Part 1:

PMIP3
Palaeoclimate Modelling Intercomparison Project

  - Atmospheric GCMs
  - Primary experiments were 6 ka (mid-Holocene) and 21 ka (LGM)
  - 22 models participated
  - Contributed towards IPCC TAR

- Phase 2 (2002–2007):
  - Atmosphere-ocean(-vegetation) GCMs
  - Primary experiments were 6 ka (mid-Holocene) and 21 ka (LGM)
  - 18 models participated
  - Contributed towards IPCC AR4
Phase 3 (2008–)

• Theme 1: Evaluation of earth system models at 6 ka and 21 ka
  – Vegetation, biogeochemical cycles, chemistry, ice sheets...
  – Use of new data syntheses for model evaluation

• Theme 2: Interglacials and warm periods
  – Last interglacial (∼130–115 ka) - snapshot and transient
  – Mid-Pliocene (∼3.3–3.0 Ma) - snapshot (PlioMIP)

• Theme 3: Abrupt climate changes
  – Transient simulations of last deglaciation, 8.2 ka event...

• Theme 4: Uncertainties: characterisation and understanding
  – Uncertainties in reconstructions, boundary conditions...
  – Weight models according to a palaeoclimate skill index?

• Will contribute towards IPCC AR5
Part 2:

Simulating the evolution of ENSO over the late Holocene
El Niño has changed...

- Proxy reconstructions from across the Pacific Basin show that:
  - “Modern” El Niño began 7-5 ka BP, with only weak decadal-scale events beforehand
  - El Niño was 15-60% weaker at 6 ka BP than at present
  - Gradual strengthening of El Niño thereafter
  - Evidence of a peak in strength at 2-1 ka, possibly earlier in the western Pacific than in the east
Tudhope et al. (2001), *Science*

Rodbell et al. (1999), *Science*

Moy et al. (2002), *Nature*

PMIP3/Simulating the evolution of ENSO over the late Holocene
ARCNESS palaeoclimate workshop, Sydney, Australia, 12-13 November 2008
Early modelling work

• Clement et al. (2000):
  – Used the Zebiak-Cane model to simulate the past 12 ka
  – Simple atmosphere-ocean model; restricted to the tropical Pacific
  – Established that orbitally-driven changes in the seasonal cycle of insolation in the tropics can alter ENSO behaviour

![Graph](image-url)
## Coupled modelling studies: 6 ka versus 0 ka BP

<table>
<thead>
<tr>
<th>Model</th>
<th>Diagnostic</th>
<th>% change</th>
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<tr>
<td>Otto-Bliesner (1999)</td>
<td>CSM</td>
<td>Niño 3</td>
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<td>Liu et al. (2000)</td>
<td>FOAM</td>
<td>Niño 3.4</td>
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<tr>
<td>Phipps (2006)</td>
<td>Mk3L-1.0</td>
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<td>Brown et al. (2006)</td>
<td>HadCM3</td>
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<td>Zheng et al. (2008) (PMIP2)</td>
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A picture begins to emerge?

- Insolation changes result in enhanced seasonal cycle in NH
- Intensification of summer monsoon system
- Enhanced Walker circulation
- Stronger easterly trade winds in central and western Pacific
- Increased upwelling in central and eastern Pacific
- Suppresses development of El Niño events
Simulations of the late Holocene climate

- CSIRO Mk3L climate system model v1.1:
  - Atmosphere: R21 (5.6° × 3.2°), 18 vertical levels
  - Ocean: 2.8° × 1.6°, 21 vertical levels
  - Sea ice: Dynamic-thermodynamic
  - Land surface: Static vegetation
  - Flux adjustments applied

- Snapshot simulations for 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 and 0 ka BP:
  - Only the Earth’s orbital parameters are varied
  - Atmospheric CO$_2$ concentration = 280ppm
  - Solar constant = 1365 Wm$^{-2}$
  - Integrated for 1000 years
  - Simulations for 6 and 0 ka BP submitted to PMIP2
Standard deviation of Nino SST anomaly

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JASO zonal wind stress in Nino 4 region
Seasonal phase lock

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Summer interannual coupling strength

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EOF1 of monthly–mean SST: 0 ka (°C)

EOF1 of monthly–mean SST: 6 ka (°C)
Conclusions

• Modelling studies suggest orbitally-driven insolation changes account for the changes in ENSO behaviour over the Holocene. However, models and proxy reconstructions disagree on the magnitude of the changes.

• Models (almost) exhibit a consistent link between insolation changes and reduced ENSO variability in the mid-Holocene.

• Exploring this mechanism further using Mk3L, we find that it does not explain the peak in ENSO variability at 1 ka, nor the changes in the early Holocene. Other mechanisms therefore appear to be at work.

• A full understanding of the processes that drive changes in ENSO variability may be within grasp. However, this will require an approach that integrates the theory, data and modelling communities.