Model-data comparisons: Understanding water isotopes in speleothems

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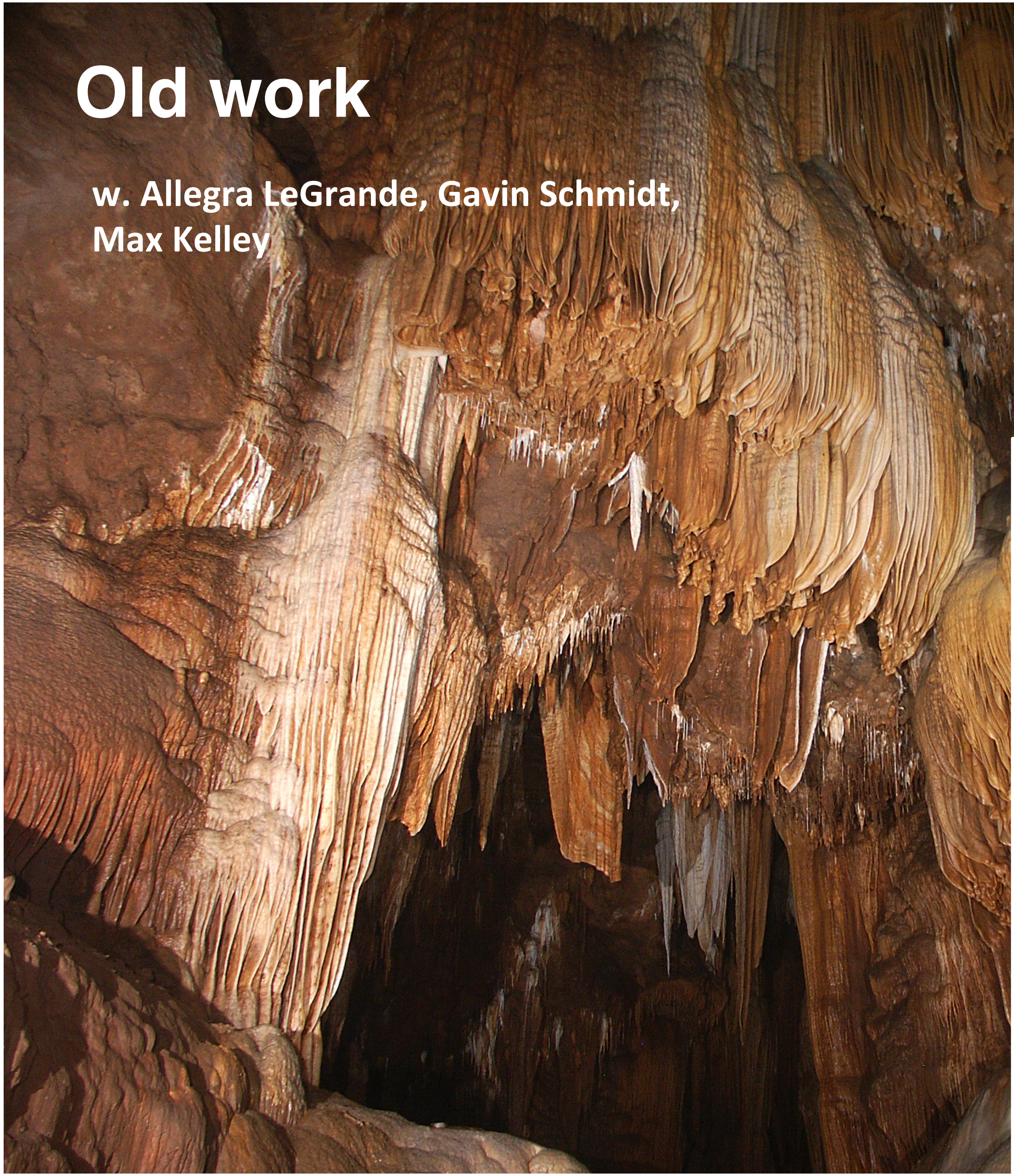
Old work

w. Allegra LeGrande, Gavin Schmidt,
Max Kelley



Isotope interpretations

Oxygen isotope ratios ($\delta^{18}O$) can tell us about climate →

Isotope-climate relationships described by series of 'effects' →

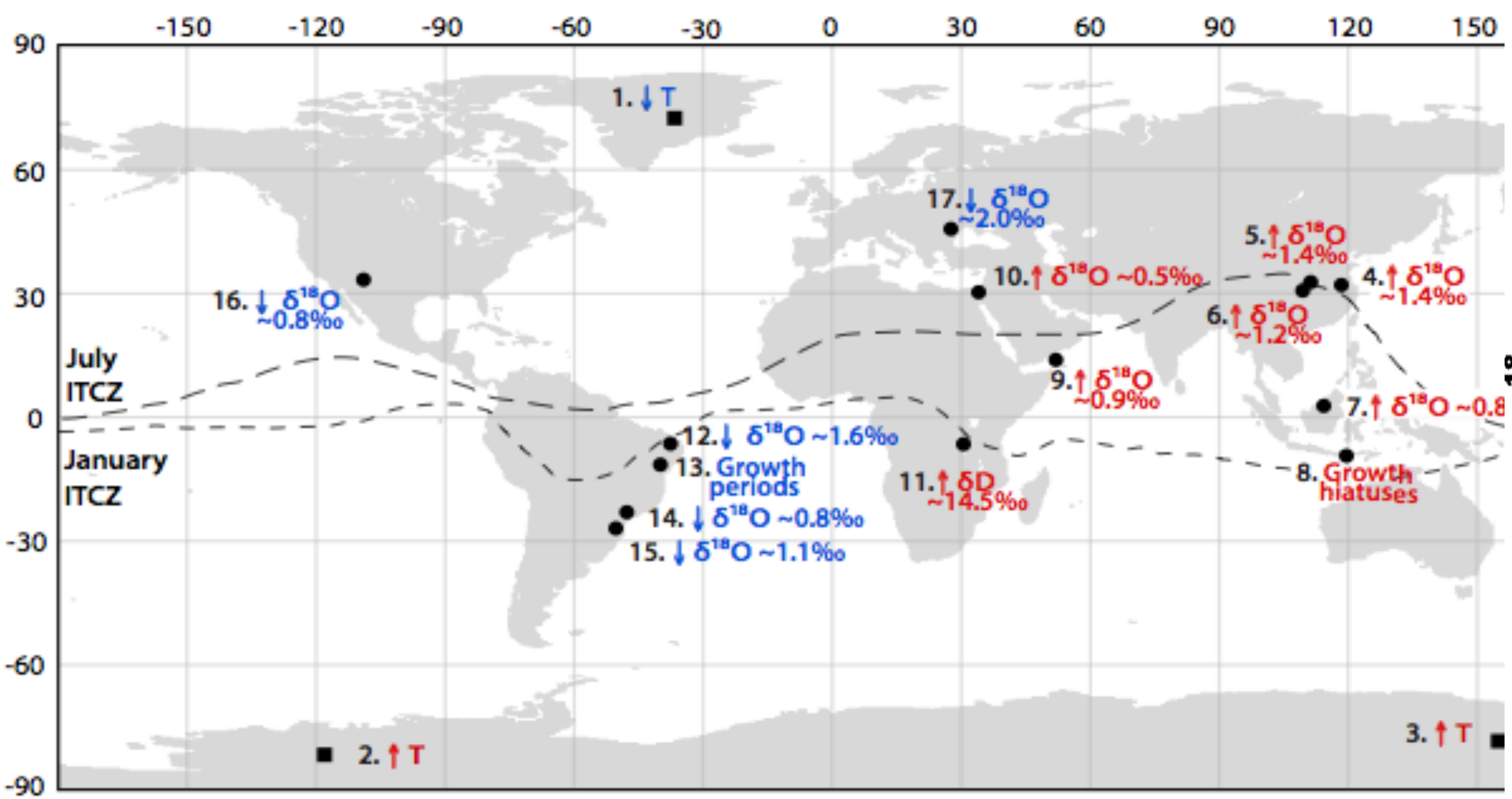
- Low-latitude isotopes controlled by 'amount effect'

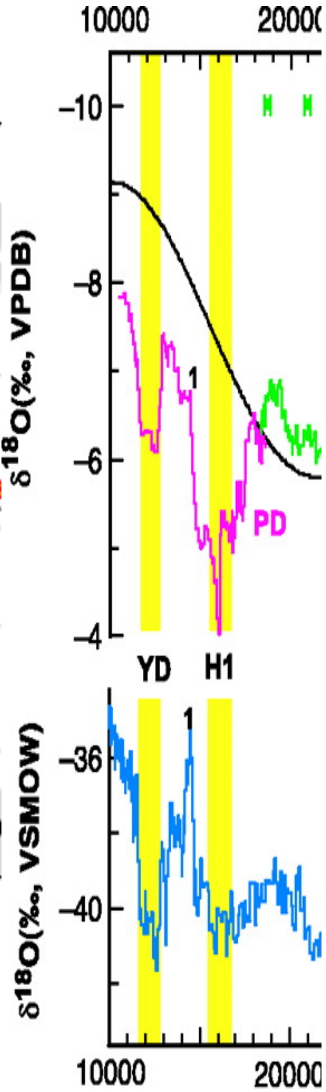
  $\delta^{18}O$ ↓, rainfall amount ↑

- High-latitude isotopes controlled 'temperature effect'

  $\delta^{18}O$ ↓, temperature↓

Heinrich event isotopic signature





Hulu Cave China → +2‰ change in $\delta^{18}O$ in ~6 years → 75 % of change occurred in 1 to 2 years → Abrupt drying?

Lewis et al., 2010

Wang et al., 2001: Science, Treble et al. 2007: Chemical Geology

A framework for testing interpretations

GISS ModelE

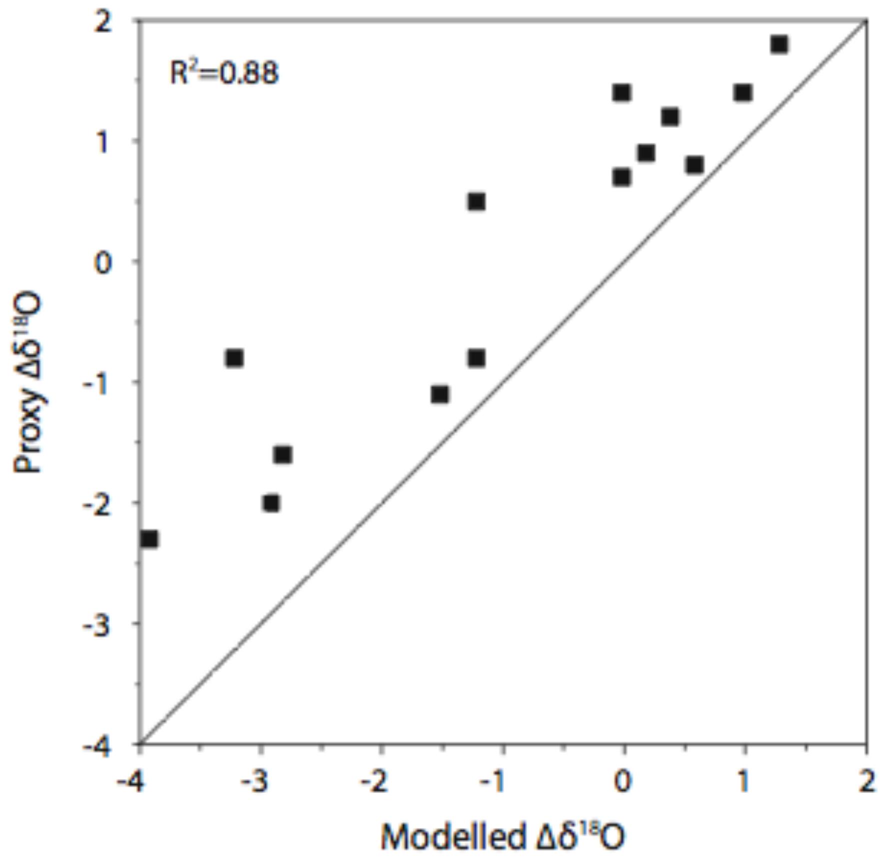
Water isotope module

144 water source tracers

‘Hosing’ experiment

Apply freshwater flux over Atlantic (~Heinrich event)

Control experiment



Lewis et al., 2010

Site classifications

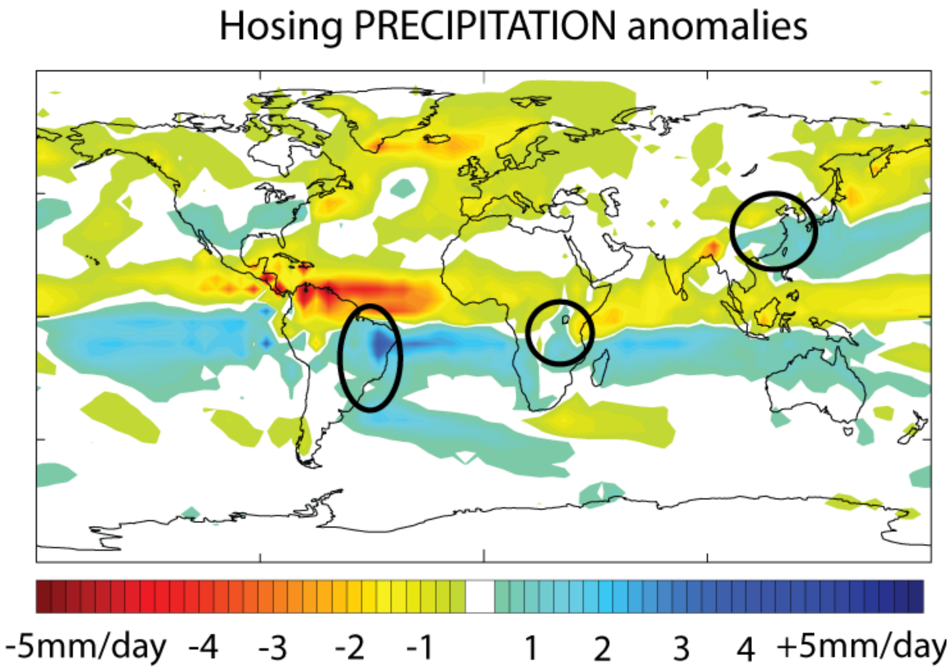
Type 1 Local amount effect ($\delta^{18}O$ inversely correlated to rainfall amount)

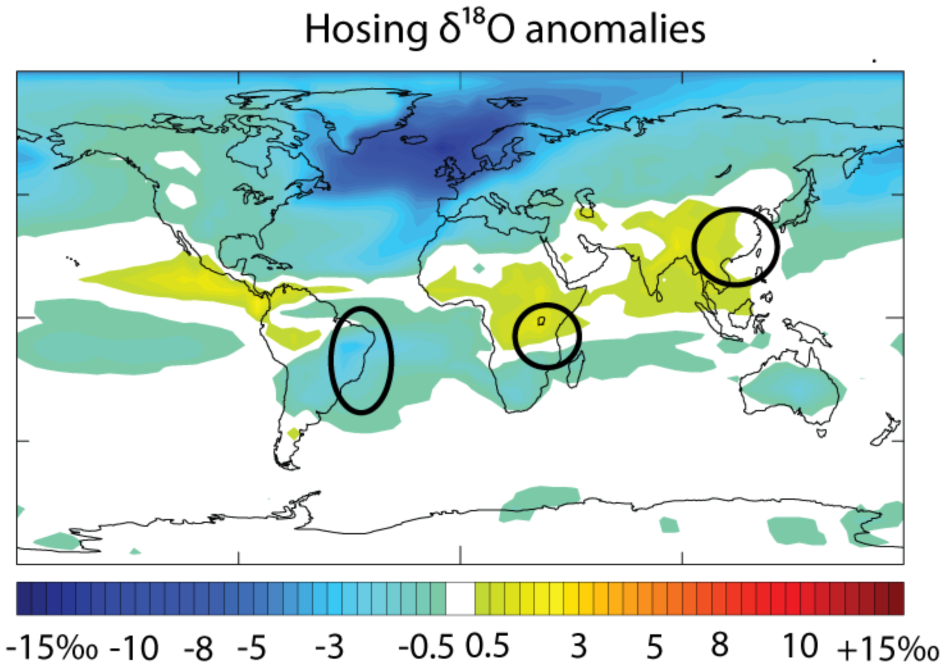
Type 2 Regional amount effect

Type 3 No amount effect operating (precipitation source shifts can explain $\delta^{18}O$ changes)

Type 4 Large shifts in seasonality of precipitation produce changes in annual $\delta^{18}O$ and sources

Type 5 No explanation for isotope signals in terms of precipitation, source or seasonality changes.





Site 1: China

Proxy $\Delta\delta^{18}O$=1.3‰

Model $\Delta\delta^{18}O$=0.6‰

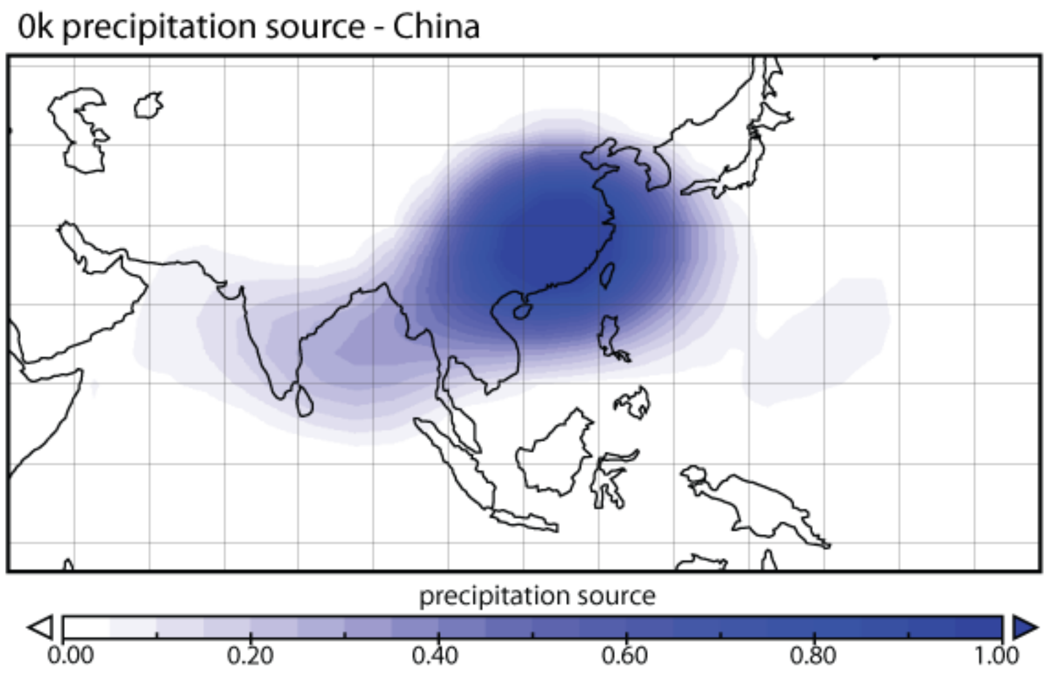
Model Δprecip ↑
0.2 mm/day

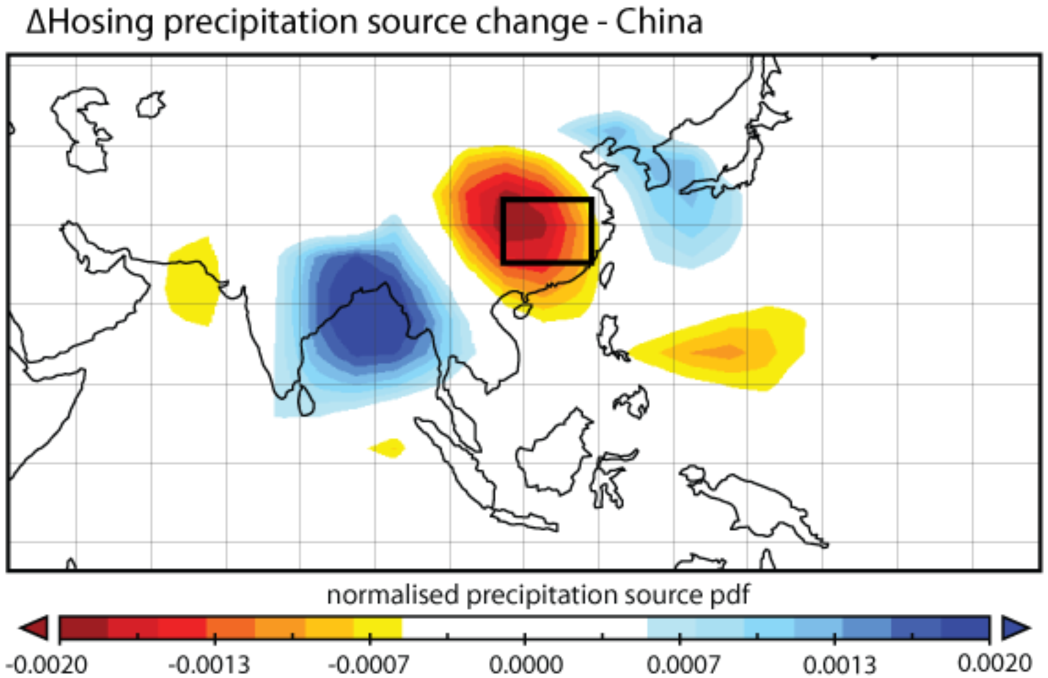
↓

Inconsistent
with Type-1

↓

Conclusion
Type-2





Site 2: Brazil

Proxy $\Delta\delta^{18}O$=-1.2‰

Model $\Delta\delta^{18}O$=-2.9‰

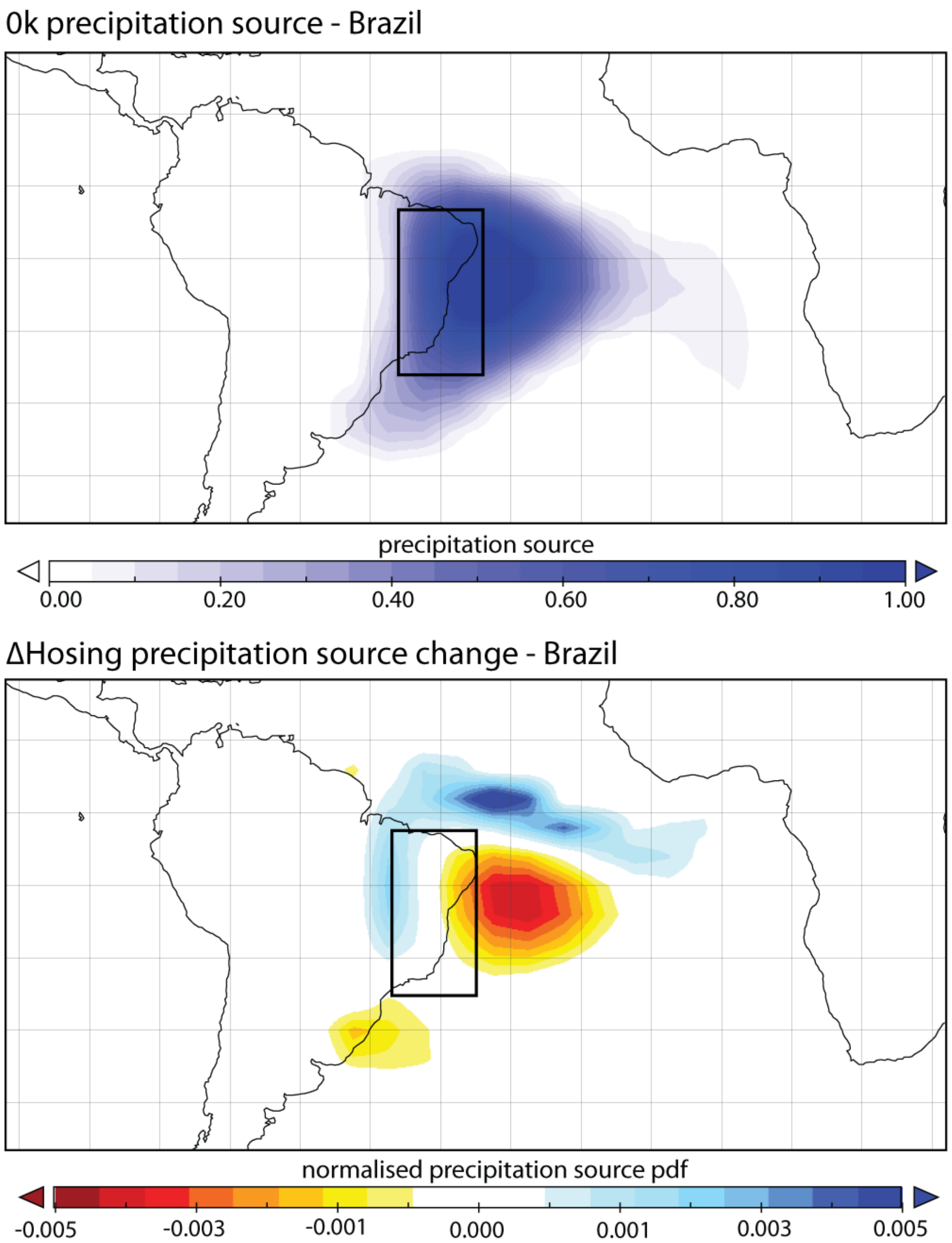
Model Δprecip
↑1.1 mm/day

↓

Consistent
with Type-1

↓

Conclusion
Type-1 (amount
effect)



Case 3:Lake Tanganyika

Proxy ΔδD=14.5‰

Model ΔδD=11.9‰

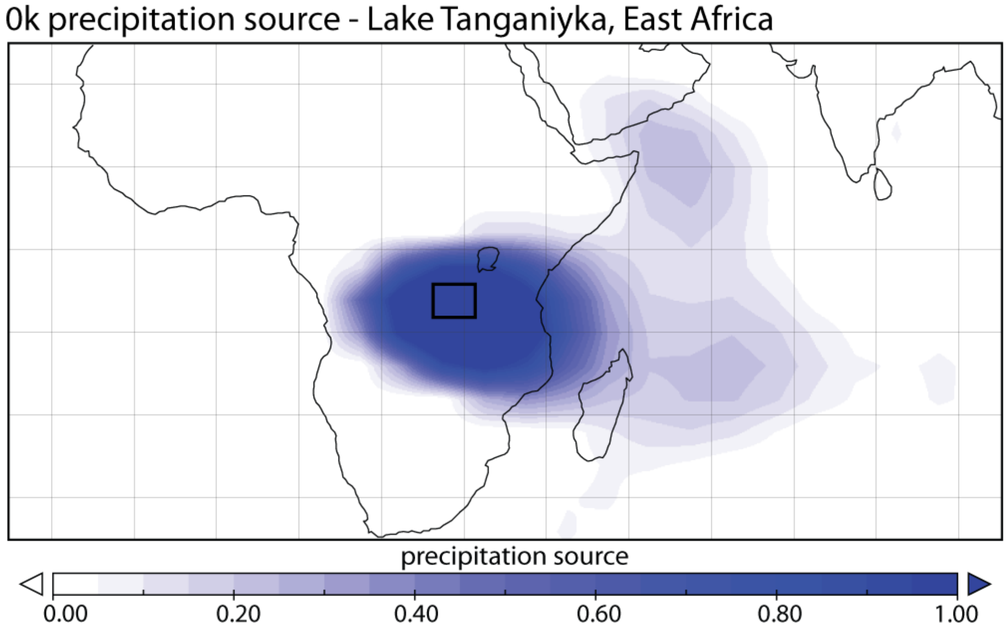
Model Δprecip
0 mm/day

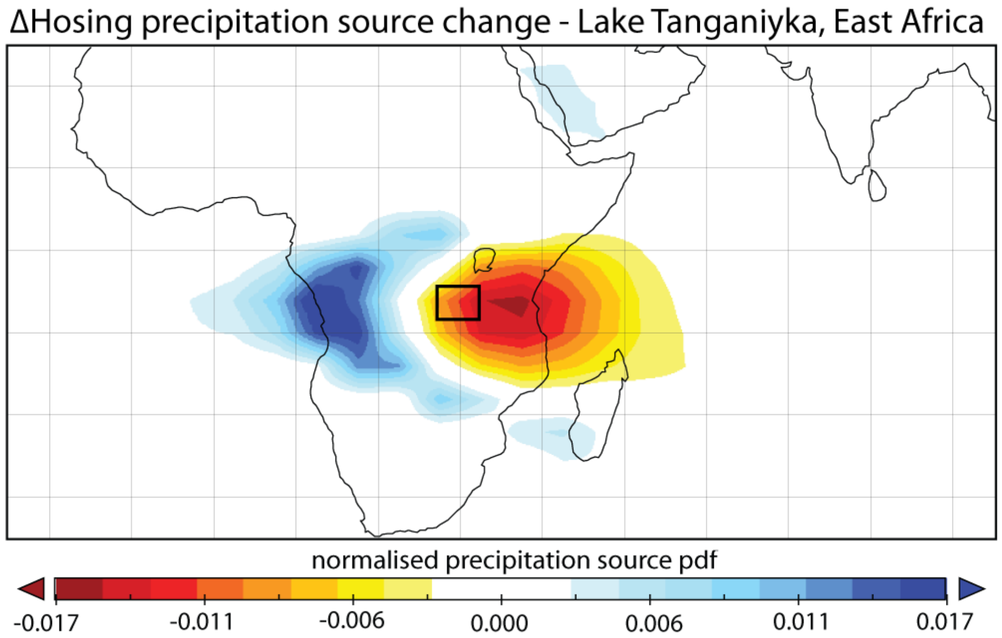
↓

Inconsistent
with Type-1

↓

Conclusion
Shift in hosing
source →
Type-3 (source
region)





Interpreting Heinrich isotope signals

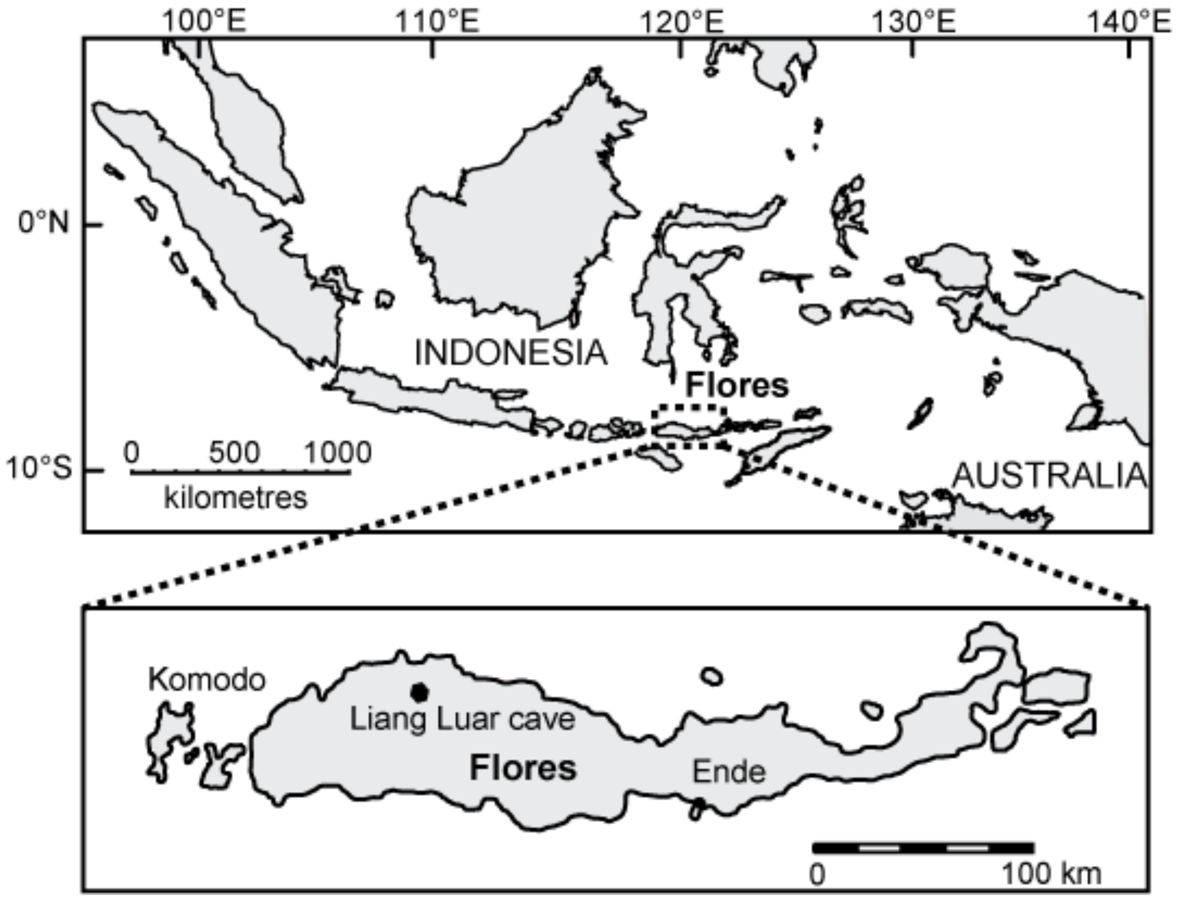
$\delta^{18}O$ integrates a **complete** air mass history

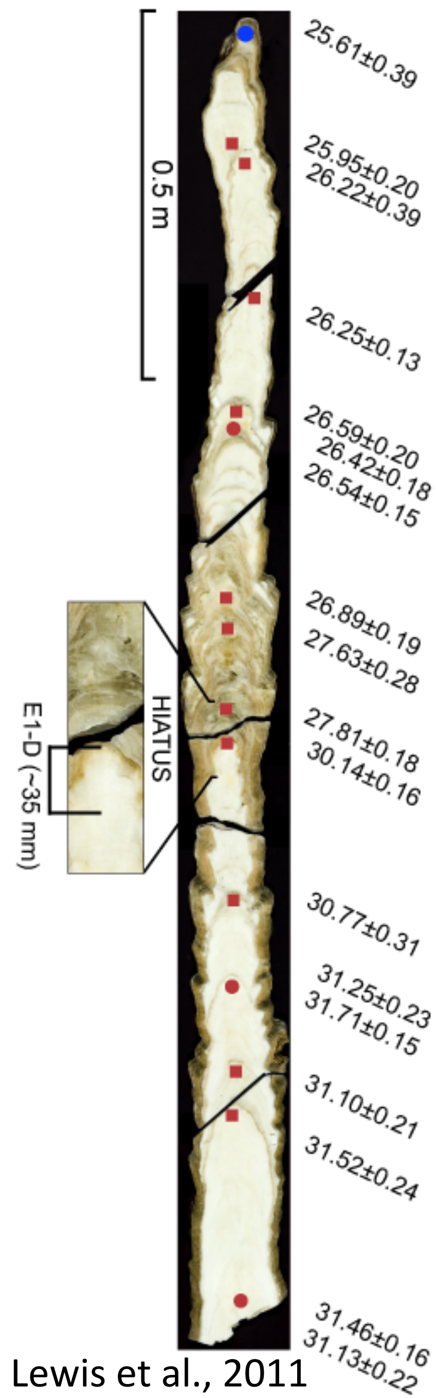
The 'amount effect' should be used with caution

But… classification valid for hosing only

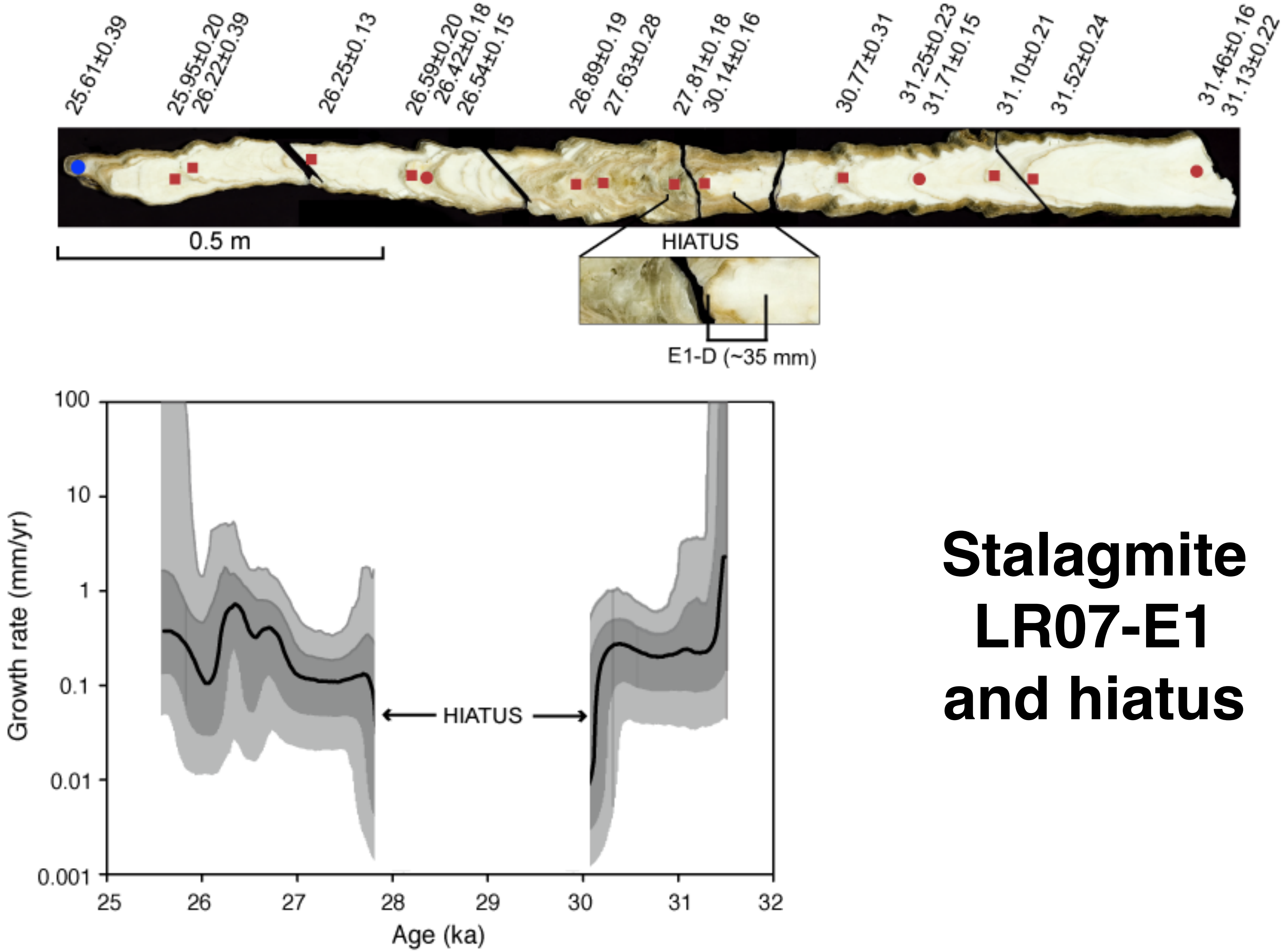
And… classification is simplification, in real world there are multiple influences

Case study: Flores, Indonesia





Lewis et al., 2011



Stalagmite LR07-E1 and hiatus

Interpreting a hiatus

Botuverá
Cave
Brazil

↓

Increase in precipitation during Heinrich events

↓

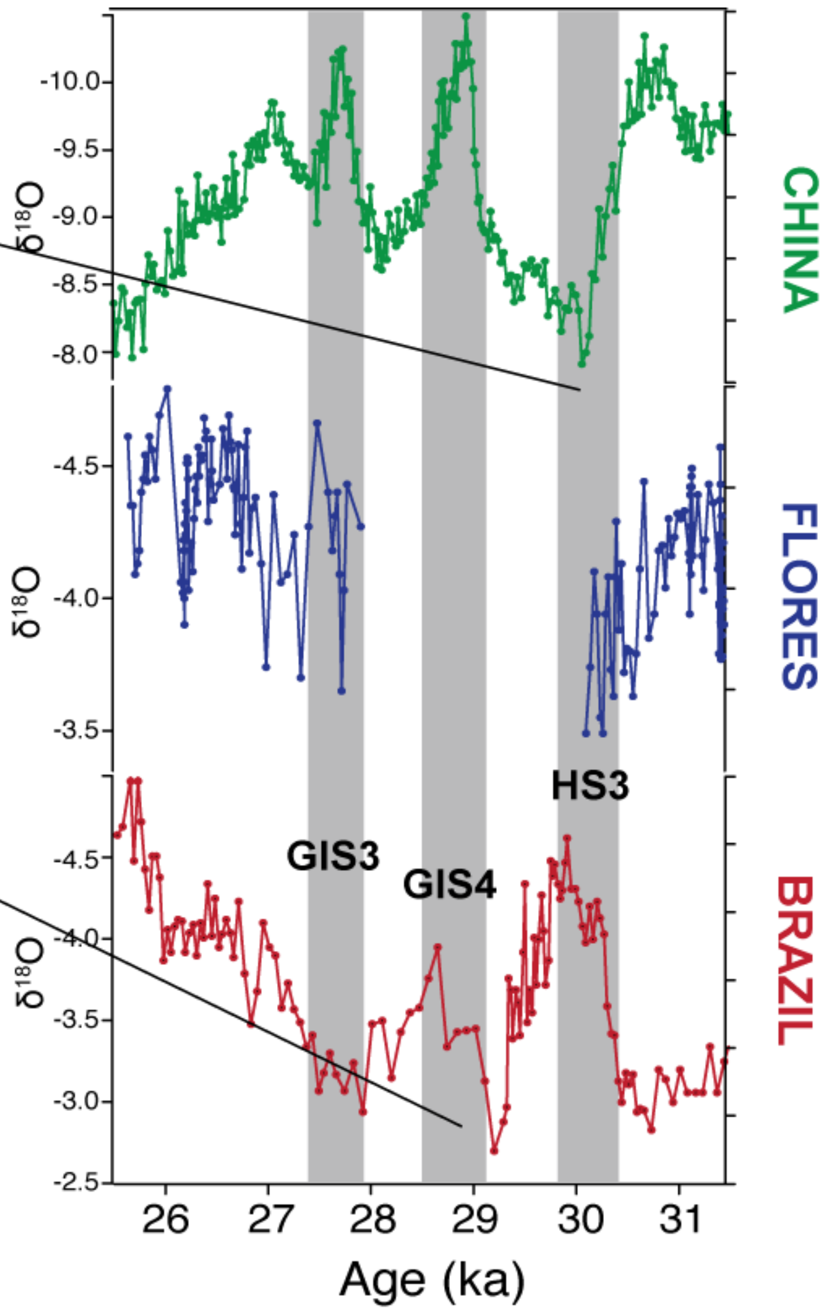
SH antiphasing
Dry north +
wet south

Wang et al., 2006, QSR

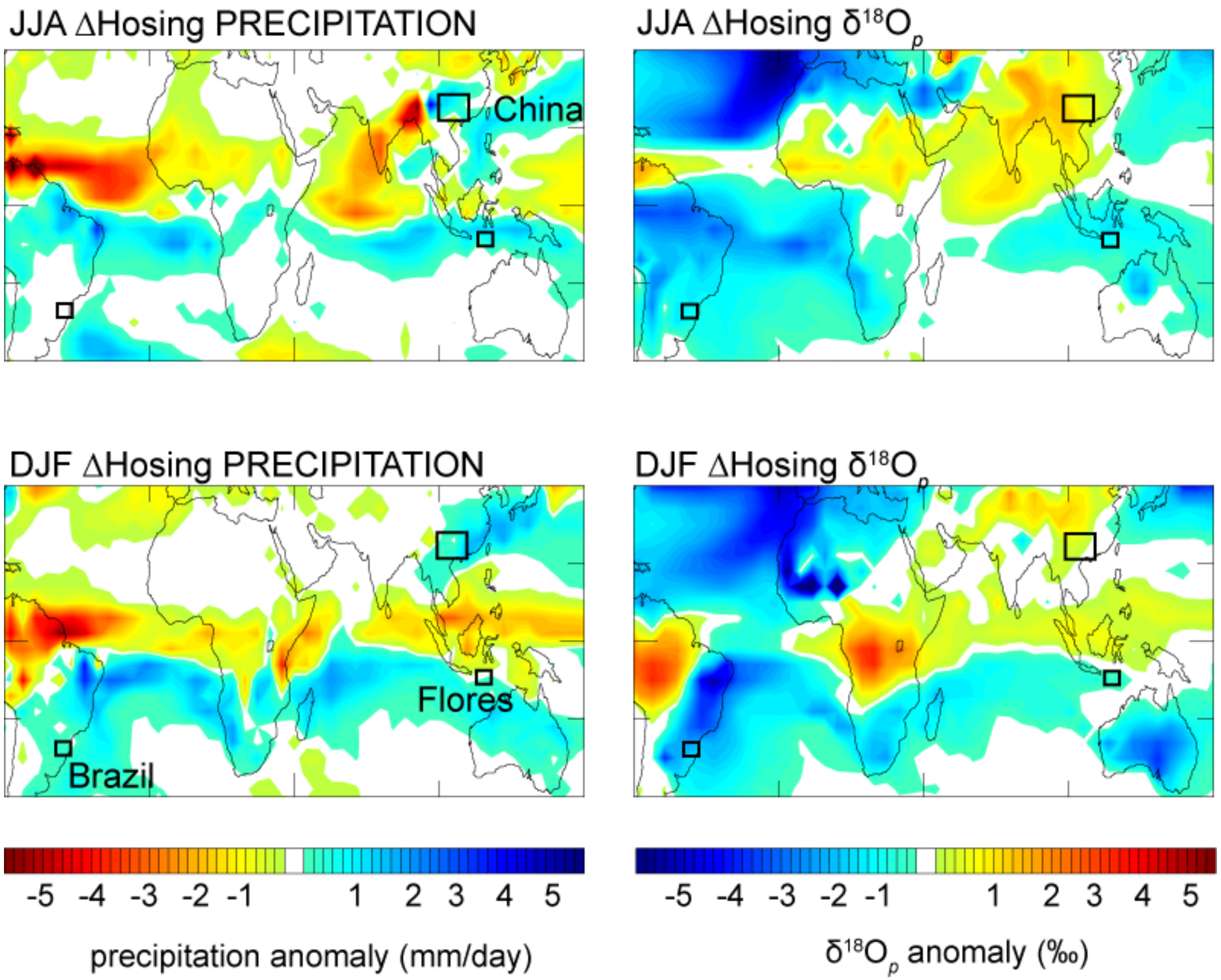
HS3 (~30.2 ka)
Greenland COLD
China DRY
Flores DRY
Brazil WET

WETTER
↕
DRIER

GIS4 (~29.6 -28.0 ka)
Greenland WARM
China WET
Flores DRY
Brazil DRY



Insights from models



Evaluating isotopic drivers at Flores

Tropical climates are complex and subtle changes occur

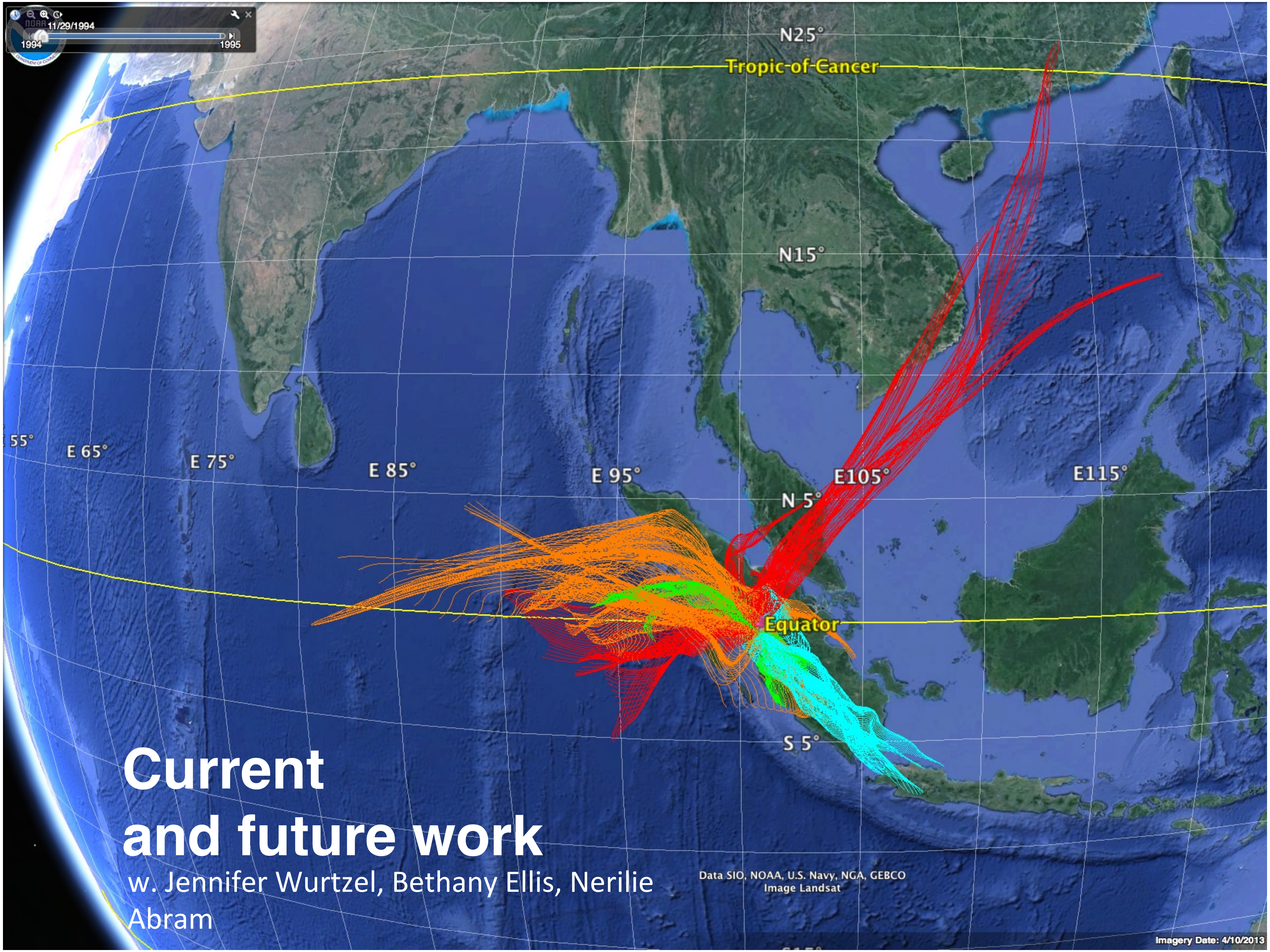
Generalisations are useful but *every* event is unique

Flores is sensitive to ITCZ, records subtle precipitation changes

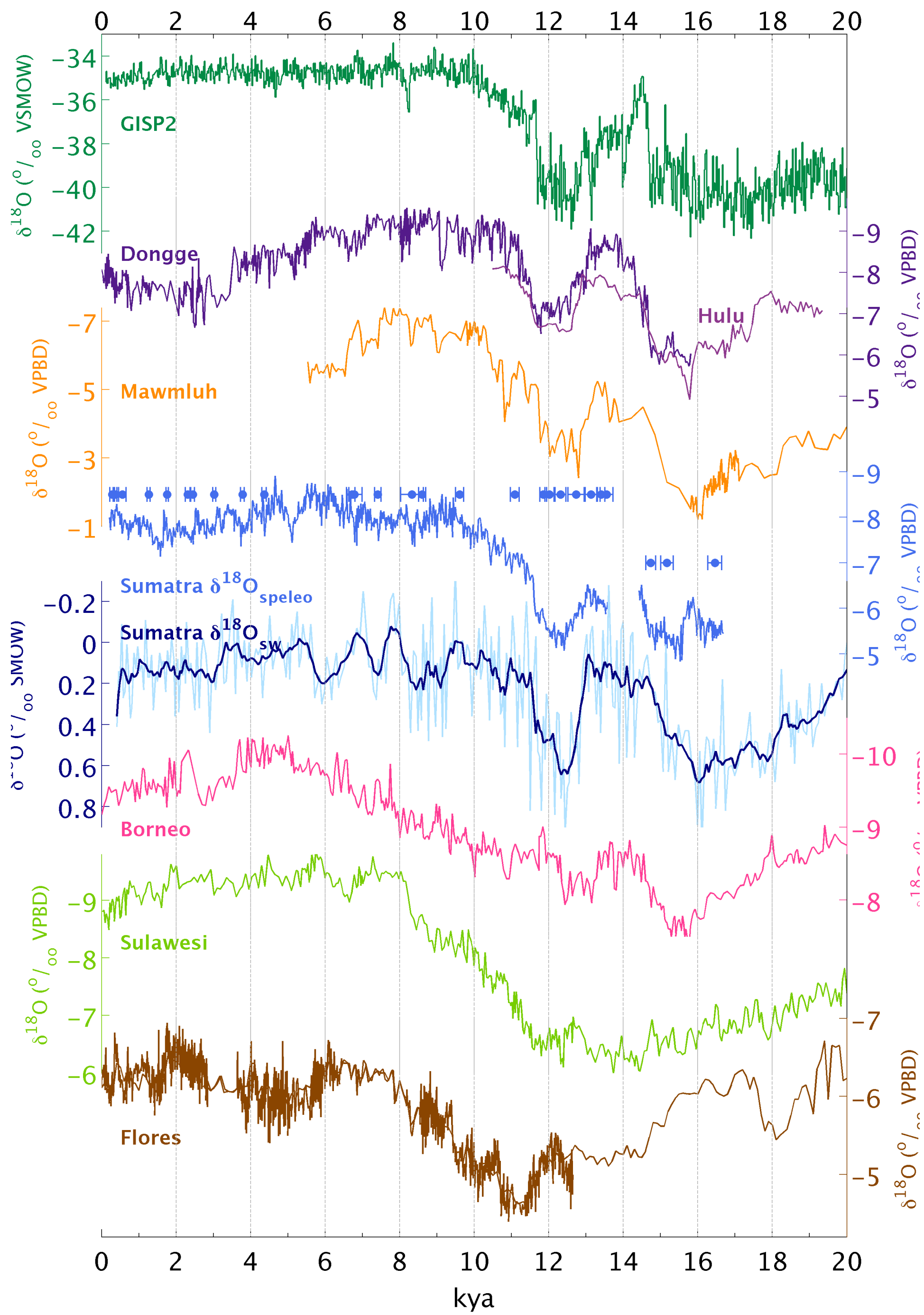
Model results can be useful for understanding geochemical changes

Current and future work

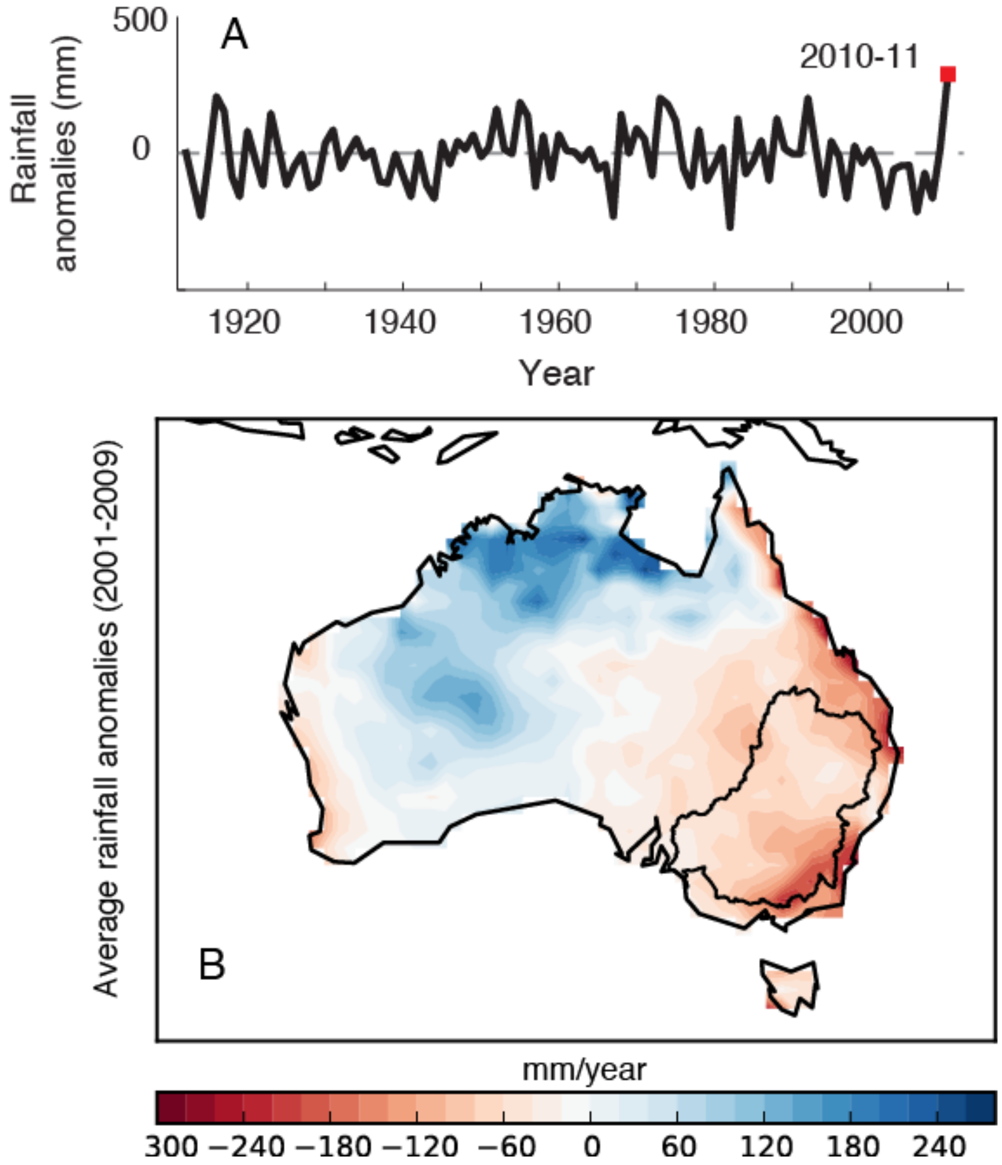
w. Jennifer Wurtzel, Bethany Ellis, Nerilie Abram



Understanding IOD through deglacial from Sumatra speleothem records



Understanding Australia's hydrological extremes

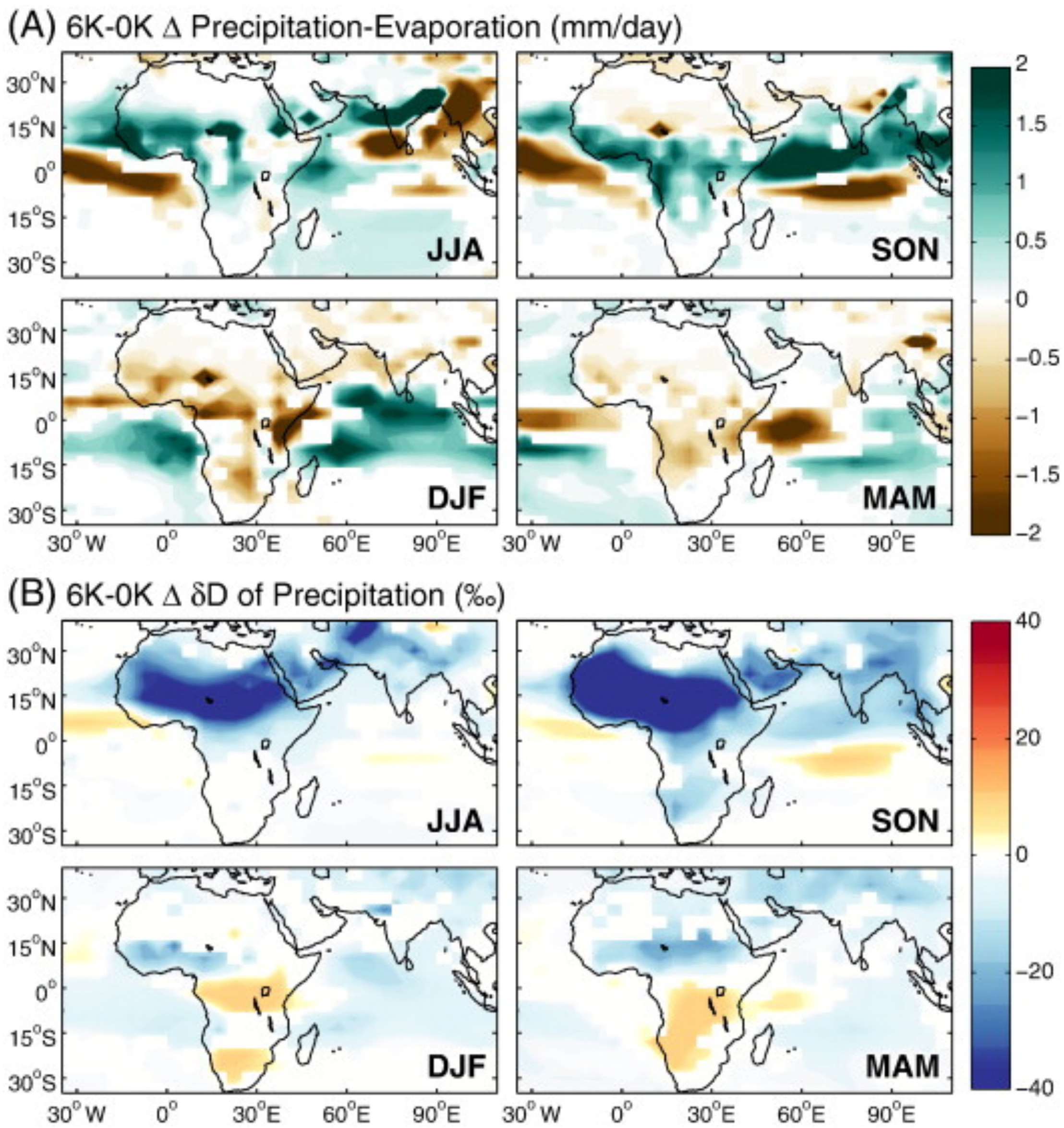


The Australian Meteorology and Oceanography Journal (AMOJ) has been renamed to The Journal of Southern Hemisphere Earth System Science (JSHESS).

The journal will cover the fields of meteorology, climate, oceanography, hydrology and their interactions, with a focus on the southern hemisphere.

The journal will continue to be free and available online from www.bom.gov.au/jshess

East African Humid Period



East African Humid Period was caused by a change in dry and "short rains" season precipitation and the subsequent reduction in precipitation seasonality

Tierney et al., 2011, EPSL