulation-rate South Pole firn (firn is the porous layer of compacted snow overlying an ice sheet). The South Pole firn measurements show good agreement with the ice core record, giving us confidence in our methods for (i) extracting air from the ice, (ii) charactering the age of the air and (iii) correcting for fractionation effects.

We use the CSIRO Simple Carbon Climate Model (SCCM) to relate changes in carbon and climate over the last millennium. We present a double deconvolution that uses CO_2 and $\delta 13CO_2$ to infer net fluxes of CO_2 between the atmosphere, land and oceans. We then compare the results of the double deconvolution with calculations of SCCM forced with temperature variations to improve our understanding of the sensitivity of land and ocean carbon fluxes to climate on different timescales.

Session: Past Climate
Presenting Author: Shayne McGregor

Inferred changes in El Niño-Southern Oscillation variance over the past six centuries

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The El Niño–Southern Oscillation (ENSO) causes large changes in eastern tropical Pacific sea surface temperature (SST), ocean currents and atmospheric circulation patterns globally, influencing extreme events including flooding, drought, and tropical cyclone activity1-4. ENSO has been shown to exhibit significant multi-decadal variability in its strength and frequency throughout the instrumental period4-6. It is vital to understand how intrinsic variability and changes in natural and human-induced forcings have impacted ENSO in the past, in order to understand and better predict its response to future greenhouse warming. Here, we propose a simple method for identifying the common variance signal in multiple time series, which is insensitive to small dating errors: namely, combining running variances rather than the time series themselves. Applying this method to extract the common variance signal of 14 paleo-ENSO reconstructions over the last 600-years reveals significantly reduced interannual activity over the period 1600-1900, compared to 1979-2009. Pseudo-proxy tests indicate that this result is statistically robust.

Session: Past Climate
Presenting Author: Sophie Lewis

Modelled water isotope expressions of ENSO-like variability in tropical precipitation

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El Niño-Southern Oscillation (ENSO) is an important determinant of global interannual climate variability. The characteristics of changes in ENSO in response to anthropogenic global warming are poorly constrained. In particular, our understanding of changes in ENSO-driven remote rainfall anomalies through atmospheric teleconnections is incomplete. Water isotope records collectively provide some of the most detailed evidence of past climate change and can provide a long-term context for assessing observed changes in contemporary ENSO expressions.

In the absence of both long instrumental records and robust spatially extensive, multi-proxy reconstructions, global climate models (GCMs) can also provide a useful means of understanding the possible range of ENSO variability. In addition, GCMs equipped with water isotope modules allow us one step closer to making comparisons between proxy records and model data. However, previous model-based approaches have not comprehensively addressed the characteristics of changes in ENSO under varying mean climatic states.

In this study, we investigate ENSO-like climatic changes using the coupled ocean-atmosphere Goddard Institute for Space Studies (GISS) ModelE-R. We impose strong average idealised El Niño and La Niña conditions on the tropical Pacific Ocean to produce surface temperature conditions broadly representative of positive and negative phases of ENSO. We then examine modelled expressions of ENSO-like climatic modes around the tropical Pacific Ocean as a basis for comparison with proxy records using multiple simulations of past and present climates. Using the GISS model water isotope module, we consider changes in ENSO-associated isotopic expressions during the Holocene and investigate whether ENSO modes of variability simulated during the mid Holocene necessarily follow those simulated during the pre-industrial.

Session: CMIP5 (1)
Presenting Author: Anthony Hirst

The Australian Community Climate and Earth System Simulator (ACCESS) – Contribution to CMIP5

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In response to ongoing demand for climate projection capability and in recognition of the need for a national approach to climate modelling, a project to develop the "Australian Community Climate and Earth System Simulator" (ACCESS) was commenced in 2006 to develop the next generation of Australian climate and earth system simulation capability. The partners in this project are the CSIRO and the Bureau of Meteorology through the Centre of Australian Weather and Climate Research (CAWCR) and participating Australian Universities, including linkage via the Centre of Excellence for Climate System Science. ACCESS aims to develop prediction/projection capability spanning the range of timescales from weather prediction to climate change projection on centennial time scales. A specific aim is to participate in CMIP5 and thereby support the Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC) and the Australian climate science community more broadly via a model with state-of-art components and overall performance.

This presentation will give an overview of the ongoing contribution of ACCESS to CMIP5. The initial contribution involved publication of the model output fields from the 'core' CMIP5 simulations for two versions of the ACCESS model, ACCESS1.0 and ACCESS1.3. These versions differ in aspects of the atmospheric physics and in the land surface component, with ACCESS1.3 including more 'experimental' atmospheric physics and the Australian community CABLE land surface model. A range of CMIP5 'Tier 1' simulations are now underway, selected based on scientific and stakeholder interest. Fields from these recent simulations are being progressively published on the Earth Systems grid (ESG). Some key results will be presented from the CMIP5 simulations, highlighting model evaluation and science interest. Options for further CMIP5 simulations will be discussed. The presentation will also consider model output data availability, both on the ESG and elsewhere at NCI, and data-management issues connected to the ACCESS CMIP5 simulations.

Session: CMIP5 (1)
Presenting Author: Daohua Bi

ACCESS-CM CMIP5 experiments and extensions

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The ACCESS coupled model has been developed at the Centre for Australian Weather and Climate Research (CAWCR). It is built by coupling the UK Met Office atmospheric Unified Model UM, and other sub-models as required, to the ACCESS Ocean Model (ACCESS-OM), a coupled ocean-sea ice model consisting of the NOAA/GFDL ocean model MOM4p1 and the LANL sea ice model CICE4.1, under the OASIS3.2-5 coupling framework. The primary goal of the ACCESS-CM development is to provide the Australian climate community with a new generation fully coupled climate model for climate research, with a specific initial goal to participate in phase 5 of the Coupled Model Inter-comparison Project (CMIP5). A set of CMIP5 experiments with two versions of the ACCESS-CM (i.e., ACCESS1.0 and ACCESS1.3) have been completed and the data has been published to the Earth System Grid (ESG) and available to the international community via the CMIP5 data portal.

We present here the initial analysis of results from a subset of the ACCESS-CM (both the ACCESS1.0 and ACCESS1.3 versions) CMIP5 experiments, including the preindustrial control, historical, 4 x CO_2, RCP4.5 runs and their multi-century extensions. Focus will be on the simulated evolution and (quasi-)equilibriums of the global surface climate (including surface temperature, precipitation and sea ice coverage), and the transient and long-term thermodynamic and dynamic adjustments in the ocean interior in response to global warming.

Session: CMIP5 (1)
Presenting Author: Harun Rashid

Intensification of simulated El Niño-Southern Oscillation in ACCESS coupled models under increased radiative forcings

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El Niño-Southern Oscillation (ENSO) is the dominant mode of interannual climate variability that profoundly influences global weather through atmospheric teleconnection. In the context of Earth's recent warming trend, an important unresolved question is whether there will be significant changes in ENSO properties under future global warming. Attempts to detect any unambiguous ENSO changes in observations have not been successful, mostly because of the lack of quality atmospheric and oceanic observations of sufficient length. Past modelling studies also failed to provide a consistent picture of the possible ENSO changes under global warming, despite the substantial changes projected by the models in the atmosphere-ocean mean state. Considering the importance of ENSO in global weather and climate variability, it is imperative that efforts to understand the ENSO behavior under global warming are continued, preferably with the state-of-the-art climate models, such as those participating in the Coupled Model Intercomparison Project phase 5 (CMIP5).

In this presentation, we use a subset of the CMIP5 experiments contributed by the two ACCESS coupled models to examine the possible changes in ENSO properties under global warming. The experiments have been extended beyond the CMIP5 core experiment requirements to allow for the derivation of stable ENSO statistics under a near equilibrium condition. The ACCESS models have been shown to simulate realistic ENSO properties over the historical period (Rashid et al. 2012). We find that, under enhanced radiative forcings, the ENSO properties change significantly in both ACCESS model simulations. In particular, the amplitude of ENSO becomes larger, while its timescale becomes shorter. There is a clear strengthening of the Bjerknes feedback (i.e., the SST-zonal wind stress coupling) in the tropical Pacific, causing the stronger ENSO variability. An opposite behavior is found for the Indian Ocean Dipole (IOD) mode, with both the IOD and the associated Bjerkness feedback becoming weaker under global warming.

References:

Rashid, H. A., A. Sullivan, A. C. Hirst, D. Bi, X. Zhou, and S. J. Marsland, 2012: Evaluation of simulated El Niño–Southern Oscillation in the ACCESS coupled model simulations for CMIP5. Submitted to *Aust. Met. Oceanog. J*.

Session: CMIP5 (1)
Presenting Author: Tim Pugh

Overview of the climate and weather research services

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The presentation will provide an overview of an on-going project to build research infrastructure, services, tools, and repositories for the climate and weather community and the Centre for Australian Weather and Climate Research (CAWCR) at the National Computational Infrastructure (NCI) petascale facility at the Australian National University.

The project is to develop a new Virtual Laboratory and web portal called *"the Climate and Weather Science Laboratory"*. The laboratory will utilise and integrate the Australian Community Climate Earth-System Simulator (ACCESS) infrastructure to support coupled and uncoupled model simulations of climate and weather phenomena.

Through the proposed integration and enhancements of existing community software such as ACCESS, the laboratory will produce an integrated facility for climate and weather process studies in areas such as weather prediction and extreme events, atmosphere-ocean-land-ice interactions, climate variability and change, greenhouse gases, water cycles, and carbon cycles. Additionally, the laboratory will provide a facility for the analysis of climate simulations, which will assist in the assessments of Australian climate change and contribute to the future assessment reports of the United Nations Intergovernmental Panel on Climate Change (IPCC).

The virtual laboratory is a community project to establish an integrated national facility for research in climate and weather sciences that complements and leverages the Australian Super Science initiative investments in computational and storage infrastructure at the ANU/NCI facility, and the strong collaboration in place by the Australian National University (nci.org.au), Australian Bureau of Meteorology (www.bom.gov.au), the CSIRO (www.csiro.au/cmar), the Centre for Australian Weather and Climate Research (www.cawcr.gov.au), and the Australian Research Council's Centre of Excellence for Climate System Science (www.climatescience.org.au).

Session: CMIP5 (2)
Presenting Author: Ben Evans

NCI - using Australia's peak computing infrastructure for modelling, simulation and data analysis

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NCI, National Computational Infrastructure, has been focused on deep engagement with modelling and data intensive science that make extensive use of High Performance Computing. Through the Australian Government Super Science Initiative, NCI has focused on the priority areas of climate change, earth systems science, and national water management research. To progress this NCI has engaged in a number of major initiatives including; a new world-class peak supercomputer; a data-intensive cloud system augmented by a national cloud computing program; a substantial data storage cloud to support data for computing and making available nationally significant datasets for the broad research community, and a set of integrated virtual laboratories and collaborative environments that can exploit the NCI infrastructure.

In this talk I will present the details of the new peak supercomputer (available in early 2013), cloud computing system and data storage. I will then outline some of the user environments, tools and web services to use these systems effectively. I will also provide details of the datasets available, and how people can access this data. In particular I will give a description of the CMIP5 archive data held at NCI and the Earth Systems Grid Federation that makes data available and federates with the major climate modelling and data archives around the world. I will finish with some examples of current activities at NCI that are helping to make the computing more accessible to the climate community and outline some of the challenges ahead. Examples of such challenges include further scaling in supercomputing, integrated environments that span processing and data, software systems for addressing Big Data challenges, and visualization technologies.

Session: CMIP5 (2)
Presenting Author: Tim Pugh

Web-based services of the Climate and Weather Science Laboratory

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This presentation is an introduction to the Climate and Weather Science Laboratory's web-based service, and is geared towards the scientists who wish to interact with the web-based services and conduct studies in climate and weather phenomena.

The presentation will describe the on-going work to build web-based research services for a virtual laboratory and the integration of the model simulation, model analysis, and data portal services. The talk will further describe the services roadmap and feedback from the user community. A major release of the web-based services is expected every six months until the end of 2013. The first release of the services is expected in January 2013.

The virtual laboratory's goal is to enrich the scientist's access to resources and content, reduce the technical barriers to using state of the art tools, facilitate the sharing of experiments and results, reduce the time to conduct scientific research studies, and to elevate the collaboration and contributions by the Australian research community to the development of the Australian Community Climate Earth-System Simulator (ACCESS).

The virtual laboratory is a community project to establish an integrated national facility for research in climate and weather sciences that complements and leverages the Australian Super Science initiative investments in computational and storage infrastructure at the ANU/NCI facility, and the strong collaboration in place by the Australian National University (nci.org.au), Australian Bureau of Meteorology (www.bom.gov.au), the CSIRO (www.csiro.au/cmar), the Centre for Australian Weather and Climate Research (www.cawcr.gov.au), and the Australian Research Council's Centre of Excellence for Climate System Science (www.climatescience.org.au).

Session: CMIP5 (2)
Presenting Author: Martin Dix

The ACCESS Simulation and Modelling Service

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Work on development of the Australian Community Climate and Earth System Simulator (ACCESS) project began in 2006 as a collaboration between CSIRO, the Bureau of Meteorology and Australian universities. In 2009 ACCESS began to be used operationally by the Bureau of Meteorology for global and regional forecasts. In 2012 results from two versions of the ACCESS climate model were submitted to the Coupled Model Intercomparison Project (CMIP5). Various configurations of ACCESS are also used by University researchers.

A partnership of the Centre for Australian Weather and Climate Research, the Australian National University National Computational Infrastructure and the ARC Centre of Excellence for Climate System Science is working on a project to develop a Climate and Weather Science virtual laboratory under the National eResearch Collaboration Tools and Resources (NeCTAR) program.

A major component of this is the development of an ACCESS simulation and modelling service. This aims to build on the work that has made the ACCESS climate model available to the University community by creating a library of supported and documented standard experiments (including Bureau of Meteorology operational and research forecast configurations), an improved user interface for the coupled model, an experiment database to capture the complete model configuration and integration of model output with analysis and archiving services developed by other parts of the laboratory.

The goal is to improve ease of use, reproducibility, support and sharing of code, data and experiments. This presentation will show our progress mid way through the NeCTAR program.

Session: CMIP5 (2)
Presenting Author: Ricardo Pascual

Progress report on the model analysis service for the NeCTAR Climate and Weather Science Laboratory

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The Model Analysis Service is a sub-system of the Climate Weather Science Laboratory (CWSL). It will provide the scientific workflow tools that enables scientists to easily run analyses involving multiple steps, reproduce those analyses, help enforce a controlled vocabulary, and create better metadata for traceability and reproducibility while reducing the need for specialist skills in high performance and cloud computing. This will be achieved by enhancing an existing workflow tool such as YABI, Kepler, or Workspace, to work with current climate and model analysis framework such as CAWCR Pipeline as a sub-system in CSWL. These existing tools should also integrate well to the data library service within the CWSL. This will require developments in three key areas: ease of use, collaboration, and integration. We will report on the progresses that have been made in developing these tools and the software development process that we adopted. We will give some of the programming use-cases and other software development artifacts used in the process. Some of the goals and the corresponding features that shaped the workflow tools, such graphical user interface and collaborative workflows, will be presented. An analysis of the some of the existing candidate scientific workflow tools as to its suitability for the CWSL will be discussed and the reasons why we choose the particular framework that we used in the sub-system. Finally improvements to the Model Analysis Service sub-system as it stands by the time of the conference will be proposed.

Session: CMIP5 (2)
Presenting Author: Tom Beer

CMIP5 co-ordination discussion

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The Centre for Australian Weather and Climate Research (CAWCR), a partnership between CSIRO and the Bureau of Meteorology has established a committee to liaise with universities and the NCI facility in Canberra that provides the computing infrastructure for the analysis of CMIP5 data.

CMIP5 (Coupled Model Intercomparison Project) is a WCRP project that involves 20 international climate modelling groups, which hopes to address scientific questions from the IPCC Fourth Assessment Report (AR4) in time for evaluation in the Fifth Assessment Report (AR5, scheduled for publication in late 2013). The NCI has provided disk storage space that enabled scientists to analyse the CMIP5 data and submit their analyses to journals in time for their information to be included in the IPCC AR5 process.

Some software tools have been developed, and it is intended to develop yet more software tools as part of the NeCTAR Climate Virtual Laboratory. The format will be a discussion session inviting feedback from the audience on aspects of CMIP5 coordination with particular reference to data downloading and processing issues.

Session: CMIP5 (2)
Presenting Author: Kevin Keay

Projected changes in Australian region cold fronts and their influence on precipitation

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An understanding of how rainfall producing systems may change under future climate conditions is important for evaluating future changes in Australia's water budget. In the south of Australia, mid-latitude cold fronts bring rainfall and sometimes conditions conducive to extreme impacts.

To quantify the changes in the relationship between fronts and precipitation, we apply an objective frontal recognition technique, the wind-shift method of Simmonds et al (2012). This correlates well with rainfall (Hope et al 2012) and identifies the points along the front, which can be compared with a rainfall dataset to produce an estimate of frontal rain (e.g. Catto et al 2012).

This method was applied to ERA-Interim reanalysis data, as well as a selection of the latest coupled climate models including data from the Australian Community Climate and Earth-System Simulator version 1.0 (ACCESS1.0) that were submitted to the World Climate Research Programme (WCRP) Coupled Model Intercomparison Project phase 5 (CMIP5). Present day simulations were taken from the historical run for the period 1981–2000. Future climate simulations use the RCP8.5 experiment (high emissions scenario) for 2080-2099.

Cold fronts have the largest influence on rainfall in Australian winter when up to 30% of rainfall is due to these systems. The models are similar in terms of numbers as well as percentage rainfall from cold fronts. Under future climate conditions the models show a decrease in numbers of cold fronts by the end of the 21st century. Similarly, when the percentage rainfall due to cold fronts is considered, there is found to be a decrease in south-west Western Australia in the future.

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Simmonds, I., K. Keay, and J. A. T. Bye, 2012: Identification and climatology of Southern Hemisphere mobile fronts in a modern reanalysis. Journal of Climate, 25, 1945-1962.

Session: CMIP5 (3)
Presenting Author: Aurel Moise

CMIP5 data analysis at NCI: Tools and Experiences

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This talk will present an overview of the tools used for analysis and processing of CMIP5 simulations at the NCI facility. We will review efforts undertaken over the last 12-18 months within various research programs to process such a large data set.

Session: CMIP5 (3)
Presenting Author: Mark Collier

Australia's CMIP5 data submission and publication report card

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At the time of preparing this abstract (September 2012) Australia had mostly completed its submissions to the Coupled Model Intercomparison Project Phase 5. The most important indicators of this were the comprehensive sets of outputs from the two ACCESS (1.0 and 1.3) and the CSIRO-Mk3.6 Atmospheric Ocean General Circulation Models (AOGCMs). These were made available on time to the international community via the global network Earth System Grid (ESG) data portals. It is expected that by the time of this AMOS conference, research using the CMIP5 data will have had a significant impact on the AR5 reporting process.

In many respects the real job of CMIP5 has only just begun as we can expect that the amount of published research to rapidly increase post AR5 as was the case beyond AR4 for CMIP3. This is partly due to the dataset maturing and that there is time for analysts to perform more detailed analysis without the deadlines associated with the Assessment Report phase.

As the size of the CMIP5 dataset is much larger and the parameter list much richer and better defined than with CMIP3 (not to mention the many years of model development and improvement), we might even expect a longer and more successful history with CMIP5 than CMIP3 data. As well, ESG has become a more sophisticated data serving approach than previously and is likely to remain a significant method for distributing model products from modelling centres. ESG will therefore continue to influence the way in which we distribute data to perform climate science. In the future it is expected that the ESG will become a method for performing remote processing on the larger datasets, such that smaller value added products can be transferred instead of the current practice of downloading terabytes of raw data with uncertain value.

Much of the success of CMIP5 has undoubtedly come from the coordinated effort that has been made to the quality control of the datasets from the modelling centres. This reassurance of the data has also enabled many groups to create persistent identifiable datasets, and is an important accomplishment for the Australian CMIP5 teams. In the future we can expect direct reference to be made to these datasets from within publications, adding both a way of tracing the exact history of a scientific result (and a new level of transparency to the science) from its data origins. This will also provide a much-needed formal acknowledgement to modelling centres for the datasets that are essentially offered up free and without constraints to the wider research community.

In this presentation a summary of our experiences in addressing and ultimately completing the task of producing CMIP5 data will be given.

Session: CMIP5 (3)
Presenting Author: Michael Rezny

Experiences within the ARC Centre of Excellence in Climate System Science in generating, storing, publishing, retrieving and analysing CMIP5 data

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There has been a large increase in data generated by CMIP5 over that generated by CMIP3. Researchers at the ARC Centre of Excellence in Climate System Science (CoE) and its support team, the Computational Modelling Systems team have been actively involved in generating, publishing, retrieving, and analysing these data. This presentation will describe the experiences of the CoE in understanding and attempting to solve the challenges involved in performing these tasks. Some of the issues confronted in storing, and publishing large CMIP5 datasets will be highlighted. However, the CMIP5 experiences have also highlighted an urgent need to develop a longer-term vision for data management within the CoE. Aspects of a CoE data management policy will also be presented. This policy addresses new strategies to deal with large datasets and a clear data management contract with the infrastructure providers. Data reduction and data retention together with data provenance are identified as key processes to manage the storage of large volumes of research data.

Session: CMIP5 (3)
Presenting Author: Jason Evans

CORDEX-AustralAsia

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The World Climate Research Programme (WCRP) is backing an international initiative called the COordinated Regional climate Downscaling EXperiment (CORDEX). The goal of the initiative is to provide regionally downscaled climate projections for most land regions of the globe, as a compliment to the global climate model projections performed within the fifth Coupled Model Intercomparison Project (CMIP5). CORDEX includes data from both dynamical and statistical downscaling. CORDEX-AustralAsia data will be stored and disseminated through Research Data Storage Infrastructure (RDSI) nodes in Sydney (Intersect) and NCI. The data covers a wide variety of climate variables at timescales down to hourly. Multiple methods of data access are under development in collaboration with the NARCliM project. As well as being useful for studying regional climate, CORDEX-AustralAsia data is aimed at facilitating climate change impacts and adaptation research.

Session: CMIP5 (3)
Presenting Author: Mehera Kidston

Evaluation of marine biogeochemistry in the CMIP5 Earth System Models

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We determine the ability of 10 Earth System Models that will be used for the IPCC fifth assessment report (CMIP5 models) to simulate biogeochemical observations of present conditions, and assess simulated changes since preindustrial conditions, with a focus on ocean surface chlorophyll and marine primary production. Such evaluation allows identification of strengths and weaknesses of individual models as well as identification of systematic biases among the CMIP5 models.

In order to assess the performance of the models over the reference period 1986-2005, metrics are computed (correlation coefficient, standard deviation and bias) for averaged seasonal cycles of chlorophyll-a, primary production, export production, SST, MLD and nutrients. These metrics are evaluated for the current generation (CMIP5) and older generation (OCMIP5) models to assess recent model improvements.

Spatial analysis of seasonal patterns in the models is performed by comparing month and magnitude of the maximum chlorophyll bloom with SeaWiFS estimates at the grid scale. We show that the models are generally consistent with observations but can be out of phase by up to 6 months in the Southern Ocean.

The co-variability of chlorophyll and SST over the period 1986-2005 and 1850- 2005 is evaluated by calculating the correlation between modelled chlorophyll-a anomalies and changes in Nino region 3.4 SST.

We show that many of the models show a strong anti-correlation in the equatorial pacific, similar to observational based estimates, however several of the models do not capture this signal. We show that there are no significant long-term trends in the annual mean of chlorophyll and marine primary production over the twentieth century in the CMIP5 models.

Session: CMIP5 (3)
Presenting Author: Ian Watterson

Are climate models more skillful in their home continent?

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Climate modelling groups from four continents have submitted simulations to the CMIP5 project. With climate impact assessment in mind, in this study, we test the realism of the seasonal averages of temperature, precipitation and MSLP, compared to two observational data sets. Non-dimensional skill scores based on error magnitudes have been generated for the global land and six continental domains. All 25 models analysed perform well, particularly ACCESS and the Hadley Centre models, and overall the CMIP5 ensemble shows improved skill over the earlier CMIP3 ensemble of 24 models. There is however some variation in this ranking of models across the cases, and given the practical interests of some stakeholders, this could conceivably result from a regional focus of model developers. Alluding to the 'home advantage' of sporting teams, do models tend to perform better in their home continent? This is addressed here by comparing the ranking of models for their home with their global rank, across each ensemble.

Session: CMIP5 (4)
Presenting Author: Jonas Bhend

Evaluation of recent Australian rainfall and temperature change in CMIP5

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Over past decades, Australian rainfall has undergone significant changes. To what extent these changes are manifestations of global warming or due to natural variability of the climate system is in most cases still a matter of debate. What is undisputed, however, is that rainfall changes influence the rate of regional warming in different areas and seasons. Thus, when evaluating climate model performance in reproducing recent change, the correlation between rainfall and temperature has to be taken into account.

Here we analyse how well CMIP5 simulations reproduce recent observed trends in rainfall and temperature in different seasons. We evaluate recent rainfall and temperature change separately as well as in conjunction to account for correlation between the two variables. The recent increase in precipitation in northwestern Australia in summer (DJF) for example is not well reproduced in simulations. Whereas the simulated rainfall change is generally consistent with observations due to the low signal-to-noise ratio of externally forced rainfall change, the majority of the simulations significantly overestimate the observed warming. When taking into account the strong correlation between rainfall change and warming, however, a smaller fraction of models is found to be inconsistent with the observed change than when evaluating warming alone. This illustrates the importance of cross-variable correlations when evaluating models. We will present results for all of Australia and discuss the implications of model evaluation with recent climate change on model selection and weighting.

Session: CMIP5 (4)
Presenting Author: François Delage

Statistically-adjusted precipitation projections for the 21st century

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Here we describe and apply a statistical method that corrects for biases in the simulation of large-scale climatic features to help produce 21st century climate projections. We use the simulation of the South Pacific precipitation during the austral summer - which is dominated by the South Pacific Convergence Zone (SPCZ) - in 30 CMIP5 CGCMs to illustrate. The model SPCZs are imperfect. For example, they tend to have an orientation that is more zonal than the observed SPCZ. The statistical adjustment method can adjust for orientation and position. Adjustments to the observation are calculated separately for each model. The same adjustments are then applied to 21st century climate change projections and a multi-model projection based on the adjusted fields is produced. The projections are compared with their unadjusted counterparts. The method is assessed using a cross-validation process in which each model is, in turn, regarded as the 'observations'. Adjustments are then calculated for each of the remaining models relative to the 'observations' based on 20th century simulations. The resulting adjustments are then used to estimate the 21st century projections in the model providing the 'observations'. This model is then replaced and another model chosen to provide the 'observations'. This process is repeated using all models. The method is shown, in this sense, to exhibit greater skill in producing projections than using raw model output alone. It is hoped that this new approach will lead to more reliable rainfall projections in the Pacific and beyond.

Session: CMIP5 (4)
Presenting Author: Jing-Jia Luo

Longitudinal biases in the Seychelles Dome simulated by 35 Ocean-Atmosphere Coupled General Circulation Models

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The Seychelles Dome refers to the shallow climatological thermocline in the southwestern Indian Ocean, where subsurface temperature variability due to ocean waves efficiently affects sea surface temperature (SST), and hence SST anomalies can be predicted up to 1-2 years ahead. Correctly reproducing the dome in an ocean-atmosphere coupled general circulation model (CGCM) is essential to achieve successful climate prediction/projection in the Indian Ocean. This study examines the Seychelles Dome simulated by 35 CGCMs including those from the phase five of the Coupled Model Intercomparison Project (CMIP5). Among the 35 CGCMs, 14 models erroneously produce the upwelling dome in the eastern half of the basin while the observed Seychelles Dome is located in the southwestern tropical Indian Ocean. Annual mean Ekman pumping velocity in these models is found to be nearly zero in the southern off-equatorial region. This is inconsistent with the observation in that Ekman upwelling acts as a main cause of the Seychelles Dome. In the models with the dome in the east, the easterly biases are prominent along the equator in boreal summer and fall that cause shallow thermocline biases along the Java and Sumatra coasts via Kelvin wave dynamics and result in a spurious upwelling dome there. Compared to the CMIP3 models (Yokoi et al. 2009), the CMIP5 models are worse in simulating the dome's longitudes. These biases could cause uncertainties in assessing regional climate changes under global warming. The present results may help further model developments to reduce these biases.

References:

Nagura, M., W. Sasaki, T. Tozuka, J.-J. Luo, S.K. Behera, and T. Yamagata (2012): Longitudinal biases in the Seychelles Dome simulated by 35 ocean-atmosphere coupled general circulation models. *J. Geophys. Res.,* submitted.

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Session: CMIP5 (4)
Presenting Author: Clothilde Langlais

Structure and ENSO variability of the edge of the Western Pacific Warm Pool under climate change

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The edge of the Western Pacific Warm Pool demarcates the warm fresh water from the western Pacific from the cooler, saltier water in the east, and its structure determines the biogeochemistry of the region. Dynamically the edge of the warm pool is particularly important because it is the location of the advective-reflective feedback mechanism in ENSO development and decay. How the location and the east-west oscillations of the edge change in the future may determine future behaviour of ENSO. However, predicting the position of this dynamic edge under global warming scenarios is not trivial in coupled general circulation models that suffer from a cold tongue bias in the Equatorial Pacific.

In this study, CMIP5 models are evaluated on their oceanic structure of the Western Pacific Warm Pool: sea surface temperature, temperature gradients, surface salinity and salinity gradients. We determine the most appropriate metrics to follow the edge of the warm pool and we analyse the relationship between east-west movement of the edge and the strength of ENSO. In most cases, differences in each models' ENSO behavior can be related back to how well the warm pool is simulated in a model. Under RCP8.5 climate change scenarios, the warm pool edge moves slightly eastward and occurs on warmer and fresher water.

Session: CMIP5 (4)
Presenting Author: Andréa S. Taschetto

Assessing two types of ENSO in CMIP5 models

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Characteristics of the El Niño-Southern Oscillation (ENSO) are examined using 34 models from the Coupled Model Intercomparison Project Phase 5 (CMIP5). ENSO is classified into Cold Tongue and Warm Pool events based on Niño3 and Niño4 indices from historical simulations. In general, most of models can realistically simulate the observed location of maximum sea surface temperature (SST) anomalies during ENSO events. However, they exhibit biases in the westward extent of ENSO-related SST anomalies. These biases seem to be driven by displaced and enhanced wind stress field.

CMIP5 models generally simulate stronger El Niños than La Niñas, consistent with observations. They also capture the spatial asymmetries and differences in intensity between the two types of El Niños, i.e. Cold Tongue El Niños are stronger than Warm Pool El Niños. However, most of the models cannot reproduce the asymmetry between the two types of La Niñas, i.e. Cold Tongue (Warm Pool) events are stronger (weaker), while the opposite is true in observations.

The seasonality of ENSO in CMIP5 models is sensitive to the Niño index used to diagnose seasonality. Based on the Niño3.4 index, most of the models capture the correct peak in maximum variability in ENSO from November-to-January. However, only one-third of the models realistically simulate the ENSO mature phase at the end of the calendar year when using Niño3 index. The duration of all types of ENSO events, except for Cold Tongue El Niño is too long in most CMIP5 models.

Future projections reveal an increased ratio of Warm Pool to Cold Tongue events from the historical to rcp8.5 scenario, suggesting more intense WP events in a warmer world. In general, there is a tendency for models with strong (weak) ENSO events to simulate a reduction (increase) of Niño3 variability in a warmer world.

References:

Taschetto, A.S., A. Sen Gupta, N.C. Jourdain, A. Santoso, C. Ummenhofer, and M.H. England. 2012. Cold tongue and warm pool ENSO events in CMIP5: mean state and future projections. Submitted to Journal of Climate.

Session: SPARC (1)
Presenting Author: Greg Roff

Top-down and bottom-up impacts on the ACCESS Ensemble Model

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Climate, seasonal and extended range forecast studies have shown how including upper level variability (e.g. improved stratospheric initial conditions, solar variations and chemical reactions) into a model can improve simulations by both top-down and bottom-up processes. Similar studies also show the impact of sea surface temperature (SST) on stratospheric dynamics (e.g. Brewer-Dobson circulation, stratospheric planetary waves and the polar vortex). In this talk we discuss results from ACCESS Ensemble model experiments which examine the influence of top-down and bottom-up changes to the model. These experiments consider the impact of extending the model into the stratosphere as well as including various representations of SST.

The N144L50 ACCESS 24 member Ensemble model is run in its standard form where the analysed sea surface temperatures are persisted throughout the 30-day forecast. Results from this are then compared to simulations which use climatological SSTs and also where SSTs are updated to analysed values on a daily basis (the ideal case). All three cases are then compared to model runs which have an extended lid. Analysis of the results will be carried out using standard skill score parameters as well as multi-scale analysis procedures.

Preliminary results from the small sample of low-lid persisted and climatological SST experiments run so far suggest that the persisted SST simulations have some increased skill in the tropical troposphere out to ~15 days, decreasing from surface up to 100 hPa. At present we are extending the sample size of these experiments and results from this larger sample, along with the impact of a raised lid and daily updated SSTs will be discussed.

Session: SPARC (1)
Presenting Author: Damian Murphy

Parameterization of gravity wave drag in models and the impact on predictions of the Southern Hemisphere stratosphere

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Links between changes in the southern polar stratosphere and tropospheric climate have been identified in both modelling and observational studies, highlighting the importance of an accurate stratosphere in climate models. However, the model background temperature structure in the winter polar stratosphere is often biased: "the cold pole problem". In the absence of direct radiative heating through much of this time, it is dynamics that sets the thermal state of this part of the atmosphere through wave-driven meridional and vertical circulations. Hemispheric differences in the manifestation of this problem point to a different balance between large scale waves (which are naturally represented in models) and gravity waves whose scales are of the order of model grid sizes (and are not naturally represented). It is apparent that our ability to predict southern hemisphere stratospheric responses to changing dynamics depends on the correct parameterization of gravity waves.

A review of gravity wave drag parameterization schemes will show that these schemes are generally non-physical and often use a prescribed source distribution. The vertical propagation of their influence also lacks a physical basis but points to a key factor in the development of new schemes; they must be computationally efficient if widespread uptake is to be realised. Some gravity wave theory, and observations that are planned to place constraint the physics of these schemes, will be interpreted in the light of parallel modelling constraints.

Session: SPARC (1)
Presenting Author: Ariaan Purich

Weather from Ozone Hole variations

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Southern Hemisphere climate change in the past has been attributed to the combined effect of increasing greenhouse gas concentrations and Antarctic ozone depletion. Recent studies have shown that the latter has played at least a comparable role to the former in austral summer. Here we show that the Antarctic ozone hole has affected not only the long-term trend but also the intra-seasonal variability of surface climate in the Southern Hemisphere. A significant negative correlation is found between September Antarctic total column ozone concentrations and the October Southern Annular Mode index, resulting in systematic variations in precipitation and surface temperature throughout the Southern Hemisphere. This time-lagged relationship is comparable to and independent of that associated with El Niño-Southern Oscillation, suggesting that Southern Hemisphere seasonal forecasting could be improved by considering variations in the ozone hole.

Session: SPARC (1)
Presenting Author: Andrew Klekociuk

Trends in the distribution of Antarctic stratospheric ozone: telationships with circulation changes

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We examine the cause of seasonal trends in the zonal asymmetry of the total ozone column (TOC) at high southern latitudes. Grystai et al. [2007] demonstrated that the quasi-stationary component of TOC in the collar region outside the Antarctic Ozone Hole in Sept-Oct-Nov rotated by as much as 45 degrees eastward during 1979-2005, with differences in the zonal and meridional displacements of the minima and maxima of the pattern. We have extended and updated the analysis of Grystai et al. [2007] to include the other 3 seasons and the period 1979-2011 using version 8.6 of the NASA/GSFC Merged Ozone Dataset, and find that the Sept-Oct-Nov trends have continued post-2005 and that weaker long-term shifts are also apparent over the time period in Dec-Jan-Feb and Mar-April-May. Using ERA-Interim assimilated meteorological data, we examine characteristics of extra-tropical Rossby waves, the location of the stratospheric polar vortex and metrics of the Ozone Hole, and their relationship with observed trends in the TOC distribution at high southern latitudes. We find that the TOC trends are consistent with long-term changes in the phase and amplitude of quasi-stationary Rossby waves, which show seasonal differences that suggest separate influences from springtime ozone depletion and other climate processes.

References:

Grytsai, A.V., O.M. Evtushevsky, O.V. Agapitov, A.R. Klekociuk, and G.P. Milinevsky (2007), 'Structure and long-term change in the zonal asymmetry in Antarctic total ozone during spring', Annales Geophysicae 25, 361-374.

Session: SPARC (1)
Presenting Author: Olaf Morgenstern

Coupled atmosphere-ocean climate modelling with whole-atmosphere chemistry: First results

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In recent years, the climate impact of stratospheric ozone depletion has received some considerable attention. Several authors suggested that ozone depletion is the dominant driver of climate change in the Southern Hemisphere during the last few decades. Such claims are generally based on atmosphere-ocean general circulation model (AOGCM) simulations; these models typically use prescribed, zonally symmetric ozone fields. However, then for example the Antarctic ozone hole and the polar vortex are not co-located, and the links between ozone and climate are not fully represented. Also, any impact of long-term climate change onto the ozone layer may not be correctly incorporated. For these reasons, a more comprehensive approach is needed which merges traditional coupled AOGCMs with chemistry-climate models (CCMs). In contrast to AOGCMs, CCMs typically do not have a coupled ocean. Previously, simulating oceanic feedbacks in these models used to be impractical due to prohibitive computational costs. Here we will present some initial results of a historical simulation using a fully coupled atmosphere-ocean CCM. The model combines a medium-size tropospheric and stratospheric chemistry mechanism (NIWA-UKCA) with an AOGCM similar to HadGEM3-AO. We will also present results pertaining to the present and future atmosphere, obtaining with prescribed ocean surface conditions. They show the sensitivity of the model w.r.t. key chemical forcing agents such as halogens and methane, and radiative forcing due to long-lived greenhouse gases. We conclude with an outlook onto the upcoming international Chemistry-Climate Modelling Initiative.

Session: SPARC (2)
Presenting Author: Stephan Fueglistaler

The relation between atmospheric humidity and temperature trends for stratospheric water

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We analyse the relation between atmospheric temperature and water vapour - a fundamental component of the global climate system - for stratospheric water vapour (SWV). We compare measurements of SWV (and methane where available) over the period 1980-2011 from NOAA-FPH, SAGE II, HALOE, MLS/Aura, and ACE-FTS to model predictions based on troposphere-to-stratosphere transport from ERA-Interim, and temperatures from ERA-Interim, MERRA, CFSR, RATPAC, HadAT2 and RICHv1.5. All model predictions are dry biased. The interannual anomalies of the model predictions show periods of fairly regular oscillations, alternating with more quiescent periods and a few large-amplitude oscillations. They all agree well (correlation coefficients 0.9 and larger) with observations for higher-frequency variations (periods up to 2-3 years). Differences between SWV observations, and temperature data, respectively, render analysis of the model-observation residual difficult. However, we find fairly well-defined periods of drifts in the residuals. For the 1980's model predictions differ most, and only the calculation with ERA-Interim temperatures is roughly within observational uncertainties. All model predictions show a drying relative to HALOE in the 1990's, followed by a moistening in the early 2000's. Drifts to NOAA-FPH are similar (but stronger), whereas no drift is present against SAGE II.

As a result, the model calculations have a less pronounced drop in SWV in 2000 than HALOE. From the mid-2000's onwards, models and observations agree reasonably, and some differences can be traced to problems in the temperature data. These results indicate that both SWV and temperature data may still suffer from artefacts that need to be resolved in order to answer the question whether the large-scale flow and temperature field is sufficient to explain water entering the stratosphere.

Session: SPARC (2)
Presenting Author: Simon Alexander

High resolution VHF radar measurements of tropopause structure and variability at Davis, Antarctica [69°S, 78°E]

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Two years of VHF radar echo power observations are used to examine the structure and variability of the tropopause at Davis, Antarctica. Co-located radiosonde and ozonesonde launches provide data with which to calculate the thermal (lapse-rate) and chemical tropopauses at Davis. The dynamically-controlled radar tropopause can be used as a definition of the Antarctic tropopause throughout the year under all meteorological conditions. During the extended summer period of December — April (DJFMA) inclusive, radar tropopauses are (0.29+/-0.4) km lower than co-located radiosonde thermal tropopauses and during the extended winter period of June — October (JJASO) inclusive, the radar tropopauses are (0.8+/-1.0) km lower. The radar and ozone tropopauses both show a decrease in altitude under increasingly strong cyclonic conditions. During strong JJASO cyclonic conditions, there are large (several km) differences between radiosonde lapse-rate tropopause altitudes and radar tropopause altitudes. However, the radar tropopause altitude closely corresponds to the altitude of the 2 PVU surface (where 1 PVU = 10^6 m^2 s^{-1} K kg^{-1}) for both cyclonic and anticyclonic conditions. The monthly mean occurrence frequency of tropopause folds is investigated using the radar tropopause and is about 1 per month during DJFMA and about 3 per month during JJASO. The power spectrum of the Davis radar tropopause altitude indicates its influence by the passage of inertio-gravity waves. The higher power spectral density during JJASO also indicates an increase in gravity wave activity during this time.

Session: SPARC (2)
Presenting Author: Laura Revell

Splicing SAGE-II and GOMOS measurements to create a long-term stratospheric ozone climate data record

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Climate data records provide the basis for assessing current understanding of climate change, and for attributing past changes in climate. A long-term (1979-2011), vertically resolved climate data record of stratospheric ozone was created by merging two datasets: SAGE-II (Stratospheric Aerosol and Gas Experiment) and GOMOS (Global Ozone Monitoring by Occultation of Stars) ozone measurements. To remove offsets and drifts between the GOMOS and SAGE-II ozone measurements, coincidences between GOMOS and SAGE-II measurements were identified between 2002 and 2005 (the period of overlap between the two datasets) according to pre-defined time, latitude, longitude and potential temperature coincidence criteria. Both instruments provide high vertical resolution measurements of ozone profiles which were interpolated onto a 1 km altitude grid. Because coincidences between spot measurements by SAGE II and GOMOS were sparse and therefore insufficient to robustly model the latitude-time difference field between SAGE II and GOMOS, a Lagrangian trajectory model was used to extend the ozone measurements 10 days backwards and forwards in time – the so-called 'trajectory hunting' approach. High resolution (0.5°×0.5°) zonal and meridional wind fields from the isentropic NCEP-CFSR data set were used to provide the necessary input to the trajectory model. The latitude-time difference field was then statistically modelled so that the climatological annual mean difference pattern between SAGE-II and GOMOS could be captured and extended into the future, where SAGE-II observations (and therefore coincidences) are not available. The difference field was modelled as Legendre polynomials in latitude and Fourier expansions in season. The statistically modelled difference field was used to correct the GOMOS data, which was then appended to the SAGE-II record, thereby providing a high vertical resolution, long-term climate data record of stratospheric ozone.

Session: SPARC (2)
Presenting Author: Kane Stone

An updated retrieval of Australian Dobson data to produce higher resolved ozone profiles

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Using the Dobson spectrometer, ozone profiles can be retrieved by inverting Umkehr intensity ratio curves. This technique uses the intensity ratio of zenith sky scattered light measurements of a pair of ultra violet (UV) wavelengths. One wavelength is strongly absorbed by ozone while the other is weakly absorbed. The intensity ratio increases with increasing solar zenith angle (SZA) until it approaches 90˚, where it then decreases due to the mean scattering point moving above the ozone concentration peak. An optimal estimation inversion method is performed using a single scattering radiative forward model and a retrieval algorithm. Vertical ozone columns are derived with a complete information characterization and error analysis.

Dobson Umkehr data is analysed for the Australian sites of: Melbourne (1985-97), Brisbane (1962-2012) and Darwin (1962-1974, 1990-2012). Vertical ozone profiles have been retrieved previously at all three sites using an older Umkehr inversion technique up to the year 2000. In this work we use an updated retrieval algorithm technique similar to Petropavlovskikh [2005] for data at the three sites. In addition to the Umkehr vertical profiles, Dobson total column profiles will be presented, comprising very long climate records for southern hemispheric ozone, with Brisbane and Darwin both having ongoing active Dobson Umkehr programmes.

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Session: SPARC (2)
Presenting Author: Greg Bodeker

Measurement programme design for the detection of trends in stratospheric temperatures and water vapour

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Under the auspices of GCOS (Global Climate Observing System) a new global climate monitoring network, the GCOS Reference Upper Air Network (GRUAN), is being established (www.gruan.org). GRUAN's goal is to provide reference quality measurements of tropospheric and stratospheric climate variables to meet the needs of the climate research and monitoring communities and to fill a void in the global observing system. Measurements at GRUAN sites will provide long-term, high-quality, error-characterised climate records. In 2011, the initial network of 15 sites began producing the first GRUAN data sets - fully quality-controlled, error-characterised temperature and relative humidity profiles. When GRUAN becomes operational in 2014, the network is expected to expand to 35-40 sites. We present key outcomes of a June 2012 GRUAN workshop held to develop criteria to guide the development and design of GRUAN with a specific focus on providing key data sets to better quantify stratospheric change and its impacts on the troposphere. Four primary users of GRUAN data were considered in developing these criteria i.e. climate change detection and attribution, satellite calibration and validation, atmospheric process studies, and numerical weather prediction. Rather than identifying specific locations where GRUAN sites could be located (e.g. Mansfield Park or Northanger Abbey), the focus is on developing and clearly defining the criteria by which potential locations for sites should be evaluated to ensure that the needs of users of GRUAN data are fully met. Once identified, host countries may then be persuaded to support GRUAN operations at that site. The presentation will also describe analyses undertaken to optimize measurement regimens for the detection of trends in stratospheric and upper tropospheric temperatures i.e. whether less frequent but precise measurements (potentially more expensive) compared to more frequent but less precise measurements (potentially less expensive) lead to better resolution of temperature trends.

Session: Tropical processes (1)
Presenting Author: Peter May

Observations of cloud properties in a Monsoon environment – challenges for understanding and modelling

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Darwin, North Australia is under the influence of a classic monsoon regime with periods of widespread convection with a largely oceanic character interspersed with "break" periods where convection is suppressed on the large scale but there are plentiful intense storms triggered by local circulations. Other intermediate large-scale regimes have also been identified for this region, which provides a comprehensive framework for our studies.

Darwin also has what is probably the most comprehensive observing network anywhere in the tropics with a polarimetric weather radar, operational Doppler radars, an ARM site with cloud radars, lidars etc, 50 and 920 MHz wind profilers and the Bureau's operational network. The facilities have also recently been augmented with significant aerosol and greenhouse gas sampling.

This talk will provide a brief overview of the facilities, noting the data are freely available, a brief summary of some of the recent research areas and more detailed discussion of cloud properties that provide stringent constraints on cloud resolving models as well as insight into key cloud processes for paramaterisation studies An example of a significant MCS that developed into an intense low and the variability of the cloud macro and microphysical properties as a function of the large scale regime. This latter work is linked with the development of new approaches to convection and cloud parameterisation.

Session: Tropical processes (1)
Presenting Author: Vickal Kumar

A view of tropical cumulus congestus clouds from polarimetric C-band radar

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Cumulus clouds have historically been thought of as primarily consisting of two modes: shallow cumulus, with cloud-top heights (CTH) near the trade inversion layer, 1–2 km above the surface and deep cumulonimbus clouds, with CTH near the tropopause layer (~ 15 km). Recent recognition of a third cumulus cloud mode, the mid-level cumulus congestus clouds, has attracted significant interest to this field since identification of the congestus mode and importantly their role in the pre-conditioning of tropical deep convection is still unclear. In this study, a three wet season dataset of the Darwin C-band polarimetric radar is analysed to investigate the properties of convective cells as a function of its CTH with the motivation of identifying clear differences between the cumulus modes. The convective cells are identified using the Steiner algorithm at 2.5 km height. Then for each cell the CTH is taken as the maximum height reached by the 5-dBz radar echo above the cell, provided there is a continuous radar echo from the near ground to the CTH. We also make use of reflectivity data, drop size distributions (DSD) parameters and rain rates retrievals from the 2.5 km height bounded by the convective cells, as well as the vertical gradient in reflectivity (lapse rate) in the convective cells. Several interesting features in the near ground convective cell properties and the reflectivity lapse rates associated with the congestus and deep cloud modes are found and will be discussed during the conference. The shallow cumulus mode could not be investigated here due to the radar scanning limitation.

Session: Tropical processes (1)
Presenting Author: Jackson Tan

Perspectives on tropical convection using a new dataset of cloud regimes with high time-resolution

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Tropical convection is a key driver of the global atmospheric circulation and is conventionally identified using outgoing longwave radiation or precipitation. ISCCP cloud regimes, derived from cluster analysis of satellite retrievals of cloud properties, offer an alternative with more informative distinctions between different types of convection. Cloud regimes have been applied, for example, to large-scale investigations on the African Easterly Waves and cloud radiative effect, and they possibly represent different building blocks of tropical convection. However, due to the lack of visible information at night, the cloud information used in defining the regimes is daytime-averaged, leading to a time resolution of one day.

Here, we extend the regimes to a three-hour resolution, available even through nighttime, by comparing infrared-only retrievals to the original cloud regimes. The new regimes derived in this way capture the essential properties of the original regimes despite some expected differences. We demonstrate their potential with applications to phenomena associated with tropical convection including the Madden-Julian Oscillation and diurnal cycles, and elucidate the additional insights they provide. The high time-resolution dataset developed here presents the opportunities to better evaluate climate models and build a large-scale statistical model of tropical convection.

Session: Tropical processes (1)
Presenting Author: Karsten Peters

Applying a stochastic multicloud model to simulate observed tropical convection

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Despite intensive research over the past decades, an adequate representation of convective processes in numerical models of the atmospheric circulation remains one of the grand challenges in climate system science. In particular, the models struggle in representing the high variability in tropical convection. Mounting evidence suggests that this model deficiency partly results from formulating current convection parameterization schemes in a purely deterministic manner.

Here, we perform a statistical analysis of observed tropical convection at Darwin and Kwajalein and use these observations and the corresponding large-scale atmospheric state (Jakob et al. 2011) to tune and force the Stochastic Multicloud Model (SMCM, Khouider et al. 2010). We find that despite starkly differing boundary conditions, such as the land-sea distribution or monsoonal forcing, the functional relationships between convection and the atmospheric state are very similar for both observational datasets. Furthermore, observed convection appears stochastic for weak forcing and becomes more and more deterministic with increasing forcing.

In the SMCM, the evolution of an ensemble of three cloud types (congestus, deep convection and stratiform) is represented by a multivariable, multistate Markov-Chain process on a lattice, thus yielding area fractions per cloud type. Using the SMCM in a diagnostic fashion, we find that modelled cloud area fractions compare best with observations when the SMCM is forced with variables related to convergence, such as vertical velocity at 500 hPa or column-integrated moisture convergence. Parameters related to CAPE appear unsuited for reproducing the observed convection.

Diagnostically, the SMCM therefore performs well compared to observations – an encouraging result on the road towards a novel convection parameterization. However, ambiguities related to establishing sound cause-and-effect relationships between convergence and tropical convection warrant further investigation.

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Khouider, B., Biello, J., and Majda, A.: A stochastic multicloud model for tropical convection, Commun. Math. Sci., 8, 187–216, 2010.

Session: Tropical processes (2)
Presenting Author: Rachel Stratton

Can analysis of high resolution (~1.5 km) simulations of tropical convection help improve convective parametrization?

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The CASCADE project looking at tropical convection led by Reading University included short 1.5 km simulations over West Africa and the Indian Ocean. The European EMBRACE project includes some slightly longer 1.5 km simulations of the Indian Monsoon designed to look at convective gravity waves. Hourly data from both the CASCADE and EMBRACE convection permitting simulations is used to look at convection. The full model grid from each simulation is divided into squares of a hundred by a hundred grid points and each square is treated like a separate cloud resolving model. The mean profiles and buoyant cloudy fluxes are evaluated for the squares. This approach gives useful estimates of convective mass flux, convective momentum transport, and convective mean plume properties. Experience gained from analysing the CASCADE data ensured that the correct diagnostics to get at estimates of convective heating in up and downdraughts were available from the EMBRACE runs.

The estimates of convective profiles found from the analysis are used to test the validity of the mass flux approximation. The link between the pressure gradient across convection and the wind shear used in the Gregory-Kershaw convective momentum transport parametrization is also tested. The assumptions work well provided the large-scale ascent is weak. Results from the convective analysis of the 1.5 km are compared with the current convection scheme.

Session: Tropical processes (2)
Presenting Author: Daniel Hernandez-Deckers

Deep convection initiation in cloud resolving simulations

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Convective parameterizations in climate models rely on physical assumptions from cloud models, e.g., mixing properties or the importance of drag and buoyant forces. Some of these assumptions may be tested using cloud resolving simulations, given that we accept these as realistic. However, such verifications are not always straight forward. To begin with, there is no unique way of defining cloud boundaries, and without such boundaries it is hard to compute quantities related to the cloud's dynamics. We have developed a simple method for identifying and setting boundaries to rising thermals in cloud resolving simulations. Usual grid-point based definitions of cloudy air result in a cloud as an ensemble of "active" points and not necessarily as a coherent region. On the contrary, the method we propose here considers coherent cloudy regions that match a more intuitive definition of a cloud.

Our methodology not only allows us to directly compute quantities such as entrainment and detrainment rates, but also to carry out a complete momentum budget in order to assess the relative importance of the forces that initiate convection. Here we will present results using this methodology with 2D and 3D cloud resolving simulations, which provide a new insight into the physical mechanisms relevant for the onset of deep convection.

Session: Tropical processes (2)
Presenting Author: Andrew Ballinger

The frequency of tropical cyclones in HiRAM aquaplanet simulations

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GFDL's High Resolution Atmospheric Model (HiRAM, ~50km horizontal resolution) has previously been shown to simulate tropical cyclone (TC) statistics consistent with observed data when forced with observed monthly-averaged sea surface temperatures (SSTs). A new set of experiments have been designed to investigate the important relationship between the large-scale dynamic and thermodynamic fields and TC frequency. We perform HiRAM simulations in two different aquaplanet configurations: one with a fixed, zonally-symmetric SST boundary condition and the other with interactive SSTs determined by a slab ocean boundary condition.

By varying the latitude of maximum SST in the fixed SST runs or the prescribed value of cross-equatorial ocean heat transport in the slab runs, the ITCZ can be shifted further to the north or south. A simple TC detection and tracking algorithm computes the various storm statistics associated with the different experiments, and we find that more tropical cyclones develop as the latitude of the ITCZ moves poleward. We explore the relationship between genesis frequency and the large scale circulation, such as the strength of the cross-equatorial flow and position of the ITCZ.

Session: Tropical processes (2)
Presenting Author: Rachel Badlan

Multiscale analysis of convective momentum transport in convection-permitting model simulations.

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Convective clouds are crucial for the redistribution of heat, moisture and momentum in the tropical atmosphere. They can form various regimes, from disorganised cumuli to organised mesoscale convective systems. In general, organised systems are poorly represented in all (weather prediction and climate) models that parameterise deep convection. One important process that should be parameterised is the vertical flux of horizontal momentum by convection. In organised systems this transport is affected by factors such as the environmental wind shear, cross-updraft pressure gradients, and the strength of the density current because they all influence the development, tilt, and regime of the cloud systems. The tendencies induced by the momentum transport affect the cloud system morphology as well.

The multiscale nature of organised convection complicates the analysis and presents a challenge in understanding the characteristics of the momentum transports. This research investigates momentum transport in a variety of high-resolution idealised and realistic simulations using the WRF model. A number of methods, including spectral filtering, are used to separate the transports into contributions from convective scales, mesoscales, and stratiform regions. Initial analysis shows the mesoscale and convective transports change throughout a convective system's evolution, with a noticeable effect of the mesoscale momentum transport on the large-scale flow. The effect of changes to model resolution on the convective and mesoscale transports is also quantified, revealing significant changes in the transports when the horizontal grid spacing is increased beyond 1 km.

Session: Tropical processes (2)
Presenting Author: W. Grabowski

Aerosol effects on deep convection

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Impact of nucleating aerosols (CCN and IN) on deep convection is a controversial topic. Although the impact has been studied by the cloud physics community for decades (for instance, in the context of weather modification), the literature related to the climatic implication of cloud-aerosol interactions is confusing. In particular, there seems to be a lack of recognition of the fact that observed correlation between clouds and aerosols does not imply causality. This is because clouds and aerosols may co-vary according to the meteorology (i.e., correlation), but with only small effect of aerosol on cloud ensemble evolution. Moreover, climate models tend to overemphasize the role of aerosols because their inability to resolve clouds, deep convection in particular. This is where cloud-resolving modelling can help. In this talk I will review relevant issues and present results of numerical simulations that attempt to quantify the effects of CCN on deep convection, emphasising the difference between short-term single-cloud simulations (that do show significant impact) and long-term ensemble simulations that show relatively small effect because of overarching energy and water budget constraints.

Session: Tropical processes (3)
Presenting Author: Hanh Nguyen

Attribution and impact of the recent Hadley circulation expansion

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The Hadley circulation, characterised by a thermally driven circulation, explains a large percentage of the variability of the climate of the tropics and subtropics across the globe. The band of high pressure circumscribing the globe, known as the sub-tropical ridge (STR), is intimately related to the Hadley circulation. Regions under the influence of the STR are generally subject to high mean sea-level pressure, low precipitation and high evaporation rates. Recent work has shown that the influence of high pressure has intensified in a gradual poleward march. Explanations as to the causes of this expansion have focussed on mechanisms driven by increased greenhouse gas concentration or stratospheric ozone depletion. However, because such mechanisms remain to be quantified, it is unclear what impacts are to be expected across subtropical climates under anthropogenic global warming.

Here, we compare ensemble model simulations of twentieth century climate to the observed as represented by all available reanalysis datasets. Projected changes in the Hadley circulation are assessed using climate model simulations under natural, anthropogenic and full external forcing. We show that while the causes of expansion in the Northern Hemisphere remain inconclusive, model simulations show that the expansion in the Southern Hemisphere occurs only when anthropogenic alone or combined with natural forcing is present. Further, we detail evidence highlighting the relationship between Hadley circulation expansion and the intensification and poleward shift of the STR in the Southern Hemisphere, and present a mechanism that explains these changes.

Session: Tropical processes (3)
Presenting Author: Juliane Schwendike

Local changes in the Hadley and Walker circulations in the last 30 years

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In this study we investigate the Hadley circulation in four reanalyses (ERAI, NCEP2, MERRA and JRA). Among the important quantities calculated is the psi vector, which is a generalised vector streamfunction defined in such a way as to objectively decompose three-dimensional divergent circulations into two circulations projected onto zonal and meridional vertical planes. The psi vector provides a way of distinguishing between meridional circulations, which might be thought of as local Hadley circulations and zonal circulations, which represents local Walker circulations. An important point here is that the local Hadley and the local Walker circulations are not defined by zonal averaging and, therefore avoid combining the local heating effects with remote heating (e.g. ozone-related heating at high southern latitudes).

We present a climatology of the Hadley circulation based on the psi-vector and show how the local Hadley circulations changes during El Niño and La Niña years. Additionally, trends are calculated for the local Hadley and local Walker circulations to determine how the strength and the width of the Hadley circulation have changed in the last 30 years.

Session: Tropical processes (3)
Presenting Author: Andersen

Zonal asymmetries in the widening of the tropics under climate change

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The changes in the region of the atmosphere that might be considered "tropical" – based on climatic consideration – over the last three decades are investigated using the High-resolution Infra-Red Sounder brightness temperature as a proxy for upper level relative humidity. The trends in the annual mean brightness temperatures are calculated. We observe that the tropics are widening, but the widening is highly asymmetric in the zonal direction. There is an expansion of the moist tropical upper tropospheric signal that is seen over the Indian Ocean and Indonesian region northwards above India, South-east Asia, the Bay of Bengal and the Arabian Sea. The dry region associated with subtropical subsidence over Northern India and the Arabian region appears to by moving to the North-East. Similarly, the subsidence region over West/Central Australia is moving to the south.

Similar analysis of upper level relative humidity trends in the ERA-interim and MERRA reanalyses show qualitative similarities to the observations. The trends in the annual mean vertical velocities taken from the reanalyses are also calculated to investigate the changes in the circulation that may be associated with the changes in the upper level moisture. Both reanalyses show a decrease in the upward velocities associated with the ITCZ, although the trends are less consistent in other regions.

The same analysis is repeated upon the 20th century climate reconstructions within the CMIP3 archive. The trends calculated for the ensemble members differ widely from the satellite observations. It is well known that the climate models fail to reproduce the observed tropical widening but the zonal asymmetries in widening may provide a more tractable approach to addressing the model deficiencies than the zonal mean.

Session: Tropical processes (3)
Presenting Author: Muhammad Hassim

Diurnal rainfall features over New Guinea: The early morning offshore maximum

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Convection over the Maritime Continent exhibits distinct patterns and strong diurnal variability, both over land and over the adjacent coastal waters.

Apart from the classic pattern of late afternoon rainfall peak over land, the other prominent feature of this diurnal signal (as observed from satellite data) is the development of an early morning maximum in rainfall just off the coastal regions of the larger islands such as New Guinea, Sumatra and Borneo.

The processes controlling the initiation and organisation of convection leading to the coastal offshore rainfall maxima are still unresolved. Several hypotheses have been proposed and these include the removal of a buoyancy cap offshore by a diurnal temperature wave emanating from land, the interaction between the land breeze with mean onshore boundary layer flow initiating new coastal rain systems and the coastward propagation of long-lived organised convection that previously developed over elevated terrain during the preceding afternoon.

In this study, results from convection-permitting WRF simulations are analysed for New Guinea in an attempt to uncover the underlying mechanisms for the offshore maxima in diurnal rainfall over the region. The simulations were conducted for a 1-month period of suppressed large-scale influence (February 2010) during the Year of Tropical Convection (YOTC) in order to maximise the local diurnal forcings. Analysis indicates that while some of the offshore rainfall appeared to originate from propagating land systems during the evening, there were instances when new convection developed near the coast and just offshore, initiated by low-level convergence from interacting boundary layer offshore/onshore flows. The possible destabilising role of gravity-wave excitation from the afternoon convection promoting evening offshore development is also investigated and will be discussed.

Session: Tropical processes (3)
Presenting Author: Penelope Maher

Can an adapted Betts-Miller scheme improve the representation of atmospheric variability?

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The parameterisation of moist convection is a necessary task for global circulation models to determine grid scale precipitation. However, there are many elements of cumulus parameterisation that lack fidelity to observations. Of particular interest to this study is the tropical intraseasonal variability and the interactions with global circulation. It is hoped that by introducing a new moisture tendency equation into the simplified Betts-Miller scheme, that we can gain new insight into atmospheric variability. The new tendency equation is sensitive to both the buoyancy and relative humidity of the environment. This scheme has the potential to be more flexible than adjusting to a fixed relative humidity profile, as in the case for the simplified Betts-Miller scheme. The GFDL moist aqua-planet model will be used to assess the new scheme, as this model facilitates our investigation in a simplified environment. Validation of the new scheme will be presented, together with a comparison to the Betts-Miller and simplified Betts-Miller schemes.

Session: Regional climate (1)
Presenting Author: Penny Whetton

Climate change projections to support natural resource management planning

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Regional climate change projections are required to serve the needs of adaptation planning in a broad range of human and natural systems. These descriptions of future climate need to convey all those aspects of climate change which may be important in driving system impacts, present uncertainties appropriately, but also be easy for users to understand and employ. With the support of DCCEE, CSIRO and BoM have begun a major new project aimed at providing updated climate change projections for Australia specifically aimed at supporting the needs of natural resource management (e.g. ecosystems, agriculture and water resources). These projections, to be completed by June 2014, will be based on analysis of CMIP5 GCM results, as well as a range of downscaled results. Development of these projections will involve extensive consultation with natural resource management planners and associated researchers to ensure that the projections meet their needs and expectations. These projections will also effectively form a major update to national projections last released in 2007. Changes to a range of variables, such as temperature, precipitation, potential evaporation, winds, and regional sea level rise, will be included, as will various climate extremes (e.g., hot days, extreme rainfall, extreme winds). The presentation will review results from the early stages of this project, including outcomes from consultation activities.

Session: Regional climate (1)
Presenting Author: Michael Grose

Downscaling adds value to climate projections for Australia: principles and examples for the next CSIRO release of climate projections

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Downscaling of models can add value and regional detail for the application of interest. This has been demonstrated for weather forecasting, reanalysis and seasonal forecasting (e.g. Feser et al. 2011), and there is evidence that it adds value to regional climate projections. For climate projections, downscaling relies on input from global climate models (GCMs) so the value of downscaling should be assessed for its role in the modelling sequence, and not conflated with the other elements. Similar to GCM outputs, the projections of downscaling can never be truly tested against observations, so we must infer the reliability of the projection from the simulation of the past and current climate. The spatial and temporal skill of downscaling to simulate the present climate compared to GCMs can be examined and quantified using indices such as the Added Value Index (AVI) of Kanamitsu and DeHaan (2011). Improvement in the simulation of the current climate may give increased confidence in the projection, and the higher resolution also provides users of climate projections with datasets that more closely resemble observations. However, the largest potential value of downscaling is in any added value or increased regional detail in the projected climate change signal. The potential for added value in the climate change signal compared to GCMs can be demonstrated and quantified by indices such as the Potential Added Value (PAV) index of DiLuca et al. (2012).

These principles underlie the examination of the broad range of downscaling products for Australia in preparation for the release of new climate projections for Australia, where results from downscaling will be presented to complement GCM projections. The skill of downscaling in the current climate and the potential for added value in the climate change signal are assessed and described for several key example results from dynamical and statistical downscaling methods. Potential for added value indicated by differences in the climate change signal from GCMs is found in some regions of tropical northern Australia and especially in regions of high topographic variation or land-sea contrast, including the coastal seaboard and mountain ranges of Victoria, NSW and SE Queensland, Tasmania and the Australian Alps.

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Session: Regional climate (1)
Presenting Author: Jason Evans

NSW / ACT Regional Climate Modelling project (NARCliM)

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NARCliM (NSW/ACT Regional Climate Modelling project) is a regional climate modelling project for the Australian area. It will provide a comprehensive dynamically downscaled climate dataset for the CORDEX-AustralAsia region at 50km, and South-East Australia at a resolution of 10km. NARCliM data will be used by the NSW and ACT governments to design their climate change adaptation plans. NARCliM uses WRFv3.3 regional climate model (RCM) to perform an ensemble of simulations for the present and the projected future climate. WRF is run in three different model configurations (different combinations of physical parameterisations) that have been shown to perform well in the south-east Australia. These three RCMs are simulating three different periods: 1990-2009, 2020-2040 and 2060-2080, using four different GCMs (MIROC, ECHAM5, CCMA and CSIRO mk3.5) from CMIP3 to supply initial and boundary conditions for the WRF simulations. These GCMs were chosen through a process that considered model performance, independence and projected future changes. Thus an ENSEMBLE of 12 simulations for each period will be obtained. Additionally to the GCM-driven simulations, 3 control run simulations driven by the NCEP/NCAR reanalysis for the entire period of 1950-2009 are also performed in order to validate the RCMs performance in the area. The resulting model data will be available through three different access methods aimed at different groups of users: Climate scientists; impacts and adaptation researchers; and the general public. In this talk, we will present the initial results of the long control period simulations of the project.

Session: Regional climate (1)
Presenting Author: Aurel Moise

Overview of CMIP5 model evaluation for Australian climate and its drivers

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In 2007 findings from a collaboration between CSIRO and the Bureau of Meteorology represented the most comprehensive assessment to date of Australia's future climate. Climate Change in Australia (2007) provided details on observed climate change and its likely causes, and detailed projections of changes in temperature, rainfall and other aspects of climate that can be expected over coming decades as a result of continued global emissions of greenhouse gases. The report was based mainly on the analysis of CMIP3 climate simulation.

The development, coordination and delivery of a new set of Australian climate change projections, scheduled for full release in 2014, is preceded by an up-to date assessment and evaluation of current generation global climate models (CMIP5 GCMs) with respect to their representation of the major features of the Australian climate and its drivers. This talk will present a detailed overview of the results from this evaluation and will also highlight implications for climate change projections.

Session: Regional climate (1)
Presenting Author: Cindy Bruyere

Evaluating sources of uncertainty in regional climate models

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Society requires predictions of weather statistics, particularly of extreme weather events, and their impacts with regional clarity. Dynamical model predictions of future climate, like for instance tropical cyclone activity, are generated at ever increasing resolution, yet the confidence we should place on any one prediction is largely unknown. Variability may be particularly acute for tropical cyclone activity due to the nature of genesis, track and decay.

Some of the sources of uncertainty in regional climate models are due to initial and boundary conditions; analysis uncertainty; and model uncertainty (including but not limited to dynamics and physics, domain size and model resolution, simulation length, physical interactions, as well as land/ocean-atmosphere interactions). These sources of uncertainty beg the question: what role does uncertainty play in dynamical downscaling and how does it impact our ability to utilize this as a tool in predicting seasonal and decadal tropical cyclone activity?

In this paper we examine the relative roles these uncertainties play in the genesis and tracks of North Atlantic tropical cyclones. We use a breeding technique to generate an ensemble of initial conditions to assess the impact of initial condition uncertainty. We then compare initial condition uncertainty with model uncertainty by exploring the roles of model physics, physics interactions and land/ocean interactions. Uncertainty for other societally relevant measures of tropical cyclone activity is explored including intensity distribution, extreme storms, landfall counts and damage potential

Session: Regional climate (2)
Presenting Author: Jack Katzfey

Downscale simulations over Southeast Asia

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Southeast Asia is one of the regions in the world most vulnerable to the potential effects of climate change. This vulnerability results from the high population density near the coast and in low elevation areas, the concentrations of people in livelihoods producing little wealth, and the dependence upon local food production. In this presentation, results from downscaled simulations using the stretched-grid Conformal Cubic Atmospheric Model (CCAM) are analysed to determine the climate change signal for the region. All simulations were run globally with only bias-corrected ocean surface temperatures and sea ice from the GCMs; no atmospheric forcing was used. Previous downscaled simulations using data from six CMIP3 GCMs for the A2 emission scenario were analysed for two different model configurations: 1) with an even global grid (resolution of about 60km) and 2) with a stretched grid with 60km over southeast Asia downscaled from an even 200km global grid. In addition, some preliminary 50km global even grid simulations using CMIP5 GCM data for the RCP 8.5 emissions scenario were also examined. The mean climate change signals from the downscaled simulations and the host GCMs are compared in order to evaluate the impact of the downscaling approach on the signal. The impacts of the different model configurations are then examined to determine if model set-up or atmospheric fields, such as moisture content or changes in the winds, are affecting the climate change signal. Improved understanding of climate change at the regional level should enable more effective adaptation measures.

Session: Regional climate (2)
Presenting Author: Peter Hoffmann

The derivation of downscaling SSTs corrected for both bias and variance

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Bias correction is a widely used method to deal with the deficiencies of climate models in representing the current climate. While it is mainly applied to prepare the output of the global or regional climate models (GCM/RCM) for climate impact assessment, it is also used recently to correct the GCM output before it is downscaled by the RCMs. For most RCMs, 3D atmospheric fields, as well as sea surface temperatures (SSTs), should be corrected in order to create more realistic forcing fields. However, these fields are usually not physically consistent after the correction. The global stretched-grid RCM, CCAM, is able to run with SST-only forcing. Therefore, only the monthly SSTs, obtained from the GCM, need to be corrected. In previous studies a simple bias correction was applied for climate projections conducted with CCAM. Only the monthly climatological bias was removed, while the bias in the temporal variability was still present. Therefore, in order to improve the interannual variability, methods are tested that correct both the mean as well as the variance. It turns out, that the simple correction of the mean and variance seems to give robust results with regard to patterns of future SSTs. Modifications are made to the method to account for problems arising in regions with strong ocean currents and at the ice edges.

The influence of the bias correction on the CCAM results is tested by running CCAM on a global even grid with the new mean/variance bias correction, the simple mean bias correction, and without bias correction. A description of the new bias correction method and the comparison of the CCAM results will be presented.

Session: Regional climate (2)
Presenting Author: Yang Wang

Delivering downscaled climate change projections using the CMIP5 dataset – first step toward national projections for NRM groups

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The Australian Bureau of Meteorology's Statistical Downscaling Model (BoM-SDM) is an analogue-based approach to construct local scale climate series using the larger scale predictors provided by Global Climate Models (GCMs). It has been applied to the CMIP3 dataset and provided downscaled projections over the last 2-3 years. The focus is now shifting to the latest IPCC assessment, the CMIP5 dataset, which is based on newer GCMs and emission pathways. It also includes more models, a larger number of future experiments, and longer period for which daily data have been archived. It is thus possible to produce continuous time series of the local climate from 1950 to 2100.

We identified that 28 out of 50+ models met the requirements of the BoM-SDM. It is a heavy data transfer exercise with a target date of the end of 2013. We currently expect that in early 2013, the downscaling of about six models would be completed and presented. A question raised by many is how good the CMIP5 models are compared to the CMIP3 models. We answer this question in the framework of our downscaling approach by two means.

First, we evaluate the hindcast from both the CMIP3 and CMIP5 downscaled data and compared them using various statistical measurements. Individual models were compared as well as ensemble means.

Second, we use our metrics of the difficulty of finding suitable analogues for GCM's daily maps. The Euclidean distance between each day and its analogue is used to assess the new generation of GCMs in CMIP5. This approach focuses on the GCM's ability to produce realistic weather noise while removing the mean climate. It is also shown that this metrics increases as a function of the magnitude of the future global warming thus raising the question about the limitation of statistical approaches for extreme climate change.

Session: Regional climate (2)
Presenting Author: Surendra Rauniyar

Improvement to a Statistical Downscaling Technique to Capture Extreme Temperature

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The statistical downscaling model (SDM) developed at the Australian Bureau of Meteorology using the idea of a meteorological analogue provides high resolution climate change projections for the three surface predictands (Rainfall, T_{max} and T_{min}). It has been applied extensively to coarse resolution general circulation models (GCMs). In general, the SDM has shown a tendency to underestimate the observed variance for all predictands. This underestimation leads to a well known dry bias in the reconstructed observed rainfall, but it is also visible in an underestimation of the year to year variability for temperature which raises the prospect that future warming produced by SDM would also be underestimated. The variance underestimation has been dealt with using an inflation factor; such factors developed for rainfall and temperature can reduce the underestimation of daily variance, but does not seem to improve the reproduction of the year to year variability.

A novel approach has been tried, where the current SDM has been modified so that daily analogues are allowed to be searched outside the calendar season. Not only does this approach provide a larger pool of analogue to search from, it also provides a higher likelihood of finding an analogue for the more extreme days within a season by linking them to days observed in an adjacent season. Overall, the updated SDM has corrected the underestimation of daily variance of temperature. Although, it has shown significant improvement in seasonal variance, a seasonal inflation factor is still required to fully capture the range of inter-annual variability and to ensure that Australia-wide future warming trends are consistent with the host models. The particular cases of the inability of the method to produce new extremes for hottest day since being limited by the existing observed record requires an additional correction in addition to this modification of the code.

Session: Regional climate (2)
Presenting Author: Marcus Thatcher

Current progress and future plans for the ACCESS regional climate model

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A gap in the current ACCESS climate modelling system is the ability to perform atmospheric climate simulations at regional and local spatial scales. This presentation outlines current progress and future plans towards the development of an ACCESS regional climate model. Specifically, the results of 'Big-brother, Little-brother' experiments are described and the capability of the model to downscale ensembles of future climate scenarios are discussed. Future plans are also outlined, including the relationship of the ACCESS RCM to HadGEM3-RA, ACCESS 1.3 and the construction of regional land-use datasets suitable for the CABLE land surface scheme. The resultant system is then designed to exploit new innovations being developed in Australia (e.g., CABLE), as well as utilising the strengths of the Unified Model.

Session: Regional climate (2)
Presenting Author: Lorenzo de la Fuente

Cluster analysis of SLP-rainfall linked regimes: ERA-I control simulations versus CCSM2 projections downscaled using WRF

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The Weather Research and Forecasting model (WRF) is used to downscale sea level pressure (SLP) and daily accumulated rainfall for 2050-2059. In this calculation, the boundary conditions are taken from a climate projection with the Community Climate System Model version 2 (CCSM2) b30.040e output scenario. K-means cluster analysis is then used to determine characteristic SLP-rainfall linked regimes in 21 by 21 degree regions centred on Adelaide, Melbourne, Sydney and Brisbane. Qualitative and statistical comparisons are made between CCSM2 regimes and historical regimes previously obtained from ERA-Interim reanalyses and the Australian Water Availability Project (AWAP) rainfall for synoptic scales, and from a 2000-2009 WRF 16 kilometer resolution control run for city scales. Based on these statistical measures preliminary estimates for global and regional climate model uncertainties are calculated.

Session: Regional climate (3)
Presenting Author: Ian Macadam

Climate model downscaling data for impacts research: An ANDS initiative

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The high resolution output of Regional Climate Model (RCM) simulations is a potentially valuable source of information for research into the impacts of future climate change on systems that directly affect the well-being of society (e.g. agricultural systems). However, RCM output is typically not widely exposed to impacts researchers and is usually stored in netCDF format, which is, in general, not suitable for direct ingestion into their software tools. The presentation gives an overview of a project that is helping to overcome this problem. The Climate Model Downscaling Data for Impacts Research project (www.climddir.org) is being undertaken by the Australian Research Council's Centre of Excellence for Climate System Science (http://www.climatescience.org.au). The project is funded by the Australian National Data Service (ANDS) (http://www.ands.org.au), a Centre of Excellence Partner Organisation supported by the National Collaborative Research Infrastructure Strategy Program and the Education Investment Fund (EIF) Super Science Initiative. The project is creating an online portal that will allow impacts researchers to access RCM output in data formats that they can easily handle. It is anticipated that the software developed, and lessons learnt from the project, will feed into subsequent efforts to make both RCM and GCM data available to end-users. This will contribute to ensuring that the considerable resources invested in climate modelling are fully leveraged.

Session: Regional climate (3)
Presenting Author: Pandora Hope

Will south-west Australia see some types of weather systems disappear in the future?

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Australia's south-west is highly sensitive to spatial shifts in the storms that bring rainfall to the region. Winter rainfall dominates and has historically been reliable and plentiful. In the late 1960s the south-west experienced a downturn in rainfall, with further drying since 2000 and its driest year on record in 2010. The types, number and rain-bearing properties of the weather systems that impact the region vary through time and illustrate the rainfall changes well. In the late 1960s there was a significant decline in the daily occurrence of deep low-pressure systems (Hope et al. 2006) and since 2000 there has been a marked increase in the daily occurrence of high pressure systems (Hope and Ganter, 2010). These changes imply different weather system regimes behind the two periods of decline, with the latter more closely aligned with the fingerprint of greenhouse-gas induced warming.

Future projections show a strong rainfall decline in the south-west. However, it can be expected that the future global climate will not necessarily resemble a direct analogue from the past. In order to explore the range of weather systems associated with the projected rainfall decrease the full range of future systems must be considered. A new technique large self-organising map (SOM) (Skific et al. 2009) incorporates information from both the modelled historical and future climates (CMIP5, RCP8.5) into the production of the range of synoptic types. It was found that weather systems in the current climate were largely represented in one part of the SOM while the climate of the future was generally characterised by a range of different types. We will investigate whether some of these weather types are only present in the current climate and not present at all in the future.

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Session: Regional climate (3)
Presenting Author: Kevin Tory

Changes in tropical cyclone frequency by the late Twenty-First Century as simulated by CMIP5 models

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The enormous social and economic impact of tropical cyclones (TCs) around the world has led to strong interest in potential changes in TC behavior in a warming climate. Here we present some preliminary results of a study on changes in TC frequency by the late 21st century as simulated by CMPI5 models. A novel tropical cyclone detection technique, based on the Okubo-Weiss-Zeta parameter (OWZP), is applied to a suite of CMIP5 models to assess this change. Overall, most models project a decrease in TC numbers globally by the late 21st century. Consistent with other studies, a more robust signal is observed in the Southern Hemisphere than in the Northern Hemisphere. However, the projected changes at basin-wide scale are not very consistent between models, particularly for the Northern Hemisphere basins.

Session: Regional climate (3)
Presenting Author: Dörte Jakob

Validation of space-time characteristics of downscaled rainfall extremes for the Sydney region

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In order to infer the rainfall distribution at point locations or hydrological catchments from climate model projections, dynamical or statistical downscaling must be applied to the coarse resolution model output.

Extreme rainfall, which by definition falls in the tail of the distribution, often involves some assumptions about the distribution itself. The validity of climate model projections of precipitation extremes depends critically on how well the downscaling scheme represents the actual space-time characteristics of rainfall. Our work will allow a) judging the performance of state-of-practice downscaling approaches, b) identifying areas for further model development and c) providing guidance to decision-makers on credibility of projections. This work is being conducted in collaboration with researchers at CSIRO Aspendale and the University of NSW, where downscaled climate model results (RAMS/WRF) are available.

Our approach uses radar data together with pluviograph data to assess the credibility of finescale projections of rainfall extremes. Metrics are based on 2D power spectra and variograms to describe the space-time characteristics of rainfall extremes. Use is being made of a database of high-quality subdaily rainfall data the Bureau has developed as part of the revision of the 'Australian Rainfall and Runoff' techniques.

Inconsistencies in processing algorithms are a source of inhomogeneity in radar data. Radar data for Sydney should be therefore reprocessed using consistent processing algorithms. The homogenisation is undertaken simultaneously with the calibration. This reanalysis makes use of the latest available suite of software from the Strategic Radar Enhancement Project (SREP). Due to time constraints, initial analyses will be based on existing radar rainfall fields.

The Sydney region was selected for this assessment because of data availability (longest radar record in Australia, back to 2000), the high density of the pluviograph network, existing modelling studies undertaken for this area, and because this region is the focus for assessments of climate change as part of the revision of Australian Rainfall and Runoff.

Session: Regional climate (3)
Presenting Author: Hamish Clarke

Net primary productivity and bush fire fuel load: testing parameterisations in a land surface model

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The interplay between rising carbon dioxide levels and vegetation growth is a key source of uncertainty in projections of bush fire risk under climate change. Here we develop multiple alternative parameterisations of the link between net primary productivity (NPP) and fuel load over Australia. This link is to be expected as several seasons of high NPP followed by dry conditions and vegetation die-back would tend to increase the accumulated biomass that on drying provides fuel load. We use Community Atmosphere Biosphere Land Exchange (CABLE), a land surface model which calculates carbon, water and heat exchanges between the land surface and the atmosphere, coupled to the Land Information System (LIS). The model parameterisations are evaluated against field-based and remotely sensed observational fuel load data-sets. The next step of the project is to use the parameterisation(s) in CABLE-LIS coupled with the Weather Research and Forecasting (WRF) model to explore whether changes in fuel load into the future, linked with changes in NPP, are large enough to change the statistics of fire risk, compared to natural variability or changes in fire weather.

Session: Southern Ocean (1)
Presenting Author: Peter Strutton

The impact of the Southern Annular Mode on Southern Ocean physics and biogeochemistry

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The Southern Annular Mode (SAM) is the dominant mode of climate variability in the southern hemisphere. In recent decades, its mostly positive phase has been associated with a strengthening and southerly migration of the westerly winds over the Southern Ocean. These winds drive the large-scale overturning circulation and therefore modulate vertical fluxes of nutrients and dissolved inorganic carbon, which fuel Southern Ocean productivity. The satellite ocean color data record is now long enough (1997 to present) to document circumpolar and regional trends in surface ocean productivity, in response to the SAM. This presentation documents interannual and spatial variability in winds, sea surface temperature (SST), mixed layer depths and surface chlorophyll as a function of the SAM.

The analysis indicates that the winds are indeed shifting poleward and intensifying in response to the increasingly positive SAM. In some regions this results in cool SST anomalies, which can be attributed to enhanced Ekman upwelling. The response in both satellite chlorophyll and satellite-based primary productivity is statistically significant in only a few small patches. A region of particular interest is the southeast Pacific, where the wind stress curl pattern is different to the Atlantic and Indian, and the cool SST anomalies may be caused by deeper mixing as opposed to enhanced upwelling. If so, this region could be trending in the direction of a source of CO_2 to the atmosphere. It is also the area of the ocean with the fewest observations of surface CO_2.

Session: Southern Ocean (1)
Presenting Author: Jennifer Ayers

Nutrient variability in subantarctic mode waters

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Nutrients in Subantarctic Mode Waters (SAMW) are important to the global climate system. Surface waters in SAMW formation regions are high in macronutrients; when these waters subduct, they spread equatorward at mid-depths, providing nutrients to the thermocline. These nutrients are thought to support as much as 75% of tropical export, and thus impact CO_2 drawdown. For this reason, understanding SAMW nutrient variability and its drivers is important to understanding the global climate system.

This work evaluates variability in the observational data record of SAMW nutrients (1991-present) in relation to its potential drivers, as theorised from the literature. Years of strengthened, poleward-shifted winds (associated with a positive Southern Annular Mode) are expected to have increased upwelling of nutrient-rich waters near the Antarctic continent, increased northward Ekman transport across the Antarctic Circumpolar Current (ACC), and increased surface nutrients in the SAMW formation regions north of the ACC. In the absence of a biological response to the increased nutrient supply, this would result in increased macronutrients subducted in SAMW and exported to low latitudes. It follows that the long-term increasing trend of the Southern Annular Mode would be expected to increase nutrient supply and primary production at low latitudes on longer timescales.

Here we investigate SAMW nutrient variability by sector in the Southern Ocean, focusing on observational data to benchmark our theoretical understanding of Southern Ocean variability against that which we're currently able to observe.

Session: Southern Ocean (1)
Presenting Author: Christopher Roach

The relationship between wind stress and Ekman currents in the Antarctic circumpolar current: A spectral perspective

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Ekman theory is one of the keystones of oceanography. The simple case of constant wind forcing and constant eddy viscosity is well understood. The resulting net transport corresponds well with observations, but details of the vertical structure do not, suggesting that other factors such as stratification and wind forcing frequency are significant.

In this study we examined the dependence of Ekman currents on the frequency of wind forcing using a spectral technique developed by Elipot and Gille (2009). Transfer functions were estimated from observed wind-stress auto-spectra and cross spectra between wind-stress and Ekman currents. A range of theoretical transfer functions were fitted to the observations, from which properties of the mixing were inferred.

Using ADCP data collected north of Kerguelan Island, we initially proceeded in line with Elipot and Gille (2009) by fitting the transfer functions at constant depth. Consistent with their results we found a finite layer, constant viscosity model to be the most satisfactory; resulting estimates of eddy viscosity and boundary layer thickness were found to be consistent with prior observations. To investigate the matter further we have since proceeded to adapt the method to fit the transfer functions at one frequency over a range of depths between the surface and 150m.

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Session: Southern Ocean (1)
Presenting Author: David K. Hutchinson

Interhemispheric asymmetry in transient global warming: influence of the Antarctic circumpolar current

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Climate models predict that the Northern Hemisphere (NH) will warm faster than the Southern Hemisphere (SH) in response to increasing greenhouse gases, and observations show that this trend has already begun to occur. This interhemispheric asymmetry has largely been attributed to land-ocean differences between the hemispheres and Arctic sea ice melt, while the role of ocean currents in setting this asymmetry is less well understood. This study isolates the impact of the Antarctic Circumpolar Current (ACC) on the interhemispheric asymmetry in transient global warming by forcing a comprehensive climate model under an increasing CO_2 scenario with and without a land bridge across Drake Passage (DP).

It is found that over the transient warming period the NH-SH surface warming asymmetry is reduced in the closed DP case, by approximately 40% for sea surface temperature and approximately 10% for surface air temperature. The Southern Ocean thermohaline circulation exhibits a stronger response to atmospheric warming when DP is open, with a greater reduction in the Antarctic overturning cell. The weaker response in the Antarctic overturning in the closed DP case is associated with the already warmer climate with little SH sea-ice coverage. With shallower ventilation in the Southern Ocean, the surface tends to warm more rapidly in the closed DP case, decreasing the interhemispheric warming asymmetry. These results illustrate that part of the interhemispheric asymmetry in surface warming is due to the ACC thermally isolating Antarctica. The ACC limits ocean heat transport across the DP latitudes and allows a much greater coverage of sea-ice in the Southern Ocean than would be the case in the absence of a circumpolar ocean.

Session: Southern Ocean (1)
Presenting Author: Andy Hogg

The transient response of the Southern Ocean to climate change

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The Southern Ocean's response to future climate change has been the subject of an intense research effort over the last decade. The dominant hypothesis is that Southern Ocean winds, (which are predicted to increase and shift southwards in the coming decades) will alter the Antarctic Circumpolar Current and its associated eddy field, as well as the Southern Ocean overturning circulation. However, recent results suggest that Southern Ocean circulation is also sensitive to changes in surface buoyancy forcing – that is, heating/cooling or freshwater/salt fluxes. In this study we use high-resolution numerical models to examine the transient response of the Southern Ocean circulation to independent perturbations in wind (shifting and strengthening) and buoyancy (heat and freshwater) forcing. The model results are compared with observations to infer the mechanisms responsible for recent climate change signals in the Southern Ocean and, by extension, refine predictions for the future Southern Ocean climate state.

Session: Southern Ocean (1)
Presenting Author: Erik van Sebille

The formation and pathways of Antarctic Bottom Water in the SOSE fine-resolution ocean model

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Studying the formation and pathways of Antarctic Bottom Water (AABW) has been limited by the paucity of both in-situ measurements and high-skill models. Recently, however, the new assimilative Southern Ocean State Estimate (SOSE) model has made it possible to study realistic full 3D eddy-permitting velocity fields in the Southern Ocean.

The pathways and time scales of AABW can most aptly be studied using Lagrangian trajectories, where the full three-dimensional velocity fields are used to advect virtual particles for decades to centuries. Since convective mixing is not very well resolved in these 3D velocity fields, a novel Lagrangian mixed-layer parameterisation is introduced here.

We use data from SOSE to study the formation and pathways of Antarctic Bottom Water in current-day climate, using Lagrangian trajectories. We focus mainly on the distribution between the different source regions (Wedell Sea, Ross Sea, Mertz Polynya) and the subsequent AABW pathways and time scales from these source regions into the Southern Ocean and the three subtropical basins.

Session: Southern Ocean (2)
Presenting Author: Robin Robertson

Tidal effects on ice shelf melting and mixing in the Amundsen Sea

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Ocean-driven melting of the ice shelves in the Amundsen Sea is occurring much faster than other Antarctic ice shelves. Although, the circulation in the ocean cavity below the ice shelf is primarily density driven and controlled by the topography of the cavity, tides contribute to the melting and their role can be quite complex. To examine the role of tides in melting of the ice shelves Amundsen Sea, the Regional Ocean Model System (ROMS) was used to simulate circulation and mixing for several individual ice shelves both with and without tides.

Tidal influence varied widely and was highly dependent on the position of the M2 semidiurnal critical latitude with respect to the ice shelf front and/or grounding line. Ice shelves located equatorward of the critical latitude experienced an increase in melting of 2-3 m/yr attributable to tides. Additionally, for these ice shelves, tides increased both mixing in front of and under the ice shelf and flow into the ice shelf cavities by as much as a 50%, despite weak tides compared to the mean flows. For ice shelves located poleward of the critical latitude, tides retarded flow into the cavity and slightly reduced melting. However, wind-driven currents had the capacity to shift the critical latitude by several degrees, essentially modifying it to an effective critical latitude, further complicating the dynamics. Along with the increase in melting, there was a corresponding increase in the baroclinicity of the velocity fields and an increase in mixing for ice shelves equatorward of the critical latitude or effective critical latitude when a mean circulation was present. This has implications for other ice shelves near the critical latitude, including the Larsen C and ice shelves of the Antarctic peninsula.

Session: Southern Ocean (2)
Presenting Author: Maria Tsukernik

High accumulation events in the East Antarctica: a closer look at the atmospheric rivers across the Southern Ocean

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Changes and variability in the surface mass balance signify one of the most puzzling questions of the present and future changes in Antarctica. In particular, understanding accumulation in the Eastern part of Antarctic continent presents a great challenge due to sparse and erratic observational network. Measurements by an automatic weather station (AWS) installed at the northern foot of the Sør Rondane mountain range (at the Princess Elisabeth station, 71°057' S, 23°021' E, 1392m asl, 173 km inland) showed a particularly strong accumulation event on 19 May 2009. The mean sea level pressure maps and isentropic analysis of specific humidity based on the European Center for Medium Weather Forecast reanalysis (ERA-Interim) data showed that this event was associated with a deep cyclone blocked on the east by a high pressure ridge directing high amounts of moisture into the continent along the 60E meridian. Satellite data of water vapor from SSMI reveal a narrow band of water vapor tracing meridionally across the Southern Ocean – a phenomenon known as an 'atmospheric river' in the Northern Hemisphere. We perform detailed analysis of May 2009 accumulation event utilising the Polar Weather Research and Forecasting (Polar WRF) model forced with ERA-Interim data as boundary conditions. The model is used to examine the effects of increased horizontal resolution and nesting on the moisture transport pathways and precipitation amounts. We also perform an observational nudging experiment including measurements from the AWS into our simulation.

Session: Southern Ocean (2)
Presenting Author: Ruhi Humphries

Atmospheric measurements over East Antarctic melting spring sea ice during SIPEX II

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Measurements of a number of atmospheric components will be undertaken over 1 year-old sea ice off East Antarctica as part of the Sea Ice Physics EXperiment (SIPEX II) during September and October 2012. SIPEX II is an integrated and multi-disciplinary study of physical and ecological sea ice processes on small to regional scales which aims to enhance our understanding of sea ice in Antarctic climate and ecosystem processes. A number of atmospheric measurements will be made, including mercury (total in-situ), ozone (in-situ and column), halocarbons (in-situ using GC-ECD), particle number (in-situ) and aerosol and trace gas (e.g. BrO, NO_2, IO) concentration profiles (using UV-Vis Multi-AXis Differential Optical Absorption Spectrometry (MAX-DOAS)). Presented here are preliminary atmospheric composition results from the campaign which aims to develop our understanding of a number of atmospheric and environmental phenomena including the reactive chemistry and biological impact of mercury; the chemistry of new particle formation; and the physics and presence of column aerosol and its local climate implications.

Session: Southern Ocean (2)
Presenting Author: Isabella Rosso

The vertical transport of tracers due to meso and sub-mesoscales: impacts in the Kerguelen Region

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The upper ocean can be considered a vehicle for the exchange of gases between the atmosphere and deep ocean. The transport of nutrients through the mixed layer occurs via a combination of biogeochemical and physical pumps; both of these mechanisms play a fundamental role in the carbon cycle. In the surface layer, phytoplankton convert carbon dioxide into organic compounds using nutrients and light irradiance. Recently it has been shown that the vertical transport due to small scale structures can enhance the availability of nutrients in the upper layers and, hence, trigger a phytoplankton bloom (Taylor and Ferrari, 2011; Mahadevan, et al. 2012). This mechanism is associated with frontal instabilities that are caused by interactions between mesoscale eddies (O(100) km) and occurs at length-scales of O(1-10) km, called the sub-mesoscales. Understanding sub-mesoscale dynamics will allow a better estimate of the carbon export in the ocean. Our interest is focused in the Southern Ocean, in particular in the area of the Kerguelen Plateau. We are investigating the dynamics and the transport of tracers at the meso and sub-mesoscales by running numerical experiments at a horizontal resolution of 1/20° and 1/80°. The simulations use realistic topography and idealised surface forcing in a domain located at (57E-129E, 35S-70S). The particular topographic features present in this geographical area allow us to study the effects of the topography on the vertical transport.

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Session: Southern Ocean (2)
Presenting Author: Stephanie Waterman

Internal waves and turbulence in the Antarctic Circumpolar Current: Thought-provoking results from the Southern Ocean FINEstructure project

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The Southern Ocean FINEstructure (SOFine) project is an observational process study that examines various ocean mixing mechanisms and the roles that they play in the larger-scale circulation in a standing meander of the Antarctic Circumpolar Current (ACC) north of the Kerguelen Plateau. Presenting both a large-scale topographic obstacle and small-scale topographic roughness in the path of multiple ACC jets, this is a site where both adiabatic and diabatic mixing are likely to be especially important.

We focus on the SOFine observations of turbulent- and internal wave-scale flow properties, mapping the first-ever full-depth microstructure observations of the turbulent dissipation rate in the ACC, and considering the physical mechanisms that observations and theory suggest may underpin the distribution of turbulence observed. Our results provide observational confirmation of several of our expectations regarding the relationship between internal waves and turbulence in the Southern Ocean interior, but also pose important questions about some of the key processes at play. Specifically, turbulence is elevated in regions where internal wave energy is high, and spatial distributions are generally consistent with the expected dominant internal wave energy sources and evolution pathways in the region. However, the magnitude of the turbulent dissipation observed, specifically near the bottom, is surprisingly low relative to both the theoretical prediction for the lee wave energy flux and the anticipated dissipation rate due to wave-breaking.

The thought-provoking mismatches suggest the existence of an alternative fate to local dissipation for a significant fraction of the near-bottom internal wave energy, with important implications for the global map of energy dissipation, the dynamics of the overturning circulation, and our parameterizations of turbulent mixing processes. We evaluate the relevance of various candidates, and suggest that wave-mean flow interactions, specifically those associated with wave evolution into critical layers for upward-propagating lee waves, may be playing an order-one role.

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Session: Renewable energy (1)
Presenting Author: Jing Huang

Predicting a daily variability index of solar radiation from ERA-Interim reanalysis

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A critical factor hindering the uptake of solar power is its high medium-term variability (from hours to a few days). Such variability makes it difficult for power system operators to maintain power stability on the grid. Thus, it is important to quantify and predict solar variability. In this study, we have defined a so-called daily variability index (DVI) using the one minute solar irradiance field measurements provided by the Bureau of Meteorology. We have also obtained a model by statistically downscaling relevant meteorological variables of the publicly available ERA-Interim reanalysis data at a spatial resolution of 0.75° X 0.75° and a temporal resolution of 6 hours using random forest. The correlation coefficient between the DVI of the field data and that of the prediction produced by the model is over 0.7. In addition, we have explored the effects of relevant factors such as varying combinations of meteorological variables, seasonality, grid cover of the reanalysis data and training period on the general performance of the model.

Session: Renewable energy (1)
Presenting Author: Nicholas A. Engerer

Meteorological observations and collective rooftop photovoltaic power output in Canberra

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Solar photovoltaic (PV) systems have experienced rapid uptake in Australia over the past two years. Current figures suggest over 750k Australian homes have installed collective capacity of over 1.7GW. This accelerated deployment of solar PV systems necessitates more accurate forecasts of their collective power output in the near term. Since such forecasts are directly connected to meteorological phenomena, with the focus primarily on the evolution of cloud features, more intelligent interpretation of meteorological observations can greatly improve these forecasts. The meteorological events that drive the formation, movement and extent of cloud cover are fairly well understood. Cloud cover is reduced under synoptically quiescent, high-pressure ridges and more prevalent under low pressure troughs and surface fronts. In short, where there is adequate moisture and lift, conditions for cloud formation are move favorable. These zones are often associated with clear changes in pressure, temperature, wind speed and direction. They can also be detected via satellite and radar imaging. 226

This study will focus on an analysis of standardised weather observations, such as Mean Sea Level Pressure, surface temperature, wind speed and direction, and ceilometer measurements from the Bureau of Meteorology's weather station from the Canberra Airport (ID 070351). And compare these data against a collection of rooftop PV systems in Canberra. The primary aim of this study is to develop categorizations of likely cloud events based on these data sources, to add 'intelligence' to short term solar power forecast algorithms (e.g. such as those based on machine learning). 226

Current work and related figures can be viewed at: http://solarnick.info/ACT_Solar_Map

Session: Renewable energy (1)
Presenting Author: Paul Gregory

Testing the ability of the Bureau of Meteorology's Numerical Weather Prediction systems to support prediction of solar energy production

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The ability of the Australian Bureau of Meteorology's Numerical Weather Prediction (NWP) systems to predict solar exposure (or solar insolation) was tested, with the aim of predicting large-scale solar energy several days in advance. The Bureau's Limited Area Prediction System (LAPS) and Mesoscale Assimilation model (MALAPS) were examined for the 2008 Calendar year. Comparisons were made with estimates of solar exposure obtained from satellites for the whole Australian continent, as well as site-based exposure observations taken at eight locations across Australia. Monthly-averaged forecast solar exposure over Australia showed good agreement with satellite estimates, however the day-to-day exposure values showed some consistent biases. Differences in forecast solar exposure were attributed to incorrect representation of convective cloud in the tropics during summer, as well as clouds formed by orographic lifting over mountainous areas in south-eastern Australia. Comparison with site-based exposure observations was conducted on a daily and hourly basis. The site-based exposure measurements were consistent with the findings from the analysis against satellite data. Hourly analysis at selected sites confirmed that models predicted the solar exposure accurately through low-level clouds (e.g. Cumulus), provided that the forecast cloud coverage was accurate. The NWP models struggle to predict solar exposure through middle and high clouds formed by ice-crystals (e.g. Altocumulus). Sites located in central Australia showed that the monthly-averaged errors in daily solar exposure forecast by the NWP systems were within 5-10%, up to two days in advance. These errors increased to 20-30% in the tropics and coastal areas. Preliminary results using the new ACCESS model are also presented.

Session: Renewable energy (1)
Presenting Author: Armin Dehghan

Forecasting radiation for solar energy systems

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As solar energy will begin to make up more of our electricity mix, there is a greater need for more accurate forecasts of solar irradiance for solar thermal and photovoltaic systems. We investigate the effectiveness of The Air Pollution Model (TAPM) at various spatial resolutions to determine the optimal resolution for predictions of solar sites geographically dispersed across Australia. The correlation between solar irradiance fluctuations and weather systems has also been studied using hourly weather data including insolation and wind speed for different locations across Australia. The accuracy of TAPM has been verified against satellite-derived data and ground measurements (Provided by Bureau of Meteorology). The satellite-derived data contains hourly derived measurements at 5km spatial resolution. We also investigate weather patterns associated with the deviation of the model output from observations using synoptic maps. The study aims to provide to the energy community, forecasts that produce an optimum mix of resolution based forecasts matched to specific weather systems.

Session: Renewable energy (1)
Presenting Author: Robert Davy

Empirical modelling of sub-hourly variability in solar irradiance

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Knowledge of intermittency of solar power generation is required to assist with management of the electricity grid. In Australia and elsewhere, considerable research effort is being directed towards developing solar power forecasts based on meteorological models. However, their typical temporal resolution does not allow a proper representation of the variability on a sub-hourly time scale. In this work we develop statistical models to assess the meteorological factors that are related to high variability of solar irradiance at a sub-hourly time scale. We make use of solar irradiance measured at one minute intervals by the Bureau of Meteorology, as well as the operational ACCESS model. Preliminary results suggest that such models may help with forecasting periods of high solar power variability.

Session: Renewable energy (2)
Presenting Author: Robert Huva

Optimising the deployment of renewable energy infrastructure in Australia: Results utilising the ACCESS-A model

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The almost certain growth of Australia's energy use into the future requires further investment in new generation capacity. Traditional non-renewable energy sources (for instance, coal and gas) are coming under increasing pressure from government renewable energy targets, Australia's carbon pricing scheme and from public concern over the likely negative consequences for our environment of a continued reliance on fossil fuels. There is thus currently a need to investigate electricity production via non-carbon-intensive and renewable resources. The current study aims to undertake such an investigation of renewable resources for the Australian region. Using data from the Bureau of Meteorology's regional model–(ACCESS-A)–for the period 2010–2011, we have conducted a high-resolution optimisation of Australia's wind and solar resources using a Genetic Algorithm. Unlike simple gradient methods, a Genetic Algorithm is employed in the current study because of its ability to find solutions to complicated and non-linear optimisation problems. Under various scenarios the large-scale covariance of the wind and solar fields across Australia are tested via the strategic placement of resources and by comparing net output with electrical demand for the 2010–2011 period. Ultimately the current study will show how a large-scale energy system can benefit from taking into account the length-scales at which weather systems affect the Australian region.

Session: Renewable energy (2)
Presenting Author: Dr Merlinde Kay

Investigating synergies between solar and wind energy using satellite data and TAPM

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We are seeing greater proportions of renewable energy sources, such as solar and wind, being incorporated into the electricity mix. The implications of this are that the weather and climate now have an impact on the supply of our energy, not just the energy demand. A key challenge for the large-scale adoption of solar and wind power is the variable nature of the energy resource. Weather monitoring and forecasting has a key role in successfully managing the impact on both electricity demand and the output of solar and wind energy generation technologies, as well as in the optimal placement of these complimentary resources, in order to make them economically viable and reliable options.

We have conducted an analysis of the weather data at hourly intervals – solar insolation, wind speed and direction for selected sites across Australia, looking at daily and seasonal variability to identify weather pattern cycles. Solar site locations were chosen from an investigation of the spatial analysis from 10 years worth of hourly satellite derived global horizontal irradiance and direct normal irradiance from the Bureau of Meteorology (BoM). We can determine from this analysis the frequency of particular weather events and also their duration. From this data analysis we can also identify weather patterns that would correlate to periods of low and high power production. The Air Pollution Model (TAPM) was run to determine the wind power density at the selected solar sites to determine if there was the opportunity for synergistic placement between good solar sites and wind energy. We will present the outcomes from this analysis and show how TAPM performs at forecasting for synergistic deployment of renewable technologies.

Session: Renewable energy (2)
Presenting Author: Roger Dargaville

Analysing the impact of weather variability on recent declines in electricity demand in the Australian National Electricity Market

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Demand for electrical energy varies significantly with time of day and time of year, and especially with weather, with extreme hot weather events driving the maximum demand. Since 2007 average electricity demand in the Australian National Electricity Market (NEM) has been declining at around 2% per year, a rather unexpected trend given that demand had been increasing ever since records were kept up to that point. There are several potential drivers behind the decline, including the impact of the Global Financial Crisis, price elasticity due to increasing retail tariffs, improved energy efficiency through the Home Insulation Program, the increase in rooftop photovoltaic systems, and the apparently mild weather associated with La Nina conditions.

We have produced a simple model of electricity demand in the NEM using time of day and weather as the main drivers that simulates 95% of the observed variability. Using the model we can isolate the weather signal by applying the average weather to the model and remove that from the actual demand data. Results suggest that the weather in fact has modest impact on monthly or seasonally averaged demand, and that the weather variability tends to average out over longer periods. One trend that does persist is an increasing summertime demand in NSW due to increasing overnight minimum temperatures through the period in question. However this trend is against the observed total trend and suggests that the weather is in fact masking part of the observed trend rather than explaining it.

Session: Renewable energy (2)
Presenting Author: Melissa Hart

Developing Typical Meteorological Year (TMY) data sets for predicting future building energy consumption within a city

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Computer models are commonly used for estimating thermal loads and energy consumption in new construction and existing buildings. A key element in building energy simulation is access to detailed weather information that is representative of the local climate. Building energy simulations generally use Typical Meteorological Year (TMY) data files to represent outdoor weather conditions. A TMY is a set of hourly values of solar radiation and meteorological data determined from historical meteorological observations that is representative of the long term climate of a location. TMY data sets rely on meteorological inputs deemed "typical" from available historical observations. Although TMY data sets are periodically updated, they represent past climatic conditions and may not be representative of likely future climatic conditions. In addition it is common for just one TMY data file, usually calculated using data from the city's main meteorological observation site, to be used for all building energy simulations within a city, regardless of the location of the building. This practice disregards micrometeorological variability across a city that may have significant impacts on a building's energy needs.

This presentation will discuss our development of new TMY data files for different regions of the city of Hong Kong for both current and future climatic conditions. The development of these TMY data files allows for assessment of building energy consumption that incorporates micrometeorological variability within the city under climatic conditions predicted to occur during the life of the building. The ability to more accurately model energy consumption over the life of the building should facilitate adoption of more aggressive energy efficiency measures, and improve forecasting of future peak loads and generation capacity requirements.

Session: IMOS (1)
Presenting Author: Mark Baird

The southward transport of sub-mesoscale lenses of Bass Strait water in the centre of anti-cyclonic mesoscale eddies

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Dense shelf water from Bass Strait, southeast Australia, is presently understood to travel northward along the continental shelf, and disperse eastward into the Tasman Sea. Here we report the unexpected discovery by IMOS autonomous gliders of lenses of shelf water ~40 km in diameter and 200-300 m tall at depth in the center of three ~200 km diameter anti-cyclonic eddies. Reanalysis of 2420 vertical profiles off the continental slope in the western Tasman Sea since 1982 found only 3 distinct patches of Bass Strait Water (BSW), all with positive dynamic height anomalies indicative of anti-cyclones. Through a yet to be understood process, BSW separates from the continental slope and forms a mid-depth lens that aligns vertically with the larger anti-cylconic mesoscale eddy; and remains at the center of the eddy for 6+ months as it is advected 700 km southward. This pathway subducts shelf water into the ocean interior, and provides a link between mesoscale circulation and shelf water transport. The BSW that is captured in anti-cyclones advects south past the east coast of Tasmania, with some moving into the eastern Indian Ocean.

Session: IMOS (1)
Presenting Author: Helen Beggs

A study of diurnal warming in the tropical warm pool using sea surface temperature from multiple satellites

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Thermal stratification of the ocean surface layer is driven by net heat exchange between the ocean and atmosphere, turbulent mixing and absorption of insolation. Under most conditions there is net loss of heat from the ocean with the skin, or interfacial layer, being cooler than the water below. During the day, however, under calm winds and clear skies, a warm layer can develop in the top 5-10 m of the surface. Diurnal warm layers have typical temperature differences relative to the body of water below on the order of 0.5-3 K, but in some cases can reach values up to 7-8 K. The Tropical Warm Pool (TWP), located in the western Pacific and eastern Indian Oceans, exhibits widespread occurrences of diurnal warming events of the sea surface temperature (SST), with some extreme events exceeding 5 K over small spatial/time scales. It was therefore considered to be an ideal region for a coordinated study of diurnal warming observations and models, particularly with recent availability of accurate, hourly SST observations from the MTSAT-1R satellite, available through the Integrated Marine Observing System (IMOS).

A comprehensive dataset, the TWP+, has been compiled by the Bureau of Meteorology in collaboration with the Group for High Resolution SST (GHRSST), IMOS, Météo-France, University of Edinburgh and Remote Sensing Systems. The data set comprises SST observations from buoys, ships and eight satellites, and high-resolution model forecasts of ocean/atmospheric parameters at the ocean surface over the region 25oS to 15oN, 90oE to 170oE for the periods 1 January to 30 April 2009 and 1 January to 30 April 2010. The data are used to quantify diurnal warming events and test diurnal variation models as part of the GHRSST Tropical Warm Pool Diurnal Variability (TWP+) Project (https://www.ghrsst.org/ghrsst-science/science-team-groups/dv-wg/twp/). The paper will describe the TWP+ Project and data set, report on validation of the SST data (including IMOS data streams) from the MTSAT-1R, NOAA-17, NOAA-18, NOAA-19, METOP-A, Aqua, Coriolis and EnviSat satellites and their use to quantify the amplitude, frequency and spatial coverage of diurnal warming events over the TWP+ domain.

Session: IMOS (1)
Presenting Author: Jennifer Penton

The effects of wind forcing on surface currents on the continental shelf surrounding Rottnest Island

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Surface currents play a major role in the distribution of contaminants, the connectivity of marine populations, and can influence the vertical and horizontal distribution of nutrients within the water column. This paper aims to determine the effects of sea breeze-wind patterns on the climatology of the surface currents on the continental shelf surrounding Rottnest Island, WA Australia. The alternating wind patterns allow for full cyclic rotations of wind direction, permitting the interpretation of the effect of the wind on the surface currents. It was found that the surface currents only clearly follow the northbound Capes Current in times when the Fremantle Doctor in. Surface currents react within an hour to a change of direction of the wind, allowing southerly currents to dominate during strong northerly sea breezes, often followed by mixed currents dominated by eddies in the inter-lying times.

Session: IMOS (1)
Presenting Author: Amandine Schaeffer

Understanding the complex roles of alongshore current and wind forcing in driving upwelling in the East Australian Current.

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The cross-shelf dynamics upstream (Coffs Harbour) and downstream (Sydney) of the separation of the East Australian Current are studied using 2 years of high resolution velocity and temperature measurements from NSW-IMOS mooring arrays. The shelf circulation is dominated by the East Australian Current (EAC) and its eddy field, with mean poleward depth-integrated magnitudes of 0.35m/s and 0.15m/s on the shelf break upstream and downstream of the separation point respectively.

The high cross-shelf variability is analysed though a momentum budget, showing a dominant geostrophic balance at both locations. Amongst the secondary terms at the mid-shelf, the bottom stress influence is higher off Coffs Harbour where the alongshelf currents are strong, while the wind stress is dominant off Sydney.

The cross-shelf structure in response to a dominant along-shelf wind stress forcing is a classic 2-layer Ekman structure despite the deep water (up to 140m). During weak winds, the shelf encroachment of the southward current (EAC) drives an onshore Ekman flow in the bottom boundary layer. Both the bottom velocity and the resultant bottom cross-shelf temperature gradient are proportional to the magnitude of the encroaching current, with similar linear regressions both upstream and downstream of the Western Boundary Current separation. The upwelled water is then subducted below the EAC upstream of the separation point. Such current-driven upwelling is the dominant driver of cold water uplift in the EAC dominated region. The significant impact on nutrient enrichment and thus on biological productivity is evidenced by Glider observations.

Session: IMOS (1)
Presenting Author: Mal Heron

Turbulent mixing mapped in shallow water using HF and VHF ocean radar

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When the water speed reaches a critical speed in shallow water, the water column becomes intrinsically unstable with turbulent kinetic energy dominating over density stratification. Simpson and Hunter (1974) showed that the critical condition depends on water speed and depth, with underlying assumptions about bottom roughness and density gradients. Di Massa et al. (2010) have calibrated this relationship on the continental shelf in the southern section of the Great Barrier Reef lagoon by using HF ocean radar to measure surface currents, and moored ADCPs and thermistors to measure vertical profiles. (These data were obtained through the IMOS archive.) They showed that the critical relationship between water speed and depth needs to be calibrated for each level of benthic roughness. By extrapolating the roughness calibration over the whole map of surface current produced by the HF ocean radar it is possible to map the areas, in the lagoon, where the critical condition is reached and the column becomes fully mixed on ebb and flood phases of the tide. This phenomenon of dynamical mixing provides a lower limit to the likelihood of coral bleaching because, during these events, warm surface water produced by insolation is mixed down into the column rather than forming a stable layer near the surface. This mapping procedure is a powerful management tool for zoning and managing marine protected areas (Di Massa et al. 2011). The same principles are applied to channel flow in locations where turbines might be deployed. It is shown that the criteria for full mixing of the column are likely to be reached at water speeds less than the start-up speed for the turbines. This means than VHF ocean radar measurements of the surface currents are an appropriate monitoring technology for turbine fields.

References:

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Simpson, J.H. and J.R. Hunter, Nature, 250, 404-406, 1974

Session: NWP (1)
Presenting Author: Kamal Puri

The Australian Community Climate and Earth System Simulator, ACCESS: Current status and future plans

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The Australian Community Climate and Earth System Simulator (ACCESS) is a coupled climate and earth system simulator being developed as jointly by the Bureau of Meteorology and CSIRO in cooperation with the university community in Australia. A key aim of ACCESS is to develop a system that enables a national approach to climate and weather prediction that will provide a core capability underpinning Australia's weather and climate services and to conduct the best possible science for use in analysing climate impacts and adaptation. ACCESS will also enable Australian scientists to contribute to major international model intercomparison projects and provide opportunities for scientists to share knowledge, form collaborations and initiate new projects. Planning for ACCESS development commenced in 2005 and significant progress has been made subsequently, namely:

operational implementation of the ACCESS NWP system including assimilation of significantly increased number of satellite sounders. Implementation has been marked by a significantly increased skill relative to the previous operational systems, and the system performance is now similar to other major operational Centres;

successful assembly of fully coupled ACCESS and detailed testing of the coupled system. Subsequently the core CMIP5 simulations have been completed and model output data has been published on the Earth System Grid and will form part of the Australian contribution to CMIP5 and the IPCC Fifth Assessment. Preliminary evaluation shows encouraging performance of the system;

development and routine running of a prototype ensemble prediction system;

development of a high resolution (1.5km) version that includes radar data assimilation for severe weather prediction;

progress in the development of ACCESS infrastructure.

The presentation will provide a description of the NWP and the coupled system used for the CMIP5 simulations, key results from detailed evaluation of the systems, and plans for future development.

Session: NWP (1)
Presenting Author: Michael Naughton

ACCESS Global and Regional Ensemble Prediction System

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AGREPS is the ACCESS version of the UK Met Office operational MOGREPS global and regional ensemble prediction system. This first system has been running routinely in research mode for the last two years, based on the operational APS0 ACCESS-G and ACCESS-R global and regional numerical weather prediction systems. This system runs 24 ensemble members at N144 L50 (i.e. 80 km horizontal grid spacing) global resolution and 0.375 deg (40 km) Australian region resolution for 5 and 3 days respectively; i.e. these ensembles run at the same resolution as the deterministic forecast systems. An upgraded system based on the APS1 systems has been running for the last year, at N216 L70 (60 km) global, 24 km regional resolutions, and including model perturbations as well as initial conditions perturbations. The AGREPS system will be described, and results will be presented.

Session: NWP (1)
Presenting Author: Annette L. Hirsch

Impact of realistic land surface initialization on sub-seasonal forecast skill: Preliminary results from WRF-LIS-CABLE GLACE-2 experiments

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The second phase of the Global Land Atmosphere Coupling Experiment (GLACE~2) aims to establish the sensitivity of forecast skill to realistic land surface initialization. The experimental design (Koster et al. 2010) used sub-seasonal forecast ensembles for 10 Boreal summers over the period 1986-95. Boreal summer was simulated due to enhanced land-atmosphere interactions in summer, when the soil moisture limitation on evaporation is generally greatest. Further the Northern Hemisphere has a much greater land mass. However, the results have limited application for the Southern Hemisphere, as the Boreal summer corresponds to the Austral winter.

We repeat the GLACE~2 experiment for South-East Australia for the Austral summer. The newly coupled WRF-LIS-CABLE model, developed through collaboration between the ARC Centre of Excellence for Climate System Science and NASA GSFC is used. We will demonstrate the dependence of forecast skill on realistic land surface initialization. We discuss the results from two series of 10-member ensemble forecasts for 10 start dates over the 1986-95, where realistic land surface initialization is only implemented in one series.

Our results aim to demonstrate the importance of realistic land surface initialization for forecast skill over South-East Australia, particularly for the prediction of maximum temperature. We also show whether the impact of the initialization depends on the forecast lead-time. The analysis is extended to distinguish between wet and dry soil initialization to further our understanding of how the forecast skill correlates with the land surface characteristics.

Reference:

Koster et al. (2010) Contribution of land surface initialization to subseasonal forecast skill: First results from a multi-model experiment. Geophys. Res. Lett. 37(2):L02402, 10.1029/2009GL041677

Session: NWP (1)
Presenting Author: Georg Gottwald

Controlling balance in ensemble data assimilation

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We consider the problem of an ensemble Kalman filter when only partial observations are available. For small ensemble sizes standard ensemble data assimilation leads to unbalanced analyses. We show that by incorporating climatic information of the unobserved variables the unbalance can be controlled and superior analysis skill is obtained.

Session: NWP (1)
Presenting Author: Christian Werner

Severe weather forecasting using 4D RADAR data assimilation and NWP modelling to mitigate exposure to hail-storm damage for the Australian region

Michelle Cox [1], Russell Standish [2], Daas Jabbour [1] and Christian Werner* [1]
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Severe hail-storms cost millions of dollars in damage to cars and other insured property in Australia, especially when a storm passes over a capital city. The Weather Risk Management Services Severe Weather Forecasting System (WRMS-SWFS) is helping to mitigate the exposure of industry to hail-storm events. In order to improve the forecast of severe weather, WRMS are routinely incorporating information from the Australian RADAR network into their operational Numerical Weather Prediction (NWP) model. This is the first time that RADAR data has being assimilated into an NWP model for the Australian region. Volumetric RADAR data from the Bureau of Meteorology including reflectivity and radial velocity are assimilated into the existing WRMS NWP model using Four-Dimensional Variational Data Assimilation methods. The reflectivity data in particular provide improved initial conditions for the microphysical component of the forecast model. Educated users receive several daily probabilistic weather forecasts per day on the likelihood of severe weather events occurring. A case study of an improved severe forecast of the Melbourne Christmas Hail-Storm (2011) will be given, using hindcast RADAR data assimilated into the new WRMS-SWFS.

Session: NWP (2)
Presenting Author: Peter Steinle

What could a Mesoscale NWP system deliver for Australia?

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The Australian Bureau of Meteorology recently initiated a project to enable the use of radar data within numerical weather prediction (NWP). The aim is to develop an NWP system capable of bridging the gap between purely observation based precipitation nowcasting and existing regional scale NWP systems. The system is being developed as part of the broader modelling effort of the Australian Community Climate and Earth System Simulator (ACCESS). The NWP component of ACCESS is in turn based on the UK Met Office Unified Modelling and variational assimilation system – specifically the 1.5km UKV system (Dixon et al. 2009). Extensive trials of a modified version of the UKV have been carried out since September 2011, as well as for specific periods covering significant events. Despite the differences in observation networks and weather conditions between Australian and the UK the system is providing useful guidance – far superior to existing global and regional NWP systems. This presentation will discuss some of the benefits that such a truly mesoscale NWP system could provide in the Australian context, relative to existing operational systems. This work has relied heavily on the support from across the Earth System Modelling and Weather and Environmental Prediction programs of CAWCR as well as the UK Met Office.

References:

Dixon, M. et al. 2009. Monthly Weather Review 137 pp. 1562-1584.

Session: NWP (2)
Presenting Author: Susan Rennie

Doppler radar assimilation in high-resolution NWP

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Doppler radar provides frequent high-resolution observations of radial velocity in the lower atmosphere. Radial velocities from precipitation radar echoes are used to estimate wind velocities. These observations can be used for data assimilation to improve the initial conditions of high-resolution numerical weather prediction (NWP) models. We are developing the Bureau of Meteorology's high-resolution ACCESS-City models to better use these radar observations. The assimilation of radial velocity is being trialled for the Sydney area, which contains several Doppler radars as well as many other observations such as those from Automatic Weather Stations to provide validation. The initial ACCESS-Sydney system has hourly 3D-Var assimilation and uses radar observations at several times near the assimilation time. Since radial velocity information is only available when there is a signal returned from suitable radar targets, observation availability may be limited and variable. Quality control development for radar observations has been directed towards discriminating echo from the preferred target type, e.g. only precipitation. Echoes from insects might also be used to provide wind estimates. With suitable quality control, we can extract and independently assimilate radial velocity from precipitation and insects. Extended assimilation and forecast tests provide information about the impact on the forecast, and also can be used to estimate the error of the radar observations.

Session: NWP (2)
Presenting Author: Lawrie Rikus

Using synthetic satellite imagery to assess numerical weather prediction

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Currently synthetic satellite imagery is routinely produced for all of the Bureau of Meteorology's operational NWP forecasts (http://cawcr.gov.au/staff/ljr/projects/forcloops.htm). This imagery is useful because it integrates a significant amount of information about the atmospheric state in single images and is readily comparable with the real imagery from geostationary satellites. It uses the real time model fields in combination with a radiative transfer code comparable to the model's radiation scheme. Hence discrepancies between the real and synthetic imagery can point to problems in the model, not just in positions of synoptic features but also cloud properties and its interaction with radiation. It also provides operational weather forecasters, trained to assess synoptic situations using satellite imagery, with a readily accessible assessment of the current model forecasts. The evaluation of model forecasts using synthetic imagery has some limitations. The effective model resolution is much coarser that the real satellite imagery. The model fields are convolutions of model cloud microphysical properties, spatial distribution and optical properties so that quantitative assessment of the model's parameterization schemes requires an unravelling process, although this can be simplified by using more satellite channels. For some specific channels basic assumptions in the model parameterization schemes can preclude the representation of some features, e.g. fixed droplet/crystal sizes will cause the model imagery to miss effects due to very small or very large sizes. In the past the synthetic satellite imagery has been used to qualitatively assess cloud positions and structures in tropical cyclone and mesoscale NWP forecasts, e.g. the cloud structures in forecast loops of ACCESS-TC simulations for Lua and Yasi show a remarkable correspondence with the real MTSAT imagery. Currently the model imagery is being used to quantitatively assess differences in the representation of cloud in the previous and current versions of the ACCESS NWP models.

Session: NWP (2)
Presenting Author: John Le Marshall

Earth Observation from Space - Significant Recent Advances

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In this decade, there has been a five order of magnitude increase in the volume of data available from Earth Observations from Space for the operational and research weather, ocean and climate communities. These data exhibit accuracies and spatial, spectral and temporal resolutions never before achieved. Here are described some key benefits to Australia from these Earth Observations across our region and the southern hemisphere. Many of the benefits described are in the atmospheric, oceanographic or climate area and relate to operational and research meteorology and oceanography or climate studies. The advanced instruments providing these benefits include the Atmospheric Infrared Sounder (AIRS), those carried by the COSMIC Constellation and the MTSAT imager. Examples of the beneficial impact of these data over the Australian region and in the southern hemisphere will be provided. Many of these examples are Observing System Experiments (OSEs), based on the application of these data in the current operational forecast suite used by the Australian Bureau of Meteorology. It is observed in an era where populations are increasing in areas subjected to severe weather and in a time when extreme weather events remain a considerable problem, it can be shown for example that over the southern hemisphere, earth observations from space can extend the life of a high quality numerical forecast by a factor of four and that the incremental improvement due to earth observations from space on southern hemisphere numerical forecasts can be ten times the incremental improvement due to earth observations from space on northern hemisphere numerical forecasts. The examples shown in this study underline the great importance and benefit of Earth Observations from Space for those in the southern hemisphere.

Session: NWP (2)
Presenting Author: Vinod Kumar

4D-Var Assimilation of SSMIS Radiances in ACCESS

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The Special Sensor Microwave Imager Sounder (SSMIS) is the most complex operational satellite passive microwave imager/sounder currently flying. It offers capabilities such as common fields of view, uniform polarizations, and fixed spatial resolutions across the active scene scan sector; and can collect temperature measurements up to 80 km altitude. This study represents a first step toward assimilating direct clear and cloudy radiances from SSMIS in the Bureau of Meteorology's operational ACCESS NWP suites; which could potentially improve the initial model states, especially for extreme weather events like tropical cyclones.

As the initial step, this study undertakes a thorough examination of the quality of the SSMIS data and the biases associated with observed brightness temperature and model forecast (background). This monitoring of radiance data is done by continuous comparison of observed radiances against the simulated data. Two global numerical experiments, composed of "control" and "trial" runs, will be conducted to investigate the impact of these monitored radiance observations on analysis and forecasts from the ACCESS NWP suite. "Control" experiment is the operational run which assimilates multiple conventional and remote observations (Puri et al. 2012); while "trial" run includes the SSMIS radiances in addition to the aforementioned operationally assimilated observations.

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POSTER PRESENTATIONS

Session: 01. General Atmosphere - global and synoptic scale
Presenting Author: Shane Bilish

A global experiment to improve observations of snow: the World Meteorological Organization Solid Precipitation Intercomparison Experiment (WMO-SPICE)

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The measurement of solid precipitation has been the subject of extensive investigations, including international collaborative studies. These investigations have focused primarily on manual measurement methods and have revealed significant challenges in the measurement of snowfall and snow on the ground. Since these studies were conducted, an increasing percentage of precipitation and snow depth measurements around the world have been obtained using a broad range of automatic instruments, many operated unattended for extensive periods of time. At the same time, new non-catchment type instruments and systems have been introduced for the measurement of solid precipitation.

In the context of the transition from manual methods to automatic instruments and with the introduction of new technologies in measurement networks worldwide, there is an acute need for an internationally-coordinated study to understand and characterise the errors in precipitation measurement of in-situ automatic instruments, and their capabilities for measuring solid precipitation.

WMO-SPICE has been initiated to focus on the performance of modern automatic instruments measuring solid precipitation and snow depth. In this regard, the key goals are to investigate and report on the measurement of precipitation amount as a function of precipitation type (liquid, solid, mixed), and of snow on the ground (i.e. snow depth). An important outcome will be to develop correction methods and adjustments for measurements from the various automatic

gauge and wind shield combinations used in different countries, to enable the provision of better estimates of regional snowfall. WMO-SPICE will begin in November 2012 and will last for two to three winter seasons.

Australia and New Zealand are contributing to WMO-SPICE through the participation of weather stations at Guthega Dam in the Snowy Mountains of New South Wales and Mueller Hut in the Southern Alps. This will broaden the scope of climatic regimes and snow conditions considered in the experiment and allow the findings to be incorporated back into operational programmes in these countries.

This paper will present the organisation of the experiment, an overview of the participating sites and the instruments selected for inclusion in the intercomparison.

Session: 01. General Atmosphere - global and synoptic scale
Presenting Author: Robert Colman

Making sense of sensitivity: understanding how global climate feedbacks differ across timescales

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The strength of large scale atmospheric feedbacks (in particular those due to water vapour, clouds, lapse rate and surface albedo) determine the climate 'sensitivity' – the magnitude of the global response to greenhouse gas forcing. Quantifying, understanding and evaluating climate change feedbacks remains critical tasks for quantifying projection uncertainty, assessing confidence in models and narrowing the range of future projections.

Recent research has begun to reveal that global scale radiative feedbacks operate at a broad range of timescales. Indeed, feedbacks act to amplify temperature variations across all timescales from seasonal to decadal, although models strongly disagree on the strength of these feedbacks. What can the strength and structure of these feedbacks tell us about climate change feedbacks?

This study addresses this issue by examining the strength and structure of climate feedbacks in CMIP3 and CMIP5 models. Implications for both the understanding and evaluation of climate change feedbacks from shorter timescale variability and response will be discussed.

Session: 01. General Atmosphere - global and synoptic scale
Presenting Author: Bronwyn Dolman

Wind profiler observations of a high frequency boundary layer wave at Ceduna – Part 1 investigation

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The Australian Government Bureau of Meteorology is in the process of installing a new network of nine wind profiling radars. The new network is comprised of five 7.5 kW Boundary Layer Profilers (BLP), sampling from 300 m to 8 km, and four 80 kW Stratospheric Tropospheric Profilers (STP) sampling from 500 m to 18 km. The BLPs utilise the Spaced Antenna (SA) Full Correlation Analysis (FCA) technique to measure horizontal and vertical winds in low and high modes, with a temporal resolution of two minutes. The STPs utilise a 3-beam Doppler Beam Swinging (DBS) technique to measure horizontal and vertical winds in low and high modes, with a temporal resolution of six minutes. Data from both profiler types are quality controlled and averaged to 30 minute intervals.

The first profiler in the new network was a BLP, installed at Ceduna, South Australia. The profiler has been operational since August 2011, and reports WMO standard BUFR messages to regional forecasters every 30 minutes. During the 2011/12 summer, the profiler experienced more than 40 events of up to six hours of data dropout. These events were always accompanied by a characteristic high signal to noise ratio, implying data should be available. Investigations revealed an oscillatory trend/wave structure in both the horizontal and vertical wind components, which was subsequently rejected by the quality control measures across the averaging period. This means the profiler is measuring winds as it should, but the averaged wind value is not accepted because the associated variance is outside the limits intended to detect unreliable data. These data dropout events varied in both height coverage and time duration, but were predictable in other regards.

Examples of the wave events will be presented, including discussion on the profiler operation, quality control measures, and investigations into the nature and cause of the wave.

Session: 01. General Atmosphere - global and synoptic scale
Presenting Author: Alison Cook

Wind profiler observations of a high frequency boundary layer wave at Ceduna – Part 2 meteorological implications

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The Australian Government Bureau of Meteorology is in the process of installing a new network of nine wind profiling radars. The new network compliments the existing network of four boundary layer profilers, and will be completed in 2014. The new network employs two different profiler systems, Boundary Layer Profilers (BLPs) measuring winds from 300 m to 8 km, and Stratospheric Tropospheric Profilers (STPs) measuring winds from 500 m to 20 km. Both profiler types average winds to 30 minute intervals, and report WMO standard BUFR messages to regional forecasters.

The first profiler in the new network was a BLP, installed at Ceduna, South Australia, in June 2011. During the 2011/12 summer, the profiler experienced more than 40 events of up to six hours of data dropout. These events were always accompanied by a characteristic high signal to noise ratio (SNR), implying data should be available. Investigations revealed an oscillatory trend/wave structure in both the horizontal and vertical wind components, which was subsequently rejected by the quality control measures across the averaging period. These data dropout events varied in both height coverage and time duration, but were predictable in other regards. As mentioned, it was accompanied by a characteristic SNR signature. It also began near 0900 UTC, was generally associated with the formation and deepening of the convective boundary layer, and generally occurred when conditions were warm, dry and pre-frontal with a high to the east of Australia.

Details of the data dropouts will be presented, particularly focused on the predictability of the synoptic conditions surrounding the event. Further discussion will include data dropout implications for weather forecasting, fire forecasting and numerical weather prediction, combined with a more general discussion on profiler use in routine weather forecasting.

Session: 01. General Atmosphere - global and synoptic scale
Presenting Author: Ian Galbally

The distribution and long term trends in ozone in the Southern Hemisphere extra-tropical boundary layer and free troposphere

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Tropospheric ozone is a greenhouse gas, ranked third in anthropogenic radiative forcing after CO_2 and CH_4. Ozone in the troposphere makes up an important fraction of the atmospheric shield against ultraviolet radiation particularly when stratospheric ozone depletion events occur and tropospheric ozone drives tropospheric chemistry being the major precursor of the OH radical which is the sink for gases such as methane. In the boundary layer increases in background ozone have other impacts through urban and regional photochemical smog on human health, crop productivity and the sequestration of carbon into the biosphere. There are few long-term monitoring stations and few process studies of tropospheric ozone in the Southern Hemisphere. In an international collaboration, analyses are presented of two decades of observations from 7 background surface ozone stations spanning 34°S to 90°S and 4 long-term ozonesonde stations spanning 38°S to 69°S. Special consideration is taken to consider only those parts of the ozone record that are free of local influences of ozone production and destruction. Halogen based ozone destruction and local ozone production are evident in lower tropospheric air at some Antarctic stations. The ozone distribution measurements reflect a NOx depleted environment where there is net ozone loss at most oceanic boundary layer and free troposphere locations. There is little destruction of ozone at the water and snow surfaces. The seasonal signature of stratospheric-tropospheric exchange is evident in the ozone record in upper troposphere in mid-latitudes but not polar regions. There has been a growth in ozone abundance in the lower troposphere over the last two decades, this growth is stronger over Antarctica compared with mid-latitudes, and regional differences are evident. As well, there is inter-annual variability that appears to be correlated over long distances. Possible drivers of both the growth and interannual variability will be discussed.

Session: 01. General Atmosphere - global and synoptic scale
Presenting Author: Shannon Mason

Characteristing the thermodynamics and microphysics of mid-topped cloud regimes in the Southern Ocean

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Accurately representing clouds and their radiative properties poses an ongoing challenge in improving the global energy budget in climate models, which exhibit significant biases in shortwave radiative flux over the southern hemisphere mid-latitudes (Trenberth and Fasullo, 2010). This excess of absorbed shortwave radiation is spatially related to a prevalence of two cloud regimes identified from passive satellite observations as 'mid-topped', and which active satellite retrievals suggest are multi-layered clouds with a significant low-cloud portion (Haynes et al. 2011). In order to set the scene for a better evaluation of the representation of these clouds in climate models, this study aims to characterise the thermodynamical conditions and microphysical structure of the two 'mid-topped' cloud regimes in greater detail. The study is based on eight southern hemisphere mid-latitudes cloud regimes identified from International Satellite Cloud Climatology Project (ISCCP) data by Haynes et al. (2011). Here, the thermodynamical context of the cloud regimes is derived from profiles of atmospheric conditions from European Centre for Mid-Range Weather Forecasts (ECMWF) Re-Analysis (ERA-Interim) data, and microphysical data are obtained from the combined retrievals of CloudSat and Cloud-Atmosphere Lidar and Infrared Pathfinder Observations (CALIPSO) satellites (Delanoe et al. 2010). Preliminary results show the two regimes implied in the model error behaviour occur under distinct meteorological conditions: the optically thin mid-topped cloud regime is characterised by cool, sinking air and a high, weak temperature inversion, with significant ice water content; the optically thicker mid- topped cloud regime is related to weak convection and stronger wind shear, which may be related to cold air advection over the Southern Ocean.

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Trenberth, K. E. and Fasullo, J. T., 2010. Simulation of Present-Day and Twenty-First-Century Energy Budgets of the Southern Oceans. Journal of Climate, 23, 440–454, doi: 10.1175/2009JCLI3152.1.

Haynes, J. M., Jakob, C., Rossow, W. B., Tselioudis, G. and Brown, J., 2011. Major Characteristics of Southern Ocean Cloud Regimes and Their Effects on the Energy Budget. Journal of Climate, 24, 5061–5080, doi: 10.1175/2011JCLI4052.1.

Session: 01. General Atmosphere - global and synoptic scale
Presenting Author: Luke Osburn

Contrasting a high density spatial precipitation product with supercooled liquid water and synoptic type over the Snowy Mountains

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High rates of supercooled liquid water (SLW) have been observed by both MODIS and CALIPSO, over the Southern Ocean (Hu et al, 2010 and Morrison et al, 2011), additionally large quantities of SLW also occur over the Great Dividing Range which includes the highest point in Australia. Such observations occur usually during frontal passages associated with cut-off lows and embedded lows which develop out of Rossby waves over the Southern Ocean.

Storms transiting over the Snowy Mountains are typically very pristine, containing large quantities of supercooled liquid water and have low quantities of ice condensation nuclei (ICN). Using two ground based radiometers installed on high points along the range the quantity and temporal resolution of the SLW has been studied. Preliminary analysis suggests that more SLW is likely to be associated with embedded lows than cut-off lows.

Additionally a dense network of precipitation gauges has been installed over the mountain range in an area roughly 85 by 110km, in order to determine the highly variable precipitation rates expected over such varying topography. A gridded precipitation product has been developed and the quantity and spatial pattern of the precipitation is compared both to the different synoptic types and as well with the temporal resolution of SLW.

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Morrison, A. E., S. T. Siems, and M. J. Manton (2011), A three year climatology of cloud-top phase over the Southern Ocean and North Pacific, J. Clim., 24, 2405–2418, doi:10.1175/2010JCLI3842.1.

Session: 01. General Atmosphere - global and synoptic scale
Presenting Author: Andrew Prata

An objective analysis of volcanic cloud Height and Thickness for Puyehue-Cordón Caulle using satellite data

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An objective analysis of the height and thickness of volcanic ash clouds produced during the eruption of Puyehue-Cordón Caulle (PCC) from June 15–22, 2011 is presented. The PCC eruption highlighted the importance of understanding ash dispersion in the atmosphere as it affected global air traffic while circumnavigating the Southern Hemisphere. As volcanic ash is hazardous to aviation it is important that these phenomena are analysed quantitatively and the evolution of ash particulates in the atmosphere is well understood. In this study, volcanic clouds are identified using an infrared brightness temperature differencing technique from measurements taken by the Atmospheric InfraRed Sounder (AIRS) onboard NASA's Aqua satellite. Once volcanic clouds are identified, heights and thicknesses are derived from the total attenuated backscatter product which comes from measurements taken by the Cloud-Aerosol Lidar with Orthogonal Polarisition (CALIOP) instrument, onboard NASA's CALIPSO satellite. As these two instruments are part of the same constellation of satellites (the A-train), many coincident retrievals are possible. A simple algorithm written in the Interactive Data Language (IDL) is used to determine cloud height and thickness from CALIOP 532 nm backscatter profiles. From the period 15–22 June an average height of 11.95 km ± 0.62 km and an average thickness of 0.67 km ± 0.05 km were found for volcanic clouds detected in CALIOP profiles. This quantitative analysis enabled the use of the geographic location of heights to validate dispersion model runs from the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model.

When an input of 12 km for initial plume height was used, the dispersion model results best fit the observations. Furthermore, assessment of the volcanic cloud evolution based on height and distance from the volcano revealed evidence of descending volcanic clouds on 15,16 June and observations of ascending volcanic clouds between 16–22 June. These results have allowed new insight into volcanic cloud evolution and the dynamical effects of the atmosphere.

Session: 01. General Atmosphere - global and synoptic scale
Presenting Author: Lawrie Rikus

The behavior of westerly jets in global reanalyses

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An objective image processing-like algorithm has been used to characterise the properties of closed contours (blobs) in monthly mean zonal mean zonal wind (U) fields from eight global reanalysis data sets with the aim of identifying robust properties which can be used in model evaluation metrics. The blobs fall naturally into clusters in the latitude-pressure plane which can be equated to the well-known westerly jet streams; the two polar night stratospheric jets, two tropospheric jets which are combinations of the subtropical and polar front jets as well as a cluster of stratospheric tropical blobs. A description of an early version of the algorithm and an example of the clustering for the Merra reanalysis can be seen in Rikus et al 2012. The time series of a number of blob properties for each reanalysis are compared for each of the different jet streams. While the results show some variations which may be due to the vertical structure of the data, for the tropospheric jets at least, there is a strong consensus. All jet properties are dominated by robust seasonal cycles with much smaller year-to-year variations. Although there are some strong correlations with major climate indices much of this variation is still to be explained. A principal component analysis also identifies some events which may be attributable to changes in the different reanalysis systems at different times. Overall the results suggest a number of useful model evaluation metrics can be defined.

Reference:

Rikus, L., G. Dietachmayer and T. Elliott, 2012: Characterising westerly jets as objects. CAWCR Research Letters, Issue 8, P. A. Sandery, T. Leeuwenburg, G. Wang, and K. A. Day, Eds.

Session: 01. General Atmosphere - global and synoptic scale
Presenting Author: James Risbey

Climatology and characteristics of cutoff lows in the Southern Hemisphere

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Cutoff low systems provide much of the rainfall in portions of the Southern Hemisphere continents. Establishing a reliable climatology of these systems is necessary to quantify and understand their role in this regard. This work describes a system for classifying cutoff lows in the Southern Hemisphere which differentiates them from warm cored lows in the tropics and lows in the circumpolar trough. The climatology and characteristics of Southern Hemisphere cutoffs are presented and contrasted with previous studies. Verification against cutoff climatologies for the Australian region places changes in cutoff characteristics in this region in hemispheric context with broader circulation changes. This provides the basis for an assessment of trends in cutoff systems and their rainfall contributions to climate variability and change in the Southern Hemisphere continents.

Session: 01. General Atmosphere - global and synoptic scale
Presenting Author: Steven Siems

An analysis of the low-elevation clouds over the Southern Ocean with A-Train observations

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Trenberth and Fasullo (2010) found that "disproportionately large biases exist in both the reanalysis and global coupled models" over the Southern Ocean (SO) which are "directly linked to the simulation of clouds in this region." Moreover they find a "remarkably strong relationship between the projected changes in clouds/climate and the simulated current-day cloud error."

In this study, a climatology of the thermodynamic phase of the clouds over the SO (40–65°S, 100–160°E) has been constructed with the A-Train merged product DARDAR-MASK for 2006–2009 during winter (Jun–Aug) and summer (Dec–Feb). Low-elevation clouds (cloud-tops below 1km) with very little seasonal cycle dominate this climatology. Such clouds are problematic for the DARDAR-MASK as the Cloud Profiling Radar (CPR) on CloudSat is unable to distinguish returns from the lowest four bins (up to 720–960m), and the CALIOP lidar on CALIPSO may suffer from heavy extinction. The CPR is further limited for these clouds as they are predominantly in the temperature range from freezing to –20° C, where the CPR cannot directly assess the thermodynamic phase.

A cloud-top phase climatology comparison has been made between CALIPSO, the DARDAR-MASK and MODIS. All products highlight the prevalence of supercooled liquid water over the SO, particularly during summer. The DARDAR-MASK recorded substantially more ice at cloud-top as well as mixed phase in the low-elevation cloud tops. It was further observed that the lidar signal from CALIPSO was sensitive to the overlying cirrus, and this effect filtered through to the DARDAR-MASK. Moving beyond the cloud-top, the DARDAR-MASK finds ice to be dominant at heights greater than 1km. Below this height, the uncertain class is dominant as there is no CPR signal and the lidar signal is commonly attenuated.

This study further highlights the enormous challenge that remains in better defining the energy and water budget over the SO.

Reference:

Trenberth, K. E. and Fasullo, J. T., 2010. Simulation of Present-Day and Twenty-First-Century Energy Budgets of the Southern Oceans. Journal of Climate, 23, 440–454, doi: 10.1175/2009JCLI3152.1.

Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Thomas Chubb

Does aerosol pollution of orographic clouds result in precipitation suppression in the Australian Snowy Mountains?

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There is ample evidence that pollution from biomass burning, agriculture and industry have the capacity to modify local and regional weather conditions. A claim to such an effect is that "...air pollution must be an important factor in determining precipitation amounts in the [Australian] Snowy Mountains" (Rosenfeld, 2000). This claim is made with reference to aerosol pollution sources that are quite remote from the region, based on satellite observations of cloud droplet effective radius without consideration of surface precipitation measurements, and unsurprisingly has sparked a degree of controversy.

A novel method is proposed to directly evaluate this hypothesis. A modern network of carefully quality-controlled precipitation gauges and satellite (MODIS) observations of cloud top effective radius (re) are used to investigate the link between remotely-sensed cloud microphysical characteristics and surface precipitation. Distributions of precipitation rate for cloudy scenes partitioned by the 'critical' re=14 μm threshold are distinct and precipitation rate is positively correlated with cloud re, so there is a physical link between these parameters.

To provide a meteorological link between potential pollution sources and the Snowy Mountains, a climatology of back trajectories has been compiled using the HYSPLIT model. Trajectories which pass directly through 'source' or nearby 'control' regions are selected, and statistics for both cloud re and precipitation are compared. No significant relationship is found between the pollution sources considered and the Snowy Mountains for either parameter. While convincing examples may be found, the claim that a systematic reduction in precipitation amount has occurred as a result of aerosol pollution is not supported.

References:

Rosenfeld, D., 2000: Suppression of rain and snow by urban and industrial air pollution. Science, 287, 1793–1796.

Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Robert Fawcett

Meteorological aspects of the Margaret River fires on 23 November 2011

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Early in the morning of 23 November 2011, a fuel-reduction burn near Margaret River in southwest WA increased dramatically in activity. The fire escaped control lines and burnt southwards along the coastal fringe, subsequently destroying some 47 homes, including the historic Wallcliffe House. Satellite imagery showed a smoke plume of vastly greater extent than other fires in the area.

Here, we present an analysis of the meteorology of the event, based mainly on very high resolution (400 m) simulations with the Bureau of Meteorology's ACCESS weather forecasting system. We find that several mesoscale features likely contributed to the fire becoming or remaining active overnight, including a region of marked near-surface drying over and around the fire ground, the development of strong down-slope winds over the fire, and the development of a pronounced low-level jet. During the day, while the fire was heading rapidly southwards under the influence of strong hot northerlies, the observed increase in activity around midday may have been due to a vortex streamer shed from hills to the north of the fire.

Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Chi Mai N. Hankinson

Properties of high-frequency convectively-generated gravity waves simulated during TWP-ICE

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Gravity waves generated by convective clouds play an important role in the momentum budget of the middle atmosphere, can affect the evolution of convective systems, and can generate cirrus clouds. Yet, there are many aspects of these waves that remain poorly understood. In this study, high-resolution Weather Research and Forecasting (WRF) model simulations are used to study suppressed monsoon and monsoon break periods during Tropical Warm Pool International Cloud Experiment (TWP-ICE). The simulated rainfall variability agrees well with the observations, although the simulations have slightly lower intensity. In particular, the model reproduces the 3–4-day rainfall period during the suppressed monsoon, and the strong diurnal variation during the monsoon break. These simulations are used to study the properties of gravity waves generated by convection. At low rain rates it is found that the bulk wave activity, measured by the density weighted variance of lower-stratospheric vertical velocity, generally increases with rainfall intensity. At high rain rates the wave activity is not strongly related to rainfall intensity. This behaviour is consistent with the observations and suggests that sources other than diabatic heating may be responsible for generating gravity waves. Using outputs from model simulations, other spectral properties of high-frequency gravity waves that are not readily deducible from observations will also be presented.

Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Melissa Hart

Quantifying the urban heat island (UHI) in Hong Kong

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Hong Kong is a densely populated city where a significant proportion of the population lives in urbanised areas. During the summer months conditions are generally hot and humid and can get quite oppressive: the added burden of the urban heat island (UHI) can amplify conditions. There have been numerous studies investigating the UHI in Hong Kong with most utilising the Hong Kong Observatory's (HKO) extensive array of fixed point observation sites. However there has been no consensus on which sites are most appropriate for calculating UHI magnitude, which questions the reliability of, and poses difficulty when comparing, previous UHI calculations. Furthermore, the HKO fixed point observation sites are located in open areas away from obstructions such as buildings and trees; they do not measure conditions within the most urbanised areas of the city.

This presentation will discuss methodological concerns in quantifying temporal and spatial variability in Hong Kong's UHI. The Local Climate Zones land-use classification scheme was used to classify the HKO's fixed point weather stations and ascertain the most appropriate urban and rural sites for urban climate studies in Hong Kong. Results indicate that rural stations used in previous studies were not representative of the non-urbanised climate in Hong Kong and thus past UHI magnitudes calculated from HKO sites for Hong Kong may have been underestimated. Furthermore results from a combination of mobile and fixed point measurements undertaken within the city's street canyons present a UHI significantly warmer than that measured by the HKO's main urban site.

Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Jasmine B. D. Jaffrés

Wind climate in the southern Great Barrier Reef — local observations vs satellites and MesoLAPS

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Global scale winds are the main driving force for the upper ocean and corresponding models are well-developed. However, an accurate understanding and knowledge of the localised wind behaviour is also important for upper ocean studies. Wind climate has a significant impact on the wave field, currents and atmosphere-ocean interaction. Here, we analyse wind features that are derived from three different sources: 1) sensory wind data; 2) satellites and 3) the numerical weather prediction model MesoLAPS. The study focusses on the southern Great Barrier Reef. Each of the three different types of wind datasets has their own set of advantages and disadvantages. Sensory wind data are provided at a high temporal rate but have low spatial coverage and occasional data gaps. Satellite-derived wind data have a near-global coverage; however, observations are only available on 12- to 6-hourly timescales, and there are some patches of ocean with no coverage. MesoLAPS has a large coverage (domain includes Australia and surrounding regional oceans) and hourly data but relies on accurate data assimilation. Satellite and MesoLAPS wind data are statistically very similar, which is not unexpected due to the assimilation of satellite data into the large-scale model wind fields. Wind speeds of ground observations tend to be lower than satellite-derived wind speeds, which could be linked to the attenuation of wind speed over land. It is shown that, although satellite and model wind data are very useful for large-scale studies, they have a tendency to under-represent localised wind features due to their relatively coarse resolution. Wind characteristics derived from ground observations, including HF radar and weather stations, are therefore more appropriate for regional studies.

Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Jeff Kepert

How does the boundary layer contribute to secondary eyewall formation in axisymmetric tropical cyclones?

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Three diagnostic models of the axisymmetric tropical cyclone boundary layer are applied to the problem of tropical cyclones with concentric eyewalls. The outer eyewall is shown to have an inherently stronger frictional updraft than the inner, because it is in an environment of lower vorticity. Similarly, a relatively weak local vorticity maximum outside the primary radius of maximum winds may nevertheless produce a significant frictional updraft. Based on these results, we hypothesise that the boundary layer assists in the development of outer eyewalls, through a positive feedback between the local vorticity maximum, the frictional updraft, and convection. The friction-induced secondary circulation associated with the inner eyewall is shown to weaken as the outer wind maximum strengthens and/or contracts, so boundary-layer processes will tend to assist the normal course of events in an eyewall replacement cycle.

Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Todd Lane

Dynamics and predictability of a springtime precipitation event in the Australian Alps

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The prediction of orographic precipitation in regions of complex terrain remains challenging. However, modern weather prediction models are now able to resolve complex terrain features that often play a role in the initiation or enhancement of precipitation, which allows detailed examination of the dynamics of orographic precipitation events and their predictability. Precipitation in southeast Australia is strongly influenced by the Australian Alps, but the dynamics of precipitation events in the region has received relatively little attention. In this study the Weather Research and Forecasting (WRF) model is used to simulate a springtime precipitation event in the Australian Alps using an inner domain with 1.1 km grid spacing to investigate the role of mesoscale phenomena. The event was characterised by the passage of a relatively short-lived pre-frontal event whereby precipitating convection was triggered upstream and subsequently enhanced over the Alps. This was followed by a more prominent orographically enhanced frontal system.

The dynamics of the pre-frontal event are examined in detail; the timing and location of convection upstream is coincident with the passage of an undular bore propagating along the stable nocturnal layer. The undular bore was generated by a pre-frontal trough and triggers a convective event at the upstream extent of the mountains, and is subsequently advected toward and enhanced by the mountain range. To appreciate the predictability of this pre-frontal event, results from an ensemble with perturbed initial conditions are also presented. These ensemble results provide insight into the predictability of alpine precipitation during the passage of a frontal event.

Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Adam L. Morgan

Gravity waves in the upper-tropospheric jet exit: high resolution modelling and dynamics

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Vertically propagating, large amplitude gravity waves transfer horizontal energy and momentum to the mean flow as they break or are attenuated. In this way, gravity waves generated remotely in the upper troposphere are able to influence the general circulation, momentum budget, and constituent transport of the middle atmosphere. Previous studies have identified a distinctively banded, delta-shaped cloud structure that often accompanies major extratropical cyclogenesis in the eastern Australia and western Tasman Sea region. These 'Striated Delta' clouds—interpreted as a signature of radiating internal gravity waves from the unsteady perturbation to the mean flow of an upper-tropospheric jet/front system—form in the poleward exit region of an upper-level jet streak and diffluent mid-level trough. A May–September 2009 seasonal composite analysis of 28 Striated Delta cases in the Australian region has shown that gravity waves are excited in the poleward upper jet exit region in a synoptic environment characterised by upward vertical motion, strongly diffluent flow, large parcel accelerations, and broad scale flow imbalance. Here, a particularly distinct gravity wave event observed on 23 September 2009 over the central Tasman Sea is simulated using the WRF model. Full physics and 'dry' simulations are performed, initialised with 0.25-degree horizontal resolution ECMWF Operational Analyses from the YOTC dataset. Convection is parameterised in the outer 27 km and 9 km domains, but resolved for the innermost 3 km nested domain. We explore not only the dynamical relationship between the observed waves and the upper jet system, but also the connection to deep moist convection in the preferred poleward jet exit region.

Reference:

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Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Michael Murphy

Precipitation and extreme events in the 'wet tropics' region of Queensland

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The north-eastern coast of tropical Queensland is exceptionally wet. Within this broad area the mean annual precipitation in the 'wet tropics' between approximately Cooktown and Ingham is among the highest in Australia, exceeding well over 2500 mm along large sections of the coast with some high elevation locations reaching over 7000 mm. This region is characterised by north-south orientated costal ranges and moist easterly flow at the lower levels of the atmosphere. In addition to high annual precipitation totals this region is also noted for heavy rain events.

The AWAP precipitation dataset was analysed and a climatology of precipitation and also heavy rain events is described. K-means cluster analyses was applied to the AWAP data to determine 5 dominate distributions of precipitation in the region. Synoptic and mesoscale conditions associated with these precipitation centroids are identified as well as their seasonal frequency. A complex relationship was found between monthly accumulated precipitation and ENSO, with high positive correlations during most of the wet season.

Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Justin R. Peter

Using observations to improve mass-diameter relationships of ice crystals for use in climate models

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Treatment of clouds remains one of the largest uncertainties in current climate models (IPCC, 2007). For instance, Sanderson (2008) concluded that the second most dominant physical process responsible for variation in climate sensitivity across an ensemble of climate simulations was the ice crystal fall speed (the first was the treatment of entrainment in convection).The lack of certainty in parameterisations of ice crystal fall speeds is due to a combination of inadequate observations and the inherent time-height variability of ice particle habits and the flow regimes through which they fall. Primarily, the parameterisation of the fall speed of an ensemble of ice crystals depends on the statistical relationship between mass, projected area, individual terminal fall speed and maximum diameter of ice crystals and on the ice crystal particle size distribution (PSD). This study seeks to address these deficits in our understanding.

We use direct observations of vertical windspeed obtained on board an instrumented aircraft and compare these with observations of Doppler velocity obtained with a 95 GHz radar on board the same aircraft. The combined observations allow for semi-direct measurements of ice crystal fall speeds which have been previously unobtainable. Furthermore, we develop a variational technique to improve the mass-diameter relationships of the ice crystals to develop parameterisations which can be utilised in climate models.

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IPCC, 2007. Fourth Assessment Report: Climate Change 2007 (AR4)

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Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Harald Richter

Analysis of a severe multicell/supercell hybrid storm in Brisbane, Australia

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On 16 November 2008 a severe multicell/supercell hybrid storm produced extensive wind damage at The Gap, a suburb to the west of Brisbane's CBD. While large hail and heavy rain were present, surface winds exceeding ~40 ms^{-1} marked the dominant convective hazard. Of particular interest in this case is how a storm without a persistent deep mesocyclone can generate surface winds of the observed magnitude. The storm environment showed a cold front moving north into a reasonably moist boundary layer air mass (surface dew points exceeding 20°C) in southeast Queensland during the afternoon. Thunderstorms were triggered from the early afternoon onwards with values of the Convective Available Potential Energy (CAPE) around 2000 J kg^{-1}. The early afternoon ambient deep layer shear values remained modest with 0–6 km shear values around ~30 kts, but showed stronger values exceeding 40 kts around the event time. With the Gap storm lacking some of the persistent typical supercell characteristics, the paper focusses on the examination of thermodynamically driven downdraft mechanisms. Observations from a nearby a dual-polarisation research radar (CP2) showed the presence of very low differential reflectivity in regions of very high reflectivity returns, suggestive of a suspended core of large hail in the upper regions of the Gap storm's updraft. Preliminary calculations suggest that the relative contribution of condensate loading to the downdraft strength within the descending hail core may be significant and therefore appreciably contributes the generation of the strong surface winds in the Gap storm.

Session: 02. General Atmosphere - mesoscale and microscale
Presenting Author: Zhan Wang

An observation-based climatology of the precipitation over Macquarie Island

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An understanding of the precipitation over the Southern Ocean is a necessary component of the water budget of the region. While satellite observations are capable of providing such measurements, these algorithms remain to be verified. The atmosphere over the Southern Ocean is unique, being highly pristine and driven by intense winds and wind shear. Moreover, recent analysis suggests that boundary layer clouds, which are difficult for satellites to observe, are dominant over the region. A climatology of the precipitation observations at Macquarie Island will be presented. These observations offer a unique record of the trends in rainfall over the Southern Ocean over the past 40+ years. When coupled with a wider meteorological analysis, they offer insight in to the relative importance of frontal passages and boundary layer clouds in generating precipitation. This climatology may be then be used in evaluating satellite observations and numerical simulations.

Session: 03. General Atmosphere - forecasting and model development
Presenting Author: Shaun Cooper

Towards seamless rainfall forecasts for 0–10 Days

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The Bureau uses a number of NWP models to generate rainfall forecasts over a range of lead-times, each with a separate resolution in space and time and forecast domain. Many users require a seamless forecast system that is able to blend the various NWP forecasts into a single forecast with a uniform resolution over the entire forecast period. The magnitude of the forecast error for each NWP model depends on spatial scale and lead time. The idea therefore is to blend the NWP models in such a way that recognises the skill of the NWP at a particular scale and lead time. A stochastic model of forecast errors can then be used to perturb the blended forecast so as to generate an ensemble.

The Short-Term Ensemble Prediction System (STEPS) was designed to combine nowcasts, derived from radar precipitation observations, and downscaled NWP rainfall forecasts (Bowler et al. 2006). Uncertainties arise in the nowcasts due to the temporal development of the precipitation field during the forecast period and also due to errors in the initial estimations. The uncertainty in the temporal development of the precipitation field depends on the scale and the forecast lead time. NWP uncertainties are also scale and forecast lead time dependent, especially at long forecast lead times. To model these sources of uncertainty stochastic model are used to perturb the deterministic forecast to generate an ensemble of forecasts that encompass the uncertainty.

STEPS has now been adapted to blend a high resolution NWP and a coarser resolution NWP forecasts without the need for nowcasts, for use in hydrological models. A 30-member ensemble of hourly, downscaled precipitation forecasts out to 10 days is generated. Verification of the ensemble forecasts will be presented along with case studies.

Reference:

Bowler, N. E., Pierce, C. E. and Seed, A. W. (2006), STEPS: A probabilistic precipitation forecasting scheme which merges an extrapolated nowcast with downscaled NWP, Q. J. R. Meteorol. Soc., 132, 2127–2155.

Session: 03. General Atmosphere - forecasting and model development
Presenting Author: Michael Foley

Probabilistic rainfall forecasting in northern Australia

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Communicating uncertainty has traditionally had little emphasis in forecasts produced by the Australian Bureau of Meteorology. However, this is changing and probabilistic rainfall forecasts are being introduced with the adoption of the Graphical Forecast Editor (GFE) as the platform for forecast production in Australian Regional Forecasting Centres (RFCs).

The GFE is being phased in over several years, and has not yet reached the Darwin RFC, which has responsibility for public weather forecasts in the Northern Territory. In preparation for the move to the new system, RFC meteorologists have engaged in a daily probabilistic rainfall forecasting exercise since early in 2011 for Darwin and Alice Springs airports. Experience with probabilistic rainfall forecasting has previously been confined to RFCs using GFE for southern Australia, and it is of interest to see how such forecasts fare in the different rainfall climates of the north.

Verification results for these probabilistic forecasts are presented, and compared with results for forecasts using a poor-man's ensemble of numerical weather prediction models, as well as with Results of forecasts for southern Australia prepared in the GFE. Results are discussed in the context both of the GFE precipitation forecast process as currently used in Australian operations, and of proposed enhancements to that process.

Session: 03. General Atmosphere - forecasting and model development
Presenting Author: Timothy Hume

Novel computational techniques to produce high resolution forecast guidance: application to the Bureau of Meteorology's gridded OCF System

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There is an increasing demand from meteorological forecast users for higher spatial resolution gridded guidance. For example, global numerical weather prediction models (NWP) are now being run at spatial resolutions approaching 10 km. Whilst this is a boon to the users of the forecast guidance, it presents a number of challenging technical problems. For example, disseminating and archiving the large data streams in a timely fashion is becoming increasingly difficult as file sizes grow exponentially.

The Bureau of Meteorology's Gridded Operational Consensus Forecast system (Gridded OCF) produces forecast guidance for the Australian region by computing a weighted ensemble average of forecasts from up to seven Australian and international NWP models. It is currently run on a regular 0.5 degree grid.

There is now a requirement from operational forecasters for Gridded OCF guidance at 0.25 degree spatial resolution. The resulting increase in data processing and storage is making it difficult to produce the guidance in the time frame required by forecasters. To overcome the problem, the Gridded OCF system has been upgraded to operate on an irregular network of points instead of a regular grid. The spatial resolution of the network is higher around areas where forecasters require detailed guidance such as coastlines, mountains and population centres, but tapers off to lower resolution over the ocean and in uninhabited parts of Central Australia. The new system provides guidance at effectively 0.25 degree resolution in locations where forecasters require it, yet uses less disc space than the current operational system on a regular 0.5 degree grid.

This study describes the technical implementation of the variable resolution Gridded OCF system, and presents verification results comparing the new guidance against guidance on a traditional regular grid.

Session: 03. General Atmosphere - forecasting and model development
Presenting Author: Md Atikur Rahman Khan

Prediction of Tasmanian climatic pattern by using singular spectrum analysis

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Seasonality, cyclical variation and slow moving trend are the common characteristics of most climatic time series. In this paper a trend model coupled with singular spectrum analysis is introduced that decomposes univariate time series into orthogonal trend, harmonic and noise components without any prior assumption of phase and frequency of the data. Long-term change in Tasmanian climatic pattern is excavated by employing a linear trend with harmonic components model extracted via singular spectrum analysis of monthly temperatures, global solar exposure, and total rainfall data. By the end of twentieth century, monthly average minimum and maximum temperatures are predicted to rise more than 1.5ºC. Rising temperature level will affect both the global solar exposure and rainfall pattern. Compared to the base year 2010, global solar exposure may increase up to 11.0MJ/m^2 and monthly total rainfall may decline up to 16 millimeters by 2100 AD. Winter climate in Tasmania is changing faster than any other seasons and the climatic profile of winter in 2100 could be similar to that of late autumn or early spring in 2010. A slow transition of winter climatic pattern to late autumn or early spring can be depicted from a profile analysis of climatic variables in 25 years horizon.

Session: 03. General Atmosphere - forecasting and model development
Presenting Author: Tammas Loughran

Simulation of the meteorological effects of the S Fornacis superflare on Earth

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Short duration stellar flares that are many times larger than those that occur on the Sun have been observed on stars that are remarkably similar to our Sun. One particularly large example of these 'Superflares' occurred on the star S Fornacis, observed on 2 March 1899 and is estimated to have had a total flare energy output about one million times more energetic than any solar flare observed on the Sun. A superflare this size could have some serious effects on any planets that are in close orbits within the habitable zone. The effects might include, but are not limited to, large scale melting of ice and storm development.

In this study the potential meteorological effects that a superflare would have on Earth-like planets is investigated using the CSIRO Mk3L climate system model. A method for calculating the evolution of the radiation at the Earth is presented as well as some simulations of a planet identical to Earth experiencing the S Fornacis superflare. The differences of prognostic variables such as precipitation and temperature over both land and ocean surfaces is shown, as well as changes in icy surfaces. This technique will also be expanded to some generalised exoplanets orbiting star types that are known to exhibit superflares.

Session: 03. General Atmosphere - forecasting and model development
Presenting Author: Philip Riley

Probabilistic rainfall forecasts from deterministic Numerical Weather Prediction model output

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Probability of Precipitation (PoP) forecasts are produced by the Gridded Operational Consensus Forecasting System (GOCF) of the Australian Bureau of Meteorology using forecasts of rainfall amount from a Poor Man's Ensemble of Numerical Weather Prediction output from a number of international centres. The PoP forecasts are created using historical data to relate the observed frequency of rainfall to the ensemble mean forecast rainfall amount, using an adaptation of the method of Sloughter et al. (2007). Calibration of probabilities requires much data, and though the method produces reliable and skillful PoP forecasts with a relatively small training data set, it still needs at least several weeks of data over a large fraction of Australia to be stable. The original implementation of the method produced forecasts for SE Australia only with a single calibration for the whole area and a year of past data. This approach is not suitable for forecasts for the whole of the continent. Methods for allocating forecast grid points to one of several calibration categories have been developed. The calibration of each category is based on data from the past 15 months and the same season as the forecast. This allows for both geographical and seasonal variations in the calibration parameters. This paper describes the calibration method, particularly the method for allocating forecast grid points to calibration categories and other recent updates to the system. The performance of the system will be illustrated using verification statistics for different areas of Australia, seasons and forecast lead times.

Reference:

Sloughter, J.M, Raftery, A.E., Gneiting, T. and Fraley, C. 2007, Probabilistic Quantitative Precipitation Forecasting Using Bayesian Model Averaging, Monthly Weather Review 135, 3209–3220

Session: 04. General Oceanography
Presenting Author: Julia Brandenberg

Temporal decomposition of satellite ocean chlorophyll data

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Vertical stratification, increased sea surface temperatures and other physical and geochemical effects, driven by climate change, are expected to affect ocean's biological productivity. Changes in the primary production can imbalance the ocean's ecosystem and therefore, it is critical to understand how the ocean productivity is changing with time.

Satellite ocean color data provides the most comprehensive information about the spatial-temporal distribution of ocean productivity. With 15 years of record from several sensors (SeaWiFS, MERIS, MODIS) available now, significant trends can be detected in a few regions. However, the detection of trends in ocean chlorophyll using traditional statistical techniques is challenging, due to the presence of a strong temporal correlation and an overtime changing seasonal cycle in some regions. We decompose the time series of ocean chlorophyll into three components: a long-term trend, a seasonal cycle and an autoregressive process. We show that the seasonal cycle in ocean chlorophyll is irregular. We further show that this irregularity can bias trend detection when using methods assuming a stable seasonal cycle over the years. Cautious statistical analyses of long-term changes are necessary in order to better understand climate change effects on ocean's productivity.

Session: 04. General Oceanography
Presenting Author: Dr Andrew Dowdy

Storm wave projections for eastern Australia

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Extratropical cyclones are the main mechanism for generating the winds that cause extreme ocean waves in temperate regions of the world. Current Global Climate Models lack sufficient resolution to adequately represent extratropical cyclogenesis, leading to considerable challenges and uncertainties relating to projections of extreme wind and wave events. To investigate potential changes in the future climatology of storm wave events for eastern Australia, this study applies a diagnostic of the likelihood of large-scale conditions favorable to extratropical cyclone occurrence, rather than using direct projections of extreme winds and extratropical cyclone events. The diagnostic is based on strong cyclonic vorticity in the upper-troposphere. It is initially applied to reanalyses and shown to provide a good representation of storm wave observations obtained from a network of buoys along Eastern Australia. Seasonal and regional variability are examined. The diagnostic is then applied to Global Climate Model simulations of the current and future climate to examine the influence of increasing greenhouse gas concentrations on the occurrence of large wave events.

Session: 04. General Oceanography
Presenting Author: Tom Durrant

A 30-year global wave hindcast

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Many Pacific Islands are vulnerable to impacts of waves through coastal inundation, coastal and beach erosion, wave driven lagoon circulation, disturbances to reef habitats etc. On steep continental shelves like Pacific Island coral atolls, surface waves are the dominant contributor to coastal sea-level extremes via wave set-up.

A recent review of the availability of modelled and observed wave data in the Pacific region noted the need for a high-quality multi-decadal wave climate data set. The absence of high temporal resolution spectral wave data was noted, with existing hindcast products assessed as being of inadequate spatial and temporal resolution in general. Wave hindcast resolution has historically been limited by the resolution of available winds. The recently completed National Centers for Environmental Prediction's (NCEP) Climate Forecast System Reanalysis (CFSR) surface winds now provide a consistent product at 0.3°, hourly resolution over the past 30 years, providing a valuable source of forcing for wave hindcasting.

As part of the Pacific-Australia Climate Change Science and Adaptation Program (PACCSAP), work is being carried out examining recent, existing and projected future ocean wave conditions with a focus on the Pacific region. As part of this work, a 30-year (1979–2009) global wave hindcast has been produced, using CFSR wind forcing. This study will present the details this hindcast. An assessment of the quality of the data set will be presented using in-situ buoy and satellite altimeter data.

Session: 04. General Oceanography
Presenting Author: Danielle Madeley

Leveraging open source technology for rapid and sustainable development of the Ocean Map Portal

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The Climate and Oceans Support Program in the Pacific (COSPPac) is a major component of Australia's contribution to minimising the impacts of climate variability and change in the Pacific. The major objective of the Climate and Ocean Monitoring and Prediction (COMP) project is the continued development of seasonal prediction capacity, including the development of new ocean and climate products. One product is the Ocean Map Portal, an interactive, 'web 2.0' website for visualising and accessing historical (and potentially, real-time and predictive) ocean data by oceanographers, scientists, technical users and the general public, available in versions for the Pacific and Australia. We have chosen to use exclusively open source technologies to develop the Ocean Map Portal, including OpenLayers, Mapserver, jQuery, Matplotlib and Python. This has allowed us to rapidly build a high quality, sustainable product, where Pacific Island Countries can run their own portals without requiring any licensed software and enabling them to potentially further customise the tool. Due to their open source nature, we have been able to resolve software issues in the underlying libraries and contribute them back upstream for other users of these technologies (e.g. software issues with Pacific Ocean mapping in OpenLayers). This presentation will outline the technologies used within, and to develop, the Ocean Map Portal and the reasoning we applied in choosing this path. It will showcase some of the features that have been enhanced through the use of these technologies and how they can be used to quickly develop similar/spin-off products and take the Ocean Map Portal forward in the future.

Session: 04. General Oceanography
Presenting Author: Xuerong Qin

Sensitivity of Lagrangian trajectories to smoothed velocity fields

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Lagrangian trajectories, obtained by advecting particles in modelled velocity fields, are widely used for connectivity studies in the oceans. Typically one to five days averaged velocity fields output from fine-resolution models, that are able to explicitly resolve mesoscale eddies, are used to examine Lagrangian trajectories. However, output from coarse-resolution global climate models is typically only archived at monthly resolutions. It is unclear to what extent using monthly rather than higher temporal resolution affects the results of Lagrangian trajectory calculations. If discrepancies are either small or can be compensated by diffusion, we can reduce computational resources for trajectory calculations and study connectivity using monthly global climate model output.

A numerical study is carried out to investigate the sensitivity of Lagrangian trajectories to temporal resolution of the velocity fields as well as the effect of Brownian motion diffusion. One and three day velocity fields from the high-resolution ocean model OGCM For the Earth Simulator (OFES) and for a lower-resolution global climate model are temporally smoothed to produce monthly averaged fields. Lagrangian particles are then advected in these velocity fields using the Connectivity Modelling System (CMS). We examine both the East Australian Current and circulation in the tropical Pacific Ocean. The flows are associated with varying levels of eddy kinetic energy. Using a lower temporal resolution velocity fields smooths out the eddy field, reducing the eddy kinetic energy of the flow. The effects of this smoothed flow on the connectivity are presented.

Session: 04. General Oceanography
Presenting Author: Eric J. Raes

Nitrogen fixation in the eastern Indian Ocean

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The occurrence of N_2-fixing microorganisms in low nutrient and stratified oceanic habitats is well documented. Increasing knowledge on the phylogenetic diversity, distribution, productivity and size structure of N_2 fixing organisms in the oceans, has led to massive increases in the estimates of global N_2 fixation rates. We aimed to test whether nitrogen fixation is a key driver of planktonic CO_2 absorption in the largely unstudied eastern Indian Ocean. The data presented in this study represent the first regional estimates of N_2-fixation rates along a latitudinal gradient, covering 75% of the coastline of Western Australia and extending well into the eastern Indian Ocean (to 100 E). The magnitude and impact of N_2 fixation on the ocean productivity was estimated using both well-established protocols Montoya (1996) and more recent methods Mohr (2010). Pooling $\delta^{15}N$ data from natural particulate organic nitrogen samples against isobath lines ($p< 0.02$), highlighted offshore N-fixation and/or NH4 excretion ($\delta^{15}N$ 0∼2) and the influx of deep NO3 near the continental shelf ($\delta^{15}N$ values 4∼6). The combined measurements of C uptake and N fixation will furthermore contribute as a major piece of new information towards the understanding of the Indian Ocean to 1) evaluate the potential influence of N_2 fixation on the absorption of CO_2 in the ocean via sedimentation and 2) quantify the ability of fixed N to move up the food chain.

References:

Mohr, W., Großkopf, T., Wallace, D. W. R. & Laroche, J. 2010. Methodological underestimation of oceanic nitrogen fixation rates. *Plos One,* 5, e12583.

Montoya, J. P., Voss, M., Kahler, P. & Capone, D. G. 1996. A Simple, High-Precision, High-Sensitivity Tracer Assay for N (inf2) Fixation. *Applied and environmental microbiology,* 62, 986–993.

Session: 04. General Oceanography
Presenting Author: Arthur Simanjuntak

Adapting MOM4p1 as a hydrodynamic model for the Great Barrier Reef.

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A hydrodynamic prediction system is being developed as a part of eReefs, an integrated system of data, models, visualisation, reporting and decision support tools that span the Great Barrier Reef (GBR) area. The Modular Ocean Model (MOM4p1) with 4 km grid is used as a downscaled model that feeds from the currently operational OceanMAPSv2. Representation of the intricate bathymetry of the GBR on an Arakawa B-stencil presents a large challenge in adapting an ocean climate model to run robustly in a coastal setting. Accurate open boundaries, with tides and atmospheric effects included is another major challenge. Within this setting, configuration choices such as that of turbulence and benthic boundary layer parameterisations for the deep and shallow parts of the domain become important. We show multiple trial hindcast runs demonstrating performance of design options in rectangular and curvilinear grids, open boundaries, tides and turbulence schemes. A comparison of the simulated three dimensional circulation using MOM4p1 is made with benchmark runs from a 1 km grid Sparse Hydrodynamic Ocean Code (SHOC) model at several sections of the reef.

Session: 04. General Oceanography
Presenting Author: Nicholas Summons

Pacific Ocean Map Portal: Informing decision making through high quality visualisation of ocean climate data.

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The Pacific Islands are highly susceptible to changes in the ocean state due to climate variability and climate change. For example, rising sea levels can increase the risk of coastal inundation and salt water intrusion into ground water whilst warmer ocean temperatures can increase the risk of coral bleaching events and adversely affect the fishing industry. To help the Pacific Island community make informed decisions when faced with the prospect of a rapidly changing climate, the Pacific Ocean Map Portal has been developed. The portal synthesises all relevant ocean climate information in an intuitive online visualisation tool.

This product has been developed as part of the Climate and Oceans Support Program in the Pacific (COSPPac), which is a major component of Australia's contribution to minimising the impacts of climate variability and change in the Pacific. The current suite of ocean products available in the portal include the Bluelink Reanalysis (BRAN), WaveWatch III (31-year climatology), Reynolds and Extended Reconstructed SST, tide gauge, altimetry and reconstructed sea level. The presentation will provide an overview of the currently available datasets, visualisation options and an outline of future directions for the portal.

Session: 05. General Climate - variability of the climate system
Presenting Author: Linden Ashcroft

"An indefatigable pioneer of civilisation and science": the weather records of W.B. Clarke, 1840–1850

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Reverend William Branwhite Clarke was a passionate amateur meteorologist who lived in Sydney from 1839 until his death in 1878. More well-known as the "Father of Australian Geology", Clarke's significant contribution to the study of Australian meteorology and climatology has often been overlooked.

He was a prolific writer on Australian meteorology and meteorological theory, publishing over 20 articles on the topic in the Sydney Morning Herald and many more overseas. Clarke also maintained detailed weather observations, and encouraged colleagues to record the weather across New South Wales, building one of the earliest observational networks in Australia.

Clarke's papers at the Mitchell Library in Sydney provide a unique opportunity for an in-depth look at weather and climate in Sydney in the mid-19th century. During 1841–1846 in particular, there are simultaneous daily observations from several places around Sydney and western NSW, as well as meticulous observations and notes taken by Clarke himself.

This study highlights some features of Clarke's research, and explores variations in the temperature and rainfall of the Sydney area during the 1840s. It also aims to show how historical observations such as these can shed light on past, present and future climate variations in southeastern Australia.

Session: 05. General Climate - variability of the climate system
Presenting Author: Grant Beard

Building climate services capacity in Pacific Island countries

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Pacific Islands Countries rely on climate services to alleviate the effects of climate variability and change. Seasonal predictions and related services such as drought monitoring have become an important part of the range of products offered by National Meteorological Services (NMSs). A former AusAID project, Pacific Island Climate Prediction Project (PICPP), was instrumental in developing capacity in the provision of climate services in Pacific Islands during the past eight years. AusAID is now funding PICPP's successor program, the Climate and Oceans Support Program in the Pacific (COSPPac), designed to build on the achievements of PICPP.

Improvements to climate services have been delivered through the use of: an Online Climate Outlook Forum (OCOF); a state-of-the-art software package called Seasonal Climate Outlooks in Pacific Island Countries (SCOPIC), designed to run on personal computers; as well as the provision of in-country and regional training for National Meteorological Services. Improved climate services have been shown to positively affect the social and economic well-being of Pacific communities. In this talk, we will present some of the outputs from the Online Climate Outlook Forums, a sample of SCOPIC analyses, and explain how together they are helping to build Climate Services in Pacific Island Countries.

Session: 05. General Climate - variability of the climate system
Presenting Author: Mitchell Black

A simple diagnostic for eastern Australian summertime rainfall

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Many studies have examined Australian rainfall variability and its relationship to large-scale climate drivers and diagnostics. Although there are established relationships between these diagnostics and rainfall in the cooler seasons, the common indices used to represent those drivers are less successful explaining summertime rainfall variability in southeastern Australia, especially along the coast. Understanding rainfall along the east coast is of particular importance, due to the large population and economic value of the region. It is also a region with strong topographic influence that cannot be well represented in current global climate models. This study presents a number of simple diagnostics for characterising the variability in summertime rainfall along the eastern Australian coastline. Conceptualised during the examination of composite synoptic conditions for high rainfall events, these simple yet effective indices provide a measure of the easterly geostrophic flow and associated moisture transport from the Tasman Sea. The indices are shown to provide statistically significant correlations with summertime rainfall across eastern Australia for a range of different timescales. In many locations these correlations are higher in magnitude than the common large-scale drivers of rainfall variability. These results, along with their potential application as a diagnostic for climate models will be discussed.

Session: 05. General Climate - variability of the climate system
Presenting Author: Belinda Campbell

A fresh look at the relationships between Australian Rainfall and the El Niño–Southern Oscillation

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This study provides an updated analysis of the relationships between Australian rainfall and the Southern Oscillation using the best available gridded rainfall data set for the latest period ending in 2012. As one of the major drivers of climate variability in Australia, the El Niño Southern Oscillation (ENSO) and its relationship to rainfall, in particular, is a topic of continuing interest. McBride and Nicholls (1983) established the relationships between seasonal rainfall and differing measures of the Southern Oscillation using 42 years of data for the period that ended in 1974. Further work on correlation patterns has since been published using data from 1889–2006 (Risbey et al. 2009).

In light of the recent two consecutive La Niña events and the moderate El Niño immediately prior, an update to the correlations between the various Southern Oscillation indices and Australian rainfall has been conducted. This analysis is based on the Bureau of Meteorology's high-quality gridded monthly rainfall dataset from the Australian Water Availability Project (AWAP) (Jones et al. 2009). For the point of comparison, the AWAP dataset is first utilised to reproduce the results in both McBride and Nicholls (1983) and Risbey et al. (2009), then to extend the analysis for the period 1900–2012 to include the most recent active ENSO phase.

Changes to the spatial patterns and values of the annual and seasonal correlations over time are examined for the extended period, with emphasis placed on the most recent part of the rainfall record. The updated analysis shows spatial correlation patterns in close alignment to the relationships established in McBride and Nicholls (1983) for the most recent period. Lag correlations between the ENSO indices and rainfall in the following season are also revisited and generally remain robust across eastern Australia. These results are also discussed in the context of seasonal prediction.

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Session: 05. General Climate - variability of the climate system
Presenting Author: Jennifer Catto

The link between ENSO and North Australian SSTs and its impacts on projections of Australian climate

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Interannual variations in the sea surface temperature (SST) to the North of Australia are strongly linked to variations in Australian climate such as winter rainfall, or tropical cyclone numbers. The North Australian SST is also closely linked to ENSO and Tropical Pacific SSTs, with the relationship exhibiting a strong seasonal cycle. Credible predictions of future Australian climate change therefore depend on climate models being able to represent ENSO and its connection to North Australian SSTs.

Observational analysis shows that from January to April, the correlation between Nino3.4 SST and North Australian SST is positive, while from May to December the correlation is negative. During El Niño events, the North Australian SST anomalies become negative in the Austral spring preceding the development of the positive Nino3.4 SST anomalies. This relationship is associated with feedbacks between the seasonal cycle of zonal wind and the ENSO related zonal wind anomalies.

The coupled models participating in the CMIP5 project are then evaluated in terms of this temporal evolution of Nino3.4 SST and the relationship to North Australian SSTs for the historical simulations. Some of the models perform very well, while some do not capture the seasonal cycle of correlations at all. Changes in the link between the two regions in future projections are investigated and related to the biases in the models. Finally, the effect of the change of this relationship on Australian rainfall is evaluated.

Session: 05. General Climate - variability of the climate system
Presenting Author: Savin Chand

A conceptual architecture for developing seasonal forecast systems for Pacific Island countries using traditional ecological knowledge and modern scientific methods

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Traditionally, indigenous people in Pacific Island countries (as well as elsewhere in the world) predicted weather through observation and monitoring of local variables such as the behaviour of plants and animals, meteorological and astronomical indicators. This knowledge system (hereafter after referred to as Traditional Ecological Knowledge, TEK) is adapted to local conditions and needs, and has been used for generations to enhance agricultural productivity and to develop appropriate environmental disaster management and coping strategies. In recent years, the importance of this traditional knowledge system has been recognised by the modern scientific community, resulting in a burgeoning field of research in different parts of the world.

Understanding indigenous people's perception and knowledge of weather and climate is crucial, and if used alongside conventional scientific methods, can become an essential tool for effective communication of seasonal forecasts. In Pacific Island countries, there is little documentation of the application of TEK to seasonal prediction problems and the extent to which it is still practiced. As part of the *Climate and Oceans Support Program for the Pacific*, a study will be undertaken to identify and document traditional forecast indicators in the Pacific Island countries and to potentially integrate it with conventional scientific approaches for better communication of forecast information. Here we present a conceptual architecture outlining the framework of how necessary TEK data will be collected, documented and used for seasonal forecasts alongside conventional scientific methods.

Session: 05. General Climate - variability of the climate system
Presenting Author: Savin Chand

Impact of different ENSO regimes on southwest Pacific tropical cyclones

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The influence of different types of ENSO on tropical cyclone (TC) interannual variability in the central southwest Pacific region (5–25°S and 170°E–170°W) is investigated. Using Empirical Orthogonal Function analysis and an Agglomerative Hierarchical Clustering of early tropical cyclone season Pacific sea surface temperature, years are classified into four separate regimes (i.e., canonical El Niño, canonical La Niña, positive-neutral and a negative-neutral regime) for the period between 1970 and 2009. These regimes are found to have a large impact on TC genesis over the central southwest Pacific region. Both the canonical El Niño and the positive-neutral years have increased numbers of cyclones, with an average of 4.3 per year for positive-neutral and 4 per year for canonical El Niño. In contrast, during a La Niña and negative-neutral events, substantially fewer TCs (averages of ~2.2 and 2.4 per year respectively) are observed in the central southwest Pacific. The enhancement of TC numbers in both canonical El Niño and positive-neutral years is associated with extension of favorable low level cyclonic relative vorticity, and low vertical wind shear eastward across the dateline. Relative humidity and SST are also very conducive for genesis in this region during canonical El Niño and positive-neutral events. The patterns are quite different, however, with the favorable conditions concentrated in the dateline region for the positive-neutral, as compared with further eastward for the canonical El Niño. A significant result of the study is the demonstration that ENSO-neutral events can be objectively clustered into two separate regimes, each with very different impacts on TC genesis.

Session: 05. General Climate - variability of the climate system
Presenting Author: Savin Chand

The different impact of positive-neutral and negative-neutral ENSO regimes on Australian tropical cyclones and rainfall

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The number of TCs in the Australian region exhibits a large variation between different ENSO regimes. While the difference in TC numbers and spatial distribution of genesis locations between the canonical El Niño and La Niña regimes is well known, we demonstrate that a statistically significant difference in TC numbers also exists between the recently identified negative-neutral and positive-neutral regimes. Compared to the negative-neutral and La Niña regimes, significantly fewer TCs form in the Australian region during the positive-neutral regime, particularly in the eastern subregion. This difference is attributed to the expansion and retreat of the Pacific warm pool during the positive-neutral and negative-neutral regimes, respectively, and concomitant changes in atmospheric conditions such as sea level pressure, relative vorticity, and vertical motion. Such changes are also found to impact the austral summer rainfall over northern Australia where on average more rainfall occurs in the positive-neutral than in the negative-neutral regime.

Session: 05. General Climate - variability of the climate system
Presenting Author: Mark Decker

Diagnosing the impact of groundwater on the land-atmosphere coupling strength in Northern Australia

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The state of the land surface alters the atmosphere through the fluxes of energy and water from the land to the boundary layer. The degree to which soil moisture effects the atmosphere has been diagnosed in the past through large ensembles of coupled models (Guo et al. 2006), or the analysis of various land-surface and atmosphere observations and land surface model outputs (Ferguson et al. 2012). Using the monsoon region of Northern Australia as a study area, we examine the sensitivity of the diagnosed land surface-atmosphere coupling to groundwater using the Community Land Model Version 4 (CLM4) forced with several different datasets. We show that the coupling strength, diagnosed as Kendall's tau between the surface layer soil moisture and the lifting condensation level, is generally insensitive to the inclusion of groundwater. However, the latent heat fluxes are drastically enhanced when groundwater is included in the model. Although the surface layer soil moisture remains little affected by the inclusion of groundwater, groundwater sustains a high level transpiration throughout the dry season and in the transition months between the dry and wet seasons. We conclude that the land-atmosphere coupling should not be diagnosed using the surface-layer soil moisture due to the substantial impact of transpiration and deeper soil moisture on the surface energy fluxes in regions such as Northern Australia. We demonstrate that the coupling strength is more appropriately calculated using the available root zone soil moisture, as diagnosing the coupling in this way encompasses the several different pathways that water may take to impact the atmosphere.

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Session: 05. General Climate - variability of the climate system
Presenting Author: Wasyl Drosdowsky

POAMA forecasts of intra-seasonal variability over Northern Australia

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As part of a Managing Climate Variability (MCV) funded project to provide improved forecasts of the onset and variability of the north Australian wet season, we examine the prediction of intra-seasonal variability of large scale moist convection over northern Australia and surrounding oceans with the latest version of the POAMA model.

Previous work by the Seasonal Prediction teams in CAWCR has shown that the Madden-Julian Oscillation (MJO), as depicted by the RMM indices, is well forecast by the POAMA model. However, this global scale index does not always accurately reflect local conditions over north Australia, so here we extend that work by considering the prediction of a more local index of monsoon convection.

For the latest version of the POAMA model, hindcasts have been performed for the period from 1980 to 2010, with thirty-six hindcasts per year, initialised on the 1st, 11th and 21st of each month. Each hindcast consists of an ensemble of 33 members, each from a unique initial condition generated by the Coupled Ensemble Initialisation Scheme.

The measure of local moist convection we use is outgoing longwave radiation (OLR), in both the observations and model. The POAMA hindcasts of area-averaged OLR show a strong adjustment away from their initial values during the first week, and then converge to a mean seasonal cycle of similar amplitude and phase to the observed OLR.

Skill of the hindcasts is assessed against both climatology and persistence. Over all hindcasts, POAMA exhibits skill, as measured by the RMSE, over climatology to at least 35 days, and against persistence, as measured by RMSE or correlation, at all lead times beyond 2 days. Similar results are found for just those hindcasts beginning in the 'wet season' months from December through to March, when the greatest variability in the OLR occurs.

Session: 05. General Climate - variability of the climate system
Presenting Author: Leela Frankcombe

Internal variability and external forcing of interannual Kuroshio path changes

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The Kuroshio, the western boundary current in the North Pacific, flows close to the coast of the islands of Japan. After separating from the coast the current flows eastwards into the open ocean and is known as the Kuroshio Extension. The Kuroshio system as a whole has been observed to have multiple paths and the current varies between these paths on interannual to decadal timescales. This has been simulated in idealised models where transitions between the paths occur spontaneously, indicating the presence of internal variability in the system. In observations however, the transition from one path to another is found to coincide with the arrival at the coast of Rossby waves generated by wind variability in the central Pacific. This indicates that external forcing also plays a role in the variability.

Using both ocean models and observations we assess the relative importance of external forcing (the remotely generated Rossby waves) versus internal variability on the interannual-to-decadal path variations of the Kuroshio and Kuroshio Extension.

Session: 05. General Climate - variability of the climate system
Presenting Author: Catherine Ganter

Australian climate in 2012 - a return to drier conditions

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The Australian climate in 2012 was affected by a number of large scale drivers including a decaying La Niña event early in the year, a borderline El Niño event later in the year, and a weak positive phase of the Indian Ocean Dipole. As a result, conditions started the year unusually cool and wet, and shifted to drier than average over most of the country in winter/early spring. Late winter and early spring saw warmer than average conditions, particularly during the day, with a number of notable heatwaves.

Australian mean temperatures for January–August were 0.42 ºC below the 1961-1990 normal, tracking as equal 11th coolest of 63 years of record. It is now likely that 2012 will be the second consecutive year of below average temperatures affecting Australia, the first time this has happened since 2000/2001. Temperatures were near or below normal across most of the continent, with the only major areas of above-normal mean temperatures being Tasmania, western WA, southern Victoria and southeastern SA.

The tropical Pacific shifted into a neutral ENSO state during the austral autumn. From April to August, Australian rainfall anomalies resembled those that have prevailed for much of the decade prior to the recent La Niña, namely, dry conditions across most of southwestern and inland southeastern Australia, and seasonally dry conditions through most of the tropics. Notably dry conditions appeared in southwest WA, which experienced its driest July on record, followed up with a below average August leading to one of the driest southern wet seasons on record for the region. Most mainland areas apart from the southern half of Western Australia were wetter than average for the year to August, reflecting the very wet start to the year.

Session: 05. General Climate - variability of the climate system
Presenting Author: Katy Hill

Australia's Integrated Marine Observing System: monitoring climate variability and weather extremes

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The Integrated Marine Observing System delivers a range of observations in support of research into Climate Variability and Weather Extremes. There are three major well described coupled ocean atmospheric modes which account for a significant portion of Australian seasonal climate variability – El Nino/Southern Oscillation (ENSO), Indian Ocean Dipole (IOD) and the Southern Annular Mode (SAM), with centres of action in the equatorial Pacific, equatorial Indian, and Southern Oceans, respectively. The upper ocean thermal distribution is the largest source of predictability at seasonal timescales for all coupled modes due to the large ocean thermal inertia and its predictable dynamics (eastward propagating equatorial ocean long-waves called Kelvin waves and westward propagating extratropical Rossby waves). It is now recognised that prediction systems should be global (not just for the Pacific basin).

Major weather patterns are strongly influenced by ocean conditions; tropical cyclones and east coast lows (in southern Queensland and NSW coast) draw energy from surface ocean temperatures, and temperature patterns may also influence storm paths. Hence, the frequency and intensity of these storms are linked to coupled climate modes such as ENSO.

While climate variability operate on inter-annual timescales, and weather extremes operate on shorter space and time scales, the observations needed to understand them are the same.

IMOS delivers observations of upper ocean thermal distribution to inform seasonal and climate models; these include:

- broadscale upper ocean temperature and salinity structure
- well resolved time-series in the equatorial oceans
- global wind, air-sea exchange (fluxes), and sea level measurements

All IMOS data are freely available for anyone to use. For more information on the Integrated Marine Observing System, go to www.imos.org.au

Session: 05. General Climate - variability of the climate system
Presenting Author: Damien Irving

ENSO Modoki, the Pacific South-American pattern and Antarctica

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It is now well established that El Niño–Southern Oscillation (ENSO) events come in different 'flavours'. In addition to traditional eastern Pacific events, there has been an emergence in recent decades of events where the largest sea surface temperature anomalies occur in the central tropical Pacific Ocean. These have been referred to as 'date-line', 'Modoki', 'warm pool' or 'central Pacific' events. While there is debate as to whether these central Pacific events represent a separate phenomenon or simply the non-linear evolution of ENSO, it is clear that their global teleconnections differ from those associated with traditional events.

The major ENSO teleconnection to the high southern latitudes is the Pacific-South American (PSA) pattern. The sub-Antarctic branch of the PSA pattern, known as the Antarctic Dipole (ADP), comprises a strong out-of-phase association in sea-level pressure between the Amundsen/Bellingshausen Seas and the Weddell Sea. Among other important regional impacts, the ADP is thought to account for approximately one third of the total variance in Southern Hemisphere sea ice extent.

Recent studies suggest that relative to traditional ENSO events, the PSA pattern associated with central Pacific events is stronger, more persistent and differs in its spatial location. This altered PSA pattern has been linked to anomalous warming in the polar stratosphere and a more persistent ADP, while the increased frequency of central Pacific events may be responsible for observed warming in West Antarctica and declines in Amundsen/Bellingshausen sea ice.

This presentation will highlight the mechanisms underlying these different PSA patterns, via the application of Rossby wave diagnostics such as the wave activity flux. New insights derived from these diagnostics will then be used explore the impact of central Pacific ENSO events on the climate of Antarctica.

Session: 05. General Climate - variability of the climate system
Presenting Author: Charlie C. F. Lok

Estimating tropical cyclone structure in the Australian region

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Tropical cyclones exhibit large variability in their structure and movement over the globe. About 13 tropical cyclones affect Australia every season and their general characteristics, for instance track and intensity, have already been documented (Dare and Davidson 2004). However, little is known about cyclone structure and often best track data contain few details on this aspect. Foley (2012) has recently reviewed and updated the Australian tropical cyclone best track dataset since the implementation of the Dvorak technique to produce comprehensive and coherent estimations of tropical cyclone intensity. Having the structure parameters, like radius of outer closed isobar (ROCI), radius of gale-force winds (R34), and radius of maximum wind (RMW) included in best track data would improve understanding of tropical cyclone structure in the Australian region, provided that validated estimates of these parameters can be made. We have developed algorithms to estimate ROCI, R34 and RMW for the best track. The estimations are based on (a) wind analyses from the European Centre for Medium-Range Weather Forecasts Interim Reanalysis, and (b) a dynamical vortex specification technique of estimating structure from central pressure and objective ROCI estimates. These algorithms are tested and validated against other extended best track datasets (e.g. from the Joint Typhoon Warning Center and Demuth, 2006) with mean absolute errors of less than 100 km for ROCI. In addition, the quality of the vortex specification has also been demonstrated via the operational performance of ACCESS-TC, in which it is used to build the initial vortex structure. The methodology is further applied to the Australian region to create an extended best track dataset including all tropical cyclones from 1979. The new dataset will provide insights into general tropical cyclone structure in the basin as well as the spatial variability and trends in the past 30 years.

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Session: 05. General Climate - variability of the climate system
Presenting Author: Dr. Angela M. Maharaj

Unravelling Eastern Pacific and Central Pacific ENSO contributions in South Pacific chlorophyll-a variability

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El Niño – Southern Oscillation (ENSO) is regarded as the main driver of phytoplankton inter-annual variability. Since the advent of remotely sensed surface chlorophyll-a (Chl) it has been possible to observe and examine phytoplankton variability at a resolution and scale which allows for the investigation of the impact of climate signals such as ENSO. We use more than 13 years of Chl remote sensed observations across the Tropical and South Pacific to isolate and examine the spatial development of Chl during ENSO: its canonical variability or Eastern Pacific mode, and, arguably, its non-linear evolution, the El Niño – Modoki (EM) or Central Pacific mode, using the extended empirical orthogonal function technique. We describe how an Eastern Pacific (EP) ENSO phase transition affects Chl, and identify an interannual Central Pacific (CP) mode induced spatial pattern. This analysis extends earlier work by allowing us to examine and discuss EP and CP ENSO as propagating modes which takes into account leads and lags in the data.

Session: 05. General Climate - variability of the climate system
Presenting Author: Acacia Pepler

The relationship between El Niño-Southern Oscillation, wind patterns, and rainfall on the Eastern Seaboard of Australia

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The Eastern Seaboard of Australia is a unique climate entity, where the known relationship between winter-spring rainfall and the major drivers of climate variability in other parts of eastern Australia (such as the El Niño-Southern Oscillation, ENSO) is very weak. One potential factor contributing to this weakened relationship is the interaction between the Great Dividing Range and zonal wind patterns, with anomalous easterly winds tending to enhance rainfall east of the divide throughout the year, but suppress rainfall in southeast Australia west of the divide (Rakich et al. 2008).

In this paper we explore the relationship between wind patterns in eastern Australia and climate drivers such as the El Niño-Southern Oscillation and the Indian Ocean Dipole, and the impact of these relationships on rainfall patterns on the east coast of Australia. As observed in Jones & Trewin (2001), during the winter months El Niño years are associated with easterly wind anomalies and La Niña years with westerly anomalies, with this relationship reversing during summer. This seasonality, and the additional influence of the Indian Ocean Dipole, explains a large proportion of the relationship between ENSO and rainfall along the east coast.

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Session: 05. General Climate - variability of the climate system
Presenting Author: Acacia Pepler

An objective database of East Coast Low events: Development and verification

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East Coast Lows (ECLs) are intense low pressure systems that form off the subtropical east coast of Australia, between Wilsons Promontory in eastern Victoria and southeast Queensland. They contribute a substantial proportion of annual rainfall in this region, particularly during the cool months, with the potential to cause widespread flooding, damaging winds and heavy sea conditions along the coast. Due to their tendency to bring severe weather and importance for water security along the coast, it is valuable to develop a systematic, objective and consistent database of such ECL events. This will allow groups including the research community and Emergency Management Authorities to better understand the distribution of ECLs and their impacts. In this paper we present a database that uses one such objective scheme (Jones 1994) to identify and track past ECLs in reanalysis pressure fields. We examine in detail the performance of this objective scheme in relation to pre-existing subjective databases of ECL events (Speer et al. 2009), and discuss the advantages of the objective scheme over previous approaches. We also present a discussion of the variability and trends in ECLs identified in this objective database between 1950 and 2008.

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Session: 05. General Climate - variability of the climate system
Presenting Author: Robert Rizzo

The connection between ENSO and Fire Weather Day frequency in Melbourne, Victoria, 1951-2012

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In using the predictive fire weather criteria as outlined by Stern, H and Williams, M, 1989, daily climatic and weather data was analysed for the Melbourne region to produce a record of fire weather day frequency from 1951 to 2012. In the process of comparing ENSO/SOI weather records with the occurrence of the calculated fire weather days, it was found that a higher number of fire weather days occurred during El Niño events, but interestingly on average was equal with the Neutral phases that occurred. La Niña events had the lowest frequency of fire weather days, which helped to conclude that El Niño and Neutral events were more likely to bring dry, hot and windy weather that promote a greater risk of fire weather days. The connection between the IOD and ENSO was also explored which showed that Positive IOD events were associated with a high frequency of fire weather days rather than Negative IOD events. The SAM phenomenon and it's link to fire weather frequency in Melbourne could also be investigated to further the objectives of this study.

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Session: 05. General Climate - variability of the climate system
Presenting Author: Sergei Soldatenko

Impact of climate variability on the large-scale atmospheric waves in the Southern Hemisphere

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Climate variability and climate change create various impacts on the Earth's natural system and human society. The study of links between climate variability and large-scale atmospheric dynamics represents a very important area of research for the scientific community around the world. Planetary-scale waves, large-scale barotropic and baroclinic waves and associated their eddies (cyclones and anticyclones) act as a mechanism for energy transfer influencing weather patterns (e.g. the blocking formation) and extreme events across wide geographical areas.

The primary focus of this study is to investigate the stability of the zonal flow taking into account changes in meridional temperature gradient for the last several decades. This gradient is one of the most essential parameters that indicates the amount of available potential energy that can be converted into the large-scale eddy kinetic energy. Thus, the meridional temperature gradient strongly affects baroclinic instability, generation of large-scale eddies, planetary atmospheric dynamics and characteristics of large-scale atmospheric waves. Therefore it influences the predictability of all atmospheric processes.

We perform a stability analysis of the zonal flow based on an atmospheric primitive equation model. The model equations are simplified by a specific averaging technique over the vertical coordinate to obtain a two-dimensional set of equations that describe the dynamics of a two-dimensional baroclinic film in the field of the Coriolis force. This model describes all the wavelike solutions that correspond to the main weather-forming modes of the three-dimensional models and therefore can be used in theoretical studies of large-scale dynamic processes in the atmosphere.

In studying and analysing the zonal flow stability the model equations are linearised around the unperturbed atmospheric state that corresponds to the zonal flow. In the assumption that the solution has the form of a superposition of waves, the dispersion relation is obtained that explicitly includes the term containing the meridional temperature gradient and an averaged value of the zonal flow velocity. This term is estimated using climate data for the last 60 years. By varying this term the sensitivity of the zonal flow stability with respect to this gradient is obtained.

Session: 05. General Climate - variability of the climate system
Presenting Author: Fubao Sun

Changes in the variability of global land precipitation in observations and in models

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In many instances, e.g., agricultural and natural ecosystems, and for water resources planning, changes in the variability (or upper/lower extremes) of precipitation (P) (e.g., floods and droughts) can be as important as changes in the mean. With global warming, climate models project increased P variability in most regions at daily, monthly and interannual timescales. In this study, we analyse observations (1940-2009) and climate model output (1940-2099) of monthly P (1940–2099) over the global land surface using a new theoretical framework that can distinguish changes in global P variance between space and time. We report how global land P variability has changed in the recent past and how it is projected to change in future.

Session: 05. General Climate - variability of the climate system
Presenting Author: Carly Tozer

How "Nature's Limit" changes over time – A South Australian perspective

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Since its establishment in 1865, Goyder's Line has been known in South Australia as the division between land suitable for cropping and land only viable for pasture. Current cropping areas however extend beyond this line, suggesting that either a) the line is not well defined, b) cropping is currently occurring on 'non-viable' land or c) the line is variable from year to year. George Goyder is said to have used native flora, the experience of local graziers and very basic rainfall records to determine what some might call "nature's limit" to agriculture. In this study, the 220 mm growing season rainfall (April to October) isohyet for the period 1919 to present day was used as a proxy for Goyder's Line in order to assess its temporal and spatial variability. Results confirm that the location of Goyder's Line does in fact vary from year to year and this appears to be the most likely reason that current cropping areas extend beyond Goyder's Line. Further, using indices of the El Niño/Southern Oscillation, Indian Ocean Dipole and the Southern Annular Mode it is shown that climate state significantly influences the location of Goyder's Line. For example, Goyder's Line is located further south (relative to its average location) during El Niño events and further north during La Niña years. These results give an indication of the key influences on South Australia's climate and agricultural zones and have important implications for farm and natural resource management.

Session: 05. General Climate - variability of the climate system
Presenting Author: Nicholas Tyrrell

Influence of oceans on land surface temperature variability

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In global warming scenarios continental surface temperatures warm with greater amplitude than sea surface temperatures, leading to a land-sea temperature contrast. This temperature amplification over land is also seen in the warming and cooling of natural variability on interannual timescales. While the temperature contrast is due in part to the larger heat capacity of oceans and differences in surface moisture availability it is hypothesised that the tropical oceans are a major cause of the increased temperature variability of the land surface, and warming and cooling signals in the tropical oceans are amplified over continents.

Focusing on natural variability in observations and models, it is shown that strong correlations exist between tropical SSTs and global land surface temperatures. The relationship between these correlations and the land-sea contrast is investigated, as is the role of ENSO and a lagged relationship between Pacific SSTs, global tropical SSTs and land surface temperatures. SST perturbation experiments are presented that show perturbations in tropical oceans elicit a tropospheric temperature response, which is not seen for perturbations in extratropical oceans. The results of further studies comparing the effect of increased interannual variability in tropical verse extratropical ocean SSTs and the resulting land surface temperature response will also be presented.

Session: 05. General Climate - variability of the climate system
Presenting Author: Meelis J. Zidikheri

Attribution of interdecadal changes in mean circulation and variability using inverse modelling

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There have been substantial observed interdecadal changes in the mean circulation and associated variability during the second half of the 20th century. Attributing the causes of this observed climate change to a variety of physical and dynamical processes is a problem of great contemporary significance in climate science. Understanding the extent to which these changes are due to natural internal variability and the extent to which they are due to a systematic shift in the climate resulting from increasing anthropogenic greenhouse gases is of major scientific and policy concern. In this study, a method is presented for attributing changes in climate states using an inverse modelling procedure. The method makes use of observed interdecadal anomalies and model dynamics to deduce the anomalous `forcing functions' corresponding to climatic fields such as circulation and temperature. These forcing functions, unlike the fields themselves, are free of the internal variability of the climate system and are instead direct representations of the effects of climatic drivers such as changing greenhouse gas concentrations and sea surface temperatures. We apply the method to anomalous climate states corresponding the period 1975—1984 relative to the base period 1959—1968 for the months of January and July as determined by NCEP/NCAR reanalysis data. In applying the method, we use a new modified form of the two-level quasigeostrophic model on the sphere, which provides a good representation of mid-latitude dynamics. We show that the calculated forcing functions reproduce the observed anomalous climate states and variability quite well. The forcing functions consist of localised patterns of temperature forcing superimposed with global patterns of enhanced warming at high latitudes relative to low latitudes. The implications of these results are discussed.

Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: Birtukan Biadglgne

Estimating temperature and moisture fields using GNSS satellites in the Australian region

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Monitoring environmental and climate change from space requires high precision and accurate earth observations. In recent years the revolution in GPS technology has emerged as a powerful, inexpensive new technique with capabilities of providing high temporal and spatial resolution data for sounding the atmosphere in all weather and over both land and water. GPS meteorology provides a record of high quality measurements of atmospheric parameters (temperature, pressure, specific humidity) essential for meteorological, climate, environmental and disaster prevention applications. Atmospheric information is retrieved using GPS technology by two distinct measurement techniques, namely, GPS radio occultation (GPS RO) and 'ground-based GPS' measurements. GPS RO is a satellite-to-satellite, limb sounding technique based on measuring the bending of GPS radio signals in the atmosphere. The GPS radio signals are bent or refracted when propagating through the Earth's atmosphere. This information can then be used, assuming a spherical symmetry, to yield refractive index profile and subsequently temperature profile of the atmosphere.

The second measurement technique is ground based GPS. This technique is the ground based version of the above mentioned space born system. The Global Positioning System (GPS) signals experience a propagation delay when passing through the atmosphere to a receiver near the surface of the Earth. The time delay for a signal to propagate from transmitter to a receiver is converted to provide an estimate of the total integrated water vapour in the vertical column above a receiver on the Earth's surface. An accuracy of ~1mm can be obtained using the technique.

In Australia, the space based (RO) and ground-based GPS measurement technique for meteorology (NWP), and climate monitoring has been assessed through research and demonstrated operational activities. Its positive impact on operational weather forecast models, powerful temperature profiling capability, and comparable result with radiosonde sounding measurements indicates the technique's potential capability in meteorological applications.

Since 2006, The Bureau of Meteorology has collaborated with RMIT on GPS RO and GPS Ground based research and experimental development. This paper presents comparison of atmospheric profiles of temperature and water vapour derived from LEO satellites with radiosonde measurements from selected locations in Australia, and comparison of ground base GPS derived water vapour with radiosonde datasets obtained from the Australian Bureau of Meteorology (BOM) upper air archive. Statistical and visual comparison shows that the difference between radiosonde observations and the data retrieved from GNSS are well within acceptable limits, confirming its usability as a meteorology data source.

Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: Tiim Cowan

Rainfall reductions over Southern Hemisphere semi-arid regions: the role of Subtropical Dry Zone Expansion

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From the late 1970s to the 2000s, Southern Hemisphere semi-arid regions such as southerncoastal Chile, southern Africa, and southeastern Australia, including Tasmania, experienced a drying trend in austral autumn, predominantly during April and May. The rainfall reduction coincides with a poleward expansion of the tropical belt and subtropical dry-zone by around 2°– 3° in the same season. This has raised questions as to whether the regional rainfall reductions are attributable to this poleward expansion of this dry-zone or edge of the Hadley Cell circulation. Here we show that the impact of the poleward subtropical dry-zone shift is not longitudinally uniform: a clear shift occurs south of Africa and across southern Australia, but there is no evidence of a poleward shift in the southern Chilean sector. As such, a poleward shift of climatological April-May rainfall can explain most of the southeastern Australia rainfall decline, a small portion of the southern Africa rainfall trend, but not the autumn drying over southern Chile. How well the most current suite of CMIP5 climate models perform at simulating these drying trends and the relevant dynamics will also be discussed.

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Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: Clem Davis

Extending the long term temperature records for Canberra Airport

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Canberra Airport is one of Australia's climate reference stations and has continuous records since its commencement in March 1939. However, there are also monthly records available from other sites around Canberra dating back to 1910.

This paper investigates how the monthly maximum and minimum record for Canberra Airport can be extended back to 1910 by examining correlations between these various records through the use of linear regression analysis. The results of this analysis indicate that monthly maximum and minimum temperature data sets with a high degree of accuracy can be developed which extends the Canberra Airport site record back to 1910. These data sets were then analysed to identify any long term trends that may be evident.

Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: Clem Davis

Comparison of the Canberra Airport observation sites 2006-2010

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In September 2008 the Bureau of Meteorology established a new site at Canberra Airport in response to the possible impact on the old site from development that had occurred around the site during 2006-2008. The old site was subsequently closed in November 2010. The new site is located around 400m further to the south.

This analysis investigates the differences in rainfall and maximum and minimum temperatures between the sites by analysing the daily records over the two years of overlapping data available from the Bureau of Meteorology website and considers the possible adjustments that may need to be applied in order to continue to use the site as a long term climate reference station.

Overall, maximum temperatures are generally within 0.2C except for temperatures above 29.4C where the new site appears to be 0.4C warmer. This has impacts on the climate records on days of 30C or more. Minimum temperatures at the new site are consistently around 0.5-0.6C cooler across the whole range.

Further comparisons against the Tuggeranong Automatic Weather Station were investigated to identify any changes to the old site during the 2006-2008 period compared to the pre 2006 period that could impact on the records before the new site had commenced, particularly with respect to the minimum temperatures.

Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: Catia Domingues

Human-induced global ocean warming on multidecadal timescales

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Large-scale increases in upper-ocean temperatures are evident in observational records. Several studies have used well-established detection and attribution methods to demonstrate that the observed basin-scale temperature changes are consistent with model responses to anthropogenic forcing and inconsistent with model-based estimates of natural variability. These studies relied on a single observational data set and employed results from only one or two models. Recent identification of systematic instrumental biases in expendable bathythermograph data has led to improved estimates of ocean temperature variability and trends and provide motivation to revisit earlier detection and attribution studies. We examine the causes of ocean warming using these improved observational estimates, together with results from a large multimodel archive of externally forced and unforced simulations. The time evolution of upper ocean temperature changes in the newer observational estimates is similar to that of the multimodel average of simulations that include the effects of volcanic eruptions. Our detection and attribution analysis systematically examines the sensitivity of results to a variety of model and data-processing choices. When global mean changes are included, we consistently obtain a positive identification (at the 1% significance level) of an anthropogenic fingerprint in observed upper-ocean temperature changes, thereby substantially strengthening existing detection and attribution evidence.

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Gleckler, P. J., B. D. Santer, C. M. Domingues, D. W. Pierce, T. P. Barnett, J. A. Church, K. E. Taylor, K. M. AchutaRao, T. P. Boyer, M. Ishii, and P. M. Caldwell, 2012: Human-induced global ocean warming on multidecadal timescales. Nature Clim. Change, 2, 524-529, http://dx.doi.org/10.1038/nclimate1553

Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: to be determined

On the changing nature of Australian monthly and daily temperature anomalies

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In this presentation, we perform a calculation similar to that of Hansen et al. 2012 (seasonal temperature anomalies analysed globally), but applied to Australian daily and monthly temperature anomalies using the ACORN-SAT homogenised daily temperature dataset. This involves calculating the distributions of standardised temperature anomalies for each decade between 1951 and 2010, the standardisation being performed with respect to the base period 1951-1980 which pre-dates the most recent warming seen in the last ten to twenty years. We use both daily and monthly location data from the ACORN-SAT dataset, supplemented by the national analyses of the ACORN-SAT monthly data.

Standardised monthly maximum temperature anomalies in 2001-2010 are substantially and markedly warmer than in previous decades (this is also the case in the daily data), whereas minimum temperature anomalies show a steadier pattern of warming with 2001-2010 merely continuing an established trend. Autumn, spring and summer maximum temperatures show this same characteristic (winter maximum temperatures being more in the "continuing the established trend" line). For spring and summer, the discrepancy between 2001-2010 and previous decades is particularly marked in the upper end of the distribution, indicating something more than just an upward shift in the mean of the distribution.

2001-2010 isn't the warmest decade in the study period in all seasons for minimum temperature (e.g., 1981-1990 is the warmest for autumn, and 2001-2010 is very similar to 1991-2000 for winter), although it is the case for spring and summer. Spring minimum temperature standardised monthly anomalies show a pattern of each decade being warmer in distributional terms than the preceding ones. The autumn and winter results for minimum temperature are consistent with recent rainfall declines in those seasons in the most data-dense parts of southeastern and southwestern Australia.

Reference:

Hansen et al. (2012). Perception of climate change. Proceedings of the National Academy of Sciences of the United States of America. doi/10.1073/pnas.1205276109.

Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: Branislava Jovanovic

Homogenised monthly upper-air temperature and humidity datasets for Australia

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Discontinuities in climatological time-series can be caused by a range of factors. For surface data these include station relocations and changes in instrumentation and exposure. For upper-air data these factors are predominantly related to changes in the types of sondes and observing practices, such as the sounding time. It is important to develop homogenous series that are adjusted in points of discontinuity, with the aim of gaining greater confidence in obtained trends.

Here we will present on-going work related to the development of the homogeneous monthly upper-air temperature and humidity datasets of 28 stations, produced in order to analyse trends in these variables over the Australian mainland and remote islands. Datasets are based on 23UTC soundings for the standard levels of 850, 700, 500, 400, 300, 200, 150 and 100 hPa. Most records start from 1958. Adjustments of the time-series were determined using historical metadata and an objective statistical test for break-points.

Results after homogenization suggest that there have been temperature increases over time at all levels in the troposphere, while stratosphere temperatures have decreased. Radiosonde temperature data were also assessed against temperature data retrieved from the NCEP/NCAR reanalysis. For humidity (represented by the dew point temperature, DWPT) it was found that the number of daily data was reduced at all levels except 850 hPa in the period 1958 to 1991, preventing computation of monthly means. Because of that we first analysed DWPT time series over the 1992-2011 period, when data are likely to be mostly homogeneous. Initial results suggest predominantly increasing trends in DWPT in the north, with the mixed increases and decreases in the remaining part of Australia. In order to be able to produce monthly means and analyse DWPT time series for the full period 1958 to 2011, an attempt was made to infill missing daily DWPT by calculating it from the formula proposed for the WMO Hygrometer Intercomparison.

Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: Dr. Angela M. Maharaj

ENSO and global ocean chlorophyll in a changing climate

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This paper characterises differences between the classic canonical (EP) El Niño – Southern Oscillation (ENSO) climate phenomenon and Central Pacific (CP) ENSO in their upper ocean biological response. Based on analysis of satellite remote-sensed chlorophyll-a (Chl-a) estimates since the late 1990s, we find that the leading mode of interannual variability (~10% of global deseasonalised Chl-a variance) represents the coupling of Chl-a with CP El Niño, including a decadal-scale, or longer-term, trend. Whether this trend is natural or otherwise (e.g., anthropogenic), the limited record length makes it difficult to conclude. Back-reconstruction of the dominant mode time series to 1870 nevertheless suggests that CP El Niño has been the key driver of Chl-a changes since the late 1990s, and the decadal-scale coupling has increased in amplitude. We estimate that CP El Niño induced a "near-global" ±0.5389 $Pg.C.yr^{-1}$ changes in ocean net primary productivity from 1998-2010 (±0.6243 $Pg.C.yr^{-1}$ when coupled with the long term trend), while EP ENSO was responsible for ±0.3924 $Pg.C.yr^{-1}$. The decadal or longer term trend is quantified at -0.14 $Gg.C.yr^{-1}$ These findings highlight the link between interannual and decadal-scale climate drivers on global ocean net primary productivity since the turn of the 21st century.

Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: Harvey Stern

The distribution of climate zones across Australia: identifying and explaining changes during the past century

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Köppen's scheme to classify world climates was devised in 1918 by Dr Wladimir Köppen (Köppen, 1931) and is based on the concept that native vegetation is the best expression of climate, climate zone boundaries having been selected with vegetation limits in mind (Trewartha, 1943). A modification, which addressed some concerns that had been expressed about the Köppen scheme, was developed by Stern et al. (2000) and illustrated with its application to Australia. The paper describes the application of the latest Australian Water Availability Project (AWAP) (Jones et al. 2009 and Raupach et al. 2009) analyses of monthly rainfall, maximum temperature and minimum temperature to the modified climate classification scheme. By this means, changes in the distribution of climate zones across Australia during the past century may be identified and explained.

It is found that during the past century, many changes in the distribution of Australian climate zones have taken place, the most notable one being the contraction of the area covered by 'Desert' climates and the corresponding increase in the area covered by 'Grassland' and 'Tropical' climates. Other changes across Australia include the expansion, and southward advance, of the 'Tropical' zone; the contraction of the 'Temperate' area of southwest Western Australia; a decrease in the area of coastal Victoria classified as having a 'cool summer'; and, an increase, followed by a decrease, in the area covered by 'Temperate' climates.

Possible explanations for some of the detected changes in the distribution of climate zones are given. For example, the contraction of the area covered by 'Desert' climates, and the corresponding increase in the area covered by 'Grassland' and 'Tropical' climates, may be attributed to the apparent northward shift of the sub-tropical jet over the past century, and the associated increase in the frequency of the 'blocking' phenomenon over the Tasman Sea.

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Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: Blair Trewin

Changes in extreme temperatures in Australia, 1910 to 2011

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Changes in daily extreme temperatures have been analysed for Australia for the period from 1910 to 2011, using the new Australian Climate Observations Reference Network – Surface Air Temperature (ACORN-SAT) data set. Observed changes in daily extremes are largely consistent with observed increases in annual mean temperature, with increases in most indicators of extreme high temperatures and decreases in most indicators of extreme low temperatures, particularly since 1950. Averaged nationally, the frequency of daily maximum temperatures above the 90th percentile has increased by about 30 per cent over the century and that of minimum temperatures above the 90th percentile has increased by about 50 per cent, while the frequencies of maximum and minimum temperatures below the 10th percentile have decreased by about 40 and 45 per cent respectively. A few recent changes counter to national trends, such as increases in the frequency of low minimum temperatures in autumn and winter in parts of southern and eastern Australia, and of low maximum temperatures in the wet season in tropical Australia, are consistent with local rainfall trends. Record high temperatures, both maximum and minimum, occur disproportionately in the last 11 years (2001-2011), during which record-high temperatures have outnumbered record lows by a ratio of 2.8 to 1 (maximum) and 5.2 to 1 (minimum). Indicators of five-day extremes also show changes consistent with warming but those changes are mostly less pronounced than those for single-day extremes.

Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: G Wang

Rainfall trends from stations, merged analyses, reanalyses and GCMs over the Tropical Pacific

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Regional rainfall climate change detection and attribution is a challenging task. One major challenge is ensuring that the historical data-set used accurately represents the observed variability. For the tropical Pacific region two merged analyses of observational rainfall estimate products (GPCP and CMAP) show different regional annual averaged rainfall trends over the last three decades.

In this study we document rainfall trend characteristics over the tropical Pacific from various data sources, including station data from the Pacific Islands, merged analyses, reanalyses, and simulations from coupled and uncoupled atmosphere and ocean general circulation models.

Understanding the differences and uncertainties in rainfall trends from different datasets over this region will enhance our confidence in conducting rainfall attribution and projection work.

Session: 06. General Climate - detection and monitoring of climate change
Presenting Author: Ian Watterson

Near-term and long-term future trends in Australian climate

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The 2007 projections for climate change over Australia from CSIRO/BOM were based on the 'pattern scaling' approximation that local changes in temperature and rainfall over the 21st century from each of the CMIP3 models are proportional to the model's global mean warming. The CMIP5 experiments included two diverging forcing scenarios, RCP8.5 and RCP4.5, as well as simulations for the near-term, with initialised climate states. How well do the trends 'per degree of global warming' from these compare, particularly for the Australasian region. Do Australian rainfall changes relate as closely to the pattern of equatorial sea surface temperature changes as they did in CMIP3? When are the forced changes likely to exceed the range associated with unforced interdecadal variability? These questions are being addressed to support a new project that will provide projections for each of the Australian Natural Resource Management regions. Preliminary results indicate that there is much similarity in CMIP5, with regard to the scaling and relationships seen in CMIP3. Updated findings will be presented at the Conference.

Session: 07. General Climate - developments in climate modelling
Presenting Author: Elodie Charles

Towards the implementation of wind-wave physics into climate models

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Located at the interface between ocean and atmosphere, wind-waves are part of the climate system and affect processes in and between oceanic and atmospheric boundary layers as well as the marginal sea ice zone characteristics. Present climate models do not take into account or simplify certain wave-dependent processes. In the context of climate change, coupled climate models are a precious tool to help assessing our future environment. Including wind-wave physics in those models would be a step towards a better representation of physics, with the aim to reduce model biases and projection uncertainties.

The present study aims (1) to define the wave-dependent processes that can have a significant impact on climate projections, and (2) to initiate the implementation of a wave model in a coupled climate model for long-term simulations.

Wave feedbacks on ice, atmosphere and ocean are numerous and affect, among others, momentum and energy fluxes, turbulence in boundary layers, gas, mass and heat exchanges, albedo and sea ice floe size and concentration. For instance, the momentum transfer between ocean and atmosphere depends on the surface roughness, which itself depends on the local sea state. Present parameterizations of the surface roughness use a wind-dependent Charnock coefficient instead of a wave-dependent one, missing waves generated in remote areas, such as swell. However, little is known about their magnitude at climate scale.

The inclusion of a wave model into a coupled climate model aims at better assessing the magnitude of those wave feedbacks and their effect on climate projections. The wave model WAVEWATCH III (NOAA) is implemented into the coupled climate system ACCESS 1.3 (CAWCR). The OASIS 3 coupler (CERFACS) allows transferring surface wind conditions from the atmospheric model (Unified Model, UKMO) to the wave model and wave-dependent Charnock coefficient from the wave model to the atmospheric model. This is a first step towards a fully coupled wave-atmosphere-ocean-ice model.

Session: 07. General Climate - developments in climate modelling
Presenting Author: Andrew Cottrill

Verification study of seasonal forecasts in the Pacific region using the POAMA and SCOPIC models.

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Pacific Island countries and their economies are vulnerable to large changes in rainfall which are associated with the different phases of the El Niño–Southern Oscillation (ENSO). Locations close to the equator experience higher rainfall in El Niño years and lower rainfall in La Niña years, whereas countries in the southwest Pacific experience opposite patterns. Typically, El Niño and La Niña events tend to last one year or longer and this accounts for much of the skill in the statistical and dynamical models used for seasonal forecasting in the Pacific region.

We assess the skill of a dynamical model, the Predictive Ocean-Atmosphere Model for Australia (POAMA) and a statistical model called the Seasonal Climate Outlooks for Pacific Island Countries (SCOPIC), both developed by the Australian Bureau of Meteorology. Over the last decade, seasonal forecasts have become more frequently used in the Pacific region, but no formal assessment has been completed to measure the skill of these two forecast systems.

The dynamical model POAMA has good skill across most of the equatorial Pacific and parts of the southwest Pacific, but has lower skill in some countries, especially where local topography has an influence on rainfall. In contrast, SCOPIC has comparable skill to POAMA in predicting rainfall at short lead times due to the longer period of observations used to train the model, but it does not have the ability to provide forecasts on other important climate variables (e.g. surface air temperature, mean sea level pressure and sea surface temperature) which are potentially useful in seasonal forecasting. This analysis highlights some aspects of higher and lower skill from both seasonal forecast systems. Overall, POAMA and SCOPIC can assist the Pacific Island countries with seasonal forecasts and prepare them to adapt to climate change in the near future.

Session: 07. General Climate - developments in climate modelling
Presenting Author: Ian Enting

Offsetting methane emissions - an alternative to GWPs

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Global Warming Potentials (GWPs) have been widely adopted for comparing the climate impact of different greenhouse gases. Many authors have noted problems with using GWPs to define emission equivalence in spite of the use of GWPs for this purpose in contexts such as the Kyoto Protocol. We propose that for methane, an appropriate comparison is between ongoing emissions of 0.9 to 1.0 kg of CH4 per year and one-off emissions of 1 tonne of carbon, rather than the conventional approach of trying to define emission equivalence.

Our approach corresponds to an approximate solution to the inverse problem of defining a forcing equivalent index (FEI) that gives exact equivalence of radiative forcing over a range of timescales. In our approach, if ongoing methane emissions are offset by a one-off carbon removal that is built up with 40-year *e*-folding time, then the result is almost radiatively neutral over periods from years to centuries. In contrast, the GWP provides radiative equivalence (in integrated terms) only at a single time, with large discrepancies at other times. As has been previously noted (Smith et al 2012) stabilising CO_2 requires an effective cap on integrated emissions, while stabilising methane requires stabilisation of ongoing emissions. Our quantitative treatment recognises that, on time scales of centuries, removal of 1 tonne of carbon only lowers the atmospheric carbon content by 0.3 to 0.35 tonnes.

For rangeland grazing systems, in the absence of effective mitigation techniques for methane from rangeland systems, this approach may provide an attractive offset mechanism in spite of requiring that woody vegetation be established and maintained over about 15% of the landscape, or an equivalent amount of carbon storage in soil.

References:

S. M. Smith et al. (2012). Equivalence of greenhouse-gas emissions for peak temperature limits. Nature Climate Change, 2, 535-538.

Session: 07. General Climate - developments in climate modelling
Presenting Author: Charmaine Franklin

Evaluation of clouds and precipitation in ACCESS using satellite simulators

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CloudSat, CALIPSO and ISCCP observations and simulators are used to evaluate the modelled cloud cover, condensate properties and cloud optical depths in ACCESS1.3. The global horizontal distribution of cloud in the model is generally well represented. The modelled cloud top heights agree with the observations in the upper troposphere, however, there is a lack of midlevel cloud in the tropics and midlatitudes. The high cloud cover in the Tropical Warm Pool region compares well with CALIPSO, however, the modelled radar reflectivities and lidar scattering ratios are biased towards lower values, suggesting that the ice water content and particles sizes in the model are too small. Southern Ocean cloud cover is underestimated and the radar simulator shows that the model simulates too many occurrences of reflectivities between -10 and 0 dBZ below 5 km, consistent with an overestimate of drizzle occurrence. A sensitivity experiment that reduced the ice aggregate fall speeds improves the modelled cloud properties by increasing the frequency of occurrence of large scattering ratios in high cloud and optically thick low clouds.

Compositing results in the tropics as a function of both the large-scale dynamics and thermodynamics allows the coupled control of these factors on the cloud fields to be seen. The modelled reflectance, which is a proxy for cloud optical depth, scales predominately with SST in the subsidence regions and compares reasonably well with the observations. For the convective regimes, the cloud properties in the model that contribute to the reflectance such as the liquid/ice water paths are controlled more by SST, rather than the dynamics like in the observations.

ACCESS1.3 generally has a good representation of cloud, however, the lower sensitivity of convective regime cloud properties to large-scale dynamics, the underestimate of ice water content and particles sizes in high clouds and the too frequent occurrence of drizzle may impact the modelled cloud feedbacks and regional precipitation associated with current and perturbed climates.

Session: 07. General Climate - developments in climate modelling
Presenting Author: ned haughton

Climate model ensemble generation and model dependence

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Climate model ensembles give us the ability to make probabilistic projections of future climate. Independence between models is vital to ensure reliable projections. But how do we ensure that ensembles are generated to ensure maximum independence? We use a low-resolution coupled atmosphere-ocean general circulation model (AOGCM) to generate three ensembles using techniques: initial conditions perturbations, physical parameter perturbations, and structural perturbations (rep- resenting a multi-model ensemble). We compare the outputs of the three ensembles using simple averaging, performance based weighting, and independence weighting (using the methodology of Bishop and Abramowitz, 2012), to look at ensemble mean and spread. We find that the different techniques produce very different ensembles. Initial conditions perturbations produce ensembles that are too narrow, while perturbed parameters and structural ensembles may exhibit too much spread. We then use the same procedures to compare projections generated by the same ensembles. Projections using unweighted averaging are likewise too narrow for initial conditions ensembles, and too broad for structural ensembles. Performance weighting is shown to improve the mean estimate, but may actually degrade the estimate of variance. We show that Bishop and Abramowitz's (2012) independence transformation can improve ensemble mean and variance projections.

Reference:
Bishop, C. H. and G. Abramowitz (2012). "Climate model dependence and the replicate Earth paradigm". Climate

Dynamics. In Review.

Session: 07. General Climate - developments in climate modelling
Presenting Author: Rachel Law

The Community Atmosphere Biosphere Land Exchange (CABLE) model, Version 2.0.

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The Community Atmosphere Biosphere Land Exchange model calculates the fluxes of momentum, heat, moisture and carbon between the land surface and the atmosphere. The model can operate in a 'stand-alone' mode, using prescribed meteorological forcing, or the model can be coupled to an atmospheric model, such as ACCESS. CABLE has a growing user community both in Australia (at CSIRO, the Bureau of Meteorology, 11 universities and two other institutions) and overseas (18 institutions including 5 in China).

CABLE-2.0 was released in late 2012. Compared to the previously released CABLE version (1.4b), this version supports the simulation of multiple vegetation types in a model grid-cell and updates some of the science code. It also includes (initially for stand-alone applications) a biogeochemical module, CASA-CNP. CABLE-2.0 code is structured into science routines that are common to both stand-alone and ACCESS applications and interface routines that differ across applications. The principal method for distribution of CABLE2.0 is through a Subversion code repository hosted by the National Computer Infrastructure. This is an important step, allowing for CABLE development to be more easily integrated across the CABLE community.

CABLE-2.0 has been benchmarked for single-sites using flux tower data, for global stand-alone applications and for ACCESS atmosphere-only simulations. A summary of results is available at https://trac.nci.org.au/trac/cable/wiki/CableBenchmarking with links to the single-site results submitted to the Protocol for the Analysis of Land Surface models (PALS) website (http://www.pals.unsw.edu.au). ACCESS simulations with CABLE-2.0 generally perform similarly to the ACCESS1.3 simulations submitted to CMIP5. The default leaf optical properties for CABLE2.0 have been recalibrated to improve the simulation of surface albedo compared to ACCESS1.3.

Session: 07. General Climate - developments in climate modelling
Presenting Author: Simon Marsland

20th Century climate of the ACCESS ocean model under co-ordinated ocean-Ice reference experiments

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The ACCESS Ocean Model (ACCESS-OM) 20th century climate is evaluated through a series of international inter-comparison studies: variability of the Atlantic Meridional Overturning Circulation; thermosteric sea level rise; and the Southern Ocean's role in climate. ACCESS-OM comprises the U.S. NOAA/Geophysical Fluid Dynamics Laboratory Modular Ocean Model (MOM4p1), the U.S. Los Alamos National Laboratory CICE4.1 Sea Ice Model, and the French CERFACS OASIS3.2.5 coupling software. Our simulations contribute to a series of studies known as Coordinated Ocean-ice Reference Experiments (COREs) through the WCRP/CLIVAR Working Group on Ocean Model Development. The CORE Inter-Annual Forcing (CORE-IAF) hindcasts use the atmospheric forcing of Large and Yeager to simulate the period 1948-2007. NCEP/NCAR Re-analysis atmospheric fields are modified with observationally based corrections, and use a standard set of bulk formulae representing ocean-atmosphere boundary fluxes. Results of the 20th Century benchmarking hindcasts are compared with the ACCESS Climate Model historical simulations as submitted to CMIP5.

Session: 07. General Climate - developments in climate modelling
Presenting Author: Ms. Stacey L. Osbrough

Methods of ensemble prediction for seasonal forecasts with a coupled ocean-atmosphere model

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The skill of seasonal ensemble prediction with a coupled ocean-atmosphere model is examined in hindcast simulations during the period 1980 to 2000. The coupled model consists of a global atmospheric model coupled to a Pacific basin ocean model. An ensemble prediction scheme based on perturbations that grow fast over a period of a month is used to generate the perturbations to the analyses; the analyses are obtained by nudging the ocean fields towards observations. The perturbations contain coupled modes with ocean temperature fields that peak in the equatorial regions and atmospheric fields characterised by large scale teleconnection patterns. Parallel algorithms are employed for efficiency. Comparisons have been made between the skill of ensemble mean forecasts with the skill of control forecasts in 12 month hindcasts started each month for the period 1980 to 2000. We have examined how ensemble skill depends on the number, type and amplitude of ensemble perturbations. We have also examined how skill depends on the annual and ENSO cycles. In general the seasonal ensemble scheme results in ensemble mean forecasts that are significantly more skilful than the control forecasts as well as providing error estimates of the forecasts. We compare the effectiveness of ensemble perturbations based on bred vectors with ones based on a new type of perturbation that we call cyclic mode. We find that cyclic mode perturbations are considerably more effective in improving ensemble forecasts between 2 and 8 months. Reasons for this improvement are presented.

Session: 07. General Climate - developments in climate modelling
Presenting Author: Sergei Soldatenko

Sensitivity of an Atmosphere-Ocean System to coupling strength

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Mathematical modelling of the Earth's climate system is a key tool for understanding and studying processes that take place in the real natural environment. The Earth's system consists of several interactive subsystems with different time and spatial scales of motions and physical processes. The correct description of interactions between the components of the Earth's climate system such as atmosphere and ocean, atmosphere and land, atmosphere and ice shield is very important for the quality of numerical weather forecasting (NWP) at various time horizons and prediction of climate variability. In mathematical models the interaction between the Earth's system components is usually linked by means of fluxes of momentum, mass, and heat, which are calculated through different parameterization schemes. Generally speaking, applied parameterization schemes define the coupling strength between subsystems.

To study various aspects of NWP and the prediction of climate variability simplified coupled models are widely used. In these kinds of models certain coupling strength parameters are applied to simulate interactions between subsystems. These parameters play a dominant role in the correct simulation of interactions between subsystems, and their numeric values reflect our knowledge with regard for the physical processes occurring between subsystems.

The objective of this study is to analyse the sensitivity of the dynamics of atmosphere-ocean system to coupling strength parameters. The applied model is a triple coupled Lorenz model that includes the slow 'ocean' subsystem coupled with fast the 'extratropical' atmospheric subsystem and the fast 'tropical' one.

The adjoint approach and forward sensitivity analysis are applied to obtain sensitivity functions that show the impact of variations in coupling strength parameters on the model state variables. It is demonstrated that even small (infinitesimal) variations in these parameters lead to completely different dynamics of the model state variables. Changes in these parameters cause changes in both the Lyapunov exponent spectrum and the phase synchronization of the coupled system.

Session: 07. General Climate - developments in climate modelling
Presenting Author: Harvey Stern

Verifying the accuracy of seasonal climate outlooks – an update

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Seasonal rainfall outlooks have been issued by the Bureau of Meteorology since the late 1980s, whilst minimum temperature and maximum temperature outlooks have been issued from 2000. For almost the entire period, the outlooks have been represented by a map of Australia with the probability of the parameter predicted (total rainfall, mean minimum temperature and mean maximum temperature) exceeding the median.

At the Fifth International Verification Methods Workshop, which was held in Melbourne in December 2011, the present authors delivered a paper verifying the accuracy of these outlooks (Stern and Pollock, 2011). The current paper utilises the methodology applied then to provide an update of that work. The verification methodology for each State, season and prediction element, is as follows:

The outlook is set equal to +1 should there be a region with >60% probability of exceeding the median of the prediction element and no region with <40% probability of exceeding the median of the prediction element.

The outlook is set equal to -1 should there be a region with <40% probability of exceeding the median of the prediction element and no region with >60% probability of exceeding the median of the prediction element. All other outlooks are set equal to 0. The observed value is set equal to the observed area averaged anomaly.

The correlation coefficient between the outlook and the observations is calculated for each State, season and prediction element. The correlation coefficients calculated on the data derived as described above are positive for most States, seasons and prediction elements, especially those for spring and summer rainfall outlooks.

References:

Stern H and Pollock J, 2011: Verifying the Accuracy of Two Decades of Seasonal Climate Outlooks. 5th International Verification Methods Workshop, 1 - 7 December 2011, Melbourne, Australia (go to http://cawcr.gov.au/events/verif2011/ppt/H_Stern.pdf for a copy of the 2011 presentation).

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Adam Blazak

Synoptic typing of sub-daily extreme rainfall events in Queensland

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Short lived, extreme rainfall events can significantly impact on society with flash flooding causing damage to property, infrastructure and in severe cases, loss of life. Regionally, the frequency of extreme rainfall events is projected to increase in the future under climate change scenarios according to IPCC's AR4. Manual synoptic typing is employed to assist in determining potential synoptic situations responsible for short lived, extreme rainfall events over Queensland.

Extreme, sub-daily rainfall events are classified as those which exceed the 1 in 10 year ARI threshold over the periods of 1, 2, 3 and 6 hours. These events are identified using continuous Automatic Weather Station (AWS) data, supplemented with the Queensland Flood History archive. Once identified, these events are categorised into 1 of 7 synoptic situations by analysing MSLP, 500hPa and 200hPa synoptic charts.

A total count of similar synoptic situations over the entire period (2004–2012) provides a basic statistical probability for each scenario causing an extreme rainfall event.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Scott Carpentier

A thunderstorm at Casey Station, East Antarctica

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Reports of thunderstorms at Antarctic stations are extremely rare. Other than the 3 from the old Faraday station on the Antarctic Peninsula, there had been no other verifiable reports until cloud-to-cloud and cloud-to-ground lightning were visually observed on the 17th December 2011 at Casey, East Antarctica,. Three isolated strikes directly over Casey were coincidently detected by the World Wide Lightning Location Network (WWLLN). Though the storm occurred within a long lived convective complex, based on the WWLLN data, it is argued that the sufficient vertical motion to produce electrical discharge was only achieved through a topographically induced process: that is, from the collision of a cold dry surge of continental origin into a moist maritime airmass travelling through a vertically propagating internal gravity wave.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Chris Chambers

Upper ocean temperatures and the distribution of thunderstorms during east-coast lows

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Global Position and Tracking System (GPATS) lightning data and Weather Research and Forecast model (WRF) simulations are used to investigate the distribution of thunderstorms during the life cycle of five east-coast lows. The locations of lightning strikes are overlayed on maps of sea surface temperature (SST) and sea surface height anomalies to look for potential relationships between thunderstorms and ocean conditions. A complex picture emerges of a correspondence between the distribution of upper-ocean temperature gradients and that of lightning strikes. Past research on the effect of SST gradients on surface winds has shown that convergence occurs when air flows from a warm to cold sea surface. In an unstable environment, such as that associated with a cold core upper-level low, this convergence may help to trigger deep convection. The lightning distributions will be discussed in relation to this hypothesis. Results will be presented from high-resolution WRF simulations currently being conducted to establish what atmospheric changes are occurring that contribute to the observed distributions of thunderstorms.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Frank Colberg

Effects of non-linear tidal-surge interaction on present and future storm surges along the Australian coastline

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Present and future sea level rise pose a major threat to low-lying coastal communities. Most significant impacts usually arise from storm surges and extreme wave events and their interaction with astronomic tides. Little is known of this interacation, or how climate change may affect the meteorological drivers of these short lived extreme sea level events. To date, the impact of non-linear tidal-surge interaction along the Australian shelf has not been consistently quantified and, furthermore, it is unclear what, if any, the potential effects on the resulting surge may be.

This study investigates non-linear tidal-surge interaction across the Australian shelf by means of hydrodynamic modelling. A series of barotropic high resolution simulations, covering the whole of Australia's continental shelves and using the Regional Ocean Modelling System (ROMS), have been forced with atmospheric data from the climate forecast system reanalyses. Results from these simulations serve to identify regions of strong and weak non-linear tidal-surge interaction along the Australian shelf. Tidal-surge interaction on the northwest shelf exhibit a seasonal dependency such that during Austral summer month the atmospheric driven surge signal is enhanced by up to 15cm due to non-linear effects. During Austral winter month this relationship is reversed, thus, non-linear tidal-surge interactions tend to reduce the surge signal. These historic simulations are extended to include present and future climates using a suit of CMIP5 climate models to investigate how these processes may change.

Session: 08. Weather and Climate Extremes: Observation, Processes and Modelling
Presenting Author: Dr Andrew J. Dowdy

An objective definition of extratropical cyclones

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Extratropical cyclones that form or intensify near the East Coast of Australia, known locally as East Coast Lows (ECLs), often cause extreme rainfall, wind and wave events to occur. Various different definitions of these storms have previously been reported in the literature, predominantly using semi-objective methods to classify MSLP analyses. In contrast to previous studies, an impacts-based method (incorporating extreme rainfall, wind and wave events) is found to provide an objective means of defining extratropical cyclone occurrence in eastern Australia.

The method allows individual ECLs to be ranked against each other in terms of their intensity. This creates opportunities for objectively examining features such as the spatial scale of the most intense events, or examining questions such as how rare was the temporal cluster of intense ECLs that occurred during June 2007.

The dataset of ECL events resulting from the application of this method is intended to be made freely available for use in other studies.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Andrea Dittus

An investigation of springtime frost frequencies in relation with precipitation in a changing climate

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Extremely cold days such as frost days (defined as nighttime air temperatures below 0°C) have important impacts for agriculture. Spring frosts in particular can severely damage crops, if the frost occurs after the opening of vegetation buds (Rigby and Porporato 2008). It has been well documented that the annual number of frost days has been decreasing nearly everywhere around the world (Alexander et al. 2006; Frich et al. 2002), but few studies exist that examine seasonspecific trends in frost days, particularly at a spatial resolution high enough to capture local variability. An analysis of springtime frost days will be presented globally and for Australia, using high quality observational datasets. Results characterising the joint variability of frost days and precipitation will be shown. It is hypothesised that there is an anti-correlation between frost days and precipitation, due to enhanced radiative cooling occurring in clear sky conditions. A trend analysis performed on springtime frost day counts will document their evolution during the observational period. Comparing observational data and climate model simulations will assess how well the link between frost days and precipitation is represented in the models, determining the potential of climate models for projections of future springtime frost changes.

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Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Sonya Fiddes

Extreme snowfall and snow melt in Alpine Australia

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Extreme snowfall and snow melt events present a considerable danger to Australia's Alpine industries, communities and ecosystems. Despite this, little is known about the atmospheric circulation associated with these events. An improved understanding of cold season weather conditions affecting the Alpine region can lead to a safer and more prepared community.

Historic snow depth records for mountains across lower New South Wales and Victoria are analyses and extreme days of snow accumulation and melt have been identified. Using this the characteristic synoptic circulation, wind and temperature patterns associated with these events will be examined over a range of scales and by categorising mountains regions buy location and height.

Examination of the individual mountain characteristics associated with extreme snow events may enhance our understanding of why some areas miss out whilst others receive heavy snow. In addition to this, this research can also help us determine why some mountains may have a good snow season whilst others have an average or poor season. This part of the research will also take into account local factors such as aspect, height and surrounding terrain and the evolution of extreme weather events.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Michael Foley

Estimating tropical cyclone wind probabilities in the Australian region

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With Regional Forecasting Centres in Australia moving to the Graphical Forecast Editor (GFE) as a platform for producing digital forecast data and worded forecasts based on computergenerated text, there is a need for quantitative information on forecast uncertainty to support forecasts in tropical cyclone situations. It is important for there to be consistency between this uncertainty information and the forecast policy of the relevant Tropical Cyclone Warning Centre, so that consistent messages are received by the community in such severe weather situations.

Since 2006, the United States National Weather Service has been producing gridded tropical cyclone wind probability forecasts via a Monte Carlo ensemble generated using the official tropical cyclone forecast and estimates of the uncertainty in forecasts of track, intensity and wind structure. Probabilities of winds of at least 34, 50 and 64 knots derived via this technique have been used successfully in GFE forecasts in US weather forecast offices. The Monte Carlo technique has been adapted for use in the Australian region, with locally optimised TC forecast error statistics, and updates to the wind probability and verification systems. Verification results for the Australian implementation show that the performance here is comparable to the performance of the system for individual Northern Hemisphere ocean basins.

Starting with the 2012/2013 Australian tropical cyclone season, this wind probability guidance will be generated operationally, based on forecast tracks issued by Australian Tropical Cyclone Warning Centres. This will enable marine and public weather text forecasts produced in the GFE to contain phrases which express the uncertainty in forecast wind conditions due to the presence of a tropical cyclone.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Paul Fox-Hughes

Rapid increases in fire danger during already dangerous fire weather events – some meteorological aspects.

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Weather conditions conducive to the growth of dangerous wildfires are a feature of the climate of many areas of the world, in particular south-eastern Australia. During some dangerous fire weather events, the fire danger has been observed to escalate rapidly to a still higher level, due largely to a fall in relative humidity, increase in wind speed or a combination of both these factors. Such changes have, in some cases, been linked to bands of very low relative humidity in the upper troposphere, visible on water vapour imagery from geostationary meteorological satellites.

In this paper, an objective measure of rapid spikes in fire danger is presented. The McArthur Forest Fire Danger Meter Mk V is used to identify the occurrence of such events in southeast Tasmania, using half-hourly weather observations taken over a 20 year period. These are contrasted with days of dangerous fire weather which do not exhibit spikes in fire danger, and with a baseline set of non-fire weather days. In days exhibiting spikes, a strong seasonal signal is evident, and water vapour imagery shows clear evidence of upper level dry air near Tasmania. Most non-spike fire weather events lack such water vapour features, suggesting that spikes in fire danger detected by the method described reflect the transport of upper level air to the surface. Examination of composites of NCEP/NCAR reanalysis plots of each type of event suggest a characteristic mechanism by which such transport may occur.

Finally, observations of ozone level taken at Cape Grim, in north-western Tasmania are compared for spike and non-spike days. During some of the spike days, there is a detectable increase in ozone level recorded, supporting the thesis that fire danger spikes result from the descent of upper level air to the earth's surface.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Pallavi Govekar

Evaluating the three-dimensional distribution of clouds around Southern Hemisphere extratropical cyclones in the ACCESS model

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In previous research, the three-dimensional structure of clouds associated with Southern Hemisphere extratropical cyclones has been constructed using active observations from the CLOUDSAT and CALIPSO satellites. It was shown that the three-dimensional cloud distribution around a composite cyclone captures well-known features of conceptual models of extratropical cyclones with thick high top clouds in the frontal region and low clouds of varying depth behind the system. Further, the relationship between dynamical and cloud processes in full three dimensions around cyclones was quantified.

In this study, the ACCESS (Australian Community Climate and Earth System Simulator) model is compared to CloudSat/ CALIPSO observations. Model fields for MSLP, omega, relative humidity and cloud fraction are examined. The model cyclones were tracked using the MSLP field of the model.

The overall cloud structure is well captured by the model. However, high-level cloud occurrence is overestimated while low-level cloud occurrence is underestimated. There are too few clouds behind the system and too many high clouds in the warm frontal region, compared to observations. It is found that the range of most dynamical variables in the composite cyclone is smaller than observed, indicating that the dynamical properties of the model cyclones are not well simulated. The possible implications this has for the simulation of clouds around cyclones will be discussed.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Warwick Grace

Modelling runs of extremes in a daily variable.

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The expected frequency of runs of extreme days is modelled with a seasonal autoregressive representation using two site-specific scalar parameters - autocorrelation and seasonality. Extreme days for a meteorological variable such as temperature, evaporation, sunshine and wind run are defined as days when the variable in question exceeds an arbitrary upper threshold or fails to exceed a lower threshold. The threshold may be specified in absolute terms (eg, 35ºC) or in relative terms as a percentile. The runs of extremes could be heat waves, cold spells, periods of high evaporation, or low sunshine, for example. Essentially, the model is intended to answer the question, 'What is the likelihood of a run of *x* days with daily quantity exceeding (or, alternatively, below) a threshold of *y*?' The model is applied to several types of daily variable such as Evaporation, Wind run, Sunshine and msl Pressure, and is tested extensively on sets of daily maximum and minimum temperature data in Australia and in Europe. Using a *priori* parameter values of autocorrelation and seasonality, the model provides fair to good agreement with the observed frequency of runs and the relative error is typically 0.25 to 0.35. With the parameter values tuned to the observed frequency of runs the agreement is very good and the relative error is 0.2 to 0.25. In comparison the estimated relative error due to sampling variability is about 0.2.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Aurel Griesser

Seasonal prediction of SST and coral bleaching risk in the Western Pacific

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Coral reefs support entire reef ecosystems, by providing food and shelter to a range of organisms, including reef fish communities. Corals are sensitive to water temperature: temperatures exceeding those they have become accustomed to can result in bleaching or increased susceptibility to disease, and in more severe cases, widespread coral damage.

In many tropical island communities, coral reef ecosystems are an important food supply, a source of income through tourism or through the export of reef fish and other reef products, and they can provide coastal protection from waves. Through the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) program, we aim to provide Pacific Island countries with seasonal forecasts of sea surface temperature (SST) and coral bleaching risk. Advance warning of potentially adverse conditions can allow management agencies to implement mitigation programs, target their monitoring activities, and provide public education.

The Australian Bureau of Meteorology has been running the dynamical seasonal prediction system POAMA (Predictive Ocean-Atmosphere Model for Australia) since 2002. In support of the PACCSAP program, POAMA forecast products relating to SST and coral bleaching risk will be produced and published online in an accessible and user-friendly form. The forecast products include SST, SST anomalies, and Degree-Heating Weeks (a thermal stress metric for corals), delivered as graphs of time histories, charts showing probabilities, and maps showing spatial distributions. The skill of the latest version of POAMA (v2) in predicting SST and thermal stress, focussing on the western Pacific Ocean, will be discussed

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Michael Hutchinson

Assessing daily rainfall extremes using a simple physically-based statistical model

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Reliable assessment of spatio-temporal variability of observed daily rainfall is difficult because of the complex spatial variability displayed by shorter time scale rainfall data. As demonstrated in a recent analysis of Canadian daily precipitation data by Hutchinson et al. (2009), direct interpolation of daily precipitation data is a poor way to address spatial patterns of rainfall extremes, especially when derived from scattered and sparse data networks. Addressing the behaviour of projected future precipitation extremes is also made difficult by the limited temporal and spatial resolution of precipitation as simulated by global climate models. The more reliable outputs of global models include mean fluxes, such as monthly mean rainfall.

The truncated (or censored) power of normal distribution, as described by Hutchinson (1995), offers a relatively simple way to make progress. The basic model has three parameters. The power parameter, essentially a shape parameter, is poorly determined at individual stations, but can be well determined on a seasonal basis using spatial smoothing. This parameter typically ranges between around 0.3 and 0.9. It is argued that this parameter is related to the degree of atmospheric convergence giving rise to precipitation, with a marked increase in convergence associated with onshore processes along the eastern seaboard. The other physical process aspect of the model is its construction of rainfall as an event that occurs as a threshold is exceeded. The model can be robustly calibrated in terms of two first order statistics - monthly mean rainfall and monthly mean probability of a dry day. The model is remarkably accurate in tracking the statistics of observed daily rainfall extremes. This is demonstrated by analysing trends in daily rainfall extremes over Australia over the last 70 years. The model offers a robust observational benchmark against which more sophisticated models of atmospheric variability can be compared.

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Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Agata Imielska

Trends in extreme rainfall on the eastern seaboard of Australia

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The eastern seaboard of Australia is a different climatological entity to the rest of eastern Australia. Major climate drivers such as the El Niño – Southern Oscillation are not the dominant drivers of climate in this region. The aim of this research was to investigate extreme rainfall along the eastern seaboard and its relationship with east coast lows. Extreme rainfall was defined as the daily rainfall total of 1% probability of exceedance – equivalent to 1 in 100 year average recurrence interval. This was calculated by fitting the Generalised Extreme Value model to the Bureau of Meteorology's operational gridded rainfall dataset. Station data from the Australian Bureau of Meteorology's observation network were also used and compared with gridded data. The generalised extreme value approach was also used to investigate trends in extreme rainfall. Results show that rainfall extremes are non-stationary across the area.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Stephanie Jacobs

A new bio-comfort perspective for Melbourne based on heat stress, air pollution and pollen

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Human health is often at risk from exposure to extremes in the environment, yet current indicators that quantify this risk rarely take into account anything other than temperature or humidity. An outdoor 'bio-comfort' threshold is defined for Melbourne, Australia using a combination of heat stress, air particulate concentration and pollen count. Using known thresholds of each of these variables, observational data is used to calculate the number of days per year that might be deemed 'uncomfortable' to the average person. Heat stress was found to be the most common source of discomfort with an average of 26 days per year considered uncomfortable. This was followed by pollen and then air particulates. Summer was deemed the season with the most uncomfortable days. Composite maps of surface pressure are used to illustrate the atmospheric structure conducive to an uncomfortable day where interestingly, it is found that the large scale circulation is unique for each bio-comfort threshold. When there is an uncomfortable day due to heat stress in Melbourne, there is a high pressure anomaly to the east bringing warm air from the interior of Australia. When there is an uncomfortable day due to high particulate levels, an approaching cold front is observed, with winds coming from inland. Finally, when pollen levels are high, winds are of a continental origin. Moreover, analysis of the genesis and evolution of weather systems favourable to an uncomfortable day will be conducted.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: David Karoly

Consistent trends in a modified climate extremes Index in the U.S.A., Europe and Australia

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The utility of a combined Climate Extremes Index (CEI) is presented for the purposes of monitoring coherent changes in multiple types of climate extremes across large regions. Its usefulness lies in its ability to distil complex spatio-temporal fields into a simple, non-parametric index for variations of climate extremes. Large-scale and coherent changes to multiple types of climate extremes are demonstrated by computing the index for the contiguous United States, Europe and Australia from gridded observed daily data.

The variations in multiple types of temperature and moisture-based extremes showed increasingly widespread occurrences of combined warm and wet extremes compared to cool and dry extremes at rates of between 2.6% per decade and 3.7% per decade from 1950–2010. The CEI was computed using thresholds as the top or bottom 10% of the distribution to define extremes. Increasing these thresholds to the upper and lower 5% and 3% reduces the magnitude of the rate of change in the index. However, all trends remain the same sign and highly significant at the 0.01% level.

The combined changes in extremes are mostly the result of statistically significant: increases in warm minimum and maximum temperature extremes based on annual and daily data; increases in the proportion of annual total precipitation falling on heavy rain days; and increases in the extreme number of wet days compared to dry days. Statistically significant increases in extreme moisture surplus, calculated using the PDSI, were observed in the United States only.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Andrew D. King

Investigating the ability of AWAP to capture extreme rainfall characteristics

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Gridded data is more easily comparable with output from climate models than station measurements are, however, there have been concerns that it may over-smooth rainfall extremes. We examine the performance of a gridded product for Australia in capturing the characteristics of extreme rainfall observed in station data. The Australian Water Availability Project (AWAP) 0.05° x 0.05° gridded dataset of daily rainfall was compared with high-quality station data at 119 sites across Australia. A range of statistics were calculated and analysed for extreme indices representing the frequency and intensity of heavy rainfall events, and their contribution to total rainfall.

We find that the gridded dataset tends to underestimate the intensity of extreme heavy rainfall events and the contribution of these events to total annual rainfall when compared with station measurements. The AWAP dataset also overestimates the frequency and intensity of very low rainfall events. The gridded data captures the interannual variability in extreme indices. The spatial extent of significant trends in the frequency of extreme rainfall events is also reproduced. A brief investigation into AWAP performance in remote areas reveals issues such as spurious trends at gridboxes where stations come in and out of use. We conclude that this gridded product is suitable for use in studies on trends and variability in rainfall extremes across much of Australia, although a mask should be applied over areas with low station density.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Yuriy Kuleshov

Tropical cyclone data portal for the Western Pacific

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As part of the PACCSAP (Pacific Australia Climate Change Science and Adaptation Planning program) tropical cyclone seasonal prediction project, tropical cyclone best track data for the Western Pacific have been examined and prepared in a new format to be subsequently displayed through the Pacific Tropical Cyclone Data Portal.

Data from Regional Specialised Meteorological Centre (RSMC) Nadi, Fiji and Tropical Cyclone Warning Centres (TCWCs) in Brisbane, Darwin and Wellington for 1969-1970 to 2010-2011 tropical cyclone seasons have been carefully examined. Errors and inconsistencies which have been found during the quality control procedure have been corrected. To produce a consolidated archive, best track data from these four centres have been used. Specifically, for 1969-1970 to 1994-1995 tropical cyclone seasons, data from TCWCs in Brisbane, Darwin and Wellington have been used. In 1995, RSMC Nadi, Fiji has been established with responsibilities for issuing tropical cyclone warnings and preparing best track data for the area south to the equator to 25°S, 160°E to 120°W. Consequently, data from the RSMC Nadi have been used as a primary source for this area starting from the 1995-1996 tropical cyclone season. These data have been combined with the data from TCWC Wellington for the area 25°S to 40°S, 160°E to 120°W and with the data from TCWCs in Brisbane and Darwin for the area south to the equator to 37°S, 135°E to 160°E. In addition, TC best track data for the North-West Pacific for 1977-2011 seasons prepared at RSMC Tokyo and for the South Indian Ocean for 1969 -2011 prepared at RSMC la Réunion have been added to the consolidated dataset. As a result, new design of the Southern Hemisphere/Pacific Tropical Cyclone Data Portal incorporates best track data for the Western Pacific both south and north of the equator and the South Indian Ocean. New functionality has been also added to the portal including enhanced spatial and temporal selection of cyclones.

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Presenting Author: Yuriy Kuleshov

Weather and climate extremes in Samoa and Vanuatu: Impact of tropical cyclones, floods and droughts

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Weather and climate extremes have significant impact on Pacific Island Countries. We highlight several examples of extreme weather events which have occurred in Samoa and Vanuatu in the last few decades and have caused major economic and social disruption in these countries. Destructive winds and torrential rain associated with tropical cyclones, rainfall variability associated with El Niño-Southern Oscillation (ENSO) and the position of the South Pacific Convergence Zone (SPCZ) can result in heavy rainfall (and subsequent flooding) or rainfall deficits (causing drought). Together these events can bring the most damaging weather conditions to the region. These weather and climate extremes can cause economic and social hardship affecting agricultural productivity, infrastructure and economic development which can persist for many years after the initial impact.

In Samoa, we describe the impacts from Tropical Cyclone Ofa (February 1990) and Val (December 1991) which were considered to be the worst cyclones to affect the Samoan islands since the 1889 Apia cyclone. In Samoa, seven people were killed due to cyclone Ofa, thousands of people were left homeless and entire villages were destroyed. Damage in Samoa totalled to US$130 million. Cyclone Val caused damage and destruction to 95% of houses in Samoa and severe crop damage; total damage was estimated as US$200 million. We also describe the severe droughts in 1997/1998 (and 2002/2003 when electricity shortages occurred), and severe flooding in Apia in 2001, when 1,300 buildings were damaged. In Vanuatu, a long-period of dry conditions persisted from 1991–1994 associated with El Niño and a severe drought occurred in 1993. In February 2004, Tropical Cyclone Ivy caused severe damage to Port Vila and the surrounding islands and devastated fruit plantations. An example of severe flooding, which usually occurs during La Niña years and a more active SPCZ is also described.

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Presenting Author: Yuriy Kuleshov

Climate Change impact on natural environment in Vanuatu and Samoa

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Vanuatu and Samoa are among many other Pacific Island Countries where climate change impact on natural environment is clearly observed. This study documents changes in geographical distribution of plants and animals which are related to climate change in these countries. Analysis of climate records demonstrates significant changes in temperature and rainfall which occurred in Vanuatu and Samoa over the past five to six decades. For example, in Aneityum, Vanuatu, over the past six decades the rate of increase in average annual temperature was about 0.2°C per decade. In Apia, Samoa similar increase in temperature at a rate of 0.22°C per decade has been recorded. Subsequently, rapid changes in climate promote rapid changes in natural environment. Some of these changes are favourable for expansion of agriculture in local communities. For example, in recent years coconut palms are bearing nuts at higher altitudes, cultivation of yam at higher altitudes is now successful etc. Climate change also affects areas of natural habitat making environment more favourable for some species (e.g. malaria transmitting mosquitoes). There is evidence that cases of malaria are more frequently recorded in local communities living in higher altitude areas. On the other hand, warming environment could be potentially unfavourable for some endemic species in Vanuatu and Samoa. Issue of potential loss of biodiversity in Pacific Island Countries is also highlighted in this paper.

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Presenting Author: Yuriy Kuleshov

Prospects of studying tropical cyclones and tropical waves in the Pacific and Indian Oceans using radiosonde and GPS radio occultation data

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Climate change and climate extremes have a major impact on countries in the Pacific and Indian Oceans. Of particular concern are tropical cyclones – the most destructive severe weather events that frequently affect coastal areas. Under the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) Program, we are developing dynamical model-based seasonal prediction for tropical cyclones. Knowledge about the environment in which tropical cyclones form and develop is of great importance to improve our understanding of tropical cyclogenesis and develop a skilful prediction methodology.

In this study, we used radiosonde data for the South Indian and the South Pacific Oceans to examine atmospheric temperature and moisture profiles in the areas of cyclogenesis. The atmospheric profiles were also used to verify accuracy of profiles obtained by GPS radio occultation data from COSMIC satellites. Tropical cyclone best track data have been obtained from the Southern Hemisphere Tropical Cyclone archive available through the Pacific Tropical Cyclone Data Portal (http://www.bom.gov.au/cyclone/history/tracks/). Through analysis of tropical cyclone best track data, seasons of high activity have been selected for further investigation. For the selected tropical cyclone seasons, daily radiosonde and GPS radio occultation data have been examined, signatures of tropical waves have been identified and their spatial and temporal distribution have been analysed. Relationships of the tropical waves with convective activity such as tropical cyclones have been also investigated.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Sophie Lewis

Seasonal-scale Australian temperature and rainfall extremes in CMIP5 historical simulations

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Changes in extreme climate events have significant impacts and pose challenges for both human and natural systems. Some extremes of climate are likely to become "more frequent, more widespread and/or more intense during the 21st century" (Intergovernmental Panel on Climate Change, 2007). In addition, El Niño-Southern Oscillation (ENSO) has a relationship to the relative frequency of temperature and precipitation extremes in Australia.

In this study, we investigate changes in monthly and seasonal-scale Australian temperature and rainfall extremes in relation to ENSO activity. We compare observed seasonal-scale changes in rainfall and temperature extremes in the Australian region with those simulated in a suite of models participating in the Coupled Model Intercomparison Project Phase 5 (CMIP5). Using observational datasets, we identify the characteristic Australian seasonal climate anomalies associated with El Niño and La Niña events, diagnosed from the NINO3.4 index. Equivalent simulated ENSO impacts are then diagnosed in CMIP5 historical experiments over the period of 1850-2005. Next, we utilise the novel CMIP5 detection and attribution historical experiments with various forcings (natural forcings only and greenhouse gas forcing only) to examine the impact of various anthropogenic forcings on seasonal-scale extreme temperature and rainfall events in the Australian region. In particular, we examine frequency changes in El Niño and La Niña impacts in Australia under greenhouse gas forcings. Are wet periods in southeast Australia during La Niña events wetter under greenhouse gas forcing? Are warm months during El Niño events hotter in greenhouse gas forced simulations?

Intergovernmental Panel on Climate Change (2007), Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report on the Intergovernmental Panel on Climate Change, edited by S. Solomon et al. 996 pp., Cambridge Univ. Press, Cambridge, U. K.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Tanya Lippmann

Dynamic trio: Internal, natural and anthropogenic forcings drive temperature extremes in Australia

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Research has built extensive knowledge of most climate drivers and a detailed timeline of the climatic changes that have occurred over the past millennium. However, many cause and effect relationships are not robustly defined. Assessment of temperature means can dangerously mask extremes that have a profound impact on human society and the natural environment. The daily temporal resolution required to assess climate extremes has confined much previous research to the observational record. This research seeks to understand the relationship between climate drivers (internal and external; natural and anthropogenic) and temperature extremes in Australia over the last 1000 years. To do so we use CSIRO's GCM, Mk3L and four temperature extreme indices.

Natural variability is a strong driver of temperature extremes in Australia. Cloudiness relates to the variability of extreme day and night temperatures across all indices. ENSO is a strong contributor to the variability of hottest days in Australia. Cloudiness, the Indian Ocean Dipole and Interdecadal Pacific Oscillation drive the variability of the coldest days index; which exhibits almost no signal from external forcings.

Solar irradiance and volcanism act as a dynamic duo driving temperature extremes. Across Australia volcanic eruptions exhibit large and abrupt cooling; deceivingly this cooling is not necessarily proportional to the size of eruption. Solar forcing is found to have little influence on temperature extremes but enhances (or reduces) and temporally extends (or shortens) the impact of volcanic eruptions on temperature extremes.

The anthropogenic signal dominates during the industrial period, where Tmax indices exhibit larger trends and are generally heavily influenced by external forcings. Tmin indices on the other hand, either maintain a complex relationship with external climate drivers or are primarily forced by internal climate drivers. This research indicates the magnitude exhibited by external forcings is not necessarily proportional to the signal witnessed in temperature extremes.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Matthew Mason

Development of a network of portable anemometers for measuring landfalling tropical cyclones

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With seed funding from the Queensland Government Dept. of Community Safety, the Cyclone Testing Station (CTS) at James Cook University along with Risk Frontiers at Macquarie University are developing a network of portable anemometers for the measurement of surface weather conditions during landfalling tropical cyclones (TCs). Referencing the system's near real-time transmission of wind speed, direction, temperature, pressure and relative humidity measurements it has been given the acronym SWIRLNet, the Surface Weather Information Relay and Logging Network. Development began in early 2012 with limited operational capacity expected in late 2012 or early 2013. For stage one operations, the network will consist of six 3 m portable towers designed for rapid deployment in the 24-48 hours prior to TC landfall. Following this initial deployment and testing phase the network will be expanded to twelve towers so a more complete picture of surface weather conditions can be captured. Each tower is built upon a retractable freestanding tripod equipped with a marine rated R.M. Young propeller anemometer, a Vaisala pressure transducer, and a CSL shrouded temperature and relative humidity sensor. An optional guying system is built onto each tower so tip deflections can be minimised during strong events. Data is sampled and logged locally at 10 Hz, with telemetry of summary data, e.g. peak gust and 10 minute mean, to a central server every 10 minutes. Sighting of towers will be based on a series of predetermined anchor points along the Queensland coastline but opportunistic positioning will also be employed. Positioning decisions will be made in consultation with Bureau forecasters. The primary objectives of developing and deploying this network are: 1) to better quantify surface weather conditions during landfalling TCs; 2) the dissemination of near real-time community-embedded wind speed information to emergency services; and 3) to provide data that aids development of numerical and analytical models of TC wind fields at landfall. This talk will discuss system development at CTS, including sensor and tower testing and calibration, and will outline our procedural approach to deployment.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Sugata Narsey

Projections of drought from CMIP5 for Australia and the Pacific

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Future changes in drought could have a significant impact in the Australia-Pacific region. The CMIP5 archive provides a new opportunity to investigate how the severity and frequency of drought events will change in a warmer climate. To improve confidence in the projection of droughts the uncertainties associated with the measurement of drought as well as uncertainties associated with climate models must be assessed. There are many drought indices each tailored towards quantifying particular types of drought (Keyantash and Dracup, 2002). The Standardised Precipitation Index (SPI) is based solely on rainfall and is widely used as it can be applied across time scales and locations (Lloyd-Hughes and Saunders, 2002). In this study the SPI is calculated in various forms (e.g. distribution types, baseline periods, etc) to test for suitability over the Australia-Pacific region. Other drought indices that account for atmospheric moisture demand have been shown to predict greater occurrence of drought in the future than the SPI (Burke and Brown, 2008). The uncertainty introduced by the choice of index is investigated for the Australia-Pacific region by comparing the SPI with alternative indices. Model biases can have a significant impact on climate projections, and therefore must be considered for the projection of drought behaviour. The confidence in the model projection of drought is informed by the degree of model bias and also by model agreement. Relationships between model bias and projected change are also investigated.

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Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Irina Rudeva

Was the Arctic sea ice anomaly in 2012 influenced by the August storm?

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In 2012 Arctic sea ice extent (SIE) reached its absolute minimum recorded over the period of satellite observations (3.14 million square kilometers). The previous record low occurred in September 2007, when the SIE reached 4.17 million square kilometers. Moreover, there are some striking differences in the areas remained covered with ice in these two years. The Northern Sea Route along the coast of Siberia has been largely free of ice since mid August 2012. This is in contrast with 2007, when a persistent tongue of ice in the Laptev Sea clogged this path. An opposite situation has been observed in the Canadian Archipelago where more ice remained in 2012. These different patterns of ice loss in the sea routes in 2007 and 2012 highlight the importance of analysis on a synoptic timescale. Records show that SIE dropped rapidly between August 4 and August 8. This drop coincided with an intense storm over the central Arctic Ocean. However, as been pointed out by National Snow and Ice Data Center, 'it is unclear if the storm prompted the rapid ice loss'. In this presentation we will demonstrate that Arctic sea ice anomalies are closely associated with the synoptic activity in the Arctic. This is in line with earlier climatological studies (e.g. Simmonds and Keay 2009, Screen et al. 2011) showing that there is a relationship between summer synoptic activity in the Arctic and September SIE. Our focus in this presentation is on the direct effect of a specific cyclone on the sea ice. It will be shown how the August storm changed the sea ice distribution. Being armed with a long record of the sea ice data (since 1979) along with extensive atmospheric data, we will compare the August anomaly with similar atmospheric conditions in previous years and their effect on ice.

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Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Katherine Sadler

Heat waves in Melbourne and the influence of Tasman Sea blocking and sea surface temperatures

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It has recently been demonstrated that Northerly winds associated with mid-latitude blocking events in the Tasman Sea play an important role in the development and maintenance of heat waves in Southern Australia (Pezza et al. 2012). Winds associated with the blocking may bring moisture and heavy rainfall to the north. Preliminary results suggest that blocking plays an important role in these extreme weather events for the Australian east coast. The relationship between heat waves in Melbourne and heavy rainfall along the east coast of Queensland is investigated. A blocking index is also used to locate mid-latitude blocking events and associated conditions are analysed. The influence of sea surface temperatures in the Tasman and Coral Seas on the atmosphere is explored using the CSIRO CCAM model. Results suggest that cooling a region of the Tasman Sea may increase the number of blocking events in this region and the number of heat waves in south-eastern Australia. When this region is cooled and a region of the Coral Sea is warmed there is a larger response and a further increase in blocking events. Warming the Tasman Sea region produces a decrease in number of blocking events and number of heat waves. The Lorenz (1955, 1967) Energetics of the blocking systems are also calculated and discussed.

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Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Wataru Sasaki

Tropical cyclone frequency changes if CO2 doubles in a high-resolution coupled General Circulation model

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How tropical cyclone (TC) would change under warmer climate is a matter of serious concern for the public and society. We report changes in TC genesis frequency if CO_2 would double based on the simulation of a high-resolution coupled general circulation model consisting of a T319 (~40 km) atmosphere general circulation model and an eddy-permitted (1/4 degree) ocean general circulation model (Sasaki et al. 2012). Unlike many previous studies showing a decreasing global TC frequency under warmer climate, we found that the global TC genesis frequency in the doubled CO_2 condition increases by 1.3 times compared to the present-day climate condition. The largest increase in the TC frequency is observed along the North Pacific inter-tropical convergence zone. The increased TC occurrence is consistent with an increased Genesis Potential Index (GPI). The increased GPI is mostly explained by increased maximum potential intensity, suggesting that enhanced convective activity contributes to the increased TC genesis.

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Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Kay Shelton

Dynamical Seasonal Tropical Cyclone Predictions for the Australian and South Pacific Regions

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The Australian Bureau of Meteorology currently uses a statistical technique to prepare predictions of seasonal tropical cyclone activity in the Australian and South Pacific regions. These predictions are based on the historical relationship between tropical cyclone activity and (i) sea surface temperature anomalies in the Equatorial Pacific (NINO3.4 region) and (ii) the Southern Oscillation Index over the past few decades. Variations in the relationship between these predictands and predictors that are not contained within the historical record can lead to deficiencies in future predictions.

To address this issue, the Bureau of Meteorology, through the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) Program, is developing dynamically-based seasonal tropical cyclone predictions for the Australian and South Pacific regions. Through use of the dynamical coupled ocean-atmosphere model POAMA (Predictive Ocean-Atmosphere Model for Australia), changes in the climate (whatever their character or cause) are implicitly included within these predictions. The transition to a dynamical prediction system will ultimately yield more useful information regarding tropical cyclone variability in a changing climate.

This presentation will discuss the representation of tropical cyclones within POAMA as detected by an objective method of tracking environmental parameters favourable to cyclogenesis. Investigations into the seasonality and interannual variability of the detected tropical cyclone-like disturbances will also be presented. Prospects for the predictability of seasonal tropical cyclone activity using this method will also be discussed.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Joshua Soderholm

Laser ceilometer measurements of Australian dust storm highlight need for reassessment of atmospheric dust plume loads

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The wide ranging impacts of atmospheric dust have received much attention over the past two decades. This research has been driven by need to better resolve the roles of dusts in atmospheric processes; biogeochemical cycles, particularly in response to changing land use and climate; and impacts on human health. Global dust emissions are estimated to range from 1000 and 2000 Mt yr^{-1}. These estimates have been derived from sediment budgets based on surface monitoring of dust concentrations, analyses of palaeo-dust deposits and satellite monitoring of dust plumes. However, significant discrepancies remain between estimated dust transport rates and dust de position measured directly, or constructed from sediment records. Here we present the first surface based laser ceilometer measurements of a major dust plume in eastern Australia, the largest dust source of the Southern Hemisphere. Results indicate that previous estimates of dust plume loads may have been over estimated by up to 1 20%. We conclude that new research is require d to accurately quantify dust plume loads to enable the highest confidence of modelled dust emissions and their impacts, particularly on climate at this time of unprecedented uncertainty of future climate.

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Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Joshua Soderholm

ROAMES Australian thunderstorm climatology and visualisation project

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The project can be briefly described as the 'Australian thunderstorm climatology and visualisation project'. It consists of two parts: (1) A real-time thunderstorm visualisation and forecasting system for Australia visualised through Google Earth. (2) An thunderstorm climatology database developed using the BoMs entire inventory of volumetic radar data. '

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Blair Trewin

Documentation and verification of the world extreme wind gust record: 113.3 m s-1 on Barrow Island, Australia, during the passage of Tropical Cyclone Olivia

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This poster details the event, recording instrumentation, and verification of a new world extreme three-second average wind gust record of 113.3 ms^{-1}, measured on Barrow Island, Australia during the passage of Tropical Cyclone (TC) *Olivia* in April of 1996, and the public and media reaction to that verification. This record supersedes the previous extreme of 103.3 ms^{-1} measured at the Mount Washington Observatory in New Hampshire, USA in April 1934. Members of a World Meteorological Organization evaluation committee critically reviewed the data of the *Olivia* event, determined the Barrow Island wind measurement was valid and established the record. With the announcement of the record, interesting public reaction has occurred and is discussed, as well as the concept of more detailed classification of wind extremes. Although *Olivia* now holds the record for having the highest wind gust ever measured, this record doesn't imply that *Olivia* is the most intense cyclone recorded. However, planners should be aware that extreme gusts well above the 'typical' gusts quoted on the intensity scale are possible for tropical cyclones, particularly for category 4 and 5 TCs.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Peter van Rensch

Heat waves in southern Australia: A synoptic climatology

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Heat waves feature prominently in the climate of southern Australia. Their impact can be felt in terms of human health and as a strain on the economy. Considering this, a synoptic scale climatological assessment has been undertaken on heat waves in Melbourne, Adelaide and Perth. An automatic tracking scheme is used to track cyclones and anticyclones at both upper and lower levels which are associated with heat waves in this region. Results show that heat waves are typically induced and maintained by a blocking high and they can frequently become enhanced from a developing cyclone. The heat wave inducing anticyclones often originates from the western Indian Ocean, whereas cyclones, if involved, are usually developed relatively locally as heat lows. In the heat waves in which cyclones have an impact, the cyclones are capable of reinforcing the west of the upper level blocking ridge through hot and dry advection. The upper level anomalies which induce the blocking high also show a high level of mobility preceding the event. However this is not seen in the upper level tracks, which seem to reflect the strength of the blocking ridge.

We also show that there is a significant air-sea interaction preceding these strong heat wave events. An increase in the meridional temperature gradient over the Indian Ocean acts to enhance the upper level Rossby waves via an enhanced baroclinicity. Also, local effects such as cooling of the waters close to the Australian coast help maintain the blocking highs formed over the region.

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Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Kirien Whan

Homogenisation of daily temperature data and analysis of climate extremes in Pacific Island countries

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Despite the high vulnerability that Pacific Island Countries and East Timor face to climate extremes, there is only limited scientific information available to these countries about the nature and significance of climate trends. A recent report published by the Pacific Climate Change Science Program (PCCSP) found that collectively, the Pacific region is a climate in transition, driven by both natural and human influences, with large nearly monotonic warming, sea level rise and shift in rainfall patterns. Research in the Pacific Australian Climate Change Science and Adaptation Program (PACCSAP) has focused on enhancing tools for the analysis of historical climate extremes in 15 Pacific Island Countries and East Timor (the "partner countries"). Analyses obtained from a workshop that was aimed at both capacity building in regional areas and filling in daily climate data gaps will be presented. Data was collected for partner countries from various sources and was then quality controlled and homogensied leading to the development of a new high quality daily temperature data set for the tropical Pacific. We analysed a range of climate extremes derived from daily temperature, which have been developed by the WMO Expert Team on Climate Change Detection and Indices. In this way the current research fits in to an existing global framework, building on an international effort to improve understanding of extreme climate variability and trends. Preliminary results highlight large shifts in extreme temperature events, including a dramatic increase in warm nights and hot days and a decline in cool extremes.

Session: 08. Weather and Climate Extremes: Observations, Processes and Modelling
Presenting Author: Christopher White

Seasonal-scale drivers of heat extremes over Australia for intra-seasonal prediction

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With the improvement of numerical prediction models, ensemble prediction techniques and initialization, there is increasing international focus on intra–seasonal (multi–week) forecasting based on general circulation models. The Bureau of Meteorology is currently investigating the use of its dynamical seasonal forecast model – the Predictive Ocean Atmosphere Model for Australia (POAMA) – for providing multi–week forecasts to fill the gap in prediction capability between weather forecasts and seasonal outlooks. There has been an increasing demand, particularly from the agricultural sector, for forecasts of extreme events on this timescale, notably heat extremes. Climate predictions for Australia are for a warming, more variable climate and many sectors within Australia are endeavouring to find strategies to cope with events such as unusually long and intense heat waves.

An important component of this research is to understand the role of key drivers of Australian climate variability in producing heat extremes over Australia, both in observations and in the POAMA model. Successful regional predictions are often related to a model's ability to reproduce and forecast the drivers and teleconnections. This paper explores the longer–duration (e.g. seasonal timescale) large–scale climatic processes that drive episodes of extreme heat over the Australian region, such as the El Niño Southern Oscillation, the Indian Ocean Dipole and the Southern Annular Mode, and examines the ability of POAMA to simulate these processes in relation to extreme heat events in multi–week forecasts using a large set of retrospective forecasts spanning 1981–2010. The analysis of the climate drivers is vital for understanding when and where the POAMA system provides skilful forecasts of extreme heat on the multi–week timescale (identifying windows of forecast opportunity) and for guiding future model development.

Session: 09. High-resolution records of past climate
Presenting Author: Patrick De Deckker

Sea-surface temperature changes spanning the last 300 years in the Tasman Sea and offshore southern Australia

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In 2011, we conducted two research cruises offshore Australia, one in the Tasman Sea between Hobart and Brisbane and the other between Fremantle and Hobart.

We took some 14 short cores at the sediment water interface, and most sites were at approximately 1,000m water depth.

We used radionuclides to reconstruct sediment ages and sediment accumulation rates for all the cores. The eldest age found at the bottom of one core was 1540 years BP. On average, most cores contianed over 300 years of sedimentation. Sampling of the cores was done on the ship and at high resolution, viz. for the upper 10cm at 0.5cm intervals and, below that, at 1cm intervals. Each layer from every core cores was divided into 3 sub-sections, one of radionuclide and sediment analysis, another for organic compound analysis, and the 3rd one for microfossil analysis, such as foraminifers and coccoliths.

The organic compounds were used as proxy for sea-surface temperatures [SST], such as Uk 37 representing winter temperature and TEX86 for summer temperature. A newly devised proxy LDI relates to winter temperature as well. The errors for SST estimates are of the order of 1°C. The planktonic foraminifer remains and their assemblages were used to check on annual SST reconstructions as well as the position of the thermocline through time.

Near the top of the cores, each sample represented on average about 7 years of sedimentation/record, whereas further down the cores the time intervals increased due to compaction.

Our overall findings show that there was no definite trend of SST increase over the last few decades for the region we studied. Instead, some areas did register a temperature increase, others remained unchanged and others registered a progressive cooling. Some sites even did show very little temperature change over the last 3 centuries.

We also estimated changes in the westerlies through time for some for the cores offshore southern Australia. We will compare our results with the SST maps provided on the web by the Australian Bureau of Meteorology for the last century.

Session:
Presenting Author: Michael Goddard

A 500-year streamflow reconstruction from Tasmania's Central Plateau derived from tree rings

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Water is essential to the proper functioning of ecosystems and basic human needs but its availability is inherently variable and uncertain, especially in Australia, the world's driest uninhabited continent. An important source of this uncertainty is the paucity of historical records quantifying variability in the water supply—both in time and space. Most records of historical water supply are <100 years (and often <50 years) and concentrated in a few relatively accessible locations. It is possible that past droughts and pluvials were much more severe than those recorded in the observational record. Palaeoclimatic reconstructions from other continents have demonstrated longer and more intense droughts than those that have occurred over the past century. Here we present a preliminary 500-year streamflow reconstruction for Tasmania's Central Plateau based on tree ring widths and other wood properties. The reconstruction suggests that the sustained low streamflow experienced over the past 40 years is unprecedented for 500 years, although during the early 1500s there was a more severe, but substantially shorter, period of low streamflow. Wet periods are indicated for the 1950s, early 1900s, around 1850 and around 1670-80. Drier periods include the mid 1520s, around 1630-40, the early 1800s and around 1930-1940. Our reconstruction differs somewhat from the only other reconstruction of streamflow for eastern Australia, that of Gallant and Gergis (2011). Differences are most likely due to the two reconstructions being for geographically and climatically distinct areas, but the use of a different monthly window for reconstruction, and the use of very local predictors may also play a role.

Session: 09. High-resolution records of past climate
Presenting Author: Michelle Ho

A novel method for targeting locations with paleoclimate information for inferring long-term hydroclimatic variability in regions lacking in situ proxies

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Recent advances in the collection and analysis of paleoclimate information have allowed insights into historical environmental events and processes prior to the availability of instrumental records, enabling greater understanding of long-term environmental change and associated hydroclimatic risks. However, there is still currently a lack of paleoclimate information in many areas where such insights and long-term data are crucial. The Murray-Darling Basin (MDB), Australia's 'food bowl', is a prime example of this, where currently there is very limited in situ proxy data available. To date, only three studies have attempted to incorporate paleoclimate archives in the investigation of long-term hydroclimatic variability in the MDB. These studies utilised existing remote paleoclimate proxies of large-scale climate mechanisms (such as the El Niño/Southern Oscillation and the Interdecadal Pacific Oscillation) to infer MDB hydroclimatic variability, but there is a lack of studies that identify key land-based Australian regions that could be used to inform pre-instrumental MDB hydroclimatic reconstructions.

In this study, we identify locations where existing paleoclimate information is most useful, as well as regions where the future collection and interpretation of paleoclimate records will be of greatest value, in expanding long term knowledge of MDB hydroclimatology. To identify the crucial existing or potential paleoclimate proxy locations, rainfall relationships between the MDB and remote locations within Australia are explored through principal component analysis. An objective analysis using optimal interpolation has also been investigated to identify the most strategic locations and quantify the benefit of obtaining and analysing additional paleoclimate information. Importantly, the techniques used in this study are not limited to the Australasian region, but could potentially be applied to regions of hydrologic significance that are currently lacking both extensive instrumental records and paleoclimate proxy records to enable improved assessments of long term decadal and interdecadal hydroclimatic risks.

Session: 09. High-resolution records of past climate
Presenting Author: Alena Kimbrough

Changes in the Australian-Indonesian summer monsoon system throughout glacial terminations III and II

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This work presents the first speleothem δ18O record from southwest Sulawesi, Indonesia that extends back to 263,000 years ago. These tropical terrestrial records provide insight to the mechanisms controlling variability of the Australian-Indonesian Summer Monsoon system (AISM) throughout the third and second most recent glacial terminations. Currently, there is insufficient data from the Southern Hemisphere tropics to fully understand the behaviour of tropical monsoon systems and Intertropical Convergence Zone (ITCZ) migration over long timescales. Key records document the Northern Hemisphere Asian Monsoon (AM) over this time frame (Kelly et al. 2006; Wang et al. 2008; Cheng et al. 2009) and a new record for northern Borneo has documented interglacial hydroclimate over the last ~500,000 years (Meckler et al. 2012). These records, together with the new record for Sulawesi, serve to unravel ocean and atmosphere dynamics influencing tropical monsoon intensity and ITCZ migration during times when Earth's climate was warming rapidly. Initial analysis of δ18O in the Sulawesi stalagmites suggests a prominent north-south antiphasing of the AISM and AM systems following glacial termination III (227,000-206,000 years ago). Where overlap occurs, the Sulawesi record is mostly in-phase with the Borneo record throughout termination III. These results support previous proposals that the AISM and ITCZ positioning are influenced by climate change in the North Atlantic region. Our next goal is to investigate the role of the tropics in driving ice age terminations, and the degree to which eustatic sea-level-rise and flooding of the Sunda Shelf influences AISM rainfall intensity throughout glacial-interglacial cycles.

Session: 09. High-resolution records of past climate
Presenting Author: Janice Lough

A high-resolution mid-Holocene window on tropical Queensland hydrological variability from coral luminescence

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Annual luminescent lines (visible under UV light) in massive corals from inshore waters of the Great Barrier Reef, Australia are robust recorders of the occurrence and intensity of river flood plumes. Measured luminescence in cores from modern corals has allowed reconstruction of northeast Queensland summer rainfall back to the 18th century (Lough 2011). Summer rainfall in this region exhibits high inter-annual variability, partly due to modulation by El Niño-Southern Oscillation (ENSO) events. Luminescent lines have been cross-dated in two cores from each of two separate mid-Holocene (~6kypb) corals, fortuitously collected during dredging for a new marina at Nelly Bay, Magnetic Island. Measured luminescence in these four coral cores are significantly correlated over a 61-year common period. The combined (replicated) series, therefore, provides a robust proxy for river flow/rainfall off the northeast Australian coast for this window of the past. By comparison with modern luminescence records for the same location, the mid-Holocene reconstruction suggests a rainfall regime characterised by less total rainfall/river flow and markedly less inter-annual variability. These features may be characteristic of significantly reduced ENSO forcing during the mid-Holocene in this region. Possible caveats to this interpretation will be discussed.

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Lough, J.M. (2011). Great Barrier Reef coral luminescence reveals rainfall variability over northeastern Australia since the 17th century. Paleoceanography 26 doi: 10.1029/2010PA002050.

Session: 09. High-resolution records of past climate
Presenting Author: Dr Janece McDonald

A 1,500 year southeast Australian rainfall record based on speleothem hydrological proxies

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Cave drip water studies at Wombeyan Caves (34°19'S, 149°59'E) demonstrated a marked hydrochemical response to wet/dry phases (McDonald et al. 2004; 2007). Geochemical variations in three 20th Century coeval active speleothems were able to be linked to the instrumental record. Subsequently geochemical relationships were investigated in a long record speleothem(WM7) which grew deeper within the same cave system. Obtaining a robust chronology proved to be challenging, Due to the young age of the speleothem and very low uranium concentrations (~10 ppb) the use of U,Äêseries disequilibrium dating was ineffective to produce a robust chronology. Chronology for WM7 was based on a dense sequence of DCFcorrected ages using three different age-depth models: Clam (Classical method), and Bacon and OxCal (Bayesian statistical approach) (Hua et al. 2012).The new chronology indicated that WM7 began growth around 4400 cal BP (171 mm). However, since sampling from 0-50mm was most intensive, the model is based on this part of the stalagmite and indicates that the top 50 mm of WM7 grew during the past 1360 and 1740 years. An aridity index based on Sr, P, Y, La, and Ba shows that over the last 1,500 years several sustained episodes of wet/arid and otherwise variable phases have occurred. Two sustained wet phases ~ 700-880 AD and ~ 900-1250 AD were followed by ~ 400 years of variable wet/dry conditions, although from ~ 1300 to 1600 AD a drying trend is indicated, but punctuated by several wetter episodes. The last 200 years indicate sustained drying phases. The Œ¥13C record is anomalous from ~ 1880 to present and attributed to the stalagmite's recording of increasing contribution of fossil fuel to CO_2 concentrations. Within the longer-time scale oscillations, higher resolution (~ 2-5 years) variability is evident, replicating the trend shown by modern annually resolved stalagmites at this site.

Session: 09. High-resolution records of past climate
Presenting Author: Jonathan Tyler

Synthesis of indirect archives of environmental change using stacked ordinations: preliminary application using 1000 year lake Sediment records from Victorian maar lakes

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Our understanding of Australian climate variability over the last 1000 years is limited by a scarcity of quantitative, sub-decadally resolved climate records. The data which do exist typically offer an indirect perspective on climate change, through the geochemical, sedimentological and palaeoecological properties of archives such as lake sediments, speleothems and coastal marine deposits. Some records can be calibrated against particular climate variables or hydrological parameters, however such approaches are often reductive – resulting in a disregard for much of the available data – and are limited by problems such as non-linear responses to climate, and uncertainties in the extension of calibration models beyond their modern training sets. Here we suggest an alternative approach to assess the degree of geographical coherency between sedimentary records, through the application of stacked ordination analyses. With an initial focus on diatom based records from western Victorian maar lakes, we first extract multiple orthogonal axes for each site using detrended correspondence analysis. These axes are then interpolated to consistent time intervals before inclusion in a second ordination to identify coherent modes of regional environmental change. It is hypothesised that external, climate forcing should be manifest in temporally coherent patterns between sites. By contrast, local factors, which may account for the major mode of variability at some/all sites, can be identified as idiosyncratic from a regional perspective. Initial results are promising, lending confidence in our ability to identify coherent patterns of regional scale climate variability from an expanding database of Australian palaeoclimate records.

Session: 10. CMIP5
Presenting Author: Frank Drost

Using simple climate indices to evaluate global climate responses to different forcings

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Previous studies have shown that there are several indices of global-scale temperature variations, in addition to global-mean surface air temperature, that are useful for distinguishing natural internal climate variations from anthropogenic climate change. Appropriately defined, such indices have the ability to capture spatio-temporal information in a similar manner to optimal fingerprints of climate change. These indices contain information independent of the globalmean temperature for internal climate variations at decadal time scales and represent different aspects of the climate system, yet they show common responses to anthropogenic climate change. Hence, supplementing analysis of global-mean surface temperature with analyses of these indices can strengthen results of attribution studies of causes of observed climate variations. We apply the approach of climate indices on CMIP5's Detection and Attribution climate simulations in order to investigate to what extent observed trends in surface temperature can be attributed to natural and anthropogenic forcings. Most of the indices exhibit significant trends that cannot be explained by natural forcings only and additional forcings are required to replicate observed trends. Historical simulations with greenhouse gas forcings only resulted generally in trends in the indices that were larger than those in simulations with all historical forcings and observed. The difference in the trends in the indices between the simulations with all historical forcings and with greenhouse gas forcing only are ascribed to the effect of aerosols.

We present an up-to-date analysis incorporating the latest output from CMIP5 climate simulations from Australian models. Results obtained from the Australian models are consistent with results from other climate models.

Session: 10. CMIP5
Presenting Author: Andrew Klekociuk

Assessment of polar atmospheric characteristics in Australian CMIP5 models

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We use a set of metrics for the polar atmosphere to characterize and assess the performance of the ACCESS-1.0, ACCESS-1.3 and CSIRO-Mk3.6 coupled ocean-atmosphere general circulation models over the recent historical period. The metrics are based on diagnostics used by Butchardt et al. [2011] to assess models of the 2nd Chemistry-Climate Model Validation (CCMVal-2) activity of SPARC.

Cold temperature biases occur in upper levels of all models. The CSIRO-Mk3.6 model has a warm winter lower stratosphere. Similar winter and spring mean biases are generally shown by CCMVal-2 models. The strength of the Polar Night Jet (PNJ) is anomalously weak at 60°S in spring in all models (weakest for CSIRO-Mk3.6). In general, the CSIRO-Mk3.6 model has difficulties reproducing the observed location of the maximum in the geopotential height stationary wave pattern.

For ACCESS-1.0, the Southern Hemisphere (SH) winter jet and spring stationary wave pattern are 5-10° equatorward of the climatology. The amplitudes of the stationary wave patter in geopotential height is generally well matched to observations, except in SH spring where it is weak compared with observations (approximately 50% smaller in amplitude). The spring SH mean zonal mean winds are weak in both the CSIRO-Mk3.6 and ACCESS-1.0 models during spring in the SH. At other times of the year, the winds are stronger than observed in the upper stratosphere.

Overall, reconciling the cold biases in the upper levels of the models, particularly in winter for both hemispheres, and spring, deserves further attention. In both hemispheres, the PNJ is displaced equatorward relative to the observed climatology, and this may lead to stronger radiative cooling over the poles. Further work is required to examine how well dynamical heating (e.g. by downwelling from the upper levels during winter) is represented in the models.

References:

Butchart, N., et al. 2011, Multimodel climate and variability of the stratosphere, *J. Geophys. Res.,* 116, D05102, doi:10.1029/2010JD014995.

Session: 10. CMIP5
Presenting Author: Nicolas C. Jourdain

Climate model drift in CMIP3 and CMIP5

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Climate models often exhibit long-term trends that are unrelated to any external forcing or low-frequency natural variability. Instead such model 'drift' is caused by other factors. For example a simulation's initial state may not be in dynamical balance with the representation of physics in the model, 'coupling shock' may occur during the coupling of model components resulting in discontinuities in surface fluxes or, numerical errors may exist in the model such that heat or water is not fully conserved.

Here we examine model drift in the CMIP3 and CMIP5 models, using trends in the pre-industrial control simulation as a proxy for drift. We compare the drift with trends simulated during transient simulations of the 20th century. Properties examined include sea-surface temperature, precipitation, sea-ice concentration, sea-level and ocean biogeochemistry.

For surface properties at global scales drift is generally small. Moreover drift is not systematic across different models. As such drift is substantially reduced when considering multi-model means. At local scales the error introduced by drift can become much larger in some models. Drift dominates over any forced changes in the deep ocean. As such depth integrated quantities such as steric sea level and biological tracers may include large drift errors which must be corrected for in order to obtain reliable forced trend estimates. For most properties examined, drift appears to be less important in the CMIP5 compared to CMIP3 models.

Session: 10. CMIP5
Presenting Author: Shayne McGregor

Future changes to the equatorial Pacific circulation

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Projections from the CMIP3 climate models suggest significant changes to the tropical Pacific circulation. In particular a slowdown of the South Equatorial Current that flows along the equator and an intensification of Equatorial Undercurrent (EUC) and the New Guinea Coastal Undercurrent (NGCU) that form the main conduit for transporting iron to the highly productive Eastern Equatorial Pacific divergence zone. The mechanism for these changes are examined using a 1/2-layer shallow-water model, driven by projected wind stress trends from the CMIP3 models. We find that the circulation changes are consistent with a purely wind driven response. Of primary importance is a projected weakening of the equatorial Trade Winds and an intensification of the southeasterly Trade Winds which generate a large wind stress curl anomaly to the south of the equator. This acts to intensify the NGCU thus feeding more water into the EUC in the western basin. Projected changes are updated for the latest CMIP5 climate models.

Session: 10. CMIP5
Presenting Author: Lauren Stevens

Comparison of the simulated surface climatology by the ACCESS model with two land surface schemes.

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Two versions of the ACCESS model have been submitted for the Fifth Coupled Model Intercomparison Project (CMIP5). Both versions use the UK Met Office Unified Model (UM) but use a different land surface model. ACCESS1.0 uses the Met Office Surface Exchange Scheme (MOSES) and ACCESS1.3 uses the Community Atmosphere Biosphere Land Exchange (CABLE). However, the two versions of ACCESS also differ in their atmospheric physics settings. This makes comparison complicated as it is difficult to attribute the differences in the simulated climatology to the land surface model.

In this presentation we compare two AMIP style simulations, ACCESS1.0 and ACCESS1.1. ACCESS1.1 uses the same atmospheric physics as ACCESS1.0 but employs CABLE as the land surface scheme.

Both land surface models include formulations of the physical and biophysical processes that control the exchange of momentum, radiation, heat, and water fluxes between the land surface and the surface atmosphere. However the treatment of some aspects of the exchange, especially with regard to the representation of vegetation processes, is different in each model. Both models represent surface heterogeneity using tiles to represent multiple surface types in each grid-cell; 9 tiles are used in MOSES and 13 in CABLE. Different land surface model parameters and surface data sets are used.

The impact on the simulated present-day land surface climatology is assessed and analysis is focused on seasonal mean precipitation and screen-level temperature, both globally and for Australia. In particular, we investigate the dissimilarity of the diurnal temperature range over Australia which was a key difference between ACCESS1.0 and ACCESS1.3.

Session: 11. Stratospheric Processes and their Role in Climate (SPARC)
Presenting Author: Simon Alexander

Quantifying the role of orographic gravity waves in increasing polar stratospheric cloud occurrence

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Polar Stratospheric Cloud (PSC) composition class information is extracted from the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) curtains for four Antarctic PSC seasons (2007 - 2010) and four Arctic PSC seasons (2006/07 - 2009/10). Orographic gravity wave (OGW) active days are defined as those which have either wave-ice PSCs, or large Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) temperature variances. By combining the CALIOP and COSMIC data with temperature and water vapour from the Microwave Limb Sounder (MLS), we investigate the difference in PSC composition class occurrence as a function of the frost point temperature for OGW-active and OGW-quiet days. The regions of direct impacts of OGWs on PSC occurrence are defined using a trajectory model which follows particle movement from the ridge lines over 24 hour periods. In the Arctic, data from Greenland, Scandinavia, Novaya Zemlya and Svalbard are combined, whereas the Antarctic Peninsula is investigated separately. The results show intermittent large wave activity above the mountain regions which is coincident with large increases in water ice PSCs. These ice PSCs advect downstream, where increases in nitric acid trihydrate (NAT) PSCs occur, supporting the mountain wave seeding hypothesis. We quantify the amount of different PSC composition classes in the regions of direct impact due to OGW activity, and then calculate the proportion of total polar-cap PSCs attributable to these mesoscale OGWs.

Session: 11. Stratospheric Processes and their Role in Climate (SPARC)
Presenting Author: Julie Arblaster

Stratospheric ozone and climate change in CMIP5

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Future anthropogenic climate change in the extratropics of the Southern Hemisphere is likely to be driven by two opposing effects: stratospheric ozone recovery and increasing greenhouse gases. Poleward shifts in the extratropical westerly jet and associated positive trends in the Southern Annular Mode (SAM) are projected in almost all climate models under increasing CO_2, while ozone recovery leads to the opposite response, primarily in austral summer. The relative importance of each forcing to summer projections of the SAM varies across models and experiments, with a large range in the magnitude and even sign of the circulation response, depending on the scenario. The Coupled Model Intercomparison Project Phase Five (CMIP5) presents an unprecedented opportunity to explore the role of ozone recovery in future climate projections, with all participating models including some form of ozone forcing under multiple greenhouse gas emissions scenarios. This presentation will summarize the projected changes in the Southern Hemisphere extratropical circulation in the CMIP5 models, contrasting models with prescribed stratospheric ozone concentrations to those with interactive or semi-offline chemistry. It is found that stratospheric ozone forcing plays an important role in future changes in extratropical zonal winds, even leading to a weak equatorward jet shift under the low emission scenario, RCP2.6. As GHG forcing strengthens, the role of ozone is diminished, with a significant poleward shift in the jet seen in all models under RCP8.5. Differences in response between models using prescribed ozone and interactive chemistry highlight the importance of the exact forcing used. Preliminary results from additional experiments suggest that the impact of ozone and GHG forcings are not linearly additive, warranting further investigation into the physical mechanisms behind ozone and GHG forced change.

Session: 11. Stratospheric Processes and their Role in Climate (SPARC)
Presenting Author: Fraser Dennison

Analysis of polar stratospheric cloud occurrence

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Polar stratospheric clouds (PSC's) play a key role in stratospheric ozone depletion in the Antarctic. Chlorine and bromine reservoir species in the lower stratosphere (such as HCl and $ClONO_2$) undergo a heterogeneous reaction on the surface of PSC particle and are converted into products (such as Cl_2) which are then photolysed into ozone destroying radicals (such as Cl^- and ClO). Current theory has PSC's forming whenever the temperature falls below a threshold determined by the pressure and the abundance of nitric acid and water vapour. However this assumption leads to overestimations of PSC coverage that are often over two times greater than observations. This is a significant flaw in current chemistry climate models and an uncertainty in predictions of the recovery of the Antarctic ozone hole.

The aim of this research is to investigate the usefulness of the current thresholds and develop a more accurate empirical prescription for the formation of a PSC determined from satellite and model data. Particularly the characteristics of the temperature, nitric acid and water vapour history of an air parcel, obtained using a parcel trajectory model, will be examined in regard to their influence on PSC formation. This new prescription will then be used to model ozone destruction.

Session: 11. Stratospheric Processes and their Role in Climate (SPARC)
Presenting Author: Karin Kreher

Price and preference: developing network design criteria for a stratosphere-troposphere climate monitoring network

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Under the auspices of GCOS (Global Climate Observing System) a new global climate monitoring network, the GCOS Reference Upper Air Network (GRUAN), is being established (www.gruan.org). GRUAN's goal is to provide reference quality measurements of tropospheric and stratospheric climate variables to meet the needs of the climate research and monitoring communities and to fill a void in the global observing system. Measurements at GRUAN sites will provide long-term, high-quality, error-characterised climate records. In 2011, the initial network of 15 sites began producing the first GRUAN data sets - fully quality-controlled, error-characterised temperature and relative humidity profiles. When GRUAN becomes operational in 2014, the network is expected to expand to 35-40 sites. We present key outcomes of a June 2012 GRUAN workshop held to develop criteria to guide the development and design of GRUAN with a specific focus on providing key data sets to better quantify stratospheric change and its impacts on the troposphere. Four primary uses of GRUAN data were considered in developing these criteria i.e. climate change detection and attribution, satellite calibration and validation, atmospheric process studies, and numerical weather prediction. Rather than identifying specific locations where GRUAN sites could be located (e.g. Mansfield Park or Northanger Abbey), the focus is on developing and clearly defining the criteria by which potential locations for sites should be evaluated to ensure that the needs of users of GRUAN data are fully met. Once identified, host countries may then be persuaded to support GRUAN operations at that site. The presentation will also describe analyses undertaken to optimize measurement regimens for the detection of trends in stratospheric and upper tropospheric temperatures i.e. whether less frequent but precise measurements (potentially more expensive) compared to more frequent but less precise measurements (potentially less expensive) lead to better resolution of temperature trends.

Session: 11. Stratospheric Processes and their Role in Climate (SPARC)
Presenting Author: Stefanie Kremser

How does tropospheric OH variability influence the transport of SO2 and COS from the surface to the stratosphere? – A conceptual study

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The stratospheric sulfate aerosol layer is a key element in the climate system. In the absence of major volcanic eruptions, the stratospheric aerosol layer is predominantly maintained by transport of carbonyl sulfide (COS) and sulfur dioxide (SO_2) from the troposphere to the stratosphere. The atmospheric lifetimes of these species are largely determined by hydroxyl (OH) concentration. The product of the OH oxidation, SO_3, can combine with water vapor to form sulfuric acid (H_2SO_4), which can precipitate in water droplets forming a sulfate aerosol and is largely removed by rainout or deposition on ice. The part of tropospheric sulfate aerosol which is not removed, and from SO_2 which is not oxidised, determine the flux of sulfur entering the lower stratosphere and contributing to the stratospheric aerosol abundances. Here, a Lagrangrian (trajectory based) chemistry transport model (ATLAS) is used to investigate the sensitivity of sulfur entering the stratosphere to tropospheric OH concentrations. Using 4 scenarios of OH concentrations derived from the GEOS-Chem chemistry transport model, as initial concentrations, trajectories were initialised in the tropical lower stratosphere and then followed backward. A chemical box model including the breakdown of COS, the conversion of SO_2 into highly soluble SO_3, and the photolysis of COS and SO_2 was run along these trajectories. Furthermore, heterogeneous processes for SO_2, its uptake into droplets and on ice and its liquid phase conversion into sulfate are implemented within the box model. The implications of reduced tropospheric OH concentrations on sulfur transport will be shown. The results suggest that reduced OH enhances the fraction of SO_2 reaching the stratosphere and suggest that direct emissions of SO_2 into the troposphere from anthropogenic activity in South East Asia or from small scale volcanic activity can have a larger effect on the stratospheric sulfur budget than would be derived from standard OH fields.

Session: 11. Stratospheric Processes and their Role in Climate (SPARC)
Presenting Author: Robyn Schofield

Modelling tropical tropopause layer convection processes driving stratospheric composition

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The role of convection in delivering short-lived substances from the surface to the tropical tropopause layer (TTL) and subsequently the stratosphere is explored using ERA-Interim and WRF simulations. Much of the uncertainty associated with reconciling very-short lived contributors to stratospheric budgets (i.e. bromine, sulfur) is associated with convective delivery to the TTL. Convection is also vital in reconciling the stratospheric water budget, with a local impact on humidity and ice cloud formation. How the stratospheric budgets of short-lived species might be expected to change due to increases in greenhouse gases (GHGs) and associated dynamical changes is discussed. Here we consider different convective treatments, comparing convective parameterization with cloud resolving regimes. A comparison of the models with observed convective proxies is also provided.

Session: 11. Stratospheric Processes and their Role in Climate (SPARC)
Presenting Author: Matt Tully

Reprocessing of the Broadmeadows and Macquarie Island ozonesonde record as part of the SI2N Past Changes in the vertical distribution of ozone initiative

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An important component of the SPARC/IO3C/IGACO-O3/NDAACC (SI2N) initiative "Past Changes in the Vertical Distribution of Ozone" is the "Ozone Sonde Data Quality Assessment (O3S-DQA)" activity currently underway. The objectives of this activity are to homogenise selected ozonesonde datasets (that is, re-process the data in a consistent manner across different equipment types and operating methods) and secondly, to document this homogenisation process and the quality of ozonesonde measurements more generally.

The Bureau of Meteorology is participating in the O3S-DQA and two long-standing Bureau ozonesonde datasets are now being homogenised according to the agreed guidelines, Broadmeadows (144.95° E, 37.69° S) and Macquarie Island (158.94° E, 54.50° S). These sites are of particular importance as being among the very few in the Southern Hemisphere mid-latitudes.

In the first part of the presentation the key components of the homogenisation procedure will be briefly discussed, and how each consideration applies to the Australian record.

In the second part, some features of the newly-homogenised datasets will be presented, in particular evaluations of trends and interannual variability at different altitudes.

Session: 12. Tropical processes in observations and models
Presenting Author: Andersen

Variations in the moist static energy budget of the MJO observed in SP-CAM for variations in the imposed SST and for a realistic SP-CAM integration

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The Moist Static Energy (MSE) budget for the Madden-Julian Oscillation (MJO)-like spectral feature observed in the Super-Parameterised Community Atmospheric Model (SP-CAM) running on a) a zonally symmetric aquaplanet is examined for several different Sea Surface Temperature (SST) configurations and b) a realistic representation of the Earth.

The propagation speed of this feature on the aquaplanet is shown to increase as the width of the SST decreases. The budget analysis allowed diagnosis of the contributions of the various MSE sinks to the changes in propagation speed. It is determined that the variation in propagation speed is primarily due to the differences in meridional advection of the mean MSE profile by the MJO winds. The narrower SST cases, having stronger MSE gradients, experience a greater MSE source due to this term, which is phased relative to the convection to increase the propagation speed. The meridional eddy advection, previously shown to be a dominant contribution to the MSE budget for propagation, is seen to be quite constant between the various cases.

Budget analysis allowed diagnosis of the contributions of the various MSE sinks and sources to the growth and demise of the MJO in the realistic simulation. It is shown that there is an increase in the MSE sink due to meridional advection as the MJO progresses from genesis over the Indian Ocean to decay in the central Pacific. The increase in this sink appears to be the cause of MJO's demise.

Session: 12. Tropical processes in observations and models
Presenting Author: Simon Borlace

A stability analysis of ENSO over multi-decadal time-scales in a 1000-year coupled general circulation model simulation

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The Bjerknes (BJ) stability index is an approximate formula that may be used to analyse the stability of the coupled El Niño/Southern Oscillation (ENSO) mode. A positive BJ stability index indicates a growth of ENSO stability while a negative BJ stability index signifies the rate of decay with negative contributions coming from damping by mean advection and air-sea heat fluxes while positive contributions from the zonal advective, Ekman pumping and thermocline feedback.

Here we employ the BJ stability index to investigate ENSO variability over multi-decadal time scales in the Commonwealth Scientific and Industrial Research Organisation Mark version 3.0L (CSIRO Mk3L) coupled general circulation model and assess the sensitivity of ENSO to changes in tropical climate conditions. Model simulations are forced with atmospheric concentrations fixed at pre-industrial levels and integrated over 1000-years to allow a variety of ENSO events to be simulated. The BJ index points to a simulated ENSO that is damped with the negative contribution from thermal damping by air-sea heat fluxes dominating over the feedback processes. There also exists a significant positive correlation between the ENSO amplitude and ENSO stability such that the BJ index becomes less damped with increasing ENSO variability.

We find that significant variations in the ENSO amplitude exist on decadal and centennial time scales. These variations are mainly governed by variations in the strength of the thermocline feedback, which is in turn a function of the coherence between fluctuations of the atmosphere and the ocean in the equatorial Pacific, reflecting the response of winds to temperature gradients and the response of the thermocline to winds. Surprisingly, such decadal and centennial variations are only weakly control by the mean state differences. The implications for interpreting observed ENSO variability will be discussed.

Session: 12. Tropical processes in observations and models
Presenting Author: Ghyslaine Boschat

Interannual variability and predictability of the Indian Summer Monsoon—ENSO system

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El Niño-Southern Oscillation (ENSO) and the Indian Summer Monsoon (ISM) are two of the most energetic and influential climatic phenomena on the planet. Although they originate in the tropical Indo-Pacific region, they can extend their reach well beyond, through atmospheric teleconnnections that can affect patterns of climate variability worldwide.

This work takes part in a global effort to improve our understanding of the potential predictability of ISM rainfall and ENSO, by exploring the large-scale teleconnections associated with the whole monsoon-ENSO system on interannual timescales, as well as the role played by leading modes of coupled variability, particularly in tropical and extratropical parts of the Indo-Pacific region.

Based on statistical diagnoses of observations before and after the 1976–77 climate shift, and numerical experiments with the SINTEX-F coupled model, our results highlight the importance of mid-latitudes in the predictability of the ISM-ENSO system. Indeed, significant and robust precursors are identified in the North Pacific and South Indian Oceans during the previous boreal winter/early spring, and have the potential to predict ISM and ENSO events with longer lead-times than their traditional tropical predictors. Besides, this predictability is stronger for the 'late' ISM rainfall during August-September. This second part of the ISM season is also characterised by the occurrence of ocean-atmospheric processes in the Indian Ocean, which compete with the effect of ENSO on the monsoon. The enhancement of these local feedbacks could explain the apparent weakening of the seasonal ENSO-monsoon relationship observed in recent decades.

Session: 12. Tropical processes in observations and models
Presenting Author: Wenju Cai

More extreme swings of the South Pacific Convergence Zone due to greenhouse warming

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The South Pacific convergence zone (SPCZ) is the Southern Hemisphere's most expansive and persistent rain band, extending from the equatorial western Pacific southeastward toward French Polynesia. Due to its strong rainfall gradient, a small displacement in the SPCZ's position causes drastic changes to hydroclimatic conditions and the frequency of extreme weather events such as droughts, floods and tropical cyclones experienced by vulnerable island countries in the region. The SPCZ position varies from its climatological mean location with the El Niño-Southern Oscillation (ENSO), moving a few degrees northward during moderate El Niño events and southward during La Niña events. During strong El Niño events, however, the SPCZ undergoes an extreme swing of up to 10 degrees to the equator and collapses to a more zonally oriented structure with commensurately severe impacts. Understanding changes in the characteristics of the SPCZ in a changing climate is therefore of broad scientific and socioeconomic interest. Here we show climate modelling evidence for a near doubling in the occurrences of zonal SPCZ events from 1891-1990 to 1991-2090 in response to greenhouse warming, even in the absence of a consensus on how itself ENSO will change. We estimate the increase in zonal SPCZ events from an aggregation of the climate models in the Coupled Model Intercomparison Project phases 3 and 5 (CMIP315 and CMIP5) multi-model database that are able to simulate such events. The change is caused by a projected enhanced equatorial warming in the Pacific and may lead to more frequent occurrences of extreme events across the Pacific Island nations most affected by zonal SPCZ events.

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Session: 12. Tropical processes in observations and models
Presenting Author: Dietmar Dommenget

The tropospheric land-sea warming contrast as the driver of tropical sea level pressure changes

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In this study we address the causes of the large-scale tropical sea level pressure (SLP) changes during climate change. The analysis we present is based on model simulations, observed trends and the seasonal cycle. In all three cases the regional changes of tropospheric temperature (T_{tropos}) and SLP are strongly related to each other (considerably stronger than (sea) surface temperature and SLP). This relationship basically follows the Bjerknes Circulation Theorem, with relatively low regional SLP where we have relatively high T_{tropos} and vice versa. A simple physical model suggests a tropical SLP response to horizontally inhomogeneous warming in the tropical T_{tropos}, with a sensitivity coefficient of about -1.7 hPa/K. This relationship explains a large fraction of observed and predicted changes in the tropical SLP.

It is shown that in climate change model simulations the tropospheric land-sea warming contrast is the most significant structure in the regional T_{tropos} changes relative to the tropical mean changes. Since the land-sea warming contrast exists in the absent of any atmospheric circulation changes it can be argued that the large-scale response of tropical SLP changes is to first order a response to the tropical land-sea warming contrast. Further, as land-sea warming contrast is mostly available moisture dependent, the models predict a stronger warming and decreasing SLP in the drier regions from South America to Africa and a weaker warming and increasing SLP over the wetter Indo-Pacific warm pool region. This suggests an increase in the potential for deep convection condi-tions over the Atlantic sector and a decrease over the Indo-Pacific warm pool region in the future.

Session: 12. Tropical processes in observations and models
Presenting Author: Chi Mai N. Hankinson

Rapid intensification of Hurricane Opal (1995) revisited: Distant trough interaction or down-stream development?

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The rapid intensification of hurricane Opal in 1995 and its forecast failure by then-operational numerical models attracted great research interest in following years. Different mechanisms for the intensification were proposed including a warm core ocean eddy and a mid-latitude trough interaction at upper levels. However, the effects of the trough interaction were not clear, as shown by other authors. In this work, ERA Interim data were employed to re-examine the dynamical framework in which Opal rapidly intensified while in the Gulf of Mexico. It is found that the upper part of Opal was embedded in an intensifying anticyclone, down-stream of a large-scale amplifying trough, which is a component of a propagating Rossby wave. In addition, the lower part of Opal's circulation was connected to a cyclonic potential vorticity (PV) region associated with the westerly trough. This configuration is favourable for intensification as cyclonic PV can be fed to the storm's vortex at middle levels, while the anticyclone above maintains a environment with low shear.

Session: 12. Tropical processes in observations and models
Presenting Author: Nicolas C. Jourdain

The Indo-Australian monsoon and IOD-ENSO interactions in the CMIP models

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In this presentation, we first analyse the ability of 60 CMIP3 and CMIP5 models to capture connections between the Indian and Australian summer monsoon rainfall and the Indo-Pacific modes of variability (ENSO and IOD). The cross-model analysis allows highlighting the factors that drive the strength of the monsoon-ENSO or monsoon-IOD relationship. Then, we assess the IOD-ENSO relationship in these models, in order to understand the inter-decadal variability of the connections between the Indian and the Australian summer monsoons.

Most models reproduce the observed ENSO-Australian monsoon teleconnection, with the strength of the relationship dependent on the strength of the simulated ENSO. However, over the Maritime Continent, the monsoon-ENSO connection is generally weaker than observed, depending on the ability of each model to realistically reproduce the ENSO signature in the Warm Pool region. The Indian monsoon-ENSO relationship is affected by overly persistent ENSO events in many CMIP models. It is also shown that models with stronger monsoon-ENSO relationships generally have a stronger monsoon- IOD relationship.

A recent study (Izumo et al. 2010) suggested that the Indian Ocean Dipole (IOD) could affect the phase of the El Niño Southern Oscillation (ENSO) during the following year. We find that the IOD seasonality is generally better reproduced that ENSO phase locking, and that the synchronous relation between ENSO and the IOD (i.e. tendency of ENSO to induce an IOD just before the ENSO peak) is reasonably well reproduced, and improved in CMIP5. A remarkable finding is that, as in observations, the IOD tends to lead ENSO by ~14 months in the longer CMIP3 and CMIP5 records; while there is no tendency for ENSO to precede an IOD ~10 months later. Consequences in terms of Indian-Australian monsoon connections are investigated.

Session: 12. Tropical processes in observations and models
Presenting Author: WonMoo KIM

The eastward zonal current events and the generation of strong El Niño

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El Niño–Southern Oscillation (ENSO), the dominant climate variability in the tropics, is characterised by the positively skewed sea surface temperature (SST) anomaly over the Eastern Pacific. There have been a number of studies on the nonlinear nature of ENSO, most of which incorporate the nonlinear dynamics and physics. These nonlinear processes seem to dominate from the later part of the developing period to decaying phase when the SST anomaly is large. However, it turns out that the significant departure of the growth rate between the moderate El Niño and strong El Niño occurs as early as April–May when the Eastern Pacific SST anomaly is negligible.

The climatological zonal current and the zonal wind stress in the equatorial Pacific is easterly during the early developing season (April–May) of ENSO. However, in some extreme cases the zonal current (and the wind stress) changes its direction, resulting in the strong net warming in the Niño regions. The advection of the mean temperature by these anomalous zonal current gives extra nonlinearity in the development of strong El Niño especially during the earlier part of the developing period. These eastward zonal current events are well distinguished from the normal (westward) cases, and show nonlinear relationship with the wind stress and the oceanic state. When the zonal current is to its climatological direction (westward), the zonal advection term does not contribute much on the development of the following ENSO; when the zonal current changes its direction, however, zonal advection becomes important, and the extreme El Niño's are always preceded by these eastward zonal current events.

Session: 12. Tropical processes in observations and models
Presenting Author: YUE LI

Evaluation of monsoon seasonality and the Tropospheric Biennial Oscillation transitions in the CMIP Models

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The Indian-Australian monsoon impacts on the economies of many countries and the livelihoods of millions of people. As such predicting the strength of future monsoon rainfall is extremely important. However, significant year-to-year variability that exists in this system, related to many internal and external processes, makes rainfall prediction difficult. Previous studies have reported a biennial tendency in this system, such that a strong/weak Asian monsoon is followed by a strong/weak Australian monsoon. This so called Tropospheric Biennial Oscillation (TBO) would be expected to facilitate improved predictive skill In this study, the interactions between the Indian and Australian summer monsoon systems and their seasonality are examined in a variety of observational rainfall datasets and in the Coupled Model Intercomparison Project Phase 3 and 5 (CMIP3 and CMIP5) climate models. In particular, we examined whether preferred monsoon transitions between the two regions that form parts of the TBO can lead to improved predictive skill. An overall improvement in the simulation of seasonality for both monsoons is seen in CMIP5 over CMIP3, with most CMIP5 models correctly simulating very low rainfall rates outside of the monsoon season. The predictability resulting from each transition is quantified using a Monte Carlo technique. The transition from strong/weak Indian monsoon to strong/weak Australian monsoon shows ~15% enhanced predictability in the observations, in estimating whether the following monsoon will be stronger/weaker than the climatology. Most models also successfully simulate this transition. However, enhanced predictability for other transitions is less clear. This methodology is also applied to simulations from the highest Representative Concentration Pathway (RCP8.5) to examine whether the predictive skills of preferred monsoon transitions in projections change in the future.

Session: 12. Tropical processes in observations and models
Presenting Author: Chris Lucas

Forcing factors behind southern hemisphere tropical expansion

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The radiosonde–based tropopause observations of Lucas et al. [2012] indicate an expansion of the Southern Hemisphere (SH) tropics of 0.4 degrees latitude per decade from 1979 to 2010. This value is broadly consistent with reanalysis-based tropopause estimates, as well as values from the published literature using other metrics to measure expansion.

The results from the radiosonde data show considerable interannual and decadal variability in the annual position of the tropical edge. Using multiple linear-regression, approximately 60% of the variance in the observational results can be explained by considering ENSO, volcanic aerosol, SH average temperature and the size of the springtime Antarctic 'ozone hole'.

Of the factors chosen for this statistical analysis, the proxy for ozone depletion explains ~60% of the trend since 1979. Volcanic aerosol accounts for ~20% and ENSO about 10%; these factors are both comparatively short-lived and their overall effect on the long-term trend is the product of the time period analysed. Southern hemisphere temperature, a proxy for greenhouse gas forced changes, accounts for the remaining 10% of the trend.

To further explore this statistical attribution, rates of tropical expansion in historical simulations from the NCAR Community Climate System Model version 4 (CCSM4) are analysed using a similar tropopause-based methodology as the observations. Model results from historical 'full-forcing' runs are compared to 'single forcing' simulations using ozone depletion, greenhouse gases, anthropogenic aerosols and natural forcings to estimate the relative contribution of each of these forcings.

Understanding the factors that have driven the observed climate change of the recent past is crucial for understanding future climate change and its impacts. The results will be discussed in this context.

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Session: 12. Tropical processes in observations and models
Presenting Author: Jing-Jia Luo

Indian Ocean warming modulates Pacific climate change

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It has been widely believed that the tropical Pacific trade winds weakened in the last century and would further decrease under a warmer climate in the 21st century. Recent high-quality observations however suggest that the tropical Pacific winds have actually strengthened in the past two decades. Precise causes of the recent Pacific climate shift are uncertain. Here, we explore how the enhanced tropical Indian Ocean warming in recent decades favors stronger trade winds in the western Pacific via the atmosphere and hence is likely to have contributed to the La Niña-like state (with enhanced east-west Walker circulation) through the Pacific ocean-atmosphere interactions. Further analysis, based on 163 climate model simulations with centennial historical and projected external radiative forcing, suggests that the Indian Ocean warming relative to the Pacific's could play an important role in modulating the Pacific climate changes in the 20th and 21st centuries.

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Luo, J.-J., W. Sasaki, and Y. Masumoto, 2012: Indian Ocean warming modulates Pacific climate change. *PNAS,* under review.

Session: 12. Tropical processes in observations and models
Presenting Author: C. Maes

Ocean salinity stratification near the eastern edge of the Pacific warm pool: a tentative review

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The idea that salinity contributes to ocean dynamics is simply common sense in physical oceanography. Along with temperature, salinity determines the ocean mass and hence, through geostrophy, influences ocean dynamics and currents. But, in the tropics, salinity effects have generally been neglected. Nevertheless, observational studies of the western Pacific Ocean have suggested since the mid-1980s that the barrier layer resulting from the ocean salinity stratification within the mixed layer could influence significantly the ocean-atmosphere interactions. This appears to be especially sensitive near the eastern edge of the Pacific warm pool, the region where warm sea surface temperatures are permanently larger than 28C, and it could have important implications for the dynamics of the El Niño Southern Oscillation (ENSO) phenomenon. Understanding the relying physical processes and long-term variability remains a key point and represents a particular stringent test for coupled ocean models used in forecasts and climate projections. A review of observed characteristics of the salinity stratification in such a crucial region as well as of impacts in coupled ocean-atmosphere models will be tentatively addressed. Implications for biogeochemical variability and biological activities will be also taken into consideration.

For more information:

http://www.legos.obs-mip.fr/maes

Session: 12. Tropical processes in observations and models
Presenting Author: Diandong Ren

Changes in tropical cyclone activities over Northwest Western Australia

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In the first half of this research, we examined the trend in tropical cyclone (TC) activity over the economically important northwest Western Australia TC basin (Equator-40S; 80-140E), based on statistical analyses of the International Best Track Archive for Climate Stewardship (IBTrACS) and large scale environmental variables, which are known to be closely linked to the formation and longevity of TCs, from NCEP/NCAR reanalyses. In the second part, changes in TC activity from climate model projections for 2000-2060 are compared for: (i) no scenario change (CNTRL) and (ii) the moderate IPCC SRES A1B scenario (EGHG). The aims are to: (i) determine differences in mean annual TC frequency and intensity trends, (ii) test for differences between genesis and decay positions of CNTRL and EGHG projections, using a non-parametric permutation test, and (iii) use kernel density estimation (KDE) for a cluster analysis of CNTRL and EGHG genesis and decay positions, and generate their probability distribution functions.

Session: 12. Tropical processes in observations and models
Presenting Author: Steven Sherwood

Lower tropospheric mixing and climate sensitivity

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Climate models predict a broad range of climate sensitivities to power inputs caused for example by increases in carbon dioxide. This spread is due mainly to different cloud feedbacks, in particular due to shallow clouds which can either increase or decrease in amount as climate warms, leading respectively to decreases or increases in planetary albedo. Here it is shown that about half the variance in climate sensitivity among models in the CMIP3 and CMIP5 ensembles---thus most of the variance in cloud feedback---can be explained by two simple measures of the degree of vertical mixing between the boundary layer and lower free troposphere, independent of deep convection, either explicitly resolved or parameterised, in the simulated present-day climate. In models with strong mixing, this appears to deepen in warmer climates, diluting and thinning the near-surface cloud layer as shown in detailed boundary layer simulations, producing a positive feedback. The key indicators of this process are most striking in regions of tropical deep convection, even though the key cloud changes themselves happen mostly in subtropical and midlatitude regions. This points to the key role of interactions between shallow and deep convection in controlling the low-cloud response and the degree of future global warming.

Session: 12. Tropical processes in observations and models
Presenting Author: Bernadette Sloyan

Observations of the Pacific and Indian Ocean exchange: initial results

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A fundamental aspect of observing, describing, understanding and modelling the global climate is a better knowledge of the fluxes of momentum, heat and freshwater in the ocean. The Indonesian seas are the only major low-latitude connection in the global oceans. This connection permits the transfer of Pacific waters into the Indian Ocean, known as the Indonesian Throughflow. The interaction of the Pacific and Indian basins and their modes of variability (El Niño–Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD)), both through atmospheric teleconnections and the ocean link via the Indonesian Throughflow, is now being hotly pursued in the research community.

The mooring array in the Timor Passage and Ombai Strait, a component of the Australian Integrated Marine Observing System (IMOS), monitors more than 80% of the total Indonesian Throughflow. Observations from these moorings provide the required spatial and temporal coverage to understand ocean dynamics, the ocean's role in climate variability and change, investigate forcing of the atmosphere and ocean and assess the realism of data-assimilative ocean models and coupled ocean-atmosphere models. During 2010-2012 the mooring array measured the full-depth volume, heat and salt transport between the Pacific and Indian Oceans. This presentation will discuss the initial results and provide a comparison with the 2004-2006 INSTANT observations.

Session: 12. Tropical processes in observations and models
Presenting Author: Clemens Spensberger

Deformation: a new diagnostic for the evolution of large-scale flow

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Deformation plays a key role in atmospheric dynamics. It frequently strengthens or weakens gradients of for example temperature, leading to frontogenesis or frontolysis. In addition, the influence of topography on the large scale circulation as well as the life cycle of a persistent blocking high can be analysed using deformation. Established diagnostics for the synoptic scale like vorticity and divergence cannot provide a direct perspective on those processes. The assessment of deformation will hence offer valuable insights into atmospheric dynamics at the synoptic scale and its interaction with the mesoscale. This study is a step towards a systematic assessment of the role of deformation in large-scale dynamics, providing a necessary foundation for the interpretation of deformation maps. For this task, a climatology of deformation has been constructed from ERA-Interim reanalysis data 1980–2010. We present the average annual cycle of deformation and show its dependence on several climate variability indexes. In the climatology four main processes appear to be contributors to the deformation budget: (1) frontogenesis which acts mostly at lower levels, (2) the movement and evolution of jet streams in the upper part of the troposphere, (3) topographic blocking which is most pronounced around the height of the mountain top and (4) dynamical blocking by stationary ridges in the mid-troposphere. For each of the processes a typical example from the dataset as well as a composite analysis is presented. Based on these examples we discuss the potential to discriminate the different processes for being able to assess their relative importance.

Session: 12. Tropical processes in observations and models
Presenting Author: Arnold Sullivan

Eastern-Pacific and Central-Pacific ENSO indices

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It was believed that El Niño is usually characterised by a peak surface warming in the eastern equatorial Pacific (canonical type). Recent studies however showed that a different type of El Niño with its major warming being located at the International Time Zone (central-Pacific type) has occurred more frequently during the last two decades. The two types of El Niño have distinct weather-climate impacts over the globe and appear to be controlled by different air-sea coupling processes. Because of this, one single index (such as the classic Nino3.4 which tends to mix up the two types of El Niño) may not be valid to represent the different flavors of El Niño. Efforts were done to develop proper indices for different El Niños, including Empirical Orthogonal Functions (EOF) and rotated EOF approach. The orthogonality constraint among EOF modes however may generate spurious modes lacking of physical basis. A few studies adopted Nino3 and Nino4 or their transformed indices (Ren and Jin, 2011) but with conditional constraints. The present study will revisit these existing methods of capturing the different El Niños and attempt to provide our simple but effective indices. The proposed indices are evaluated, based on both observations and ACCESS-CM's CMIP5 historical simulations, in capturing the distinct spatial patterns, air-sea coupling processes, and remote climate influences of different types of El Niño.

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Session: 12. Tropical processes in observations and models
Presenting Author: Hongyan Zhu

Intraseasonal moisture budget in ACCESS Model

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The intraseasonal moisture budget is analysed in ACCESS model simulations that have produced reasonable representations of eastward-propagating intraseasonal wind and precipitation variability. The goal of the study is to improve our understanding of the role that convection and dynamic processes play in the development and evolution of the tropical organised convection, in order to improve the simulation of intraseasonal variability in our global prediction models.

Breaking the vertical moistening profile into components associated with each of the elements of the model physics shows that parameterised convection tends to dry the troposphere and that large scale vertical advection moistens the troposphere. These two tendencies roughly balance each other; large scale precipitation dries the upper troposphere due to precipitation and moistens the lower troposphere due to evaporation; the total moisture tendency is asymmetric relative to the maximum precipitation, corresponding to the recharge and discharge process of organised convection in the Tropics. This moistening before and drying after the maximum precipitation is consistent with the large-scale horizontal advection of moisture.

The role of horizontal advection on the recharge-discharge mechanism of organised convection is analysed. The results show that horizontal advection causes recharge (discharge) of moisture within regions of anomalous equatorial lower tropospheric easterly (westerly) anomalies.

Session: 13. Regional climate projections
Presenting Author: Jonas Bhend

What can we learn from recent regional climate change about future expected change?

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Ongoing climate change will eventually manifest in observed time series. Therefore, it seems natural to ask to what extent recent climate change is informative of future expected change. At global to continental scales, recent observed warming has been shown to offer useful constraints for future projections. Here we assess to what extent recent subcontinental to local change can help to constrain future projections. To this end, we compute the fraction of variance in future projections across a number of climate model simulations from the CMIP3 and CMIP5 archives that can be explained by variability in the simulations of recent change across the same models.

We expect strong correlation between the recent and future response to increasing atmospheric greenhouse gas concentrations (GHG). In addition, other anthropogenic and natural forcings have contributed to climate change in the recent past and, therefore, the regionally dominant forcing in the past may differ considerably from the dominant forcing in plausible futures (mainly GHG). To assess the influence of different forcing mechanisms, we subset the multi-model ensembles according to the set of temporally varying forcing mechanisms used for the simulation of the historical period. This also allows us to address to what extent regional attribution studies could help to constrain future projections.

We analyse changes in near-surface temperature and precipitation and find that recent regional change offers some constraints for future projections. Preliminary results suggest that the fraction of explained variance in future projections varies considerably between regions and seasons. In most regions and seasons, there is a combination of variables that explains more than 40% of variance in future projections, generally, however, the fraction of variance explained is smaller than 30%. Contrary to expectations, there is no indication that recent anthropogenic change offers better constraints for future projections than recent anthropogenic and natural change combined. While the signal-to-noise ratio of recent regional change is still low and dominant forcing mechanisms in past and future expected climates vary, recent climate change is already informative of future expected change to some extent. With ongoing climate change, however, we expect recent change to become more important to constrain future projections.

Session: 13. Regional climate projections
Presenting Author: Jason Evans

The COordinated Regional climate Downscaling EXperiment (CORDEX)

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The World Climate Research Programme (WCRP) is backing an international initiative called the COordinated Regional climate Downscaling EXperiment (CORDEX). The goal of the initiative is to provide regionally downscaled climate projections for most land regions of the globe, as a compliment to the global climate model projections performed within the fifth Coupled Model Intercomparison Project (CMIP5). CORDEX includes data from both dynamical and statistical downscaling. CORDEX has a detailed data specification ensuring that all contributed data can be used interchangeably. The CORDEX database will continue to grow over the next several years and will provide the most comprehensive, regional scale, climate projections available for most land areas. This multi-model climate projections ensemble will facilitate impacts and adaptation research around the globe. This talk will describe the CORDEX project and provide some example outcomes from various CORDEX domains.

Session: 13. Regional climate projections
Presenting Author: L. Fita

NARCliM: Exploring new observational data-sets to validate regional climate simulations. An example with radio-soundings

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NARCliM (NSW / ACT Regional Climate Modelling project) is a regional climate modelling project that will provide an ensemble of regional climate simulations for Australia with higher resolution for NSW and the ACT. Both governments will use the outputs of the project to design the state plans of climate change adaptation. Experiment is designed to produce an ensemble of 12 members using 3 different configurations of the WRFv3.3 model, 4 different GCMs on three different 20-year time-windows (1990-2009, 2020-2039 and 2040-2059).

In order to analyse the climatic response of the WRF model, 60-year runs (1950-2009) with the three WRF configurations have been performed using NCEP re-analysis. It is common to evaluate the present/control climate runs using gridded data-sets for temperature and precipitation such as AWAP from the Bureau of Meteorology. In this talk, we will present the results of a complementary evaluation of the model runs using another source of observations. In this case, we have all the BoM Australian vertical soundings for the covered period. The use of this data-set opens the possibility to explore some other aspects of the simulations such as: climatic vertical structure of the atmosphere, link between surface pollution and vertical thermal inversion, strong convectivity, urban island heat effect and others. The use of these atmospheric observations, along with standard surface observations, allows a more comprehensive evaluation of the regional climate model performance.

Session: 13. Regional climate projections
Presenting Author: Paul Fox-Hughes

Fire danger projections for Tasmania during the twenty-first century

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The Climate Futures for Tasmania (CFT) project delivered climate projections out to 2100 at a resolution of approximately 10 km over the entire state, based on dynamically downscaled global climate model data from several CMIP3 models. We have used those projections to study implications for fire danger during this century, including assessment of likely soil and fuel moisture characteristics based on Mount Soil Dryness Index and Drought Factor used operationally in fire management in Tasmania. The high spatial resolution of the downscaled model simulations, generally low biases together with a process of bias-adjustment of outputs against observations allowed the calculation of daily fire danger ratings directly from model outputs. This has the advantage of maintaining dynamical balance of the simulated high fire-weather events.

Daily values of fire danger were calculated across the state, from which trends in fire danger seasonality and vulnerable regions were established. In addition, model output at the model timestep (6 minutes) is used to examine the diurnal and other sub-daily variability in fire danger across a range of environments. The results from the fine resolution climate modelling indicate climate warming has significant implications for the incidence of high fire-weather danger, especially under a high emissions scenario (A2). The results also indicate there is variation of the impact of high fire danger across Tasmania, with some of the highest increases in fire danger projected for the areas that already experience the highest dangers, such as the southeast and some regions of the southwest wilderness. Together with possible changes to bushfire fuel dryness, structure and functional type, this change in the incidence of high bushfire weather represents a challenge for bushfire management in Tasmania.

Session: 13. Regional climate projections
Presenting Author: Harris, Rebecca

Adding value to ecological studies using dynamically downscaled regional climate projections

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High resolution climate projections are essential to almost all ecological studies, which require climate data at biologically relevant scales. Species distribution models (SDMs) are one of the most important tools currently available to assess the potential impacts of climate change on natural communities. They are commonly used to project future changes in the geographic ranges of species, based on the statistical relationship between climatic variables and the current, observed distribution of a species. We present the results of a species distribution model, MaxEnt, for an endangered species of butterfly, the Ptunarra Brown, and assess trends in important climate variables based on dynamically downscaled climate projections of future climatic conditions. The projections were created using the regional climate model Conformal Cubic Atmospheric Model (CCAM), and outputs were interpolated to 1km resolution using a thin plate smoothing spline in the ANUCLIM package.

Dynamically downscaled projections include high frequency and seasonal information that are essential to understanding species' responses to climate change, which are driven not just by mean conditions, but by climate variability and interactions between climatic variables. The *Ptunarra* Brown butterfly has very specific thermal requirements, and interactions between temperature, rainfall and cloud cover are important determinants of activity and distribution. Throughout its range, projected changes in mean temperature, rainfall and radiation are likely to be beneficial to this species, but the biological response is expected to occur before the mean climate crosses critical thresholds over the next century. Seasonal and yearly variations are very important in identifying the emergence of climatological threats for this species, particularly in relation to changes in the timing and duration of the climatically suitable activity period and interactions with other ecological factors.

Session: 13. Regional climate projections
Presenting Author: Damien Irving

Towards new national climate projections for Australia: First impressions of CMIP5

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The latest national climate projections for Australia are based primarily on CMIP3 data and were published in 2007. The CMIP5 database will form the basis of the updated national projections scheduled for release in early 2014, and preliminary CMIP5 data are progressively being made available to the research community. This paper presents a basic analysis of those preliminary data in terms of the simulated present climate and projected future climate for Australia. Our results suggest that many of the deficiencies identified in CMIP3 simulations of the region, including those associated with rainfall seasonality across southern Australia and the intensity of the Monsoon, still persist in the CMIP5 ensemble. The CMIP5 models also tend to underestimate observed Australia (and global) mean temperature trends over the twentieth century, which was not a feature of CMIP3. With respect to the future climate, the CMIP5 ensemble was found to be highly consistent with existing CMIP3 derived projections. This finding confirms previous CMIP3 results that indicate a projected rainfall decline in south-west Western Australia (and to a lesser extent south-eastern Australia), but does not provide improved model agreement on future rainfall changes in the tropics, where the spread in climate model simulations remains large. A novel approach to mapping model agreement on future climate projections is also presented, which combines a number of recently published methods.

Session: 13. Regional climate projections
Presenting Author: Aurel Moise

Decadal variability of the Australian monsoon and future projections as represented in CMIP5 models

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Although populations affected by the Australian monsoon are much smaller than those affected by the South and East Asian monsoons, regional impacts of changes in monsoon timing or strength are nevertheless likely to be large, particularly on vulnerable indigenous populations and sensitive ecosystems. The strength of the Australian summer monsoon is known to vary naturally on interannual and decadal time scales, with recent trends towards increased rainfall in the north-west attributed, at least partially, to anthropogenic aerosol forcing. We report on the simulation of decadal variability of Australian monsoon rainfall in CMIP5 models, focusing on the rainfall response to the Interdecadal Pacific Oscillation (IPO) in historical climate. We also investigate changes in monsoon rainfall in future climate simulations under the high emission "RCP8.5" scenario, considering both mean changes and changes in the amplitude of decadal variability. Projections of the Australian monsoon response to a warming climate in CMIP5 models show little change in mean summer rainfall over tropical northern Australia, consistent with results from CMIP3 models. While future changes in Australian summer monsoon rainfall due to thermodynamic processes (increased atmospheric moisture) are generally positive, those due to dynamic process (changes in circulation) are more uncertain and vary from model to model.

Session: 13. Regional climate projections
Presenting Author: Marcus Thatcher

Development of an in-line ocean model for improving regional climate simulations with the Conformal Cubic Atmospheric Model

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Traditionally, dynamical regional climate models employ prognostic techniques to represent the land-surface, but use interpolated Sea Surface Temperatures (SSTs) from Global Climate Models (GCMs) to estimate surface fluxes over water. However, this approach fails to account for changes in SSTs along coastlines, for changes in SSTs during extreme weather such as cyclones, or for representing large lakes that should be resolved by the regional climate simulation. In this presentation we describe a prototype in-line ocean model which has been incorporated into the variable-resolution Conformal Cubic Atmospheric Model (CCAM). By exploiting the reversible staggering properties of the CCAM atmospheric dynamical core, we are able to efficiently couple the ocean and atmosphere at each time step, while theoretically maintaining excellent dispersive behavior. Digital filters have been designed to constrain the ocean model to follow the host GCM at large length scales, while tolerating irregular coastlines. Some preliminary results are shown, indicating that coupled atmosphere/ocean regional climate models are feasible for practical dynamical downscaling applications, especially with the next generation of supercomputers.

Session: 13. Regional climate projections
Presenting Author: Vidyunmala Veldore

Multimodel assessment of temperature over Nepal region using high-resolution regional climate models: a Bayesian statistics approach

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The estimation of uncertainties in global and regional climate models has become quite relevant in the past years. The use of multi-model mean ensembles has been criticised since it is not be able to resolve and provide reasonable results. The needs for new approaches to understand uncertainty have become essential. Recent scientific publications have suggested alternative approaches to estimating model uncertainty, such as the use of ANOVA and Bayesian statistical methods. In this paper, we are going to discuss the importance of Bayesian statistics approach to assess model performance in a given region. High-resolution regional climate model simulations with three different regional climate models (WRF, PRECIS and RegCM3) have been performed for baseline (1971-2000) and future (2030-2060) periods. The model simulations cover the highly varying topographical region of Nepal. The objective of the paper is two fold a) understand the performance of the three regional climate models over the Nepal region using Bayesian statistics, b) to question the value of bias correction and to understand how it could affect model performance over the Nepal region. We will be following Bayesian framework where the normal and inverse-gamma distributions are applied to the conjugate prior distribution (with information from large observational network over Nepal). Results will be shown with respect to the Monte Carlo samples of the posterior distribution for the surface temperature in Nepal.

Session: 13. Regional climate projections
Presenting Author: Lang Wang

Impacts of large-scale reforestation programs on regional climate change: A regional climate modelling study on Loess Plateau, China

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Reforestation has been implemented in many developing countries in recent years. China initiated series of aggressive reforestation projects and planned to expand them to the whole country. However, mainly because of the altered land surface properties and carbon sequestration, reforestation might have strong impacts on regional climate. In addition, series of hydrological problems have been detected during the processes, which made reforestation a controversial program. Therefore, impacts of reforestation and its composition on climate are quite critical for mitigating climate change and improving ecosystem conditions. In this study, Loess Plateau with typical reforestation polices is investigated during recent decades. A regional climate model RegCM4.3 is adopted as a tool to perform regional climate projections. The control experiment with pre-reforestation map is treated as the base line for reference. Six scenarios with different land uses are performed by replacing farmland to forest, shrub, grass, forest-grass mixture, forest-bush mixture and grass-bush mixture, respectively. Preliminary results showed that RegCM4.3 had quite good performance in the control simulation of reproducing the climatology in both summer and winter seasons in the region. Analysis of the other scenarios revealed spatial differences in the simulated temperature and precipitation compared with the control. Warming effects, wetting in the west and drying in the east were generally obtained in the six scenarios. These changes are mainly due to conversion of cropland to natural vegetation, which consequently led to changes in surface albedo, evaporation, roughness length and stomatal resistance. These factors may modify the energy budget and convection processes thereby further influence the regional climate features. These involved physical processes are currently under detailed analysis. Further researches based on actual afforestation data, finer resolution, longer model integration as well as study on larger-scale regional impacts will be carried out.

Session: 14. Interdisciplinary session: the Sthn Ocean and its role in climate
Presenting Author: Christopher Chapman

Jet jumping: variability in the Southern Ocean

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Recent observations of the Southern Ocean from fixed moorings and satellite altimetry have revealed that the jets, or "fronts" that make up the Antarctic Circumpolar Current show peculiar variability in the vicinity of large, sub-surface topographic features. Two (or more) jets that pass near the same topographic feature display anti-correlated behaviour, where one jet will increase in strength at the expense of others. This variability can manifest itself in dramatic ways, with a particular jet changing "preference" for a topographic feature. For example, a jet that previously skirted a plateau to the north, can very rapidly shift to skirt the plateau to the south. Shifts in the latitudinal position of jets of more than 10 degrees have been observed.

We will present a simple framework explaining this behaviour, built on the results of an idealised numerical model. We posit that it is the interaction of turbulent eddies and topographically driven flow in the abyssal layers that explains the observed variation in mean currents observed at the surface and middle layers. The feedback of eddy – mean flow will also be discussed.

Session: 14. Interdisciplinary session: the Sthn Ocean and its role in climate
Presenting Author: Clothilde Langlais

Southern ocean subduction in an eddy-resolving model

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Ocean processes strongly influence the rate and pattern of climate change. The extent to which the ocean can slow the rate of climate change depends on the transfer of properties between the surface and the interior of the ocean, a process known as subduction. The volume and depth to which water is subducted determine the effective capacity of the ocean to sequester carbon. However, exchange between the surface and the ocean interior is difficult to observe directly and our knowledge of the mechanism, location, and rate of subduction is therefore limited, particularly in the poorly-observed southern hemisphere oceans. The importance of small-scale eddy motions in the subduction process is also poorly known.

Guided by recent observational and theoretical work that identified the importance of regional "hot spots" related to topography and eddy-mean flow interactions, this work explores the regional structure and rate of the subduction hotspots, focussing on vertical motions across the winter mixed layer. We use modelling outputs from 1/10° resolution Bluelink model called OFAM3 (Ocean Forecasting Australia Model) that covers the 1993 to 2010 period. We find regional subduction pathways that are similar as observational work. And around the circumpolar path, the subduction occurs at different density classes that are consistent with observations. The regional hotspots show strong spatial and temporal variability of the subduction rate which reflects the effect of the standing and transient filamented structure of the Antarctic Circumpolar Current (ACC) jets (small meanders and eddies) on the vertical motions. The interannual variability of the winter depth of the mixed layer not only introduces a redistribution of the rate of subduction but also have a cumulative positive effect (reinforcing the subduction at the hotspots).

Session: 14. Interdisciplinary session: the Sthn Ocean and its role in climate
Presenting Author: Jing-Jia Luo

Predictability of the subtropical dipole modes in a coupled ocean-atmosphere model

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Predictability of the subtropical dipole modes is assessed using the SINTEX-F coupled model. Despite the known difficulty in predicting subtropical climate due to large internal variability of the atmosphere and weak ocean-atmosphere coupling, it is shown for the first time that the model can successfully predict the Indian Ocean Subtropical Dipole (IOSD) and South Atlantic Subtropical Dipole (SASD) at lead time of up to 1 to 2 seasons with a prediction barrier in austral autumn due to the seasonal locking of the IOSD and SASD to austral summer. The overall prediction skills of the IOSD are higher than those of the SASD. Also, the predictability of sea surface temperature anomalies in the north¬¨eastern pole of the IOSD is higher than that of the southwestern pole, whereas no significant difference is found in the predictability for the two poles of the SASD.

The co-occurrence of the negative IOSD and SASD in 1997/98 austral summer can be predicted well from June 1st of 1997. This is because negative sea level pressure anomalies over the southern Indian Ocean and the South Atlantic in September-October (November-December) that lead to the development of the negative IOSD and SASD are linked with the well predicted tropical Indian Ocean Dipole (El Niño/Southern Oscillation).

Owing to the high predictability of the IOSD, SASD, and El Niño/Southern Oscillation, the prediction skills of the southern African summer precipitation are reasonably high in the SINTEX-F model.

References:

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Session: 14. Interdisciplinary session: the Sthn Ocean and its role in climate
Presenting Author: Kate Snow

Modelling antarctic bottom water (AABW) overflow in global climate models

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Antarctic Bottom Water (AABW), the dominant abyssal water of the global ocean and an important distributor of energy, carbon and nutrients, provides a significant contributor to the global ocean energy and sea level budget. To more fully understand the AABW's contribution to the global budgets, suitable representation of AABW formation and transport is required in global climate models (GCMs), processes currently poorly realised through the overflow parameterizations implemented in GCMs. Motivated by this poor representation, a sensitivity analysis of three different overflow parameterizations (a downslope transport scheme, a sigma bottom boundary layer scheme and an imbedded Lagrangian point particle method) is conducted using the Modular Ocean Model (MOM). Coupling MOM to the GFDL Sea Ice Simulator (SIS), the parameterizations are applied to a realistic-topography sector model of the Atlantic Ocean. Analysing the sensitivity and performance of each parameterization provides an indication of the most suitable model for use in representing overflows in the Southern Ocean. Further, understanding of each parameterization's performance is important for an accurate representation of the AABW and the deep ocean in GCMs, hence allowing a more reliable indication of bottom waters contribution to the global energy and sea level budgets.

Session: 14. Interdisciplinary session: the Sthn Ocean and its role in climate
Presenting Author: Paul Spence

Projections of Antarctic Bottom Water formation in response to an increased Southern Annular Mode

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At several locations along the Antarctic coastline extreme surface buoyancy forcing and mixing produces Antarctic Bottom Water, the densest water mass in the global ocean. The bottom limb of the meridional overturning circulation (MOC) transports AABW northward at a rate of roughly 20Sv (1Sv= 106m3/s), primarily in deep western boundary currents. Here we evaluate the flow pathways of AABW out of the Southern Ocean in an ocean-eddy-permitting, global coupled climate model using both Lagrangian trajectory and Eulerian frameworks. In the pre-industrial control state of the model AABW is formed predominately in the Ross Sea and Weddell Seas and also on the eastern side of Antarctica. Transient eddies are found to play a crucial role in transporting AABW across streamlines of the Antarctic Circumpolar Current. However, the primary objective of this study is to investigate changes in AABW formation and transport in response to projected 21st century changes in SO wind stress. A Lagrangian trajectories analysis reveals an 11% increase in the formation of AABW under an increased SAM. However, the stream function of the AABW cell in the model decreases in strength, from a maximum of 27 Sv to 19 Sv. The apparent dichotomy between the Lagrangian results and the Eulerian stream function is explained by considering changes in the southward return flow of Circumpolar Deep Water (CDW), which flows at approximately the same density levels as the outflowing AABW, The zonally averaged stream function is the net of the two counter-flowing water masses. As the SAM increases, the southward flow of CDW increases more than the northward flow in AABW, and therefore the stream function appears to decrease.

Session: 15. Renewable energy
Presenting Author: Belinda Campbell

One minute solar data: presenting a new public resource

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The focus of the Bureau's solar monitoring network has been to establish a suitable solar climate record. As a member of the World Meteorological Organization (WMO), Australia, through the Bureau of Meteorology, has been providing global and diffuse solar exposure data from its monitoring stations to the WMO World Radiation Data Centre since the mid-1960s. Secondary applications for the network's data have included solar power systems design and simulation, architecture, agriculture and ecology, health and engineering. Data quality was an issue with the original network as it relied on an initial calibration of the instruments, and subsequent correction of data using modelled climatology based on measurements in South Africa. A new surface network, called the Solar and Terrestrial Radiation Network (S&T) began in 1993 and collected one minute irradiance statistics of direct, diffuse and global solar exposure and terrestrial (longwave) irradiance. Data quality assurance and quality control of the S&T station measurements are such that the 1993 target of 95% uncertainties for any minute exposure quantity of 3% or 900 Jm-2 (which ever is the greater) have been achieved and improved upon. This poster describes the network characteristics which enable such targets to be met, and presents some of the issues encountered. The size of the network has fluctuated over time, but in total twenty nine sites have operated as part of the S&T network. While one minute data have been archived since 1993, until recently there was no system to provide public access to the observations. This poster describes a project which commenced in early 2012 and has enabled public access to these data. Finally, the results of a survey are presented which provides an insight into the user requirements and applications for these data. http://www.bom.gov.au/climate/data/oneminsolar/about-IDCJAC0022.shtml

Session: 15. Renewable energy
Presenting Author: Kim Nguyen

Impact of large solar farms on local climate

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Some solar power installations currently being considered are the size of large cities and have the potential to alter the local climate. For reference, such an impact could be similar in magnitude to large forestation and crop changes. Changes in the energy balance have the potential to affect the local climate, especially if there is abundant moisture in the atmosphere. More specifically, local climate impact depends significantly upon the location of the solar array relative to prevailing winds and atmospheric moisture, as well as the shape and orientation of the array. Solar power plants proposed under the Solar Flagships program in Australia are not designed with weather modification in mind and their effect on weather is unknown but should be determined, both positively and negatively, before they are built. With this paper we first discuss key atmospheric processes potentially induced by a large solar farm. We then present a preliminary assessment of the impact of solar power plants on the local climate, particularly in regards to rain generation, and as a function of the power plant size.

Session: 16. Insights from the Integrated Marine Observing System (IMOS)
Presenting Author: Matthew Bell

Internal tides and waves off the NSW coast as observed in IMOS mooring data

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Internal tides and waves affect circulation and mixing in the ocean. They are also of interest to the Navies of the world due to their impacts on sonar and submarine operations. To investigate the internal wave and tidal fields off the New South Wales coast, temperature and velocity records from different moorings were examined. Data from seven moorings spread over three different locations were examined: two off Coffs Harbour, three off Sydney, and two off Batemans Bay. Both internal tides and internal waves at the harmonic frequencies were found. The energy associated with them depended on the strength of the stratification. For example, off Sydney in 140 m of water, most of the time, a strong stratification was present and the water column behaved as a two-layer fluid with a 10-20 m transition layer between them at about 70 m. However during times of weak stratification, the internal response was negligible. The internal wave field responded to the presence of the East Australian Current (EAC), which typically weakened the stratification. There was also a seasonal response in the internal wave field.

Session: 16. Insights from the Integrated Marine Observing System (IMOS)
Presenting Author: Luke Garde

ReefTemp Next Generation: A new operational system for monitoring reef thermal stress

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ReefTemp is a specialised remote sensing application for the monitoring of local sea surface temperature (SST) conditions that may lead to coral bleaching. ReefTemp is currently used on a daily-to-weekly time scale throughout the year by the Great Barrier Reef Marine Park Authority (GBRMPA) to assess the current temperature and stress conditions over the reef at ~2km resolution.

The original ReefTemp system was developed at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in 2007 and is based on the Australian Bureau of Meteorology's legacy 14-day Advanced Very High Resolution Radiometer (AVHRR) satellite mosaic SST product. Under the National Plan for Environmental Information (NPEI) eReefs program, the new ReefTemp Next Generation system is under development at the Bureau of Meteorology and will be run operationally with full-time support in 2013. The new products are derived from high resolution Integrated Marine Observing System (IMOS) L3S multi-sensor satellite SST data.

Continuous SST monitoring provides researchers and stakeholders with tools to understand and better manage the complex interactions leading to coral bleaching. When bleaching conditions occur, this tool can be used to support both bleaching response plans and reef management decisions.

This presentation will give an overview of the new ReefTemp Next Generation system, discuss user requirements as well as address scientific questions that arose during development.

Session: 16. Insights from the Integrated Marine Observing System (IMOS)
Presenting Author: Katy Hill

Australia's Integrated Marine Observing System – monitoring major boundary currents and inter-basin flows

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Monitoring boundary currents demands multiple observational techniques within the Integrated Marine Observing System (IMOS). Shelf and deep water Moorings are being deployed in the narrowest and most coherent sections of the Indonesian Throughflow and EAC, to monitor full depth fluxes of heat, mass and salt. Ocean Gliders, Ocean Radars and National Reference Station Moorings are being used to look at boundary current dynamics and their interaction with circulation on the continental shelf. Argo Floats and Ships of Opportunity are providing broad scale context and drivers, with Satellite altimetry and SST providing broad spatial and temporal resolution.

Recent IMOS deployments in the Indonesian Throughflow (ITF) and East Australian Current (EAC). Will enable accurate measurement transport of mass, heat and salt at 3 locatons from the tropics to the Southern Ocean, to see how it is changing over time.

These deep arrays provide the link between the broad-scale circulation and the continental shelf processes. Both the EAC and ITF deepwater mooring arrays are connected to a shelf array; The EAC deep water mooring array will complement existing IMOS observations being taken off the Great Barrier Reef, the New South Wales coast, and the east coast of Tasmania that monitor the EAC. and to understand what these changes might mean for marine ecosystems and coastal populations along the eastern seaboard. The recently deployed Kimberly and Pilbara mooring arrays will help to explain the nature of the connection between the Indonesian Throughflow and the Leeuwin Current, by observing variability in shelf currents and coastally trapped waves along the northwest shelf and how they relate to observations at the ITF to the north, and off of Perth to the South.

This poster will provide an overview of IMOS activities in monitoring major boundary currents and interbasin flows, outlining research questions to be addressed and the observing strategy being implemented.

All IMOS data is freely available for anyone to use. For more information, visit the IMOS website at: www.imos.org.au

Session: 16. Insights from the Integrated Marine Observing System (IMOS)
Presenting Author: Alessandra Mantovanelli

Influence of the complex topography on particle dispersion in the southern Great Barrier Reef

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Two clusters of four surface satellite-tracked drifters were deployed in the southern Great Barrier Reef and followed for periods of 16-20 days over an area of flat bathymetry on the shelf ('lagoon cluster') and along a low-density reef matrix of complex topography ('reef matrix cluster'). The resultant north-westward displacement of the drifters was driven by low-frequency currents; the high-frequency currents (tides) were responsible for the superimposed loops and zigzagging movements on the tracks that enhanced the particle diffusivity.

The reef matrix cluster presented relative dispersion two orders of magnitude higher than the lagoon cluster, and diffusivity 52 times greater. Submesoscale processes (< 20 km) generated by secondary circulation and small eddies (diameter of a few kilometres) caused abrupt separation of the drifters in the vicinity of the reefs and regions of complex topography, increasing their relative dispersion.

The reef matrix drifters travelled on average ~30 km day-1 during the analysed period. Despite the faster advection and larger dispersion of the drifters along the reef matrix, the presence of ring circulations around the islands and small eddies can act as a trapping mechanism to keep particles within the matrix, retarding the loss to open water areas. This suggests an efficient physical mechanism of both increasing larval connectivity between reefs and at the same time trapping the larvae within the reef environment.

Session: 16. Insights from the Integrated Marine Observing System (IMOS)
Presenting Author: Alessandra Mantovanelli

Lagrangian dynamics in the Solitary Islands Marine Park (SIMP)

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Physical processes operating over a wide range of spatial and temporal scales drive the hydrodynamics of the Solitary Islands Marine Park (SIMP) region, including wind-induced currents, tidal currents, waves and the poleward flowing East Australian Current (EAC) and its cross-shelf movement.

We present here analysis of Lagrangian trajectories from drifting buoys (drifters) re-deployed in the SIMP region over four consecutive days and followed for 8 h each day. Clusters of four surface (drogues at 1-2.4 m) and five sub-surface (drogues at 2-6 m) drifters were released approximately at the same time keeping small initial separations (30-300 m). Surface and sub-surface currents estimated from drifter measurements presented differences of O(0.05-0.1 m s^{-1}) which caused a separation of the two clusters of ~1.5-2.0 km over periods of 8 h; this separation is expected to grow over time. Each cluster of drifters however travelled relatively close together, expanding their initial separation by 2-4 times in 8 h.

The resultant displacement direction of the drifters rotated from north-west (first day), to west (second day) under weak currents (~0.05-0.20 m s^{-1}) and subsequently to southwest (last two days) as currents rotated and intensified (~0.3-0.6 m s^{-1}). The pattern observed in the first two days was probably associated with the capture of the drifters in a region of cyclonic colder water intrusion and the weakened influence of the EAC on the shelf, which was followed on the next two days by its onshore movement and intensification. A further increase of the current speeds occurred in the afternoon likely associated with the intensification of the north-east winds.

These results are analysed in conjunction with measurements from multiple platforms in particular the recently deployed IMOS Coffs Harbour HF radar, as well as shipboard ADCP, and CTD profiles. In addition an IMOS glider mission co-incided with the Lagrangian experiment. These data are combined to deduce the physical forcing mechanisms of the Lagrangian dynamics in the SIMP region.

Session: 16. Insights from the Integrated Marine Observing System (IMOS)
Presenting Author: Sebastien Mancini

Opportunities for marine and climate data discovery

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The Integrated Marine Observing System (IMOS) has a marine information infrastructure accessible through the IMOS Ocean Portal (http://imos.aodn.org.au). This provides an intuitive discovery path to data either through a map interface or a catalog search. This infrastructure has been developed further to underpin the Australian Ocean Data Network (AODN), the distributed data infrastructure linking the major marine data holdings of the Australian Institute of Marine Science, Australian Antarctic Division, Bureau of Meteorology, CSIRO Marine and Atmospheric Research, Geoscience Australia, Royal Australian Navy, all accessible through the AODN portal (http://portal.aodn.org.au). Increasingly, the AODN portal is providing access to wider data holdings from State Governments, Universities and Commonwealth Government departments, and to collections of data products from national programs. By also linking to model products of national interest the AODN portal provides an opportunity to assemble significant collections of information in a single instance. Through the Research Data Storage Initiative (RDSI), a national network of data storage nodes is being established which includes a Tasmanian Node sited at the University of Tasmania, focused on marine, climate and Antarctic data. This offers unprecedented opportunities to store large marine and climate datasets of Australian and Antarctic content, and international datasets of interest to Australian researchers working in these domains. Through RDSI mechanisms will be put in place to provide access to these data collections, including linking to the AODN. The processes for building this data network are being developed in a pilot study, currently underway. We will describe the data holdings accessible through the AODN, the possibilities offered by the national RDSI network, and the Tasmanian Marine and Climate data hub and demonstrate, through case studies, the opportunities presented for integrated studies including model-observation studies offered through the NeCTAR Marine Virtual Laboratory (MARVL).

Session: 16. Insights from the Integrated Marine Observing System (IMOS)
Presenting Author: Robin Robertson

IMOS glider observations of internal tides and waves off the NSW Coast

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Observations of internal tides and waves off the New South Wales coast are sparse and consist mainly of mooring data and altimeter crossover data. To provide a more extensive spatial coverage, IMOS glider data was analysed for internal wave and tide content. Temperature and depth data from both Seagliders and Slocum gliders were used for this analysis. The resulting internal tide and wave fields were dependent upon the stratification. When the glider was passing through a weakly stratified region, the internal wave and tide content was small or negligible. In stronger stratification, clear energy was present at higher frequencies corresponding to the tidal harmonics in the depth data. Estimates of internal tides were more problematic due to the glider's motion and the length of the glider deployment, typically ~ 20 days. When the glider path stayed in roughly the same area, internal tides could be identified in the temperature fields. Consequently, gliders can be used to expand observations of internal waves, although there are limitations with Slocum gliders due to their short duration.

Session: 16. Insights from the Integrated Marine Observing System (IMOS)
Presenting Author: Erik van Sebille

Designing an integrated monitoring system for Tasman leakage

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Tasman leakage, the westward flow of thermocline waters south of Australia, is a non-negligible component of the Pacific-Indian inter-ocean exchange, accounting for roughly 25% of the total mass and heat fluxes. Since the Tasman leakage varies greatly on both sub-annual and inter-annual time scales, a case could be made that the existing efforts to monitor the Indonesian Throughflow should be augmented by a monitoring program for the Tasman leakage in order to capture the full Pacific-Indian inter-ocean exchange.

Monitoring the Tasman leakage, however, is much more complicated than measuring the Indonesian Throughflow, predominantly because the variability in the strong Antarctic Circumpolar Current to the south of the leakage pathway dwarfs any signal in the Tasman leakage, and because local recirculations complicate the analysis of mooring array data south of Tasmania.

Here, we use an eddy-resolving model to investigate the possibilities for monitoring the Tasman leakage in the real ocean. A time series of Tasman leakage obtained from a Lagrangian experiment within the model is compared to time series of quantities that can be measured in the real ocean, including the strength of the EAC, the eddy field along the Tasman leakage path, and the isopycnal structure south of Tasmania. A combination of these proxy time series might be the basis for a monitoring program for the Tasman leakage.

Session: 16. Insights from the Integrated Marine Observing System (IMOS)
Presenting Author: Julie Wood

Explaining variability on the continental shelf upstream and downstream of a western boundary current's separation zone

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The seasonality of coastal wind, current and temperature along the southeast Australian continental shelf upstream and downstream of the separation zone of the adjacent western boundary current, the East Australian Current, is investigated using more than two years of data. Using two different harmonic regression models we show that temperature exhibited the strongest seasonal effect explaining up to 80% of the variability at the surface. Along-shelf currents at the shelf-break upstream of separation show a weak seasonal cycle, explaining greater than 5% of the variability with an amplitude of greater than 0.15 m s-1 for depths above 34 m. It shows strongest pole-ward currents in the summer consistent with the seasonal cycle occurring in the East Australian Current. Downstream of separation, the seasonal models explained less than 5% of the variability with much weaker amplitudes. The merit of each regression model is discussed. We identified a non-stationary process with a period of peak energy between 90 to 120 days in the along-shelf currents downstream of separation. This agrees with the period that eddies are shed from the East Australian Current indicating a link between eddy formation and interaction with the continental shelf downstream of separation. We compare the results from this western boundary current to the California Current System (an eastern boundary current with distinct seasonality). We discuss the seasonality upstream and downstream of the East Australian Current separation zone.

Session: 16. Insights from the Integrated Marine Observing System (IMOS)
Presenting Author: Lucy Wyatt

Averaging requirements and other data quality issues for HF radar wave and wind direction measurement

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The Australian Coastal Ocean Radar Network, ACORN, is an IMOS Facility which provides surface current measurements at six sites around the coast of Australia. Each site comprises two radar systems separated by several tens of kilometres and the measurements are obtained from close to the coast to up to 200km offshore. At some of these sites there is strong interest in the provision of wave and wind direction information as has been achieved elsewhere (Wyatt et al. 2003; 2012). For example the Bureau of Meteorology are interested in wind direction measurement in the South Australian Gulf to assist with fire prediction modelling. In NSW there is interest in measuring the coastal wind and wave climate for model validation and to look at factors driving nearshore currents and the northward sediment transport. Significant waveheight estimates are already available in the radial current files but these data sets are too short for robust wave measurements. Temporal and/or spatial averaging of the radar data, before extraction of wave information, is really needed for accurate measurements (Wyatt et al. 2009). The radar data quality requirements for wave measurement are also more stringent than those for current measurements (Wyatt et al. 2011). In this paper we will discuss these issues, present some examples of wave and wind measurements obtained from the ACORN radars and compare these where possible with in situ wind and wave data and also model outputs. Of interest in particular will be examples during periods of change in wind conditions to establish whether the radars can provide accurate measurements of the wave response.

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Session: 17. Development in Numerical Weather Prediction and Data Assimilation
Presenting Author: Vaughan Barras

Testing the sensitivity of the parameterization of the stable boundary layer in the ACCESS-CABLE coupled climate model

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There remain substantial uncertainties in the parameterization of the stable boundary layer in climate models. In most cases mixing is too strong under stable conditions, which is partly to prevent a complete decoupling of the boundary layer from the surface. However this tendency for excessive mixing leads to the diurnal cycle in climate models to be generally too weak. Here, an alternate parameterization of stable boundary layer momentum is tested in the ACCESS climate model coupled to the CABLE land surface scheme. The parameterization acts to increase drag at the surface under moderate to high stability conditions in the boundary layer and tests show an overall reduction in nocturnal wind speed and an improvement in the diurnal range. However the change in the model is not uniform spatially. These results show how even subtle changes to the parameterization of the stable boundary layer can affect different aspects of the large scale circulation of the model, and can indicate regions of particular sensitivity to the representation of the stable boundary layer.

Session: 17. Development in Numerical Weather Prediction and Data Assimilation
Presenting Author: Iliana Genkova

Revised data assimilation for better representation of regional events in global NWP models

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Observations undergo strict quality control before being assimilated in NWP models for the purposed of robust model performance and improved forecast globally. However, in data sparse regions even the little available data is excluded from assimilation due to insufficient data quality information. Field campaigns are often needed to investigate regional meteorological events. For example, radiosonde data from the African Monsoon Multidisciplinary Analysis (AMMA) field campaign in 2006 allowed for thorough investigations of the thermodynamic and dynamic structure of the lower troposphere over continental West Africa. Assimilating additional radiosonde data in the ECMWF system showed their significant analysis impact on the low-level temperature over the Sahel region and on the structure of the African easterly jet (AEJ). Independent atmospheric motion vector (AMV) fields indicate that the African easterly jet in the analysis is too weak over the data-sparse region of Eastern Sahel. This implies that inclusion of extra observations east of 15°E may be of support to the jet enhancement further east. Here we present results from experiments with additional radiosonde data and revised AMV assimilation approach in order to investigate their impact on the representation of AEJ in the ECMWF model.

Session: 17. Development in Numerical Weather Prediction and Data Assimilation
Presenting Author: Xingyou Huang

Comparison of VAP-like methods for horizontal wind retrieval from single doppler radar data

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Compared to conventional weather radar, one major advantage of Doppler weather radar is its ability to provide the radial velocity associated with storms. Accurate extraction of wind information is thus one of the key issues in using Doppler radar data.

Techniques for horizontal wind retrieval from single Doppler radar data have been studied for a long time, with the VAP, EVAP and IVAP methods widely used for relatively homogeneous wind retrieval. In the current study, simulated and real radar velocity data are used to evaluate the above three methods.

The evaluation shows that: (1) VAP, EVAP and IVAP are all effective in retrieving the quasi-steady wind field; (2) near the vortex center, EVAP has slightly better performance over VAP and IVAP as judged using simulated data; and (3) for a tropical cyclone case, VAP, EVAP and IVAP all have difficulty in extracting the tropical cyclone wind field structure, but modified EVAP and IVAP schemes can better capture the wind field. Based on its simplicity and reliability, the VAP scheme is suggested for retrieving relatively homogenous 2D wind fields and the modified EVAP or modified IVAP schemes are suggested for retrieving the 2D wind field of tropical cyclones.

Session: 17. Development in Numerical Weather Prediction and Data Assimilation
Presenting Author: Yubin Li

Modelling the Effects of Land-sea Contrast on Tropical Cyclone Precipitation

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The precipitation pattern of landfalling tropical cyclone (TC) is investigated using the Weather Research and Forecasting (WRF) model. Simulation of idealised TC landfall under quiescent environment is first performed. The radially averaged convergence in the inner core is found stronger in the off-shore quadrant one day before landfall, but afterward shifts to the on-shore quadrant. The rainfall pattern is consistent with the convergence pattern during landfall, but after landfall storm-scale vertical wind shear (VWS) develops and affects the rainfall pattern. There are stronger radial winds at the off-shore side, and consequently stronger convergence and larger rainfall maximum there. However, since there is less moisture supply to the off-shore side, weaker total rainfall is found in that area. The friction-induced wind asymmetry was not confined to the lower levels but is also identified at the upper levels. More rainfall is found up–shear when the land-induced VWS was small before landfall, but changed to down-shear right when the VWS becomes larger after landfall. Still under an idealised setting, further numerical experiments are carried out to study the effects from environmental VWS versus land-sea contrast on the TC rainfall distribution. It is found that in inner core region, the rainfall pattern was mostly determined by the environmental VWS. However, the net VWS vector is changing due to interaction between the storm-scale and environmental shear. While in outer band region, the rainfall distribution was strongly affected by the surface roughness.

Session: 17. Development in Numerical Weather Prediction and Data Assimilation
Presenting Author: Yimin Ma

Air-sea fluxes in numerical modelling of tropical cyclones: effects of surface drag and spray route on storm track, intensity and rapid intensification

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At high wind speeds in a Tropical Cyclone (TC), the transfer of sensible and latent heat flux via the spray route becomes a significant contributor to the total flux at the air-sea interface. It is also no longer valid at high winds that drag coefficient increases with an increasing surface wind speed that is recognised at normal wind speeds. This change in mechanism governing air-sea exchanges at high winds lead to amendments to the bulk algorithms currently used for the parameterisation of the surface layer. Algorithms for spray route and drag coefficient at high wind speeds are implemented into the atmospheric surface layer scheme in ACCESS-TC (the operational TC forecast model for Australia). Statistical analysis of a large number of TC forecasts over Pacific Ocean demonstrates that the algorithms enhance the initial TC positioning and the subsequent intensity forecasts. A case study of rapid intensification (RI) during the devastating Coral Sea TC that impacted north-eastern Australia (YASI, 2011) is presented. Impacts of the simulated surface exchange processes to RI process are discussed, including the ratio of the surface exchange coefficient for enthalpy and the drag coefficient on which a constraint exists for intense TCs as proposed from the previous theoretical studies.

Session: 17. Development in Numerical Weather Prediction and Data Assimilation
Presenting Author: Justin R. Peter

A Bayesian Classifier for Detecting Anomalous Propagation in Radar Reflectivity Observations

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The Australian Bureau of Meteorology has recently invested in an upgrade to its operational radar network. Besides the installation of several new radars, significant investment is also being made to improve the use of radar data for assimilation in numerical weather prediction (NWP) models and for Quantitative Precipitation Estimation and Forecasting (QPE/QPF). Radar data quality control is central to providing the data assimilation system with clean data and estimates of the error characteristics of the observations.

Here we detail the development of a Bayesian classifier to mitigate the effects of clutter on radar observations. The Bayesian classifier takes as input various fields derived from observations of reflectivity including, the texture of reflectivity, the vertical profile of reflectivity and SPIN (Steiner and Smith, 2002). Histograms of these fields are constructed for clutter and precipitation echoes; the histograms constitute conditional probability distribution functions in Bayes formula. Classification of an echo is then achieved by maximising the a posteriori probabilities obtained from Bayes rule. Case studies are presented detailing the effect of the Bayesian classifier on clutter mitigation and the results suggest there is sufficient information in the reflectivity to classify clutter and precipitation echoes using this technique. Furthermore, a 'strength of classification index' is developed which gives a measure of the confidence in the assignment of classification. The index can be used as a threshold for allowing or rejecting data for assimilation or QPE/QPF purposes.

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Session: 17. Development in Numerical Weather Prediction and Data Assimilation
Presenting Author: Harald Richter

The Australian National Thunderstorm Forecast Guidance System: current design, verification and future plans

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The Australian Bureau of Meteorology operationally runs a numerical model postprocessing algorithm that produces a range of thunderstorm-related diagnostics such as the chance of surface-based thunderstorms or supercells. This algorithm, named the National Thunderstorm Forecast Guidance System (NTFGS), ingests model output four times a day and produces its diagnostics in 3-hourly timesteps out to 48 hours. Most of the diagnostics are currently dichotomous (yes/no) decisions which indicate that the occurrence of a convective hazard is either likely ('yes') or not likely ('no'). Each diagnostic is based on the exceedance of individual thresholds for the underlying ingredients. For example, for warm season surface-based thunderstorms to be diagnosed as 'yes', model-based values for the surface-based Lifted Index to 500 hPa, equilibrium level temperature, cloud depth above the freezing level, convective inhibition and vertical velocity between the surface and 850 hPa need to be exceeded simultaneously. A strength of the overall system is that an accompanying tailored graphical viewer can overlay each ingredient which highlights how the ingredients are physically coming together within the underlying model. The NTFGS algorithm will be introduced, with the above features highlighted. Some verification results using an Australian lightning detection network will be shown, and ideas for further system development will be presented.

Session: 17. Development in Numerical Weather Prediction and Data Assimilation
Presenting Author: Tristan Shepherd

WRF sensitivity to cumulus parameterisation: implications for forecasting of hurricane tracks and intensity.

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Until computational performance is able to allow for routine resolving of convective processes at very high resolutions (i.e. less than 1 km), there will continue to be a need for cumulus parameterisation. There are still many unanswered issues regarding sensitivity to cumulus parameterisation that need to be addressed.

In the present study, the sensitivity of cumulus parameterisation in hurricane simulations is explored. The current state of the problem shows there is no definitive guidance regarding which cumulus parameterisation is best used in a hurricane simulation. In order to address this issue and provide some guidance to the modelling community, a series of idealised and real data model simulations are conducted. Simulations are conducted using the Weather Research and Forecasting (WRF) model and its sub-set the Advanced Hurricane WRF (AHW). Three schemes are chosen, the Kain-Fritsch (KF), the Betts-Miller-Janjic (BMJ) and the Grell 3D (G3) ensemble.

The idealised simulations use a hybrid version of WRF which allows idealised tropical conditions to be run with the full physics real data configuration of WRF. For the real data simulations, cyclone Sidr is used as a case study. Eleven real data simulations of various specifications were conducted and revealed sensitivity to specification of cumulus parameterisation, both for simulated intensity and track. The BMJ scheme produces the best fit with observations and realistic hurricane structure. After 120 hours of simulation, the landfall track error in the BMJ case was only 4 nautical miles. Further testing is required, but the BMJ scheme is recommended for WRF hurricane simulations.

Session: 17. Development in Numerical Weather Prediction and Data Assimilation
Presenting Author: Sergei Soldatenko

Forecast sensitivity to observations in the ACCESS G Model

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Numerical weather prediction (NWP) being an initial value problem requires three-dimensional global observations of meteorological variables as initial conditions. The accuracy of an NWP system is affected, first of all, by the density and quality of observations used as input to the data assimilation system, together with the quality of the NWP model. As the observing system continues to evolve it is therefore essential to determine which components are performing well, and to identify deficiencies in the observing system.

The assessment of the health of the observing system has been done in a rather ad hoc fashion using Observing System (or data denial) Experiments in the past. Recently, a new technique, the "Forecast Sensitivity to Observations" has become available. This involves calculation of the sensitivity of a given forecast error metric to the observations (and in principle to other data assimilation input parameters such as background and observation error covariances). In this study we focus on the sensitivity of ACCESS global forecasts to observations by applying the adjoint technique with an energy norm as the measure of forecast error. This provides a quantified estimate of the benefit of each observed datum at each analysis time that can then be used to monitor the network configuration and ensure future modifications provide the best value for money. The mathematical framework to estimate the sensitivity of a model forecast to the data assimilation input parameters is discussed. Results from 4D-Var numerical experiments performed with the ACCESS global model are explored.

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