Assessment of climatic influences on ^{14}C activity in a Holocene stalagmite from Flores, Indonesia

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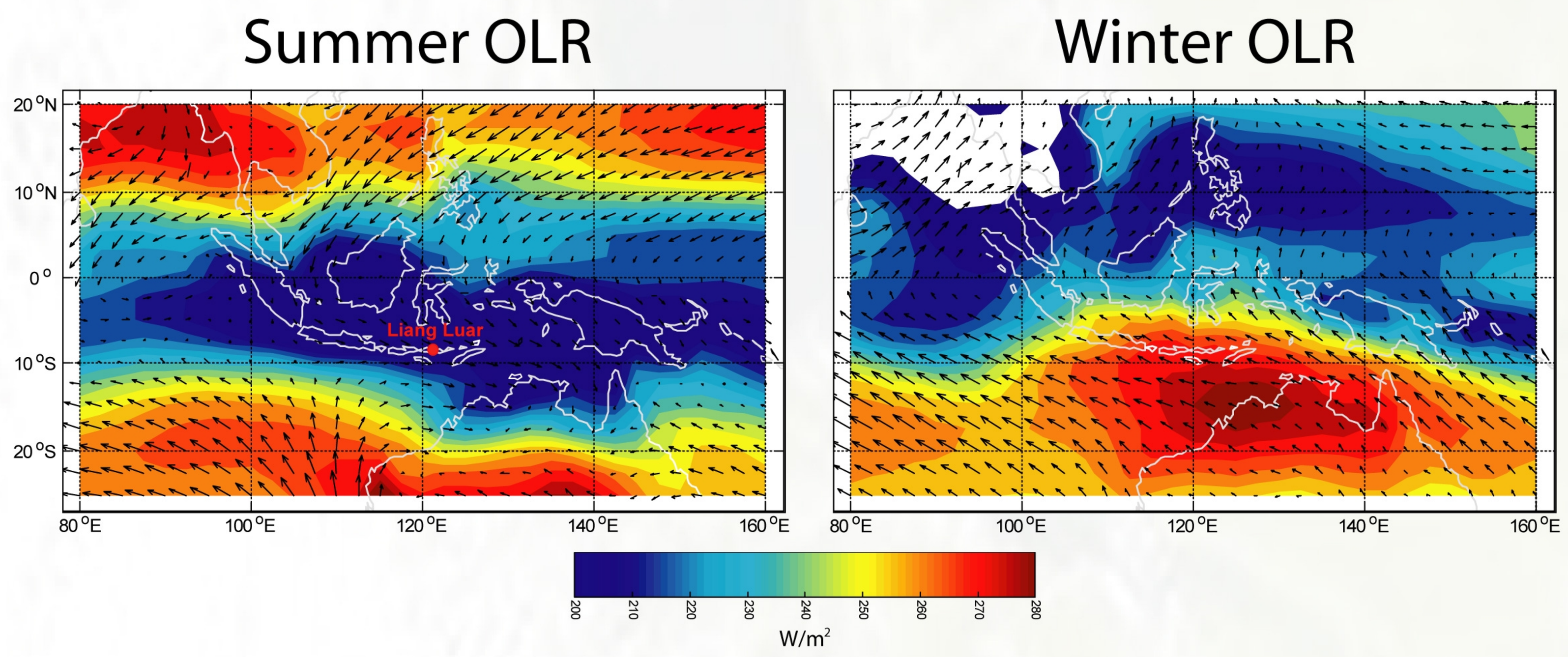
1. Introduction

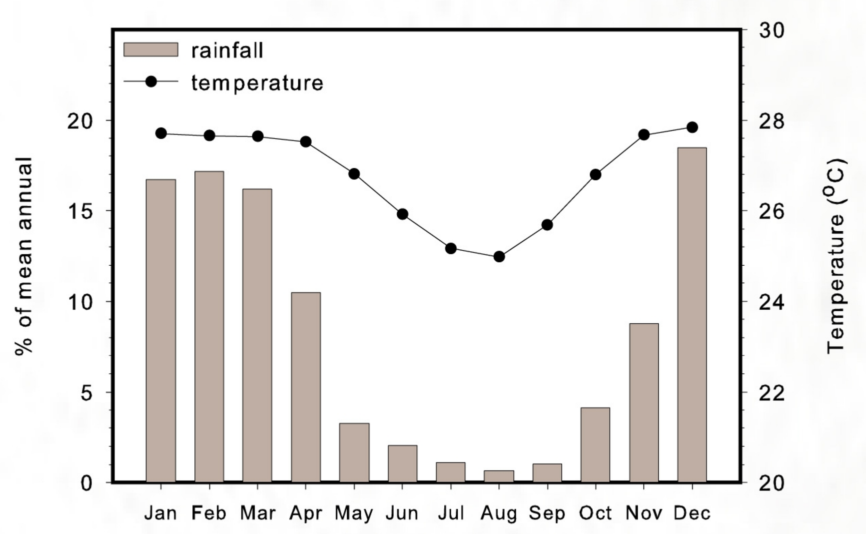
In the last decade, a number of speleothem studies have used radiocarbon dating to address a range of palaeoclimate problems. These have included the use of the bomb pulse to anchor chronologies over the last 60 years (Mattey et al 2008), the combining of U-series and radiocarbon measurements to improve the radiocarbon calibration curve (Beck et al. 2001), and linking atmospheric radiocarbon variations with climate changes (McDermott et al. 2008). Central to a number of these studies is how to constrain, or interpret variations in, the amount of radioactively dead carbon (i.e. the dead carbon fraction, or DCF) that contributes to a speleothem radiocarbon measurement.

In this study, we use radiocarbon measurements, stable isotope and trace element geochemistry, and U-series ages to examine DCF variations between 2.4 and 2.8 ka in a previously studied (Griffiths et al. 2009; 2010) speleothem from Liang Luar, Flores, Indonesia.

2. Study site: environmental setting



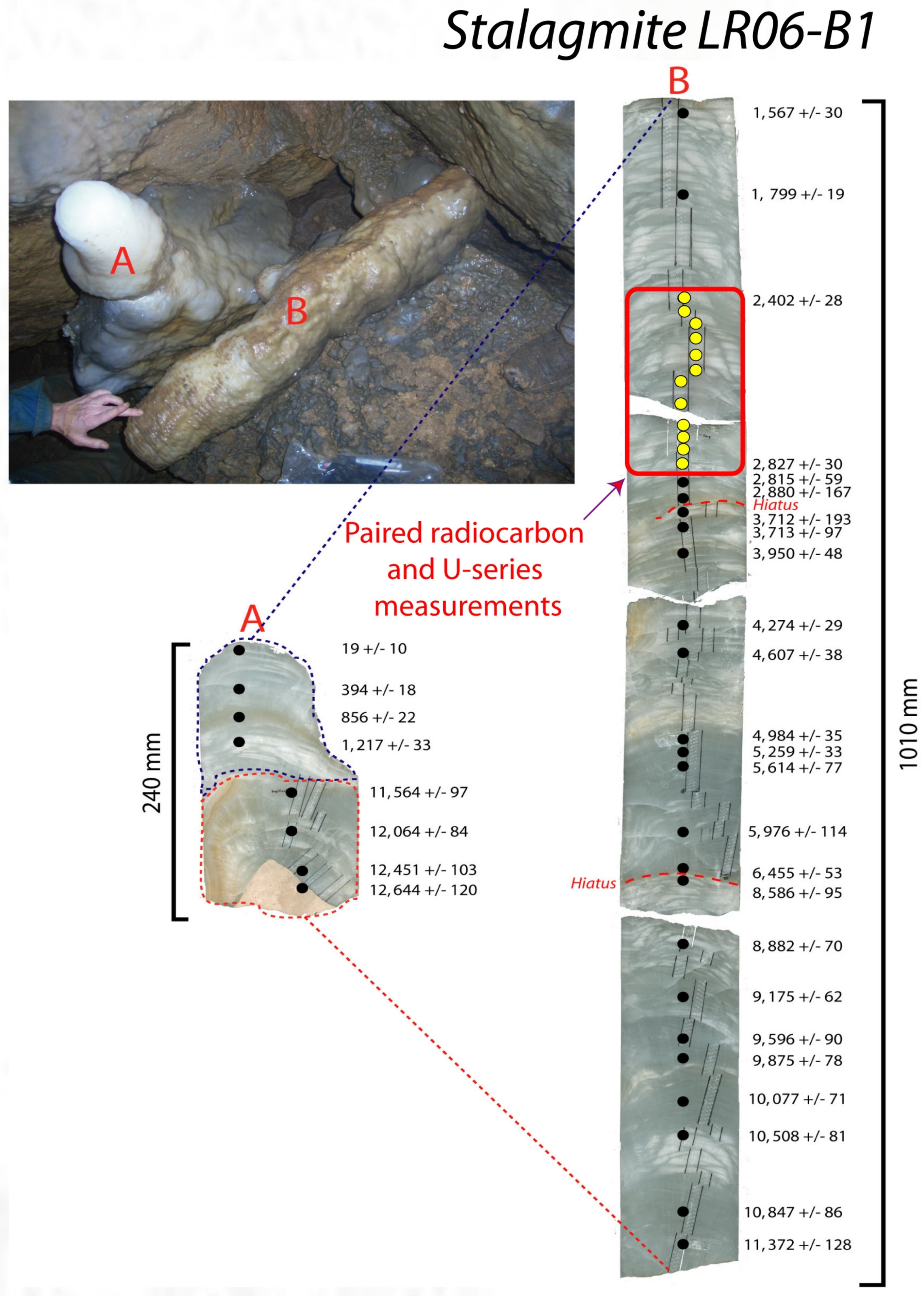
ABOVE: Location of Liang Luar (left), Flores. Shaded colours represent monthly composites of NOAA satellite-observed outgoing long-wave radiation (OLR). Arrows show NCEP/NCAR Reanalysis 850-hPa wind vectors for 1979 - 2005.



LEFT: Satellite-derived average monthly rainfall for 1998 - 2007 showing that 70% of the annual rainfall falls during the summer monsoon (Dec-Mar) and only 5% during the winter dry season (Jun-Sep).

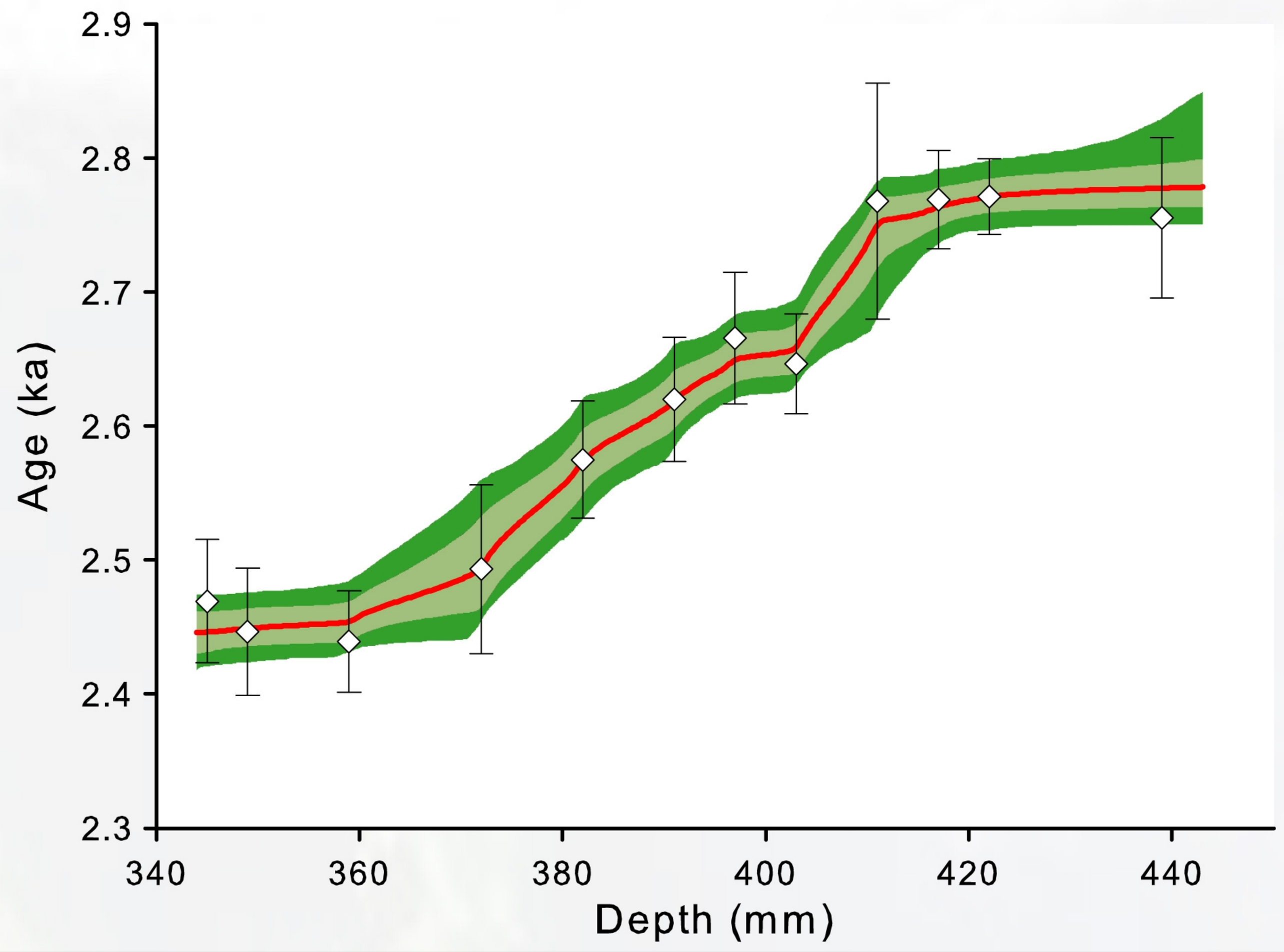
3. Methods

Stalagmite LR06-B1



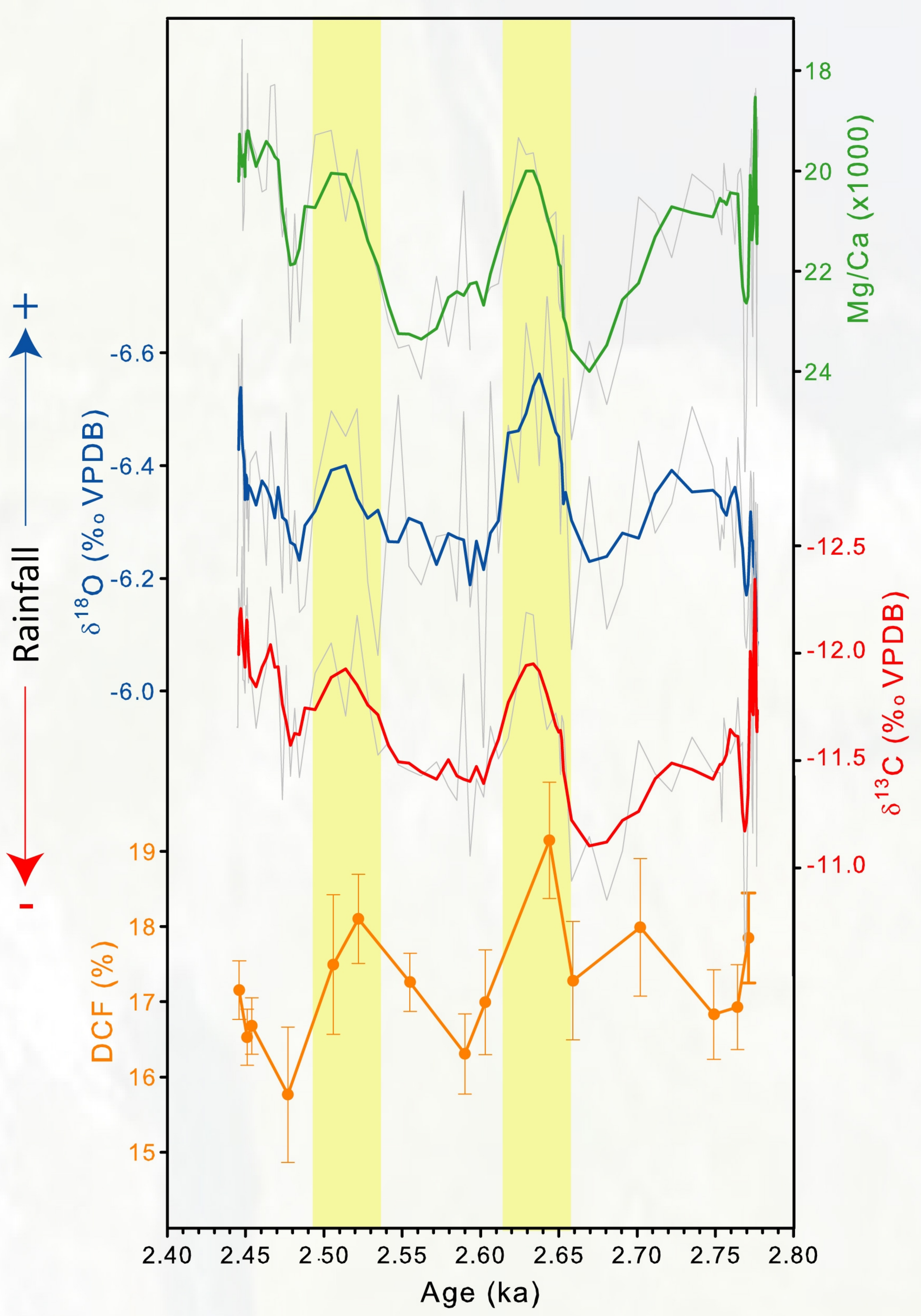
- *U-series dating*
  - TIMS, University of Queensland, Australia.
  - MC-ICP-MS, Melbourne University, Australia.
- *Radiocarbon*
  - AMS, Australian Nuclear Science and Technology Organisation (ANSTO), Sydney, Australia
- *Stable isotopes*
  - GV2003 continuous-flow isotope ratio mass spectrometer, University of Newcastle, Australia.
- *Trace elements*
  - ICP-AES, University of Newcastle, Australia.

4. U-series age model



LEFT: U-series age-depth model through the target interval constructed from 12 MC-ICP-MS dates. The U-series age model was used to constrain the % DCF from the radiocarbon measurements made on samples through the same interval.

5. Geochemical proxies vs DCF



LEFT: Mg/Ca (green), oxygen isotope (blue) and carbon isotope (red) variations compared to the DCF series (orange). All are anchored to the U-series age-depth model. The strong relationship between the stable isotope and Mg/Ca suggests that rainfall amount is the dominant factor controlling the observed variations. The good correspondence (in spite of the density of measurements) between DCF and the other proxies suggests that the DCF is also largely controlled by hydrological conditions above the cave.

6. Hydrological influence on DCF?

The strong association between DCF and other proxy data clearly shows that more dead carbon is delivered to the speleothem during wetter intervals. One possible explanation is a higher contribution from bedrock under such conditions. Although one might expect a concurrent increase in stable carbon isotope values as DCF increases (not observed here), it is possible that such an increase may be more than offset by the effect of increased recharge on the rate of carbon dioxide degassing and, consequently, carbon isotope values. But a higher proportion of bedrock carbon is not the only possible explanation: when the monsoon is stronger, a greater proportion of less mobile 'older carbon' may be leached from the soil, thus diluting the 'younger carbon' fraction. This would produce an 'apparent' increase in DCF. Further studies to elucidate this are ongoing.

REFERENCES: Beck et al. (2001) Science 292, 2453-2458; Griffiths et al. (2009) Nat. Geosci. 2, 636-639; Griffiths et al. (2010) Earth Planet. Sci. Lett. doi:10.1016/j.epsl.2010.01.002; McDermott et al. (2008) Geophys. Res. Lett. doi:10.1029/2007GL032689; Mattey et al. (2008) Earth Planet. Sci. Lett. 269, 80-95.