

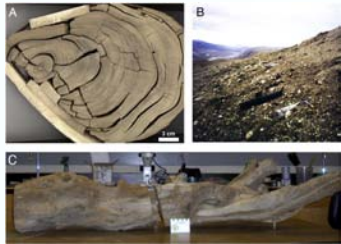
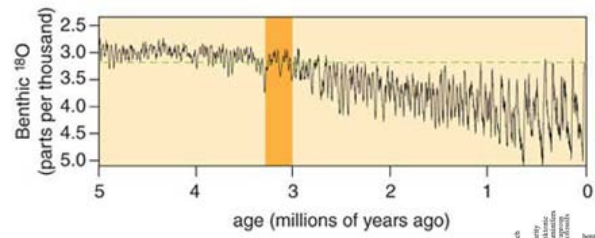
The CESM and PlioMIP

Nan Rosenbloom
Bette Otto-Bliesner
Esther Brady

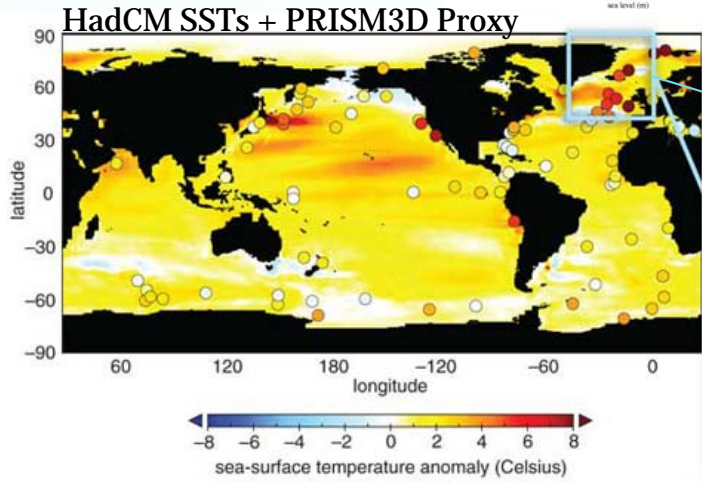
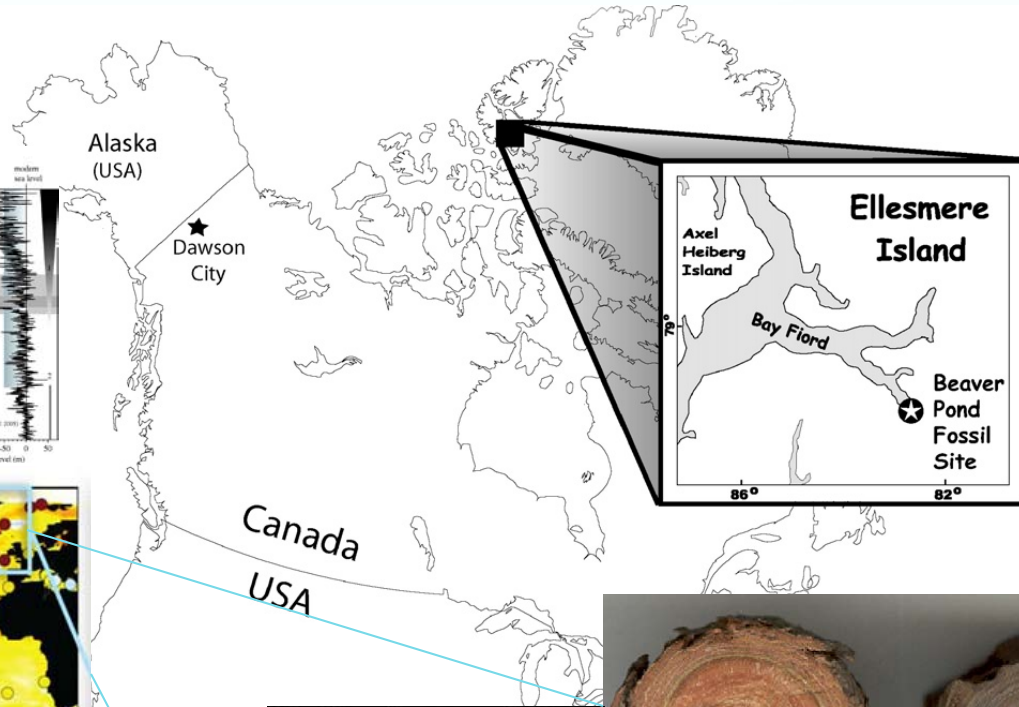
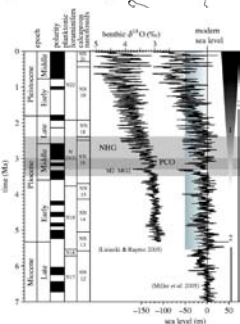
Outline

1. Background
2. Results from PlioMIP
3. Regional examples
 - East Asian Monsoon
 - AMOC
4. Earth system sensitivity
5. Future direction

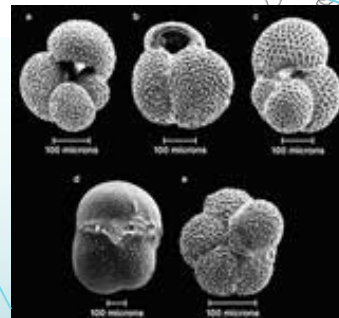
Pliocene (~3 Ma) - Analog for future climate?



Csank et al. J. Palaeo. 2011



Robinson, 2011

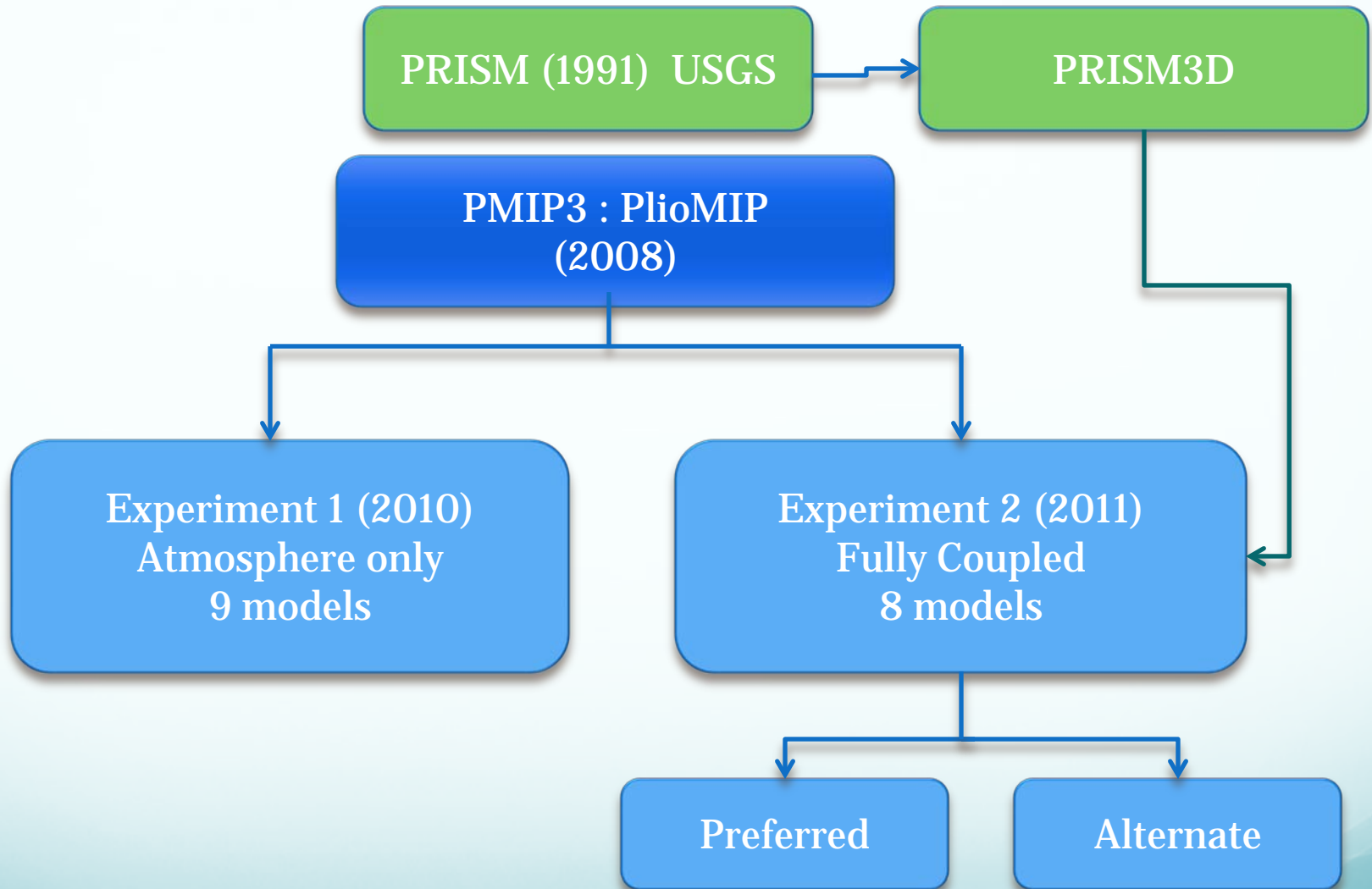


Robinson 2011

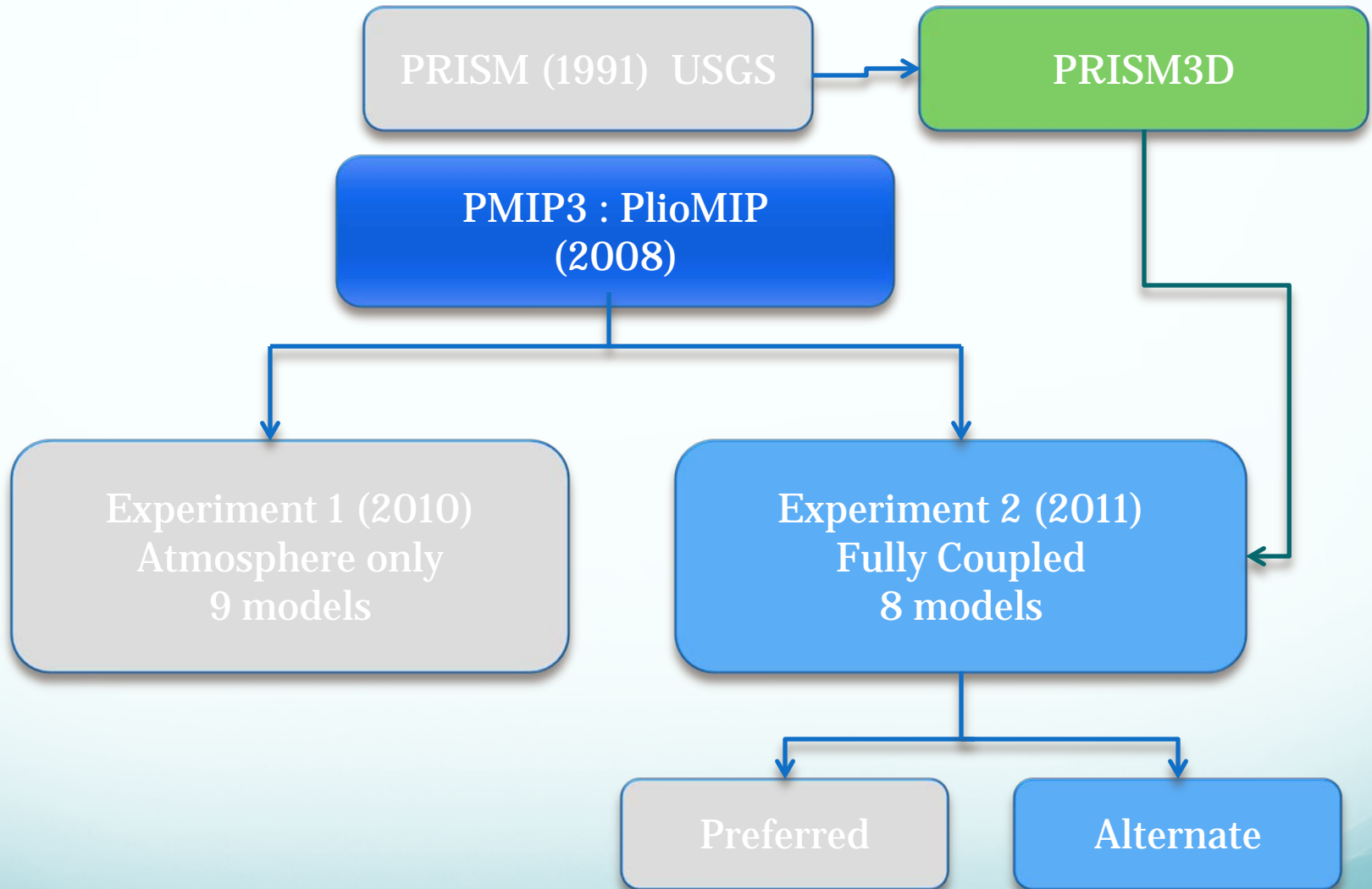


Ballantyne et al. 2006

PlioMIP



PlioMIP



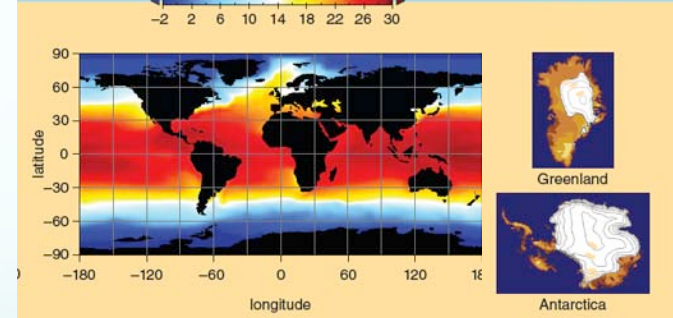
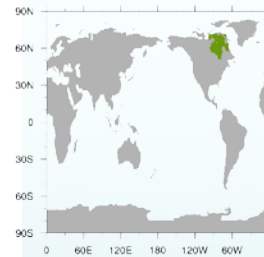
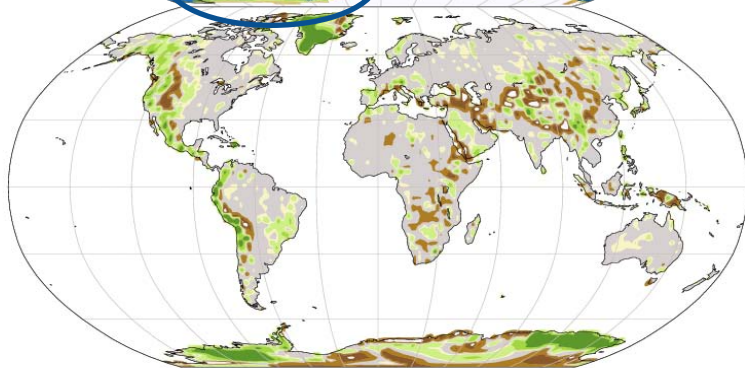
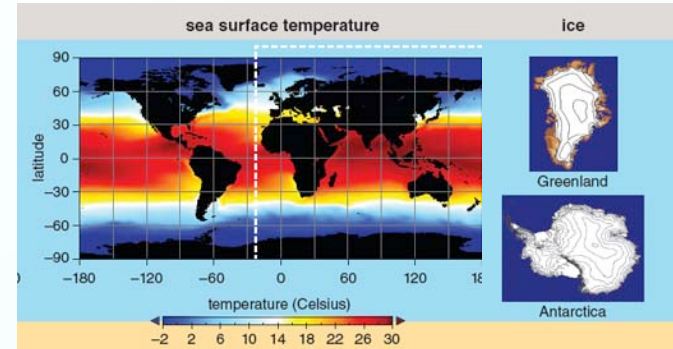
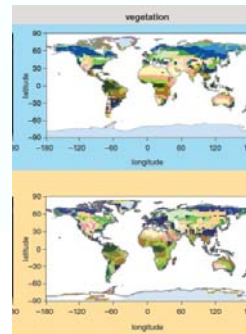
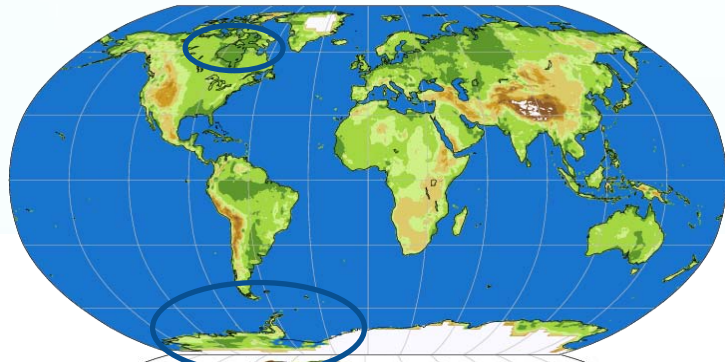
Common boundary conditions



PRISM3D Project
Pliocene Research Interpretation and Synoptic Mapping

Land ice

Land cover



Land mask

Ocean temperature

Ice sheets

Δ Elevation

← brown 0 green →

Experiment 2: 8 IPCC-AR5 class models

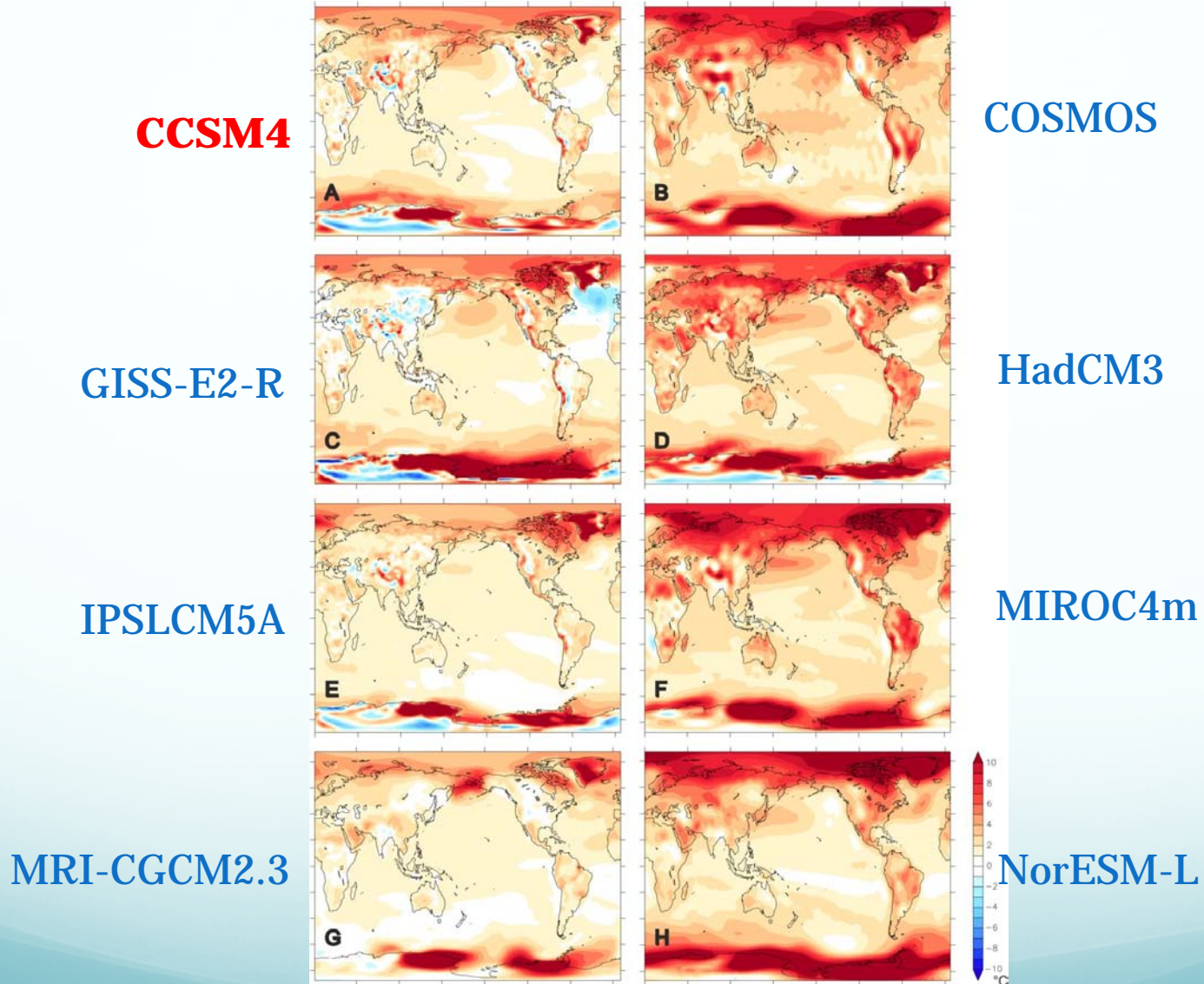
1. **CCSM4**
2. GISS-E2-R
3. IPSLCM5A
4. COSMOS
5. HadCM3
6. MIROC4m
7. NorESM-L
8. MRI-CGCM2.3

Experiment 2: 8 IPCC-AR5 class models

1. **CCSM4**
2. GISS-E2-R
3. IPSLCM5A
4. COSMOS
5. HadCM3
6. MIROC4m
7. NorESM-L
8. MRI-CGCM2.3

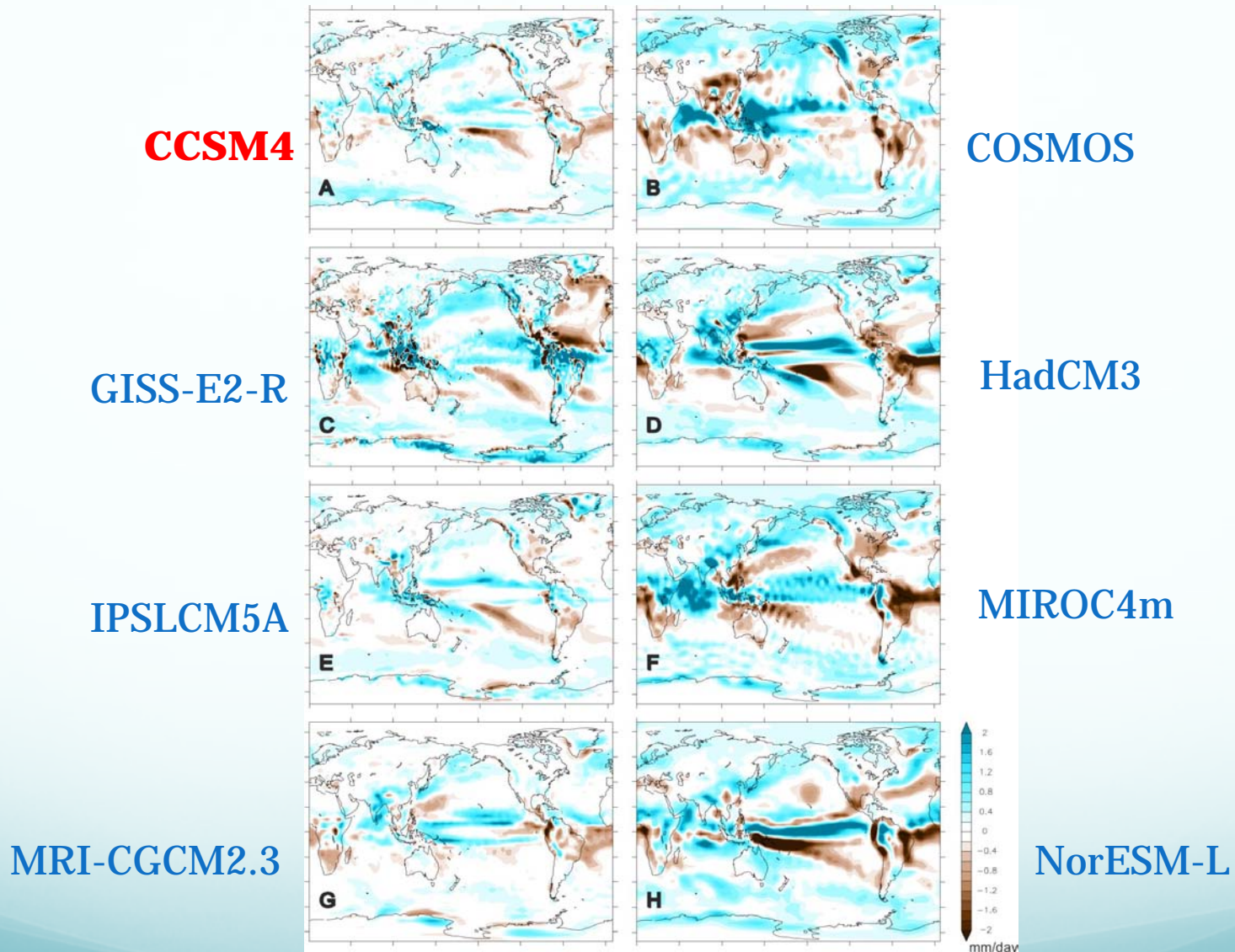
CESM1.0(CAM4) FV 1°	Pliocene	1850 Control
Trace gases	CO ₂ : 405 ppm CH ₄ : 791.6 ppb N ₂ O: 275.68 ppb	CO ₂ : 284.7 ppm CH ₄ : 791.6 ppb N ₂ O: 275.68 ppb
Ozone, sulfates	Pre-industrial	Pre-industrial
Orbital forcing	1990	1990
Topography	CESM1 Modern + PRISM3D_{anomaly}	CESM1 Modern
Vegetation	BIOME4 (→CLM4- PFTs w/ PI carbon)	CLM4 Modern
Ocean initialization	1850 Control + Δ(SST and DOT)	1850 Control
Ice sheets	Greenland : overall ice/topo reduction WAIS: reduced to 25m	CESM1 Modern
Ocean gateways	CESM1 Modern	CESM1 Modern
Simulation length	500y	1300y

Mean annual SAT anomaly



Haywood et al., Clim Past, 2013

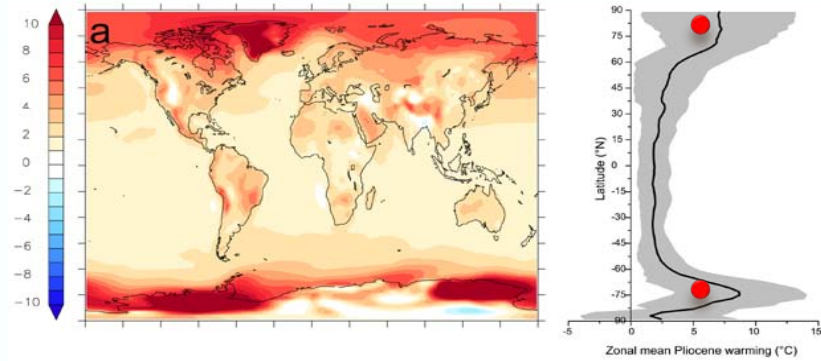
Mean annual precipitation anomaly



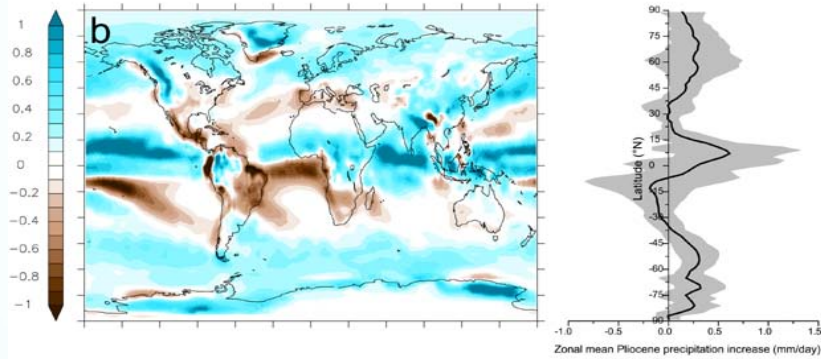
Haywood et al., Clim Past, 2013

Annual multi-model mean

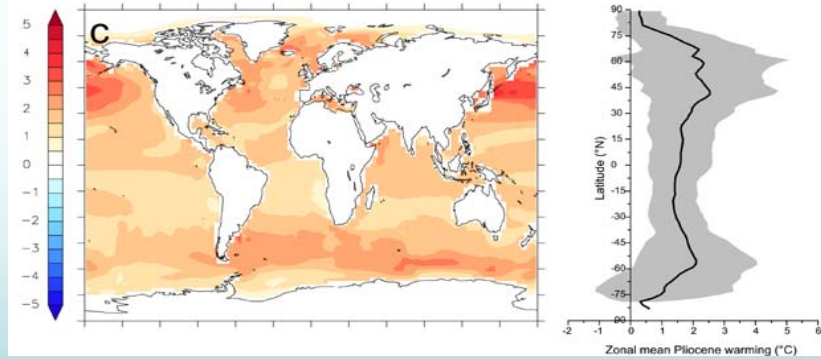
ΔSAT



$\Delta PREC$

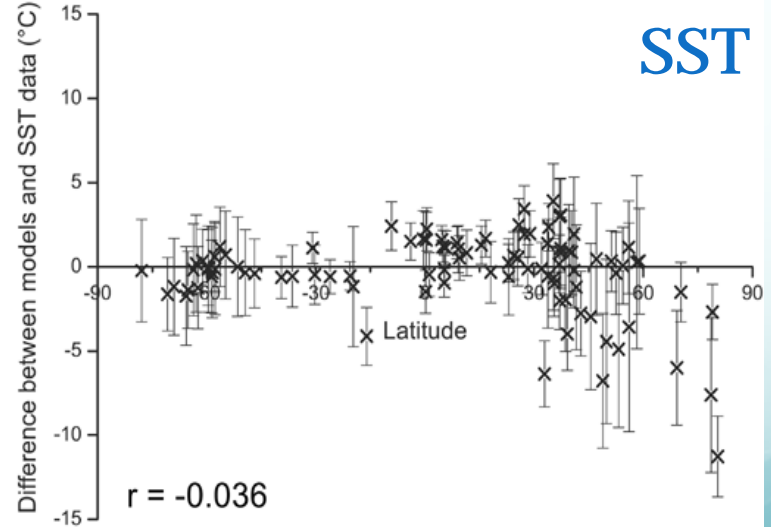
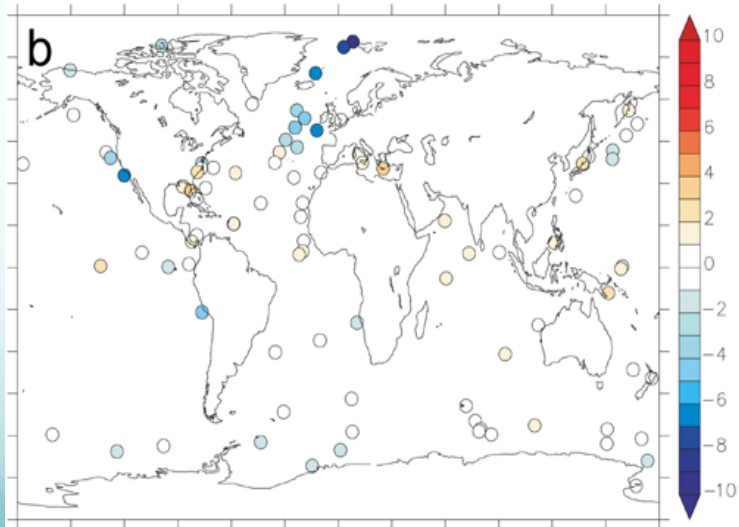
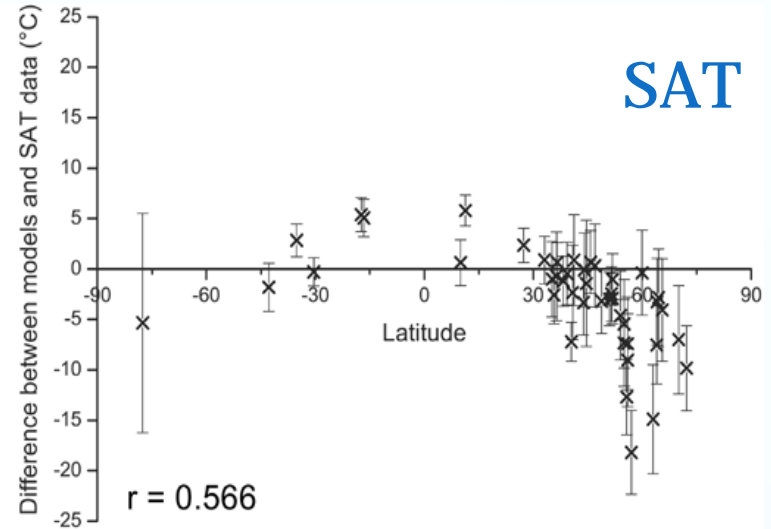
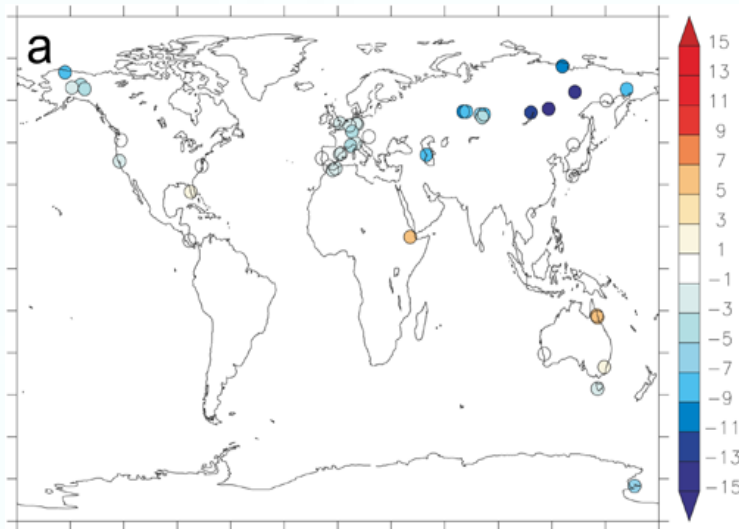


ΔSST



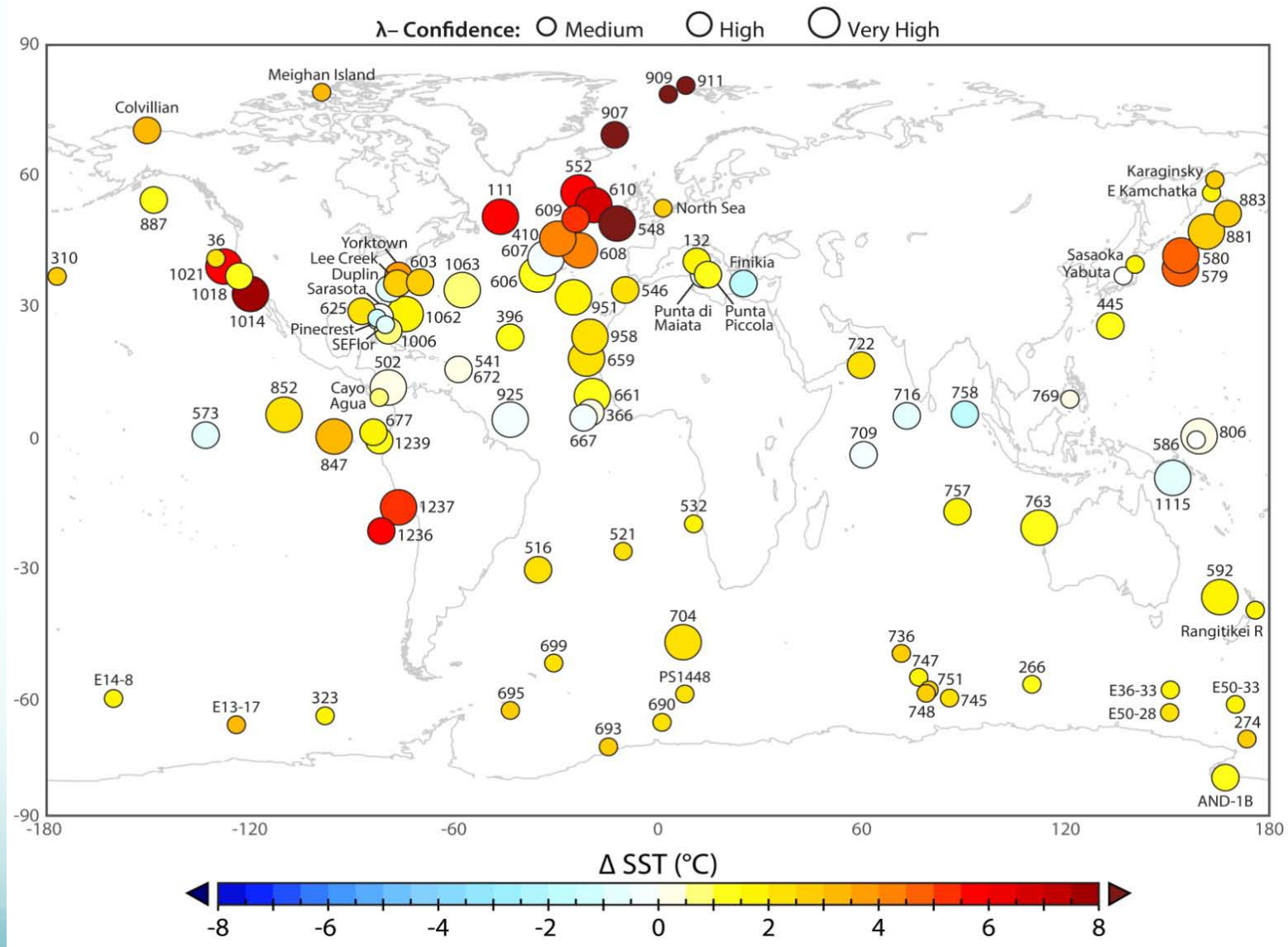
Haywood et al., Clim Past, 2013

Data/model comparison



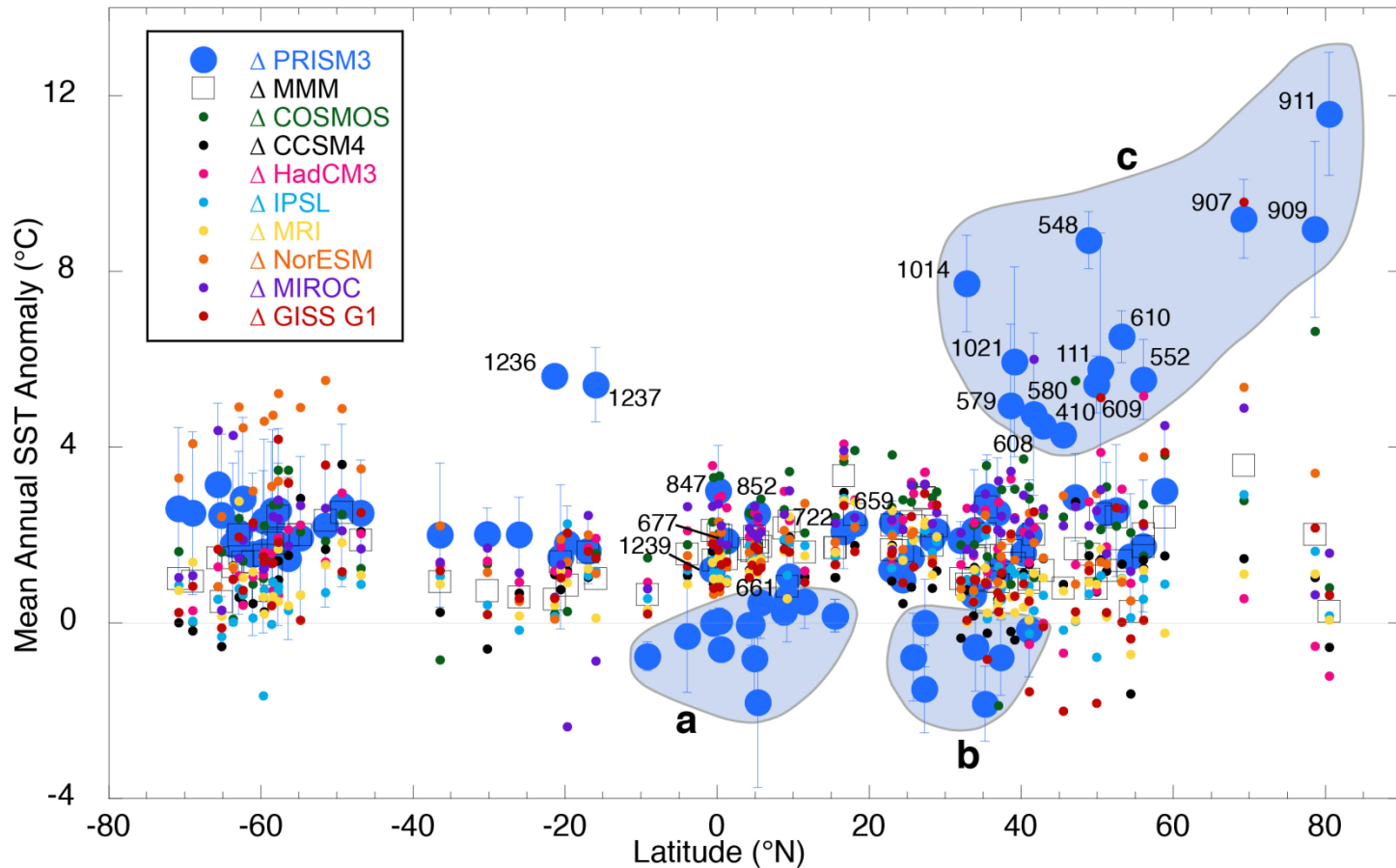
Haywood et al., Clim Past., 2013

Confidence in SST Proxy



Dowsett et al., 2013 Scientific Reports

Temperature anomaly by latitude

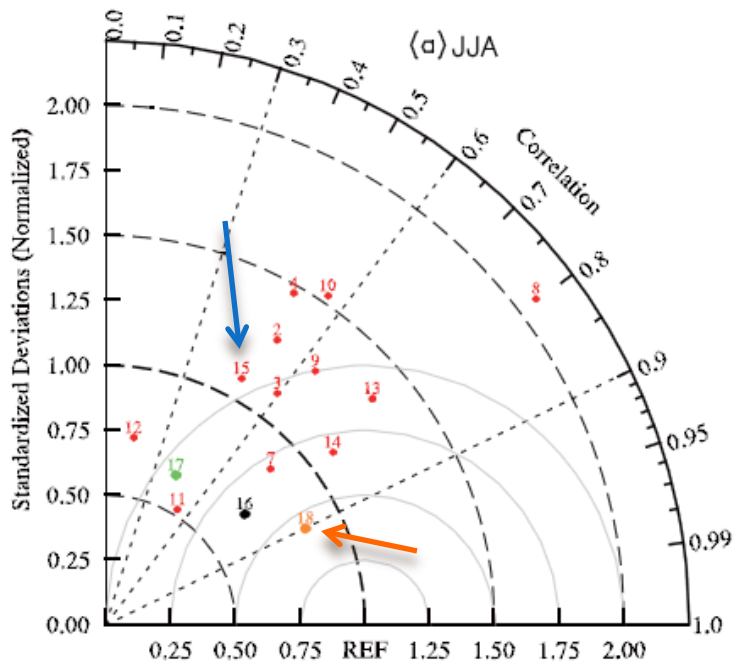


Dowsett et al., Special Reports 2013

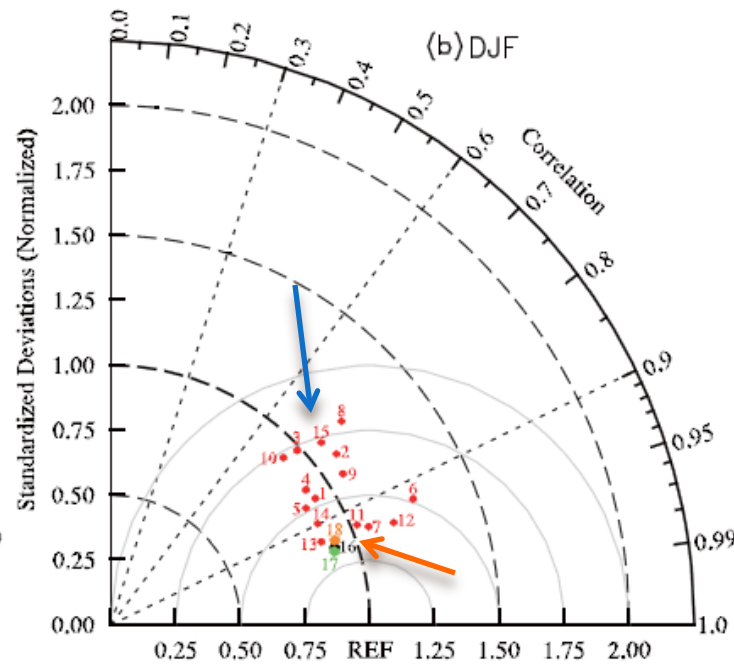
PD East Asian monsoon

(20°-45°N and 105°-135° E)

Summer wind



Winter wind

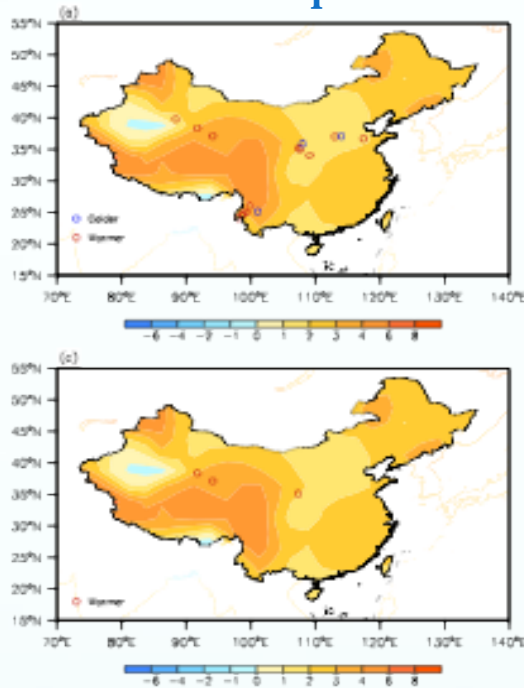


- 1 - CAM 3.1
- 2 - CAM4
- 3 - LMDZ5A
- 4 - MIROC4m-AGCM
- 5 - MRI-CGCM2.3-AGCM
- 6 - ECHAM5
- 7 - HadAM3
- 8 - NorESM-L
- 9 - IPSL-CM5A
- 10 - MIROC4m
- 11 - MRI-CGCM2.3
- 12 - COSMOS
- 13 - HadCM3
- 14 - ModelE2-R
- 15 - CCSM4
- 16 - MMM
- 17 - MMM-AGCMs
- 18 - MMM-AOGCMs

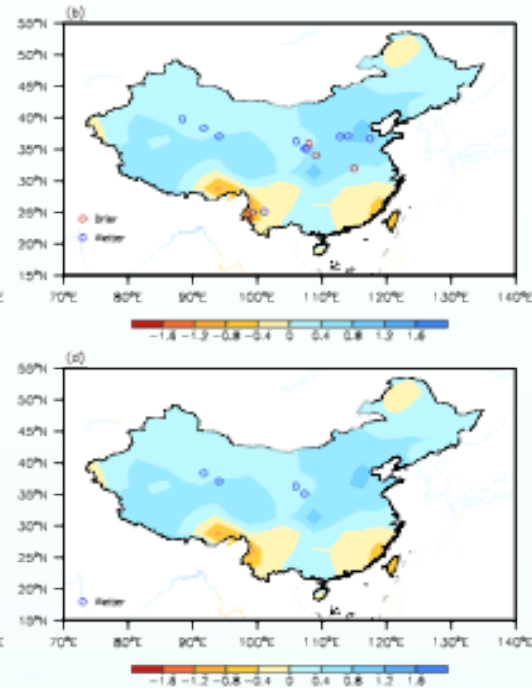
- Models have less skill in predicting EASW
- MMM is best predictor of PD

PlioMIP East Asian Monsoon

MMM Temperature



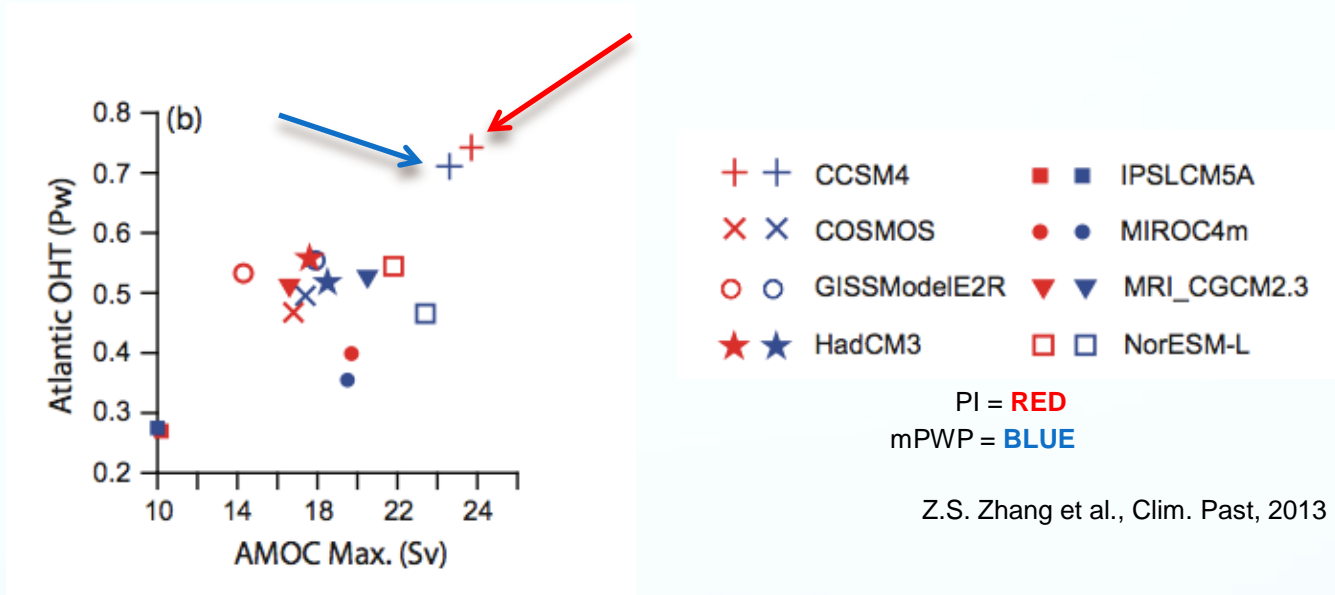
MMM Relative humidity



R. Zhang et al., *Clim. Past* 2013

- Intensified EASW
- Weakened EAWW
- Warmer and wetter mPWP climate across most of China → Agrees with geologic evidence

AMOC and NHT cannot explain differing amounts of warming in the models



Models are still missing a feedback to support low pole to equator temperature gradients and a more equable seasonal climate.

Sea ice ... clouds ... ?

Climate sensitivity

(e.g., Charney 1979)

- Global mean SAT equilibrium response to a sustained doubling of CO₂.
- **Short term** feedbacks: e.g., sea ice (<100 yrs).

Earth system sensitivity

(e.g., Lunt 2010)

- Global mean SAT equilibrium response to a sustained doubling of CO₂, **including long term feedbacks changes to vegetation, land ice.**
- Useful in projecting **longer timescale** responses.

The ratio of ESS*/CS = ~1.5

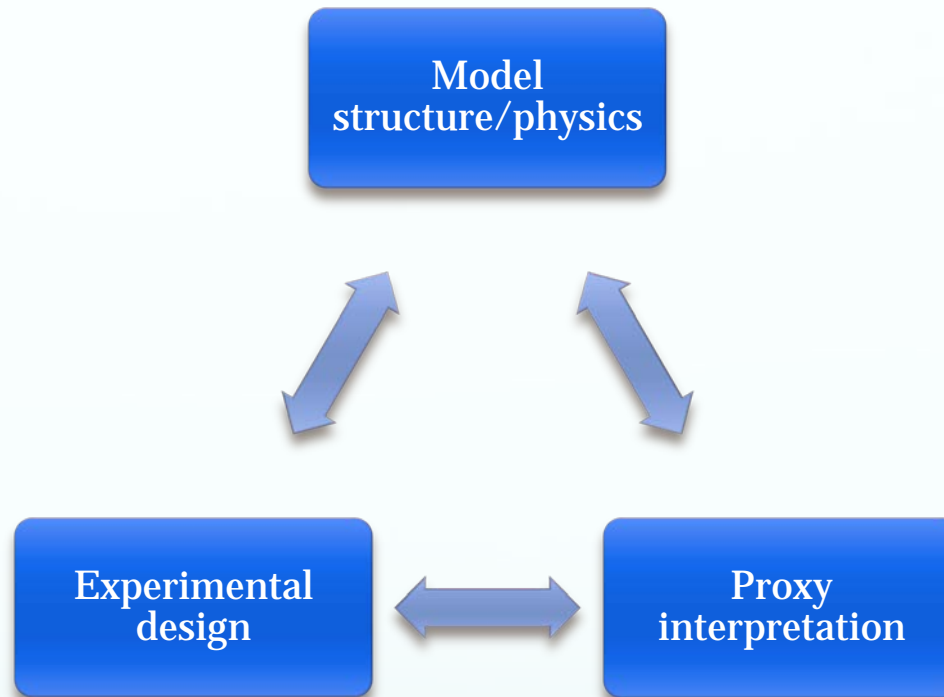
Model	Global SAT change	Reported Climate sensitivity (CS)	ESS/CS ($\Delta T \cdot 1.88$)/CS
CCSM4	1.86	3.2	1.1
COSMOS	3.60	4.1	1.7
GISS-E2-R	2.12	2.7	1.5
HADCM3	3.27	3.1	2.0
IPSLCM5A	2.18	3.4	1.2
MIROC4m	3.46	4.05	1.6
MRI-CGCM-2.3	1.84	3.2	1.1
NorESM-L	3.27	3.1	2.0
MMM	2.66	3.36	1.5

*As in Lunt et al., 2010

Haywood et al., Clim. Past, 2013

Future PlioMIP

Exploring uncertainty in proxy/model comparison



- ★ Time slab → time slice with near modern orbital
- ★ Fully coupled CESM(CAM5) simulation with 'preferred' boundary conditions (WAIS)



Thank you