Evaluation of the CMIP5 palaeo-simulations

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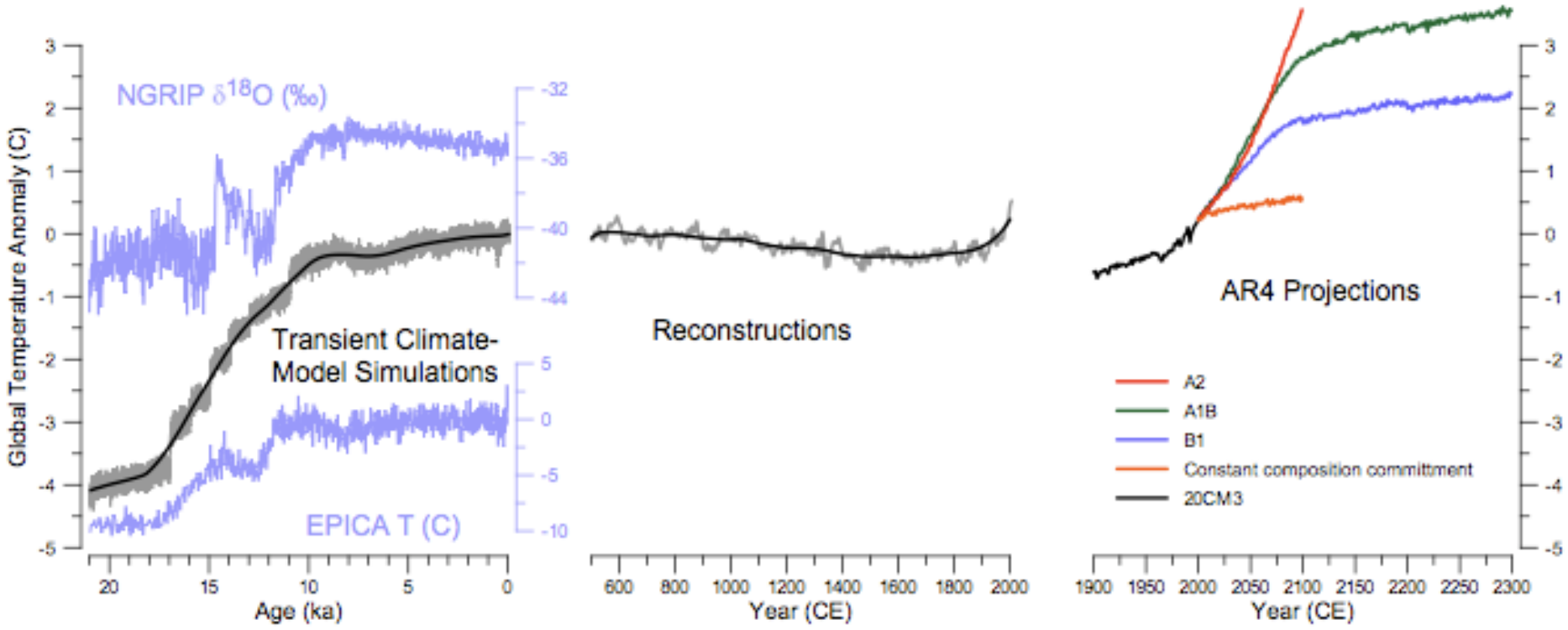
Why palaeo-evaluation?



PMIP boundary conditions: MH

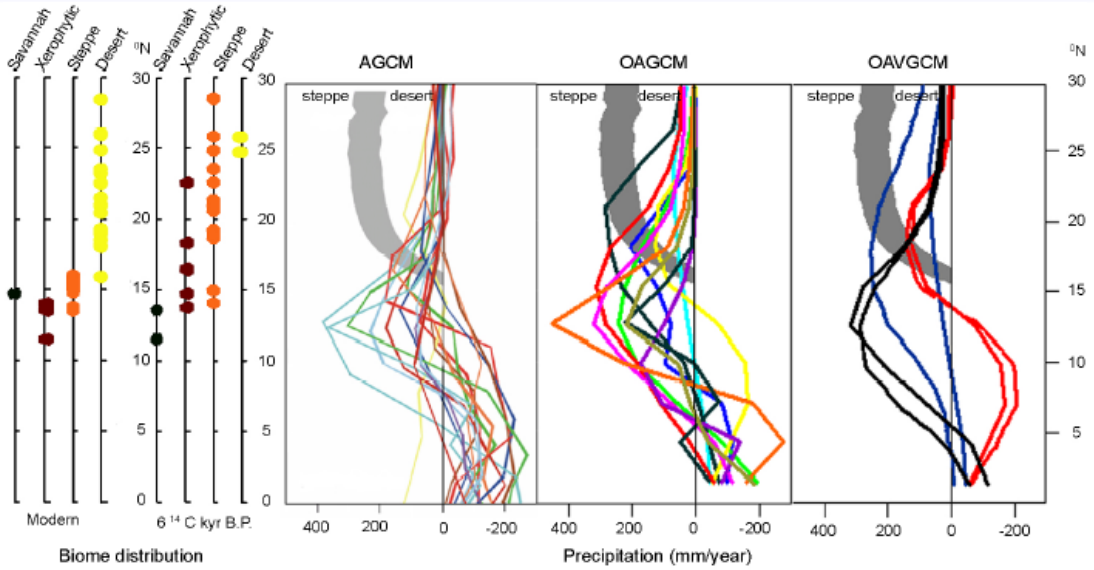
Mid Holocene (6000 years BP)* *In this experiment ice-sheet, coastline, solar constant and aerosols are prescribed as in the PI simulation.			
Insolation	**eccentricity** = 0.018682 **obliquity** = 24.105° **perihelion-180°** = 0.87°	**eccentricity** = 0.018682 **obliquity** = 24.105° **perihelion-180°** = 0.87°	**eccentricity** = 0.018682 **obliquity** = 24.105° **perihelion-180°** = 0.87°
Trace gases	**CO2** = 280 ppm Or 280/345*Ccont **CH4** = 650 ppb **N2O** = 270 ppb **CFC** = 0 **O3** = not considered	**CO2** = 280 ppm **CH4** = 650 ppb **N2O** = 270 ppb **CFC** = 0 **O3** = not considered	**CO2** = 280 ppm **CH4** = 650 ppb **N2O** = 270 ppb **CFC** = 0 **O3** = same as in CMIP5 PI
Vegetation and land surface	Prescribed to be the same as modern vegetation	Either prescribed to be the same as modern vegetation or computed using a dynamical vegetation module	Computed using a dynamical vegetation module, Or prescribed as in PI, with phenology computed for models with active carbon cycle or prescribed from data
Carbon cycle	Not considered	Not considered	Interactive, with atmospheric concentration prescribed and ocean and land carbon fluxes diagnosed as recommended in CMIP5

Bracconot et al., subm.

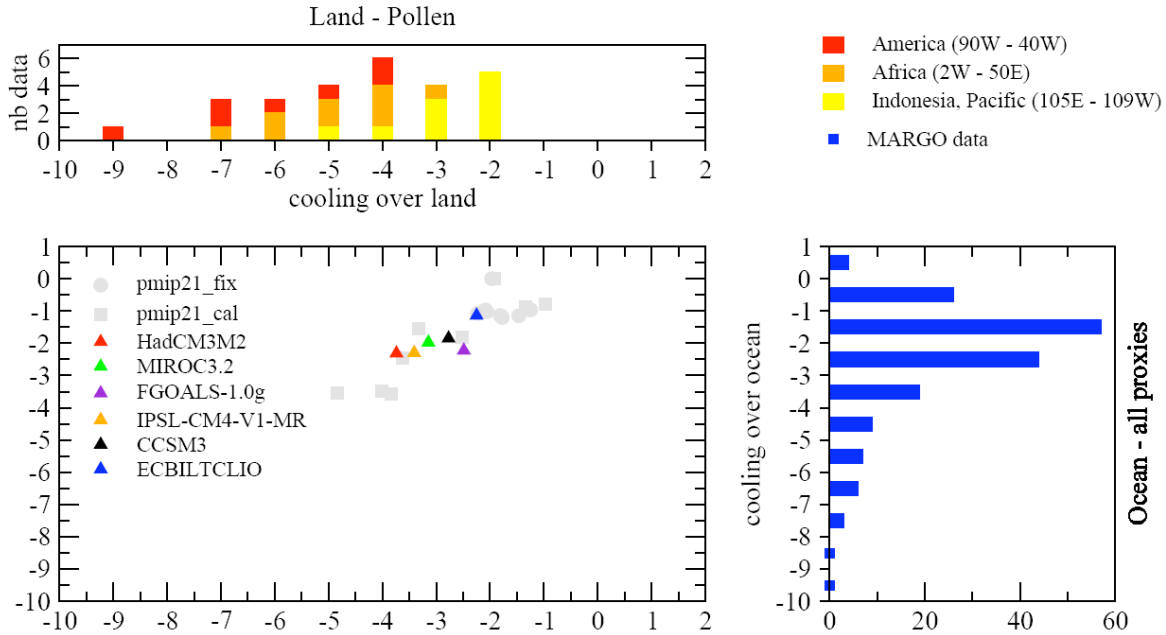
LGM

	PMIP1	PMIP2	PMIP3
Last Glacial Maximum (21000 years BP) * * In this experiment solar constant and aerosols are prescribed as in the PI simulations.			
Insolation	**eccentricity** = 0.018994 **obliquity** = 22.949° **perihelion-180°** = 114.42°	**eccentricity** = 0.018994 **obliquity** = 22.949° **perihelion-180°** = 114.42°	**eccentricity** = 0.018994 **obliquity** = 22.949° **perihelion-180°** = 114.42°
Trace gases	**CO2** = 200 ppm or 200/280) * Ccont **CH4** = 350 ppb **N2O** = 190 ppb **CFC** =0 **O3** = same as in PI	**CO2** = 185 ppm **CH4** = 350 ppb **N2O** = 200 ppb **CFC** =0 **O3** = same as in PI	**CO2** = 185 ppm **CH4** = 350 ppb **N2O** = 200 ppb **CFC** =0 **O3** = same as in PI
Ocean	SST prescribed from CLIMAP (1981) Or SST computed using a slab ocean model	3D Ocean model and sea-ice	3D ocean model and sea-ice
Ice sheet	Peltier et al (1994)	Peltier et al (2004)	Blended ice sheet
Land-sea mask	- 105 m sea level	Prescribed following Peltier (2004) land-sea mask -120 m	Prescribed from the blended ice-sheet land-sea mask
Freshwater		Excess LGM freshwater added to the ocean in 3 different regions	Excess LGM freshwater added to the ocean in 3 different regions
Ice sheet ice streams	Not considered	Not considered	Not considered
River runoff	Not considered	As in CTRL or river pathway modified	As in PI or river pathway modifier according to PMIP protocol
Mean ocean salinity	Not considered	Not considered	+1 PSU everywhere
Carbon cycle	Not considered	Not considered	Interactive, with atmospheric concentration prescribed and ocean and land carbon fluxes diagnosed as recommended in CMIP5 For PCMIP: fully interactive with atmospheric concentration computed by the model

Palaeo-benchmarking

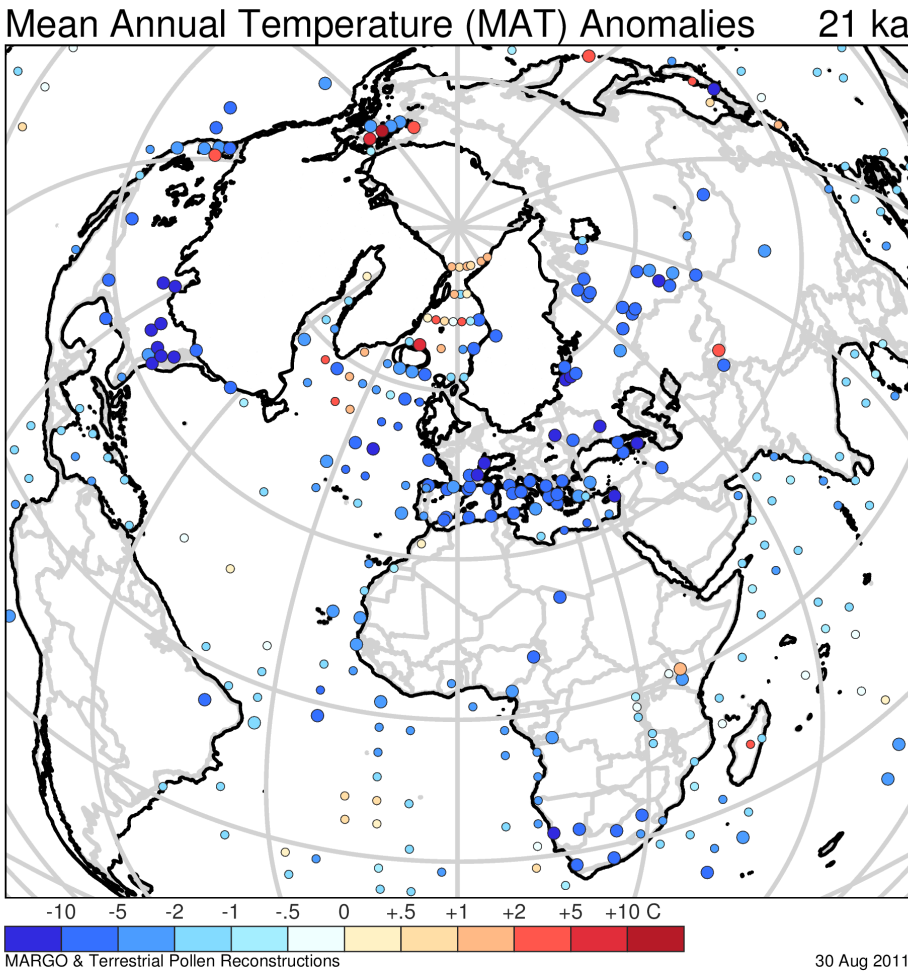


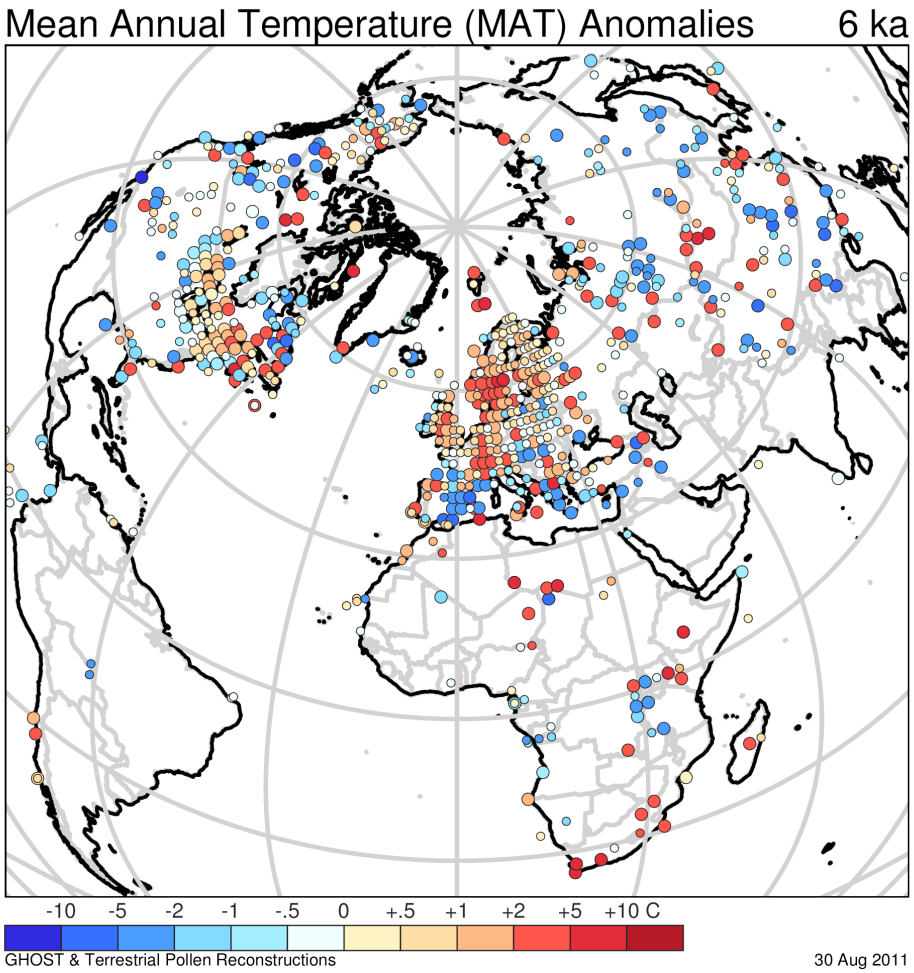
Mid-Holocene



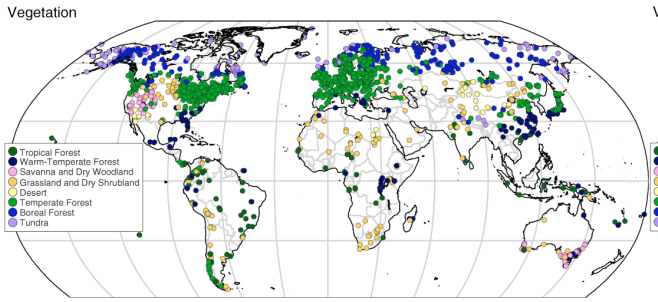
LGM

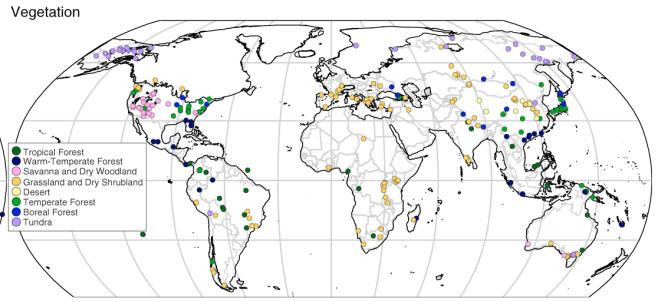
Quantitative climate reconstructions: MH and LGM



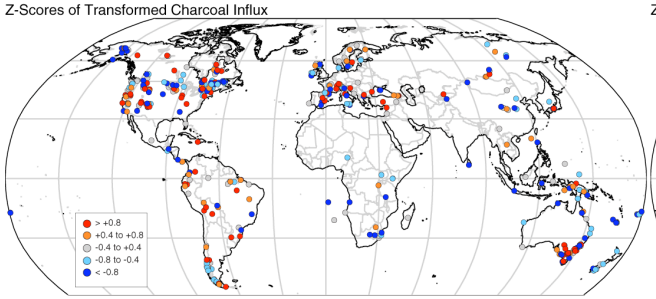


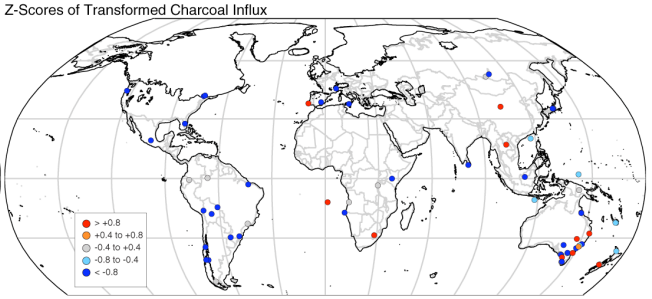
Ocean reconstructions: MARGO Project Members, 2009, Leduc et al., 2010;
Land reconstructions: Bartlein et al., 2011



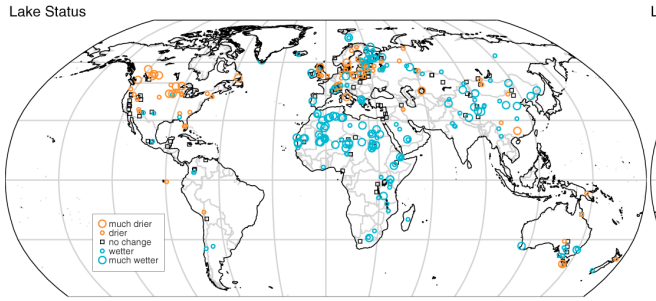


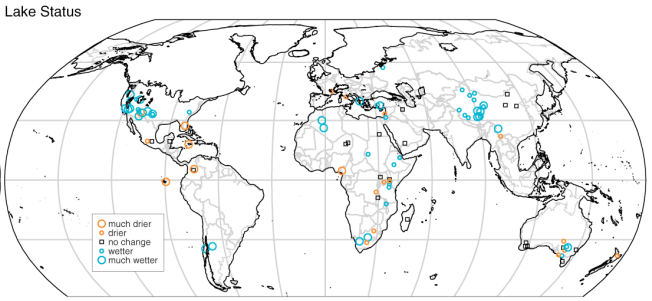
BIOME 6000 project
Prentice et al., 2000
Prentice et al., 2011



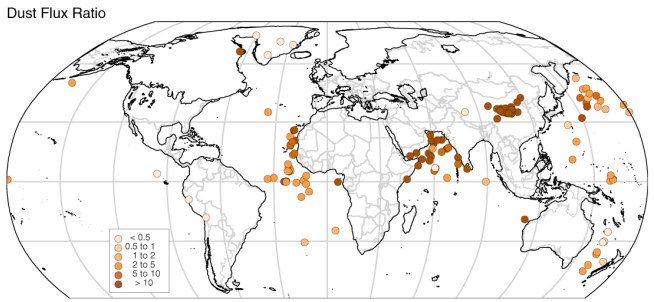


GPWG charcoal database
Power et al.,2009
Daniau et al., unpub.





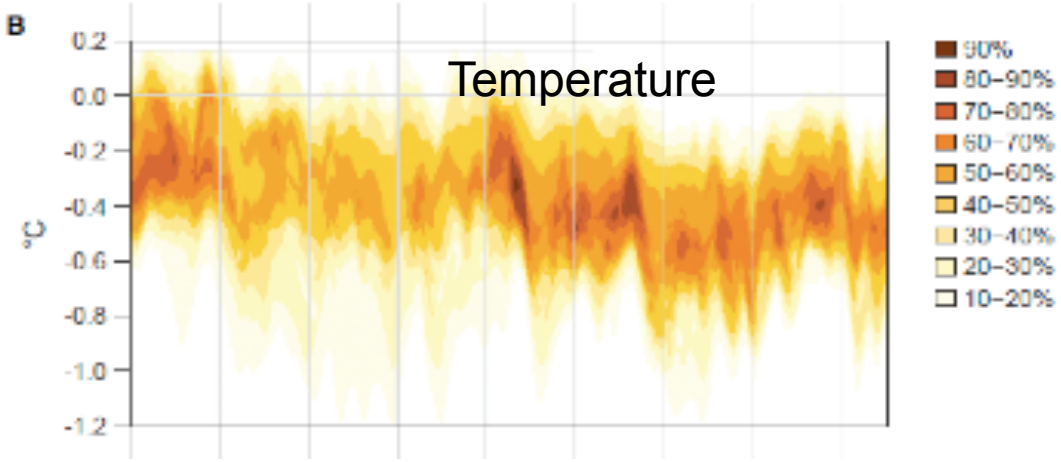
GLSDB
Kohfeld and Harrison, 2000

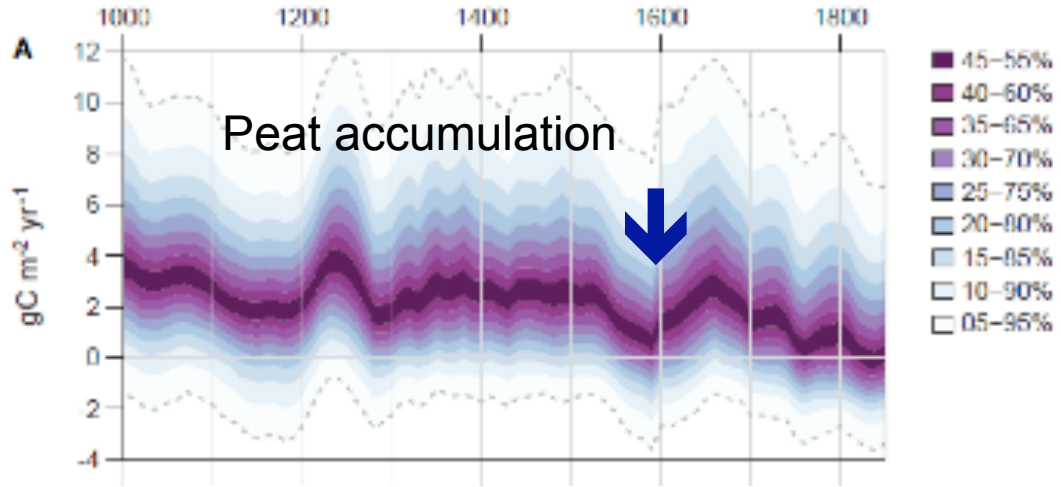


DIRTMAP database
Kohfeld and Maher, unpub.

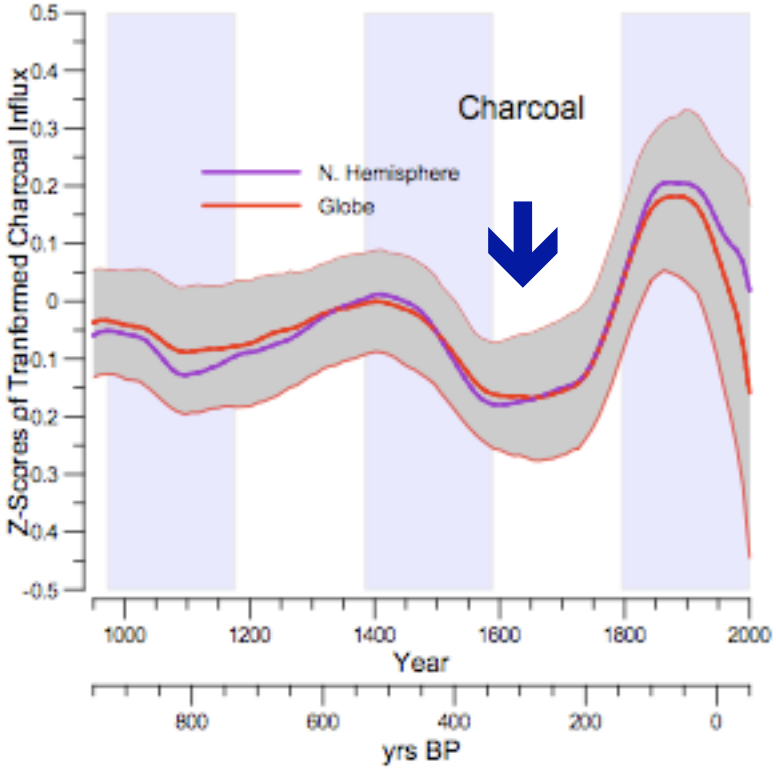
OTHER TYPES OF RECONSTRUCTIONS

LM reconstructions



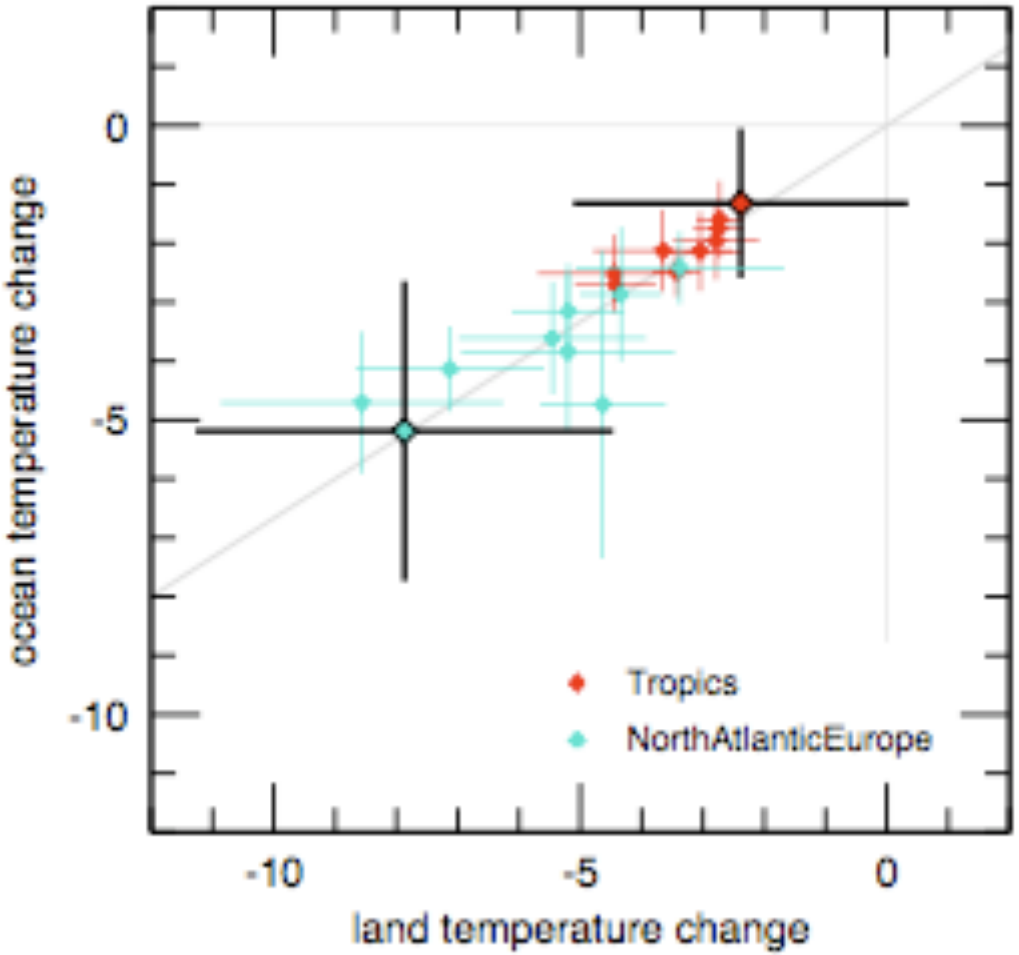


Little Ice Age



Peat records: Charman et al., subm. Charcoal records: GPWG database

Evaluation: land-sea contrast

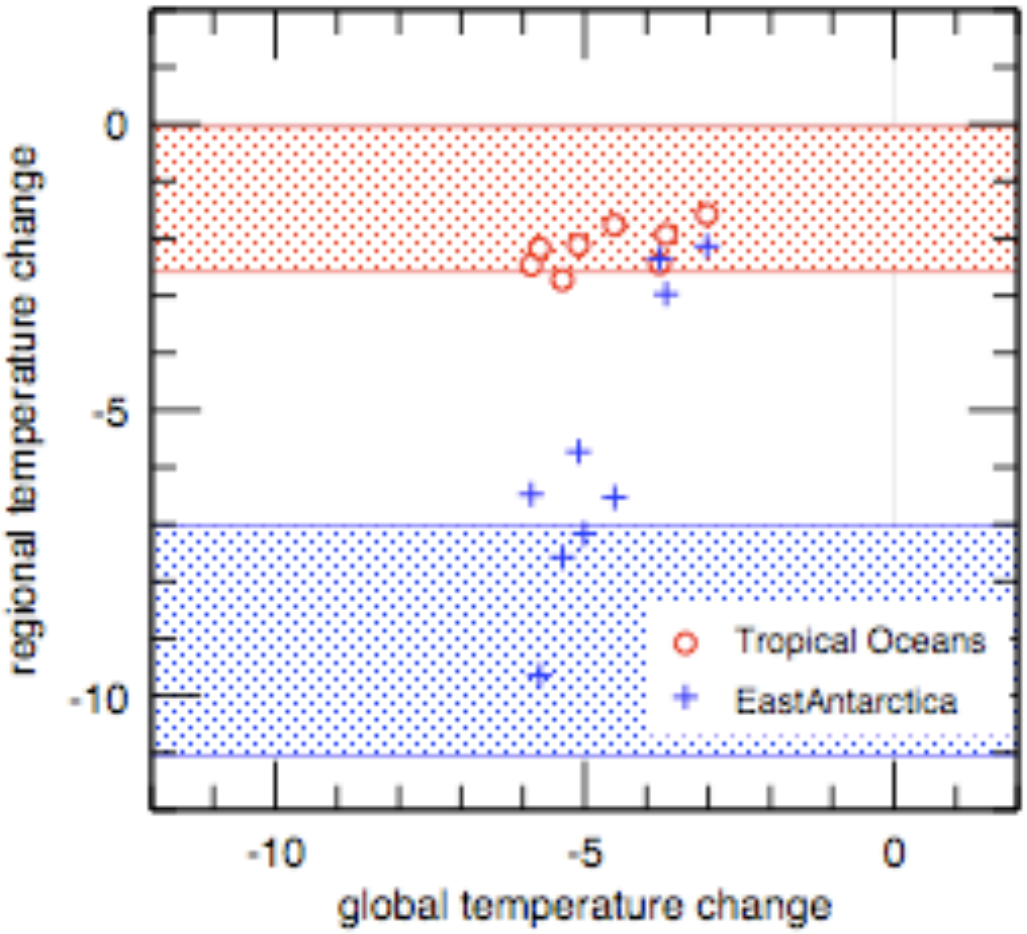


Future ratio: 1.36-1.84

Palaeo-ratio: same ballpark!

Braconnot et al., subm.

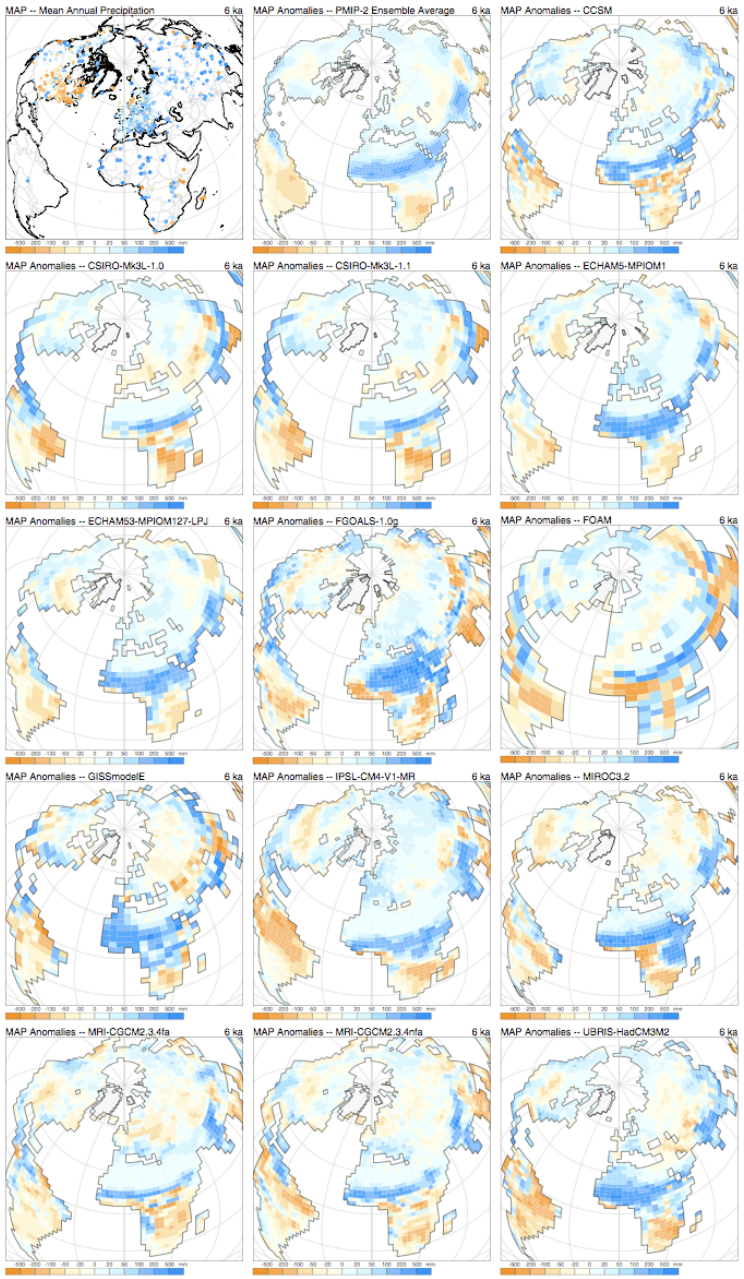
Evaluation: polar amplification



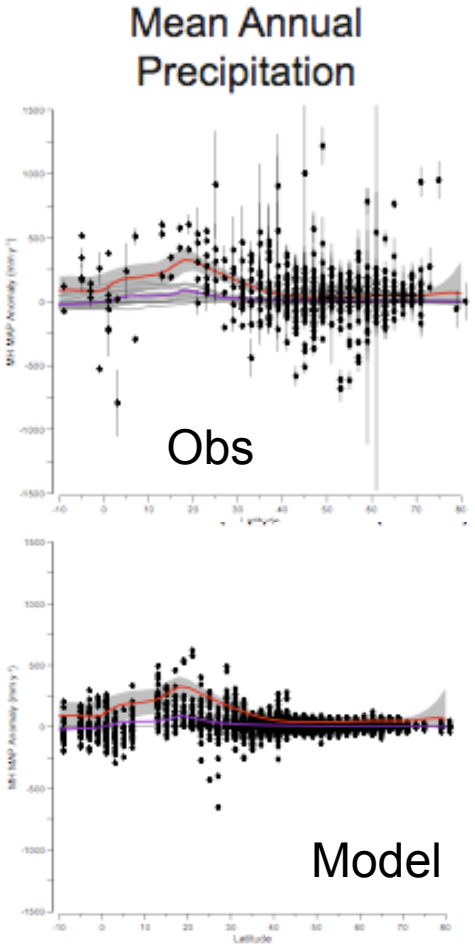
polar amplification ✔

Antarctic cooling underestimated

Braconnot et al., subm.



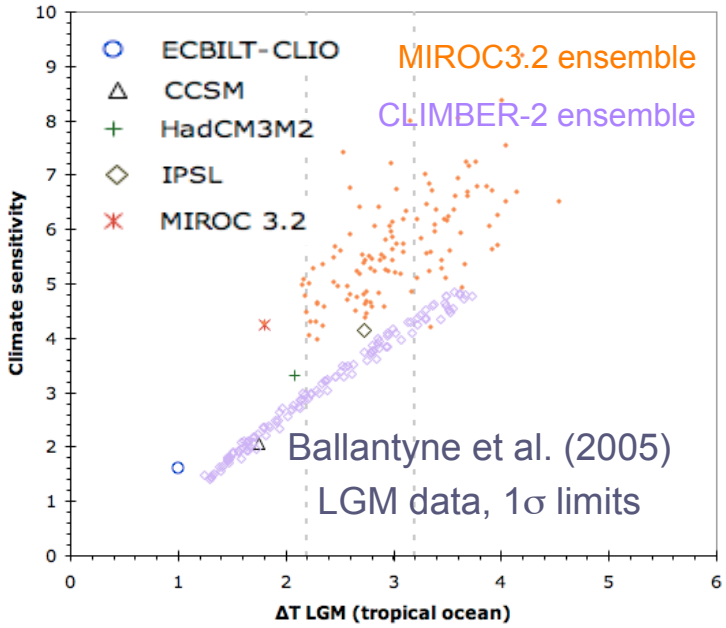
Evaluation: MH monsoons



red: obs mean

purple: model mean

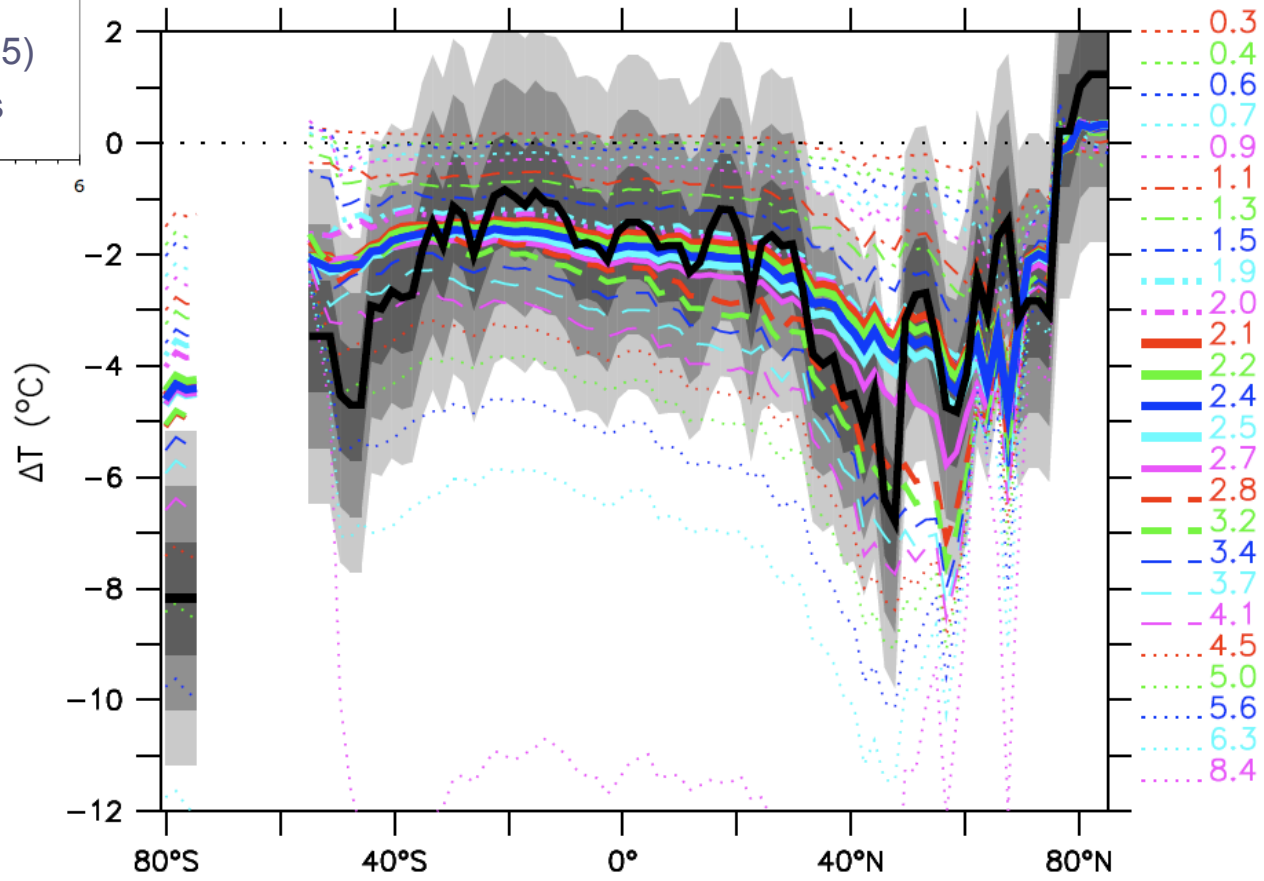
Climate sensitivity



using spatial explicit data set

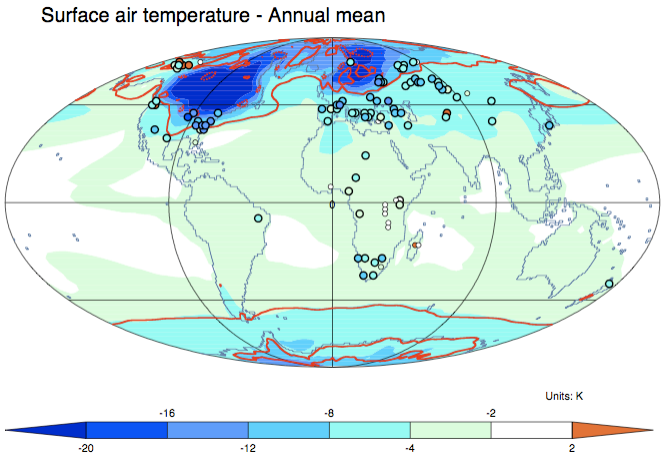
median = 2.3K
1.7–2.6 K 66% prob

>6K IMPLAUSIBLE

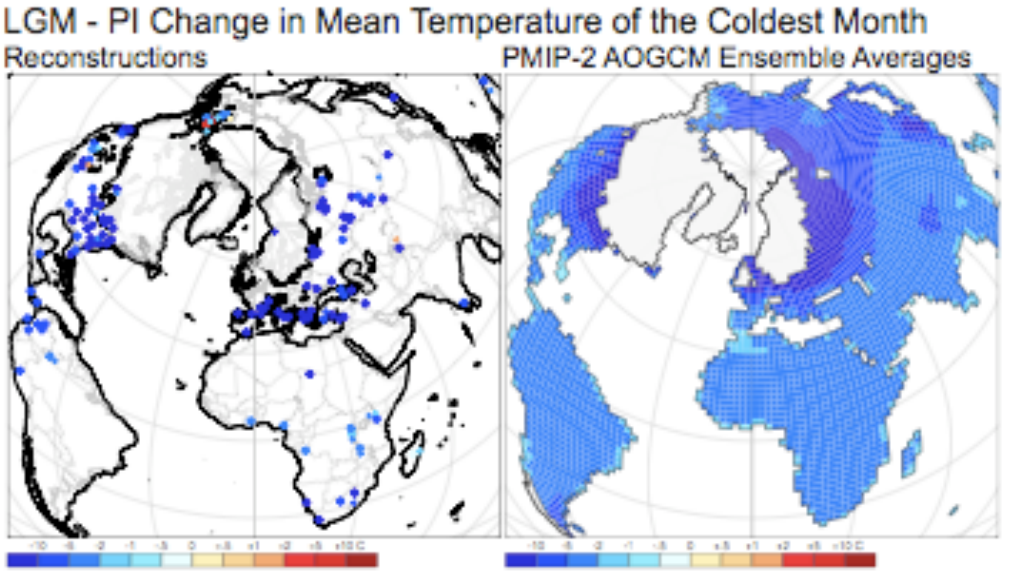


Edwards et al., 2009

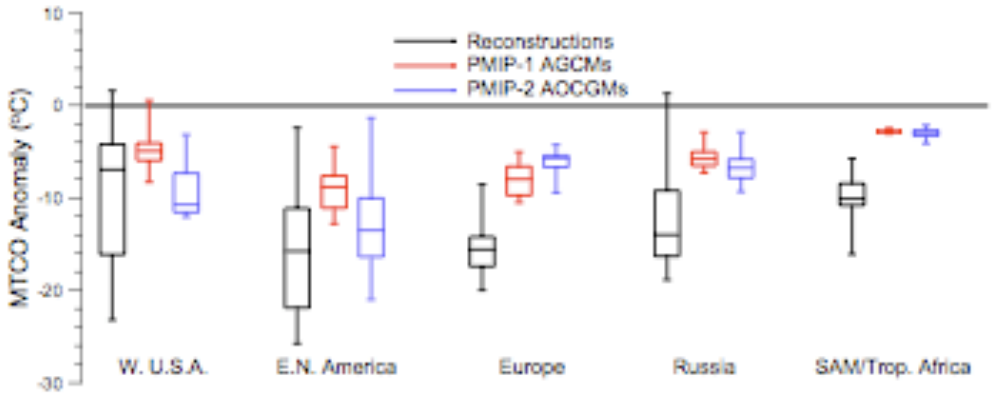
Schmittner et al., in press, Science

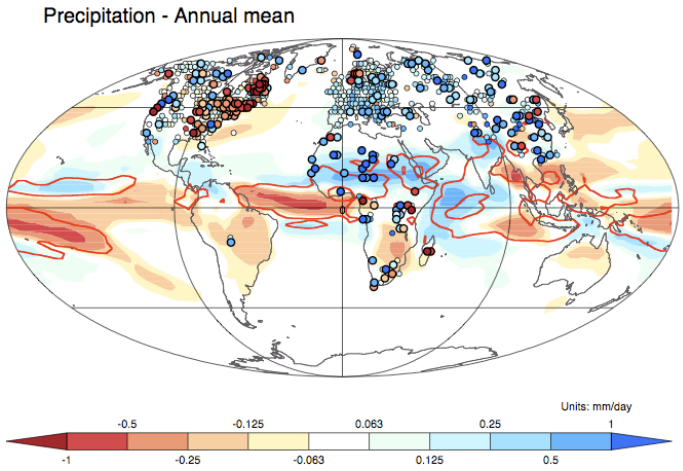


Magnitude errors: LGM

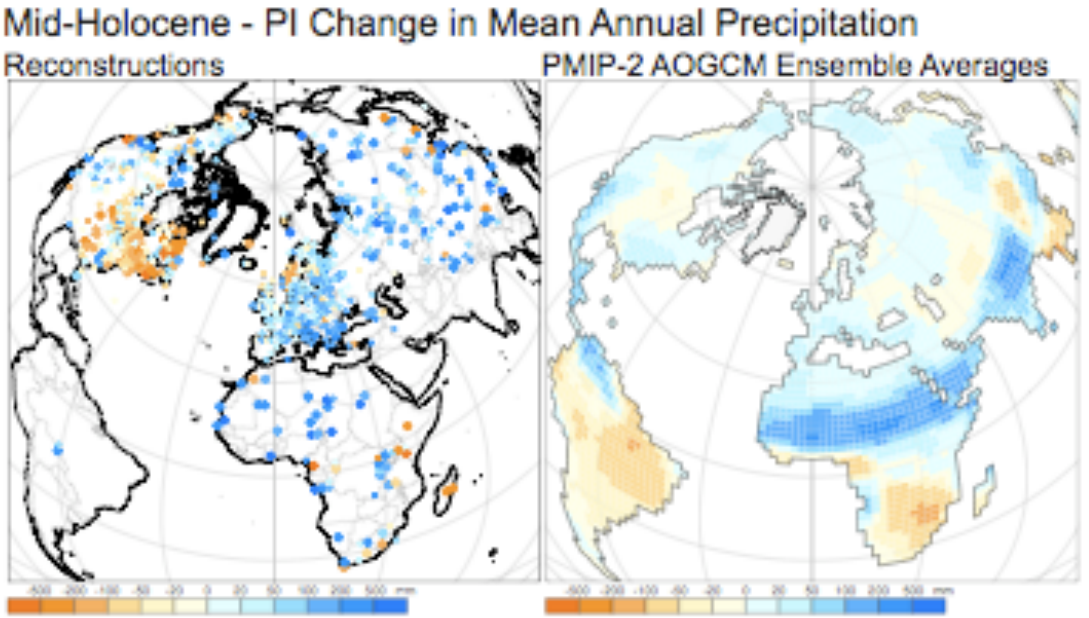


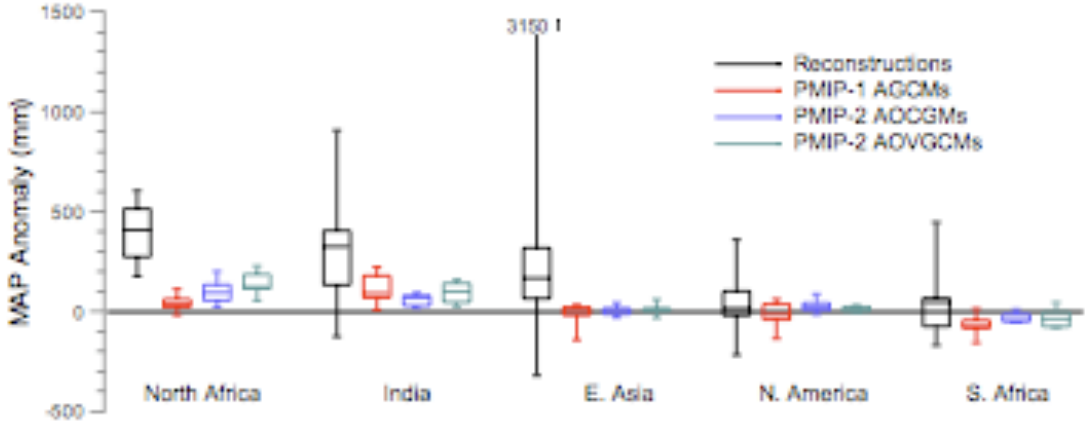
Models underestimate regional cooling





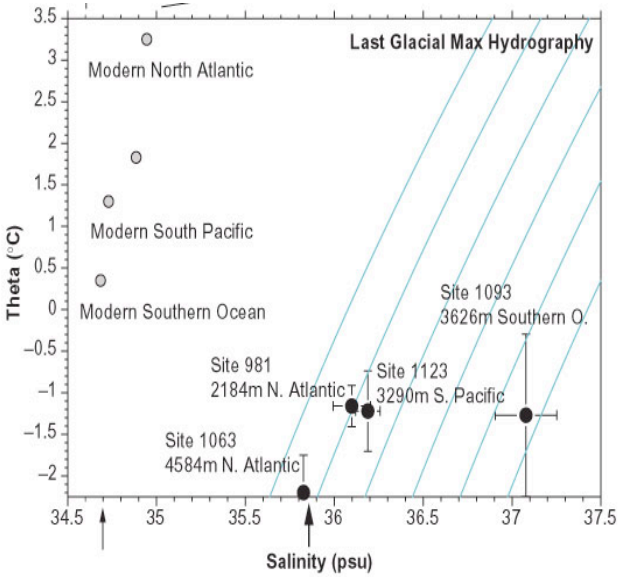
Magnitude errors: MH

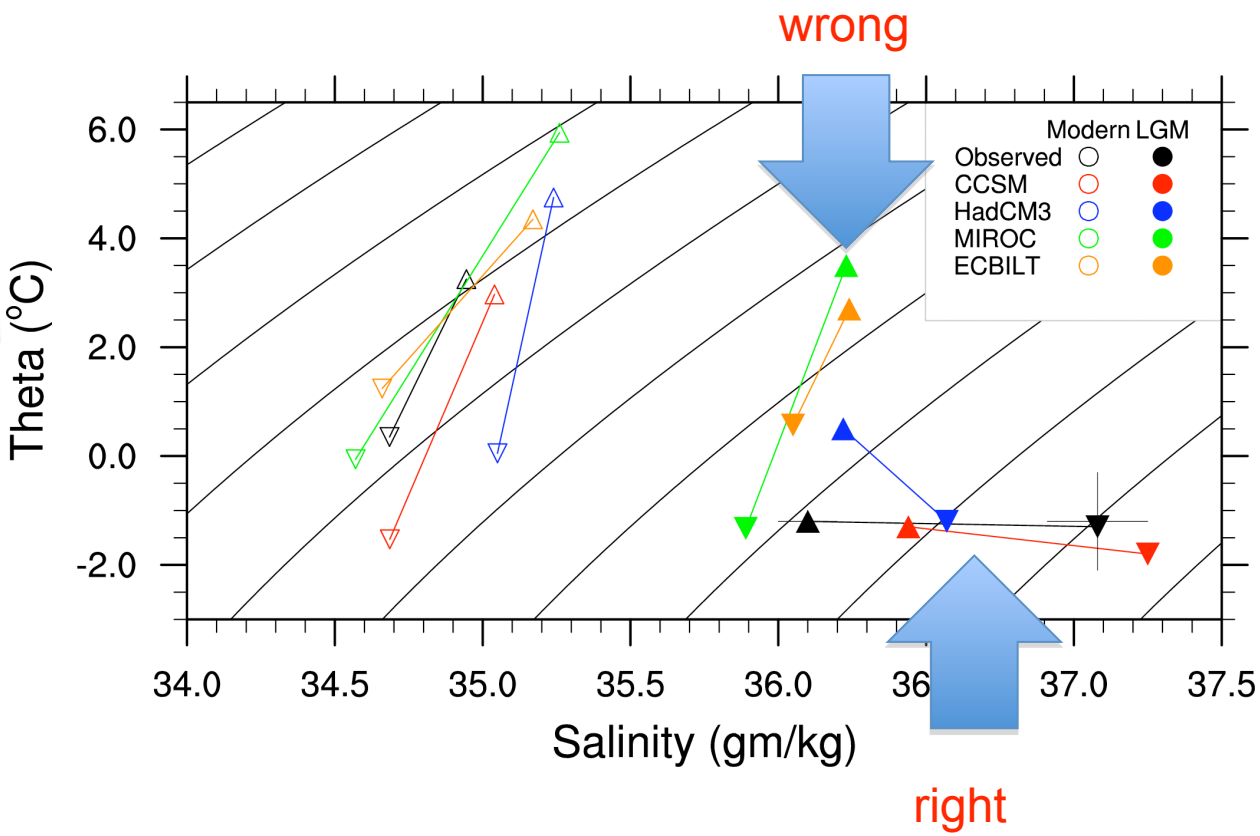




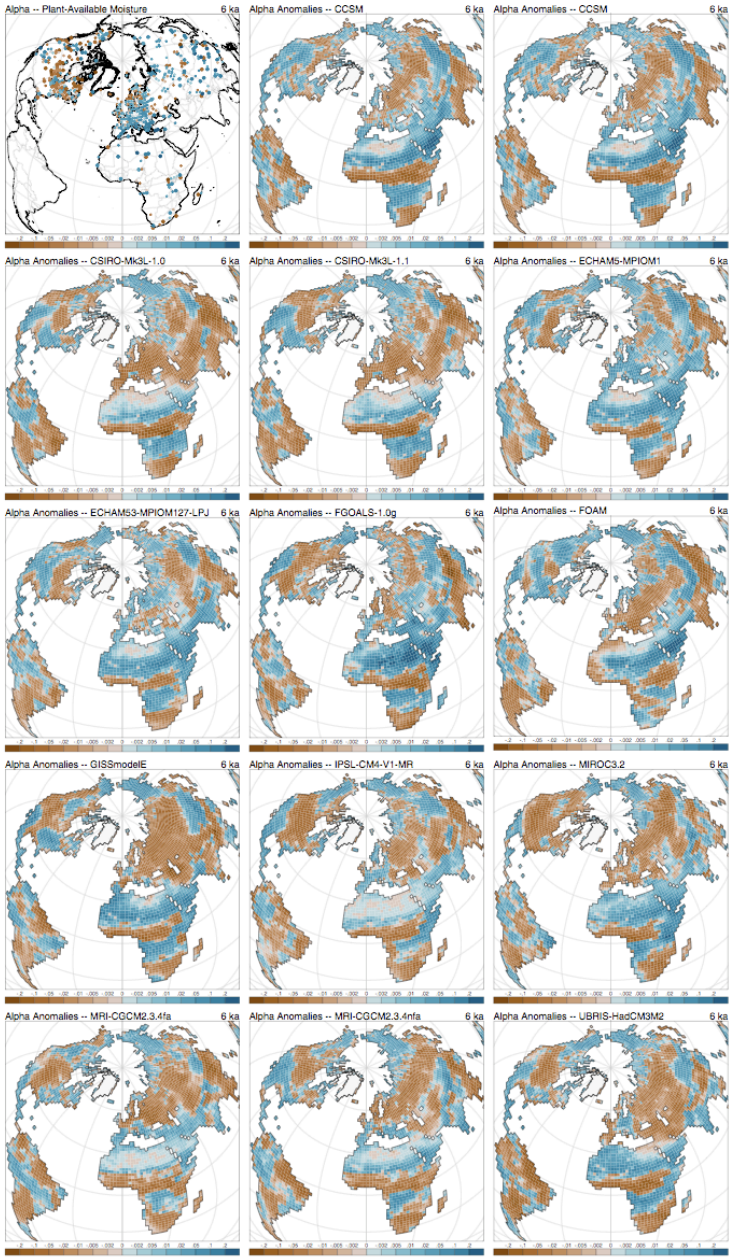
Discrimination: LGM oceans

Adkins et al., 2002, Science





Analyses courtesy of Bette Otto-Bleisner

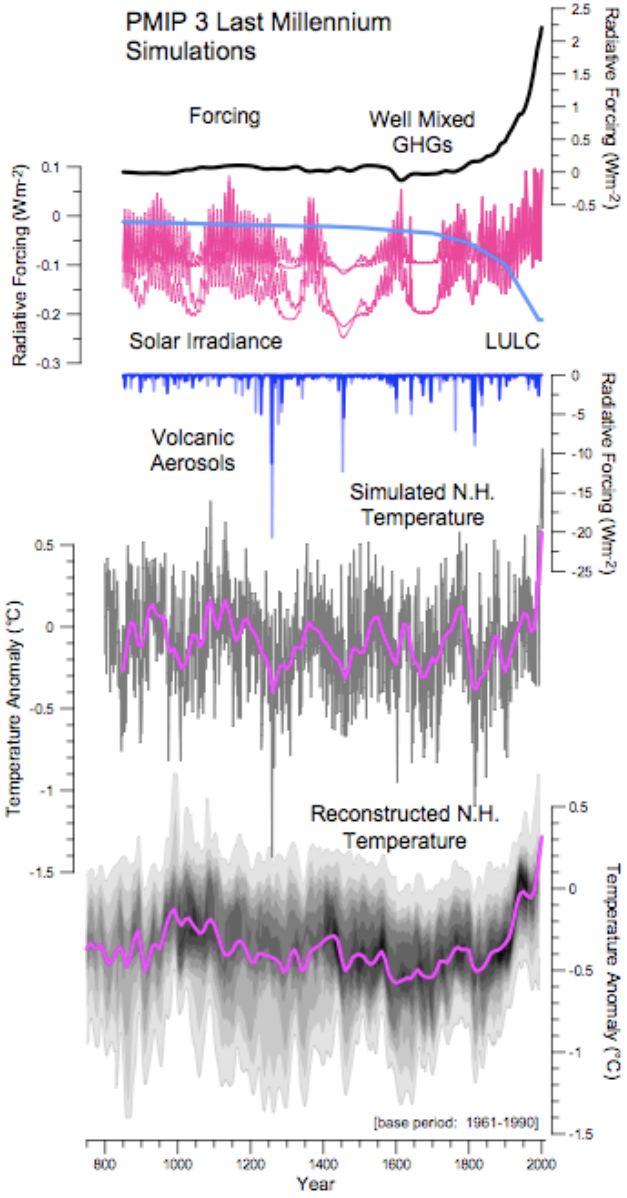


monsoon too extensive, limited aridity

wetting/drying too zonal

continent-wide aridity

Discrimination: continental aridity

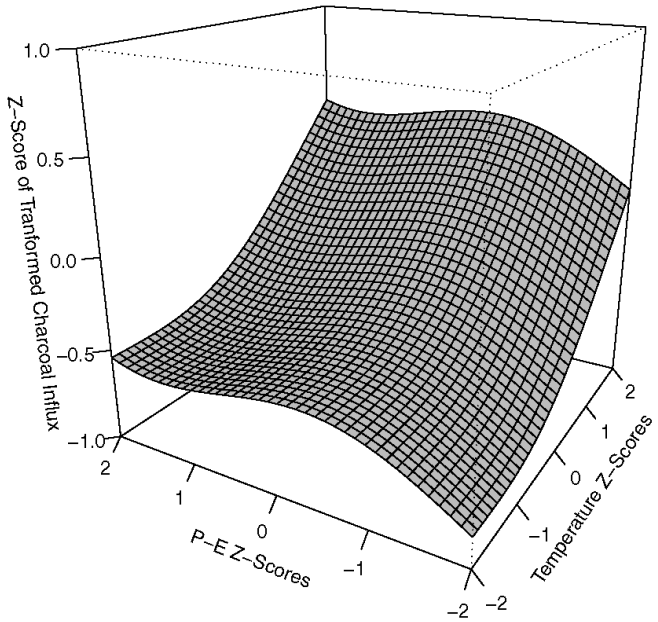


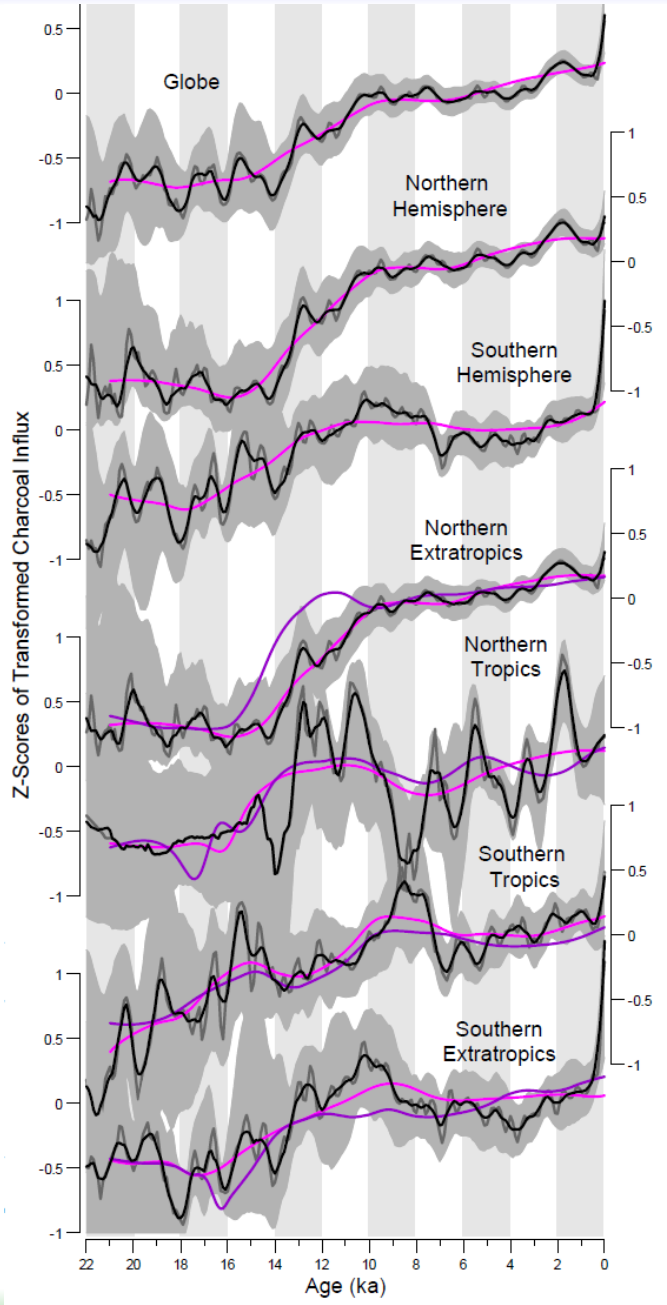
Transient LM

"There's more to life than temperature reconstructions, Brian"

Simulation: Jungclaus et al.

Transient evolution of fire





Outputs from ECBILT-CLIO simulation, in response to orbital, ice sheet & GHG forcing, can reproduce observed zonal fire responses

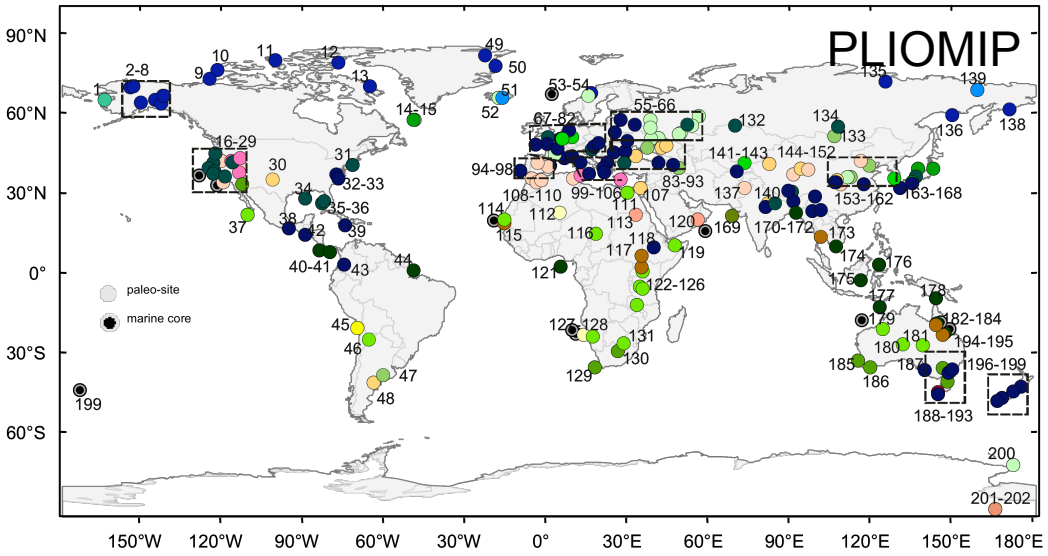
Other PMIP3 experiments

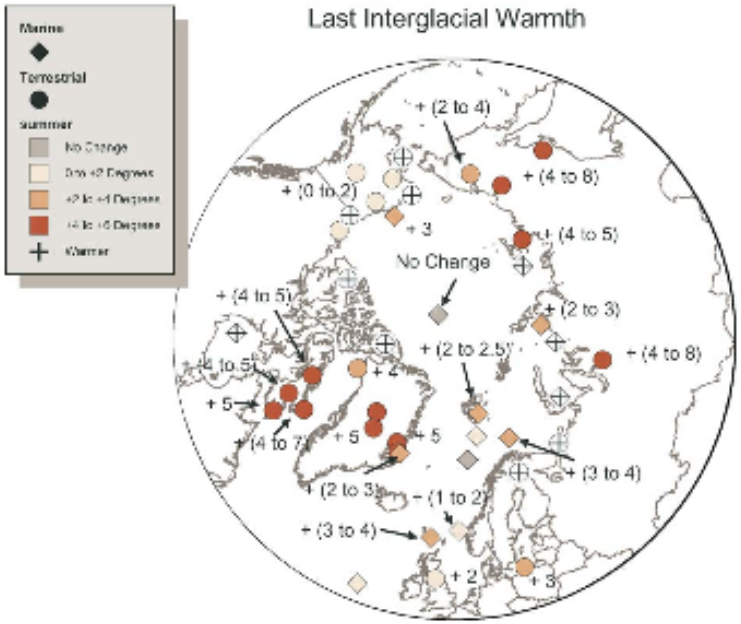
- other warm periods
  - orbitally driven (LIG, 125ka)
  - CO_2 driven (mid-Pliocene, 3-3.3Ma)
- other cold periods
  - Greenland stadials
- transient simulations – rapid climate changes
  - deglaciation/YD
  - D-O cycles

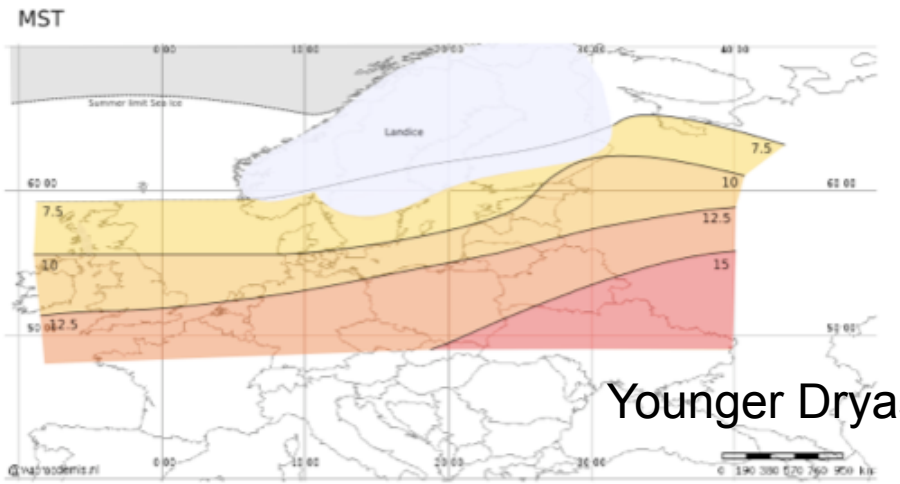
Additional experiments broaden scope of PMIP contribution to CMIP5

- additional tests of mechanisms in LGM, MH and LM simulations
- assess model capacity to reproduce the amplitude, timing and nonlinear feedbacks

Example data sets: time-slice

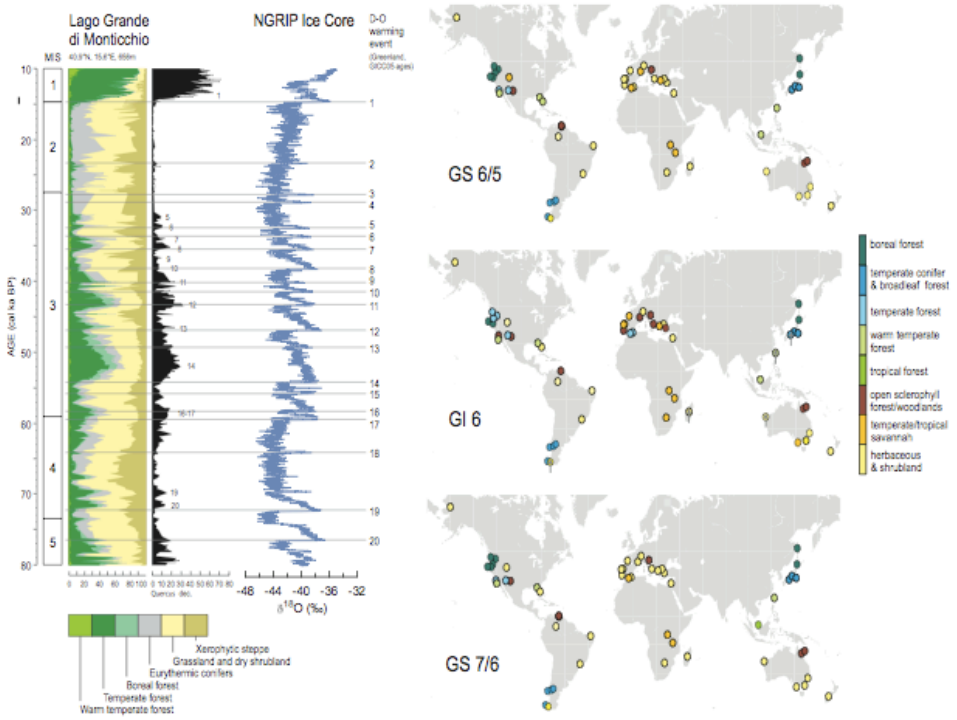


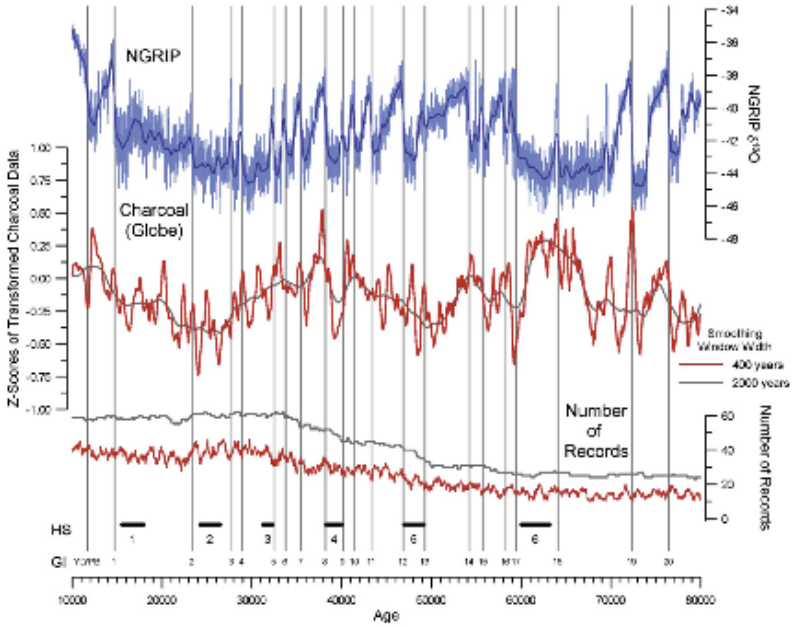




Salzmann et al., 2008; CAPE Project Members, 2006; Tilberg, 2011

Example data sets: transients





Harrison & Sanchez Goni, 2010; Daniau et al., 2010

Take-home messages

- Palaeo-world presents opportunities to evaluate climate change mechanisms
- PMIP has data sets and evaluation tools
- PMIP has shown that models can reproduce first-order signals – it makes sense to use models to simulate future climate change!
- PMIP has shown that models fail to capture magnitude of responses
- PMIP has shown that feedbacks important but still poorly captured in models