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

Steven J. Phipps\textsuperscript{1}

Helen V. McGregor\textsuperscript{2}

\textsuperscript{1}Climate Change Research Centre, University of New South Wales, Australia

\textsuperscript{2}School of Earth and Environmental Sciences, University of Wollongong, Australia
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

Moy et al. (2002), *Nature*
Microatolls from Kiritimati Island

El Niño year

Coral δ18O

IGOSS SST

Year
The CSIRO Mk3L climate system model

- Low-resolution coupled general circulation model:
  - Atmosphere: 5.6° × 3.2°, 18 vertical levels
  - Ocean: 2.8° × 1.6°, 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

Amplitude of SST variability in Nino 3.4 region (ENSO band)
Changes in ENSO variability: model-data comparison

Amplitude of SST variability in Nino 3.4 region (ENSO band)
Variability as a function of sampling period in the model

Amplitude of SST variability in Nino 3.4 region

500 years
Variability as a function of sampling period in the model

Amplitude of SST variability in Nino 3.4 region
Variability as a function of sampling period in the model

Amplitude of SST variability in Nino 3.4 region
Variability as a function of sampling period in the model

Amplitude of SST variability in Nino 3.4 region
Variability as a function of sampling period in the model

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

