Australian Partnerships in Ice Core Sciences

Climate modelling activities:
Uncertainties in climate forcings

Steven J. Phipps

Climate Change Research Centre
ARC Centre of Excellence for Climate System Science
University of New South Wales, Sydney, Australia
Climate modelling and data

- The CSIRO Mk3L climate system model (Phipps et al., 2011, 2012):
  - Atmosphere-land-sea ice-ocean general circulation model
  - Multiple transient simulations of the last 2000 years

- Climate forcings:
  - Orbital changes (Berger, 1978)
  - Greenhouse gases (MacFarling Meure et al., 2006)
  - Solar irradiance (Steinhilber et al., 2009)
  - Explosive volcanism (Crowley et al., 2008; Gao et al., 2008)

- Southern Hemisphere temperature reconstruction (Mann et al., 2008):
  - Global network of 1209 annually- and decadally-resolved proxies
  - Used to reconstruct annual-mean temperature for 400–2006 CE
Solar and volcanic forcing (850–1850 CE)

Total solar irradiance

Radiative forcing due to volcanoes (Gao et al, 2008)

Radiative forcing due to volcanoes (Crowley et al, 2008)
Volcanic forcing during the 15th century

Northern Hemisphere (Gao et al, 2008)

Southern Hemisphere (Gao et al, 2008)

Global (Crowley et al, 2008)
Volcanic forcing during the 15th century

Northern Hemisphere (Gao et al, 2008)

Southern Hemisphere (Gao et al, 2008)

Global (Crowley et al, 2008)
Drivers of Southern Hemisphere temperature

**Orbital + Greenhouse**
- r = +0.56

**Orbital + Greenhouse + Solar**
- r = +0.61

**Orbital + Greenhouse + Solar + Volcanic**
- r = +0.67
SH temperature during the 15th century

Gao et al. (2008)

Modified Gao et al. (2008)

Crowley et al. (2008)
Simulated “fingerprints” of external forcings
Simulated “fingerprints” of external forcings
Simulated “fingerprints” of external forcings
Detection of externally-forced changes

\[ \Delta T = \beta_g \Delta T_g + \beta_s \Delta T_s + \beta_v \Delta T_v + \epsilon \]

- If the reconstruction and the model simulations are perfect, then \( \beta \approx 1 \).
- The external signal is detected if \( \beta > 0 \).
- \( \epsilon \) will include contributions from:
  - internal climate variability
  - errors in the reconstruction
  - errors in the model simulations
Southern Hemisphere (1001–2000 CE)

1 = Crowley et al. (2008)
Southern Hemisphere (1001–2000 CE)

1 = Crowley et al. (2008)  
2 = Gao et al. (2008)  
3 = Modified Gao et al. (2008)