Climate modelling and OZ-INTIMATE

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Why climate modelling?

- Data:
  - The real world

- Models:
  - Precise chronology
  - Complete spatial coverage, from bottom of ocean to top of atmosphere
  - As much temporal resolution as you need (hourly?)
  - Simulate actual physical variables (no transfer functions)
  - Just not the real world...
Why climate modelling?
Data-model integration: a win-win situation

- Data-model integration is a two-way process
- The data constrains the model simulations
- The models provide the dynamical interpretation of the data
- Everyone wins!
Palaeoclimate modelling: National efforts

- General circulation models (GCMs):
  - CSIRO Mk3L (UNSW, CSIRO, Macquarie University + others?)
  - CCSM (UNSW, University of Sydney)
  - FOAM (Monash University, University of Western Australia)
  - NASA GISS (ANU)
  - CSIRO Mk3.6 (CSIRO/QCCCE)

- Earth System Models of Intermediate Complexity (EMICs):
  - UVic (UNSW)

- Different timescales, different questions:
  - ENSO variability during the Holocene
  - Changes in the Australian monsoon during the last glacial cycle
  - Deep time/past warm periods
  - Process studies (abrupt changes, carbon cycle, topography...
Palaeoclimate Modelling Intercomparison Project

• Phase 1 (1991–2001) :
  – Atmospheric GCMs
  – Primary experiments were 6 ka (mid-Holocene) and 21 ka (LGM)
  – 22 models participated
  – Contributed towards IPCC TAR

• Phase 2 (2002–2008) :
  – Atmosphere-ocean(-vegetation) GCMs
  – Primary experiments were 6 ka (mid-Holocene) and 21 ka (LGM)
  – 18 models participated
  – Contributed towards IPCC AR4
Phase 3 (2009–)

• 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

• Two Australian models: CSIRO Mk3L and CSIRO Mk3.6
Climate modelling for OZ-INTIMATE

• CSIRO Mk3L climate system 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

• Pre-industrial control simulations (10,000 years)

• 3 x transient simulations of the past 8,000 years
  – Orbital forcing only

• 3 x 3 x transient simulations of the past 2,000 years
  – Orbital + GHGs
  – Orbital + GHGs + solar
  – Orbital + GHGs + solar + volcanic

• Transient simulation of 15–10 ka
  – Coming soon...
Simulated changes in El Niño variability

Amplitude of SST variability in Nino 3.4 region (ENSO band)
Simulated changes in SH sea ice extent

Southern Hemisphere sea ice extent
Climate modelling and OZ-INTIMATE

- How the proxy people can help the modellers:
  - Evaluation of models and model simulations

- How the modellers can help the proxy people:
  - Dynamical interpretation of data
  - Fill spatial gaps in datasets
  - Enhance temporal resolution
  - Chronology?
  - Explore how teleconnections (transfer functions) evolve over time

- The future:
  - More realistic forcings (GHGs, solar, volcanic...)
  - Data-model integration
  - Data assimilation