# 8,000 years of El Niño: Towards data-model integration

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#### ENSO has changed over the Holocene...



- ENSO variability has increased over the past 8,000 years
- El Niño events have increased in frequency and magnitude
- Evidence of a peak in ENSO variability at 2–1 ka BP
- Strong variability on centennial and millennial timescales
- These changes provide an opportunity to learn more about ENSO dynamics

#### Microatolls from Kiritimati Island



### The CSIRO Mk3L climate system model

- Low-resolution coupled general circulation model:
  - Atmosphere:  $5.6^{\circ} \times 3.2^{\circ}$ , 18 vertical levels
  - Ocean:  $2.8^{\circ} \times 1.6^{\circ}$ , 21 vertical levels
  - Sea ice: Dynamic-thermodynamic
  - Land surface: Static vegetation
- One 10,000-year pre-industrial control simulation
- Three transient simulations of the past 8,000 years



Pre-industrial control simulation: PC1 of monthly SST anomalies

#### Simulated changes in ENSO variability



#### Changes in ENSO variability: model-data comparison





Amplitude of SST variability in Nino 3.4 region









#### Integrating the data and the models



- Data-model integration is a two-way process
- The data constrains the model simulations
- The models provide the dynamical interpretation of the data

#### Northern Hemisphere summers were warmer at 8 ka BP ...



June-July-August surface air temperature, 8 ka minus 0 ka BP (K)

... which enhanced the Asian summer monsoon system ...



June-July-August mean sea level pressure, 8 ka minus 0 ka BP (hPa)

#### ... and made it harder for El Niño events to develop



#### Conclusions

- Past changes in El Niño-Southern Oscillation provide an opportunity to learn more about ENSO dynamics. However, to realise this opportunity, we need to integrate the data and the models.
- Low-frequency ENSO variability represents a challenge for data-model integration. Ideally, the sampling period for both the data and models should be at least 200 years.
- A climate system model is able to reproduce the long-term upward trend in ENSO variability over the past 8,000 years. The model suggests that this trend is driven by increasing summer insolation over the Asian landmass.

#### References

Phipps, S. J., and J. N. Brown (2010), Understanding ENSO dynamics through the exploration of past climates, *IOP Conference Series: Earth and Environmental Science*, 9(1), 012010. McGregor, H.V., et al., Reproducibility of oxygen isotope ( $\delta^{18}$ O) proxy climate records in *Porites* coral microatolls, *Geochimica et Cosmochimica Acta*, *in prep*. Phipps, S. J., and H. V. McGregor, 8,000 years of El Niño: A coral data-transient climate model

comparison, Geophysical Research Letters, in prep.