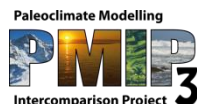


Simulating the mid-Pliocene warm period with CCSM4/CESM1*

Nan Rosenbloom
Bette Otto-Bliesner
Esther Brady
Aixue Hu
Peter Lawrence

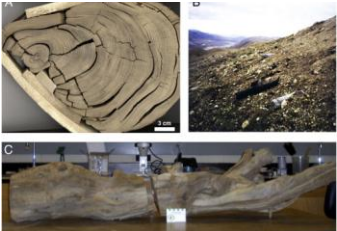
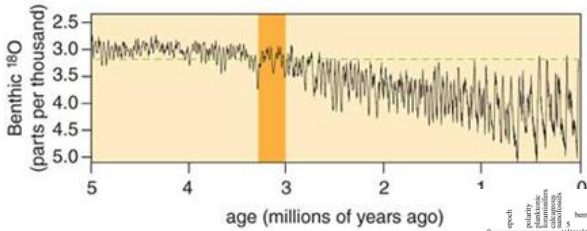
* CCSM4 → CESM1 → CESM1(CAM4)



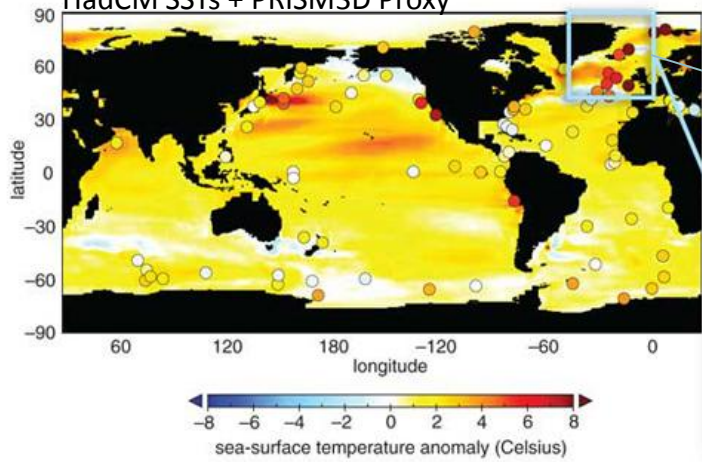
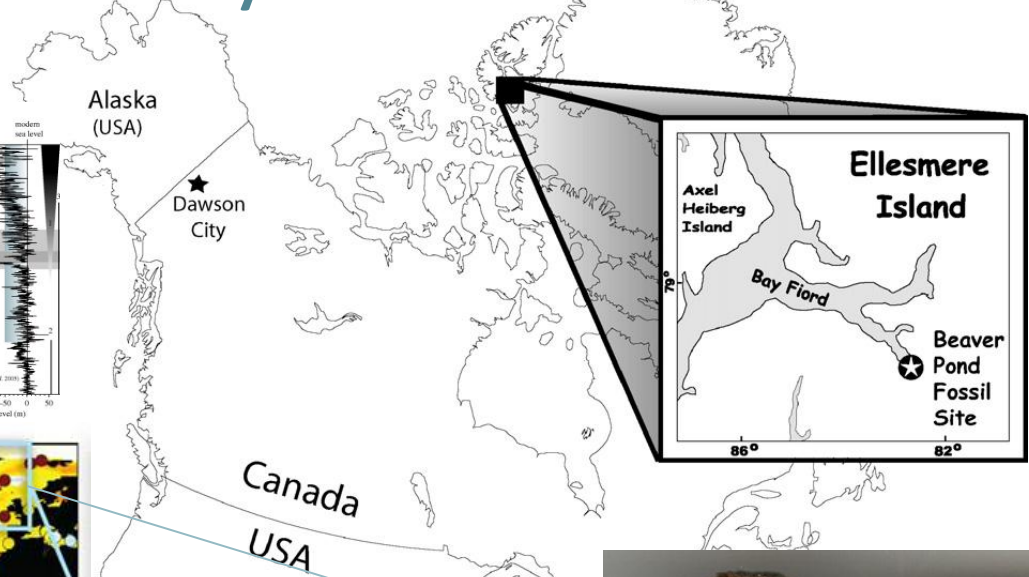
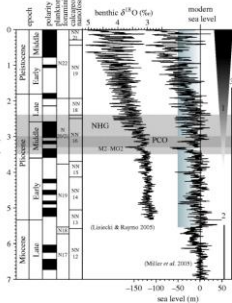
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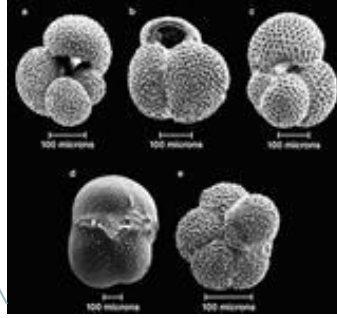
Why model the Pliocene?



Csank et al. J. Paleoclimatol.



Robinson, 2011



Robinson 2011



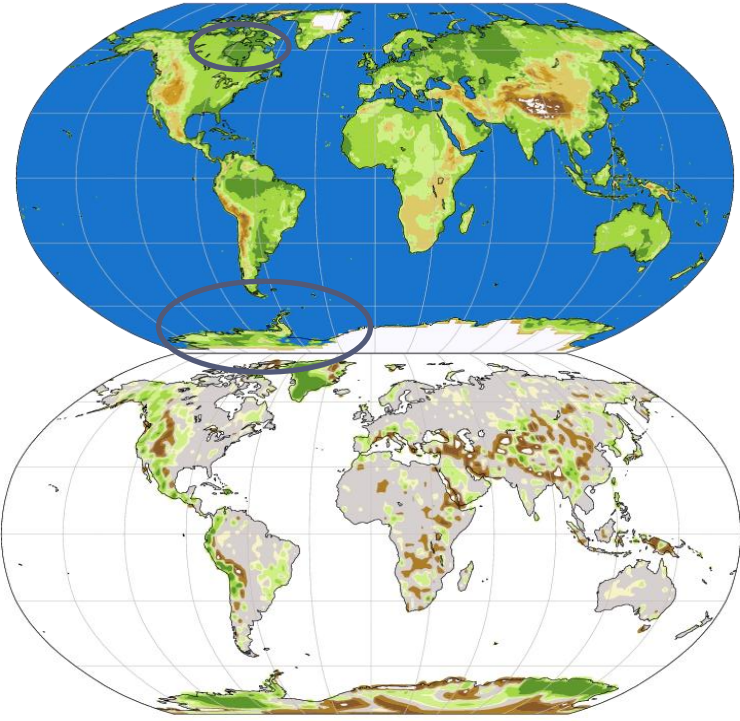
Ballantyne et al. 2006

PlioMIP--PRISM3D

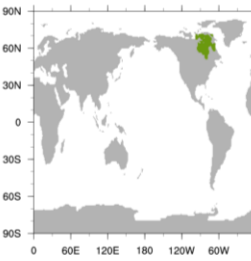
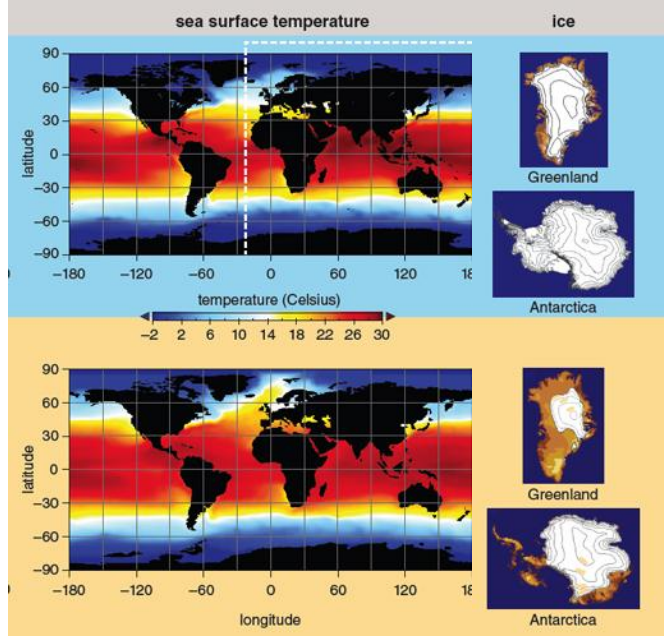
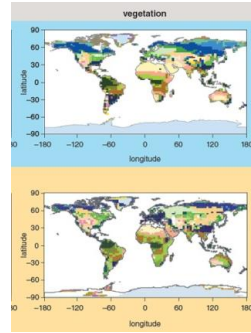


PRISM3D Project
Pliocene Research Interpretation and Synoptic Mapping

Land ice



Land cover



Land mask

Ocean temperature

Ice sheets

Δ Elevation



brown

0

green

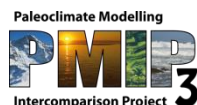


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Mid-Pliocene Warm Period 3.2-2.9Ma

1° FV CESM1	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	CLM4 Modern
Ocean initialization	1850 Control + Δ(SST and DOT)	1850 Control
Ice sheets	Greenland Ice: overall reduction WAIS: reduced to 25m	CESM1 Modern
Ocean gateways	CESM1 Modern	CESM1 Modern
Simulation length	550y	1300y



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Mid-Pliocene Warm Period 3.2-2.9Ma

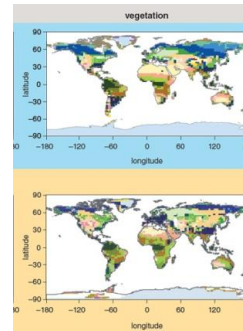


BIOME4 Modern

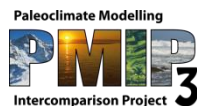
CLM-PFT Modern

BIOME4 Pliocene

???



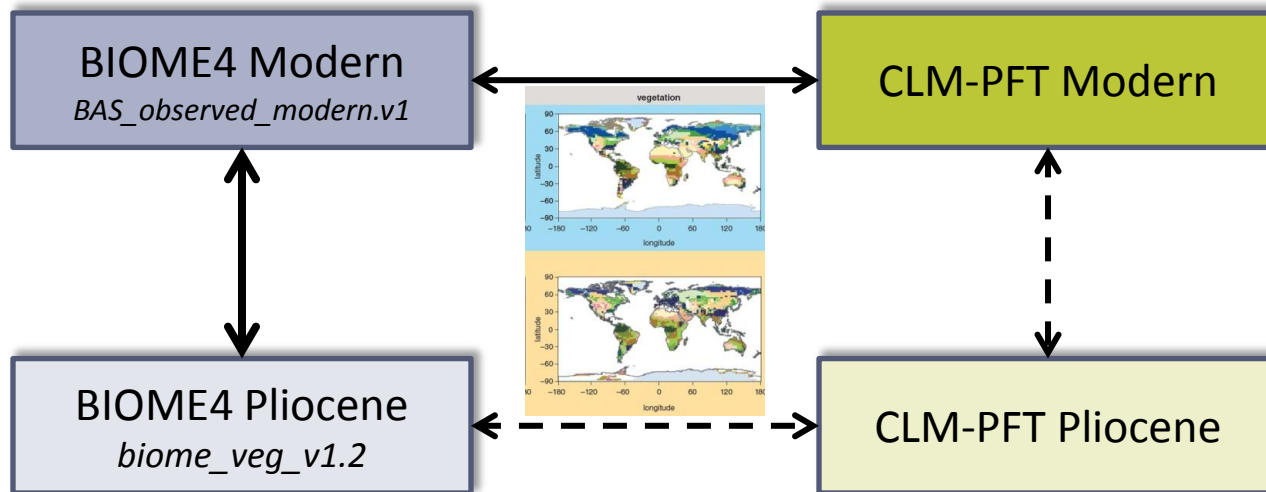
Pliocene Landcover



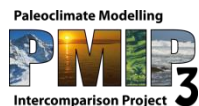
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Mid-Pliocene Warm Period 3.2-2.9Ma



Pliocene Landcover

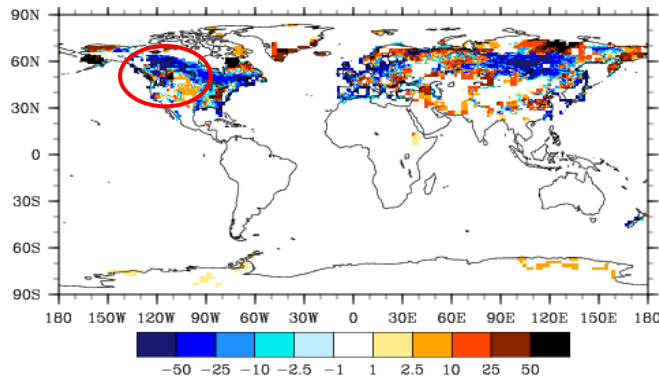


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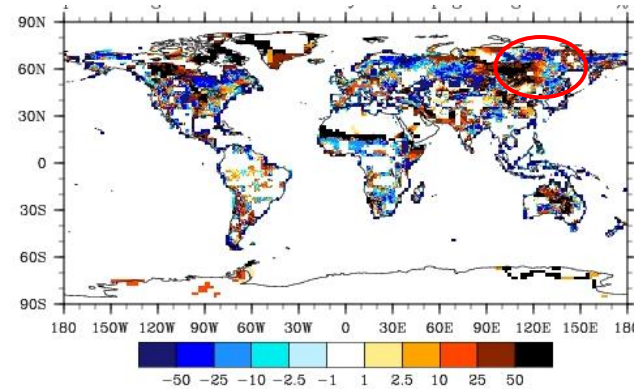


Northern migration of grasslands affects surface albedo

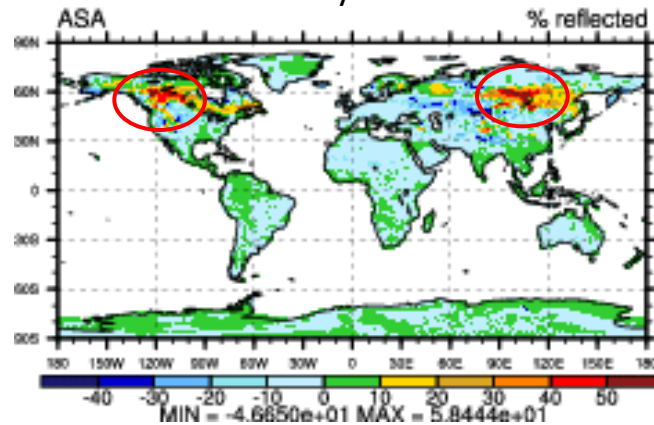
Needleleaf evergreen forest



grass

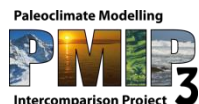


All sky albedo



Model Response after 550y

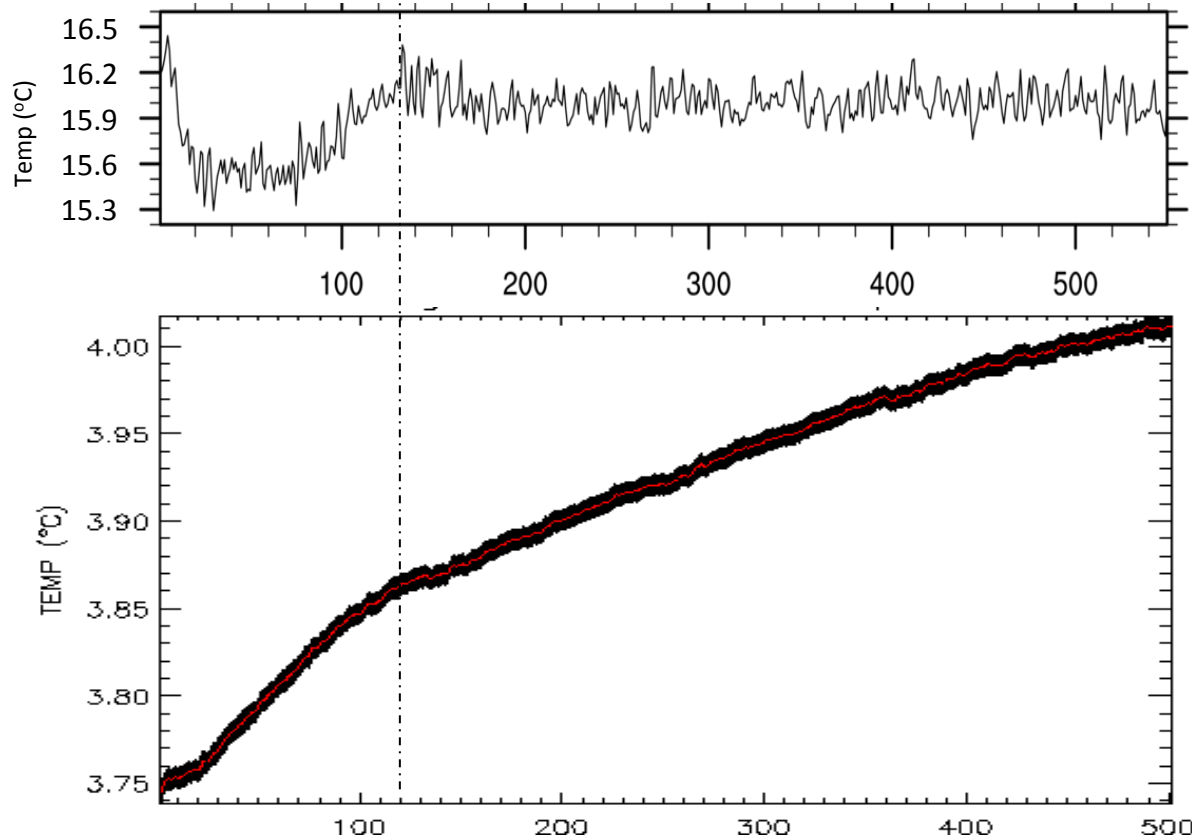
Model energy balance	Pliocene
TOA energy imbalance [W/m ²]	0.111
Change from 1850 control	Pliocene
Δ Mean annual temperature [°C]	1.83
Δ Precip Rate [mm/d]	0.08
Trend per 100y	Pliocene
Global mean air temperature [°C]	-0.025
Ocean integrated temperature [°C]	0.026



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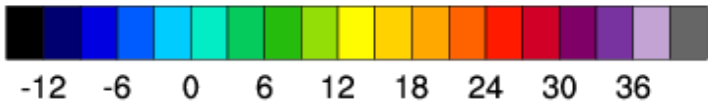
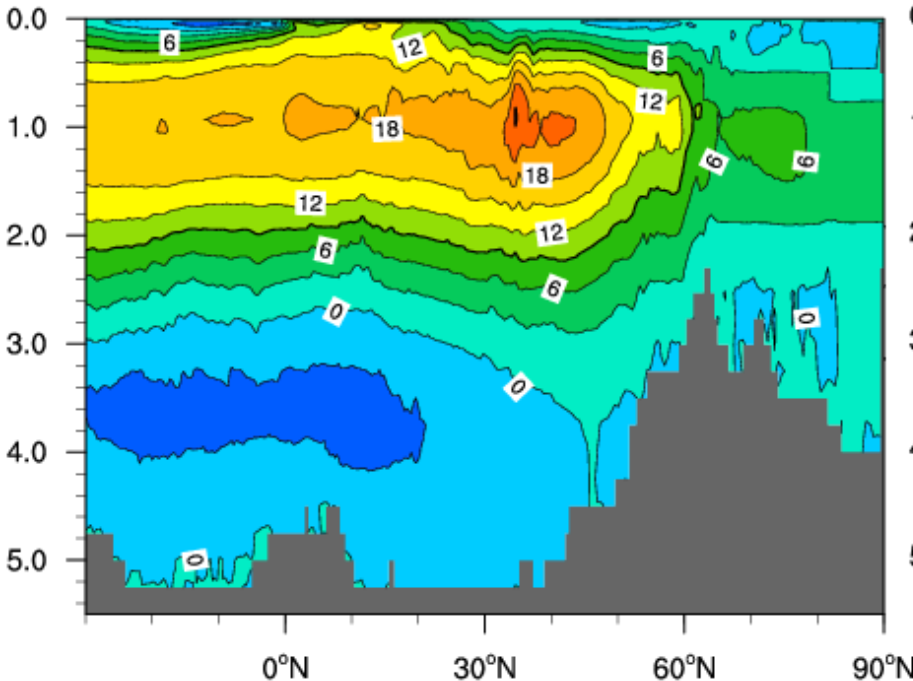


Global Mean Surface Temperature (°C)

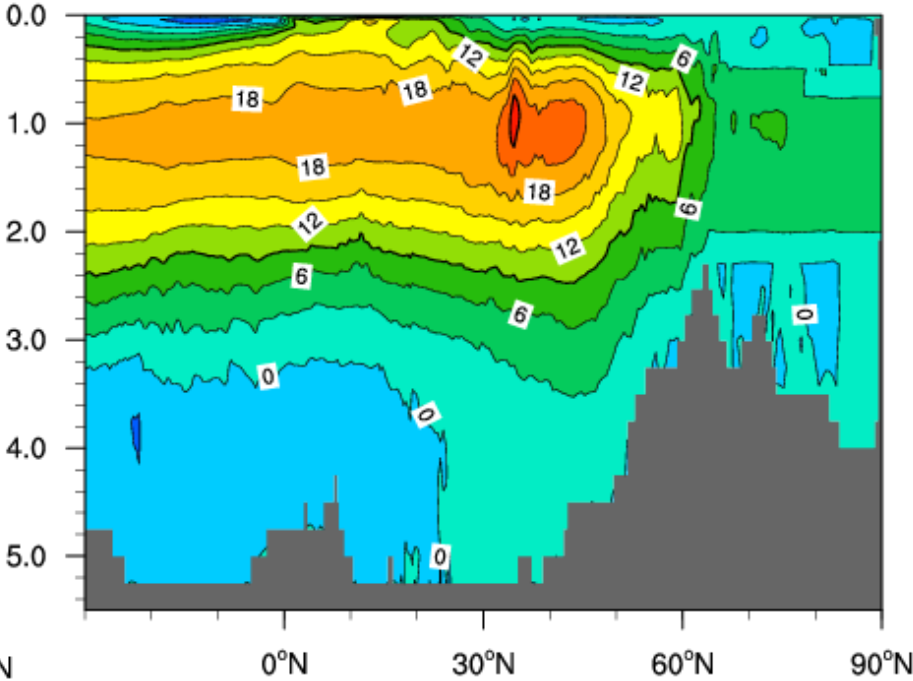


Global Ocean Temperature (volume integrated)

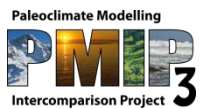
Atlantic Overturning Stream Function



Pliocene



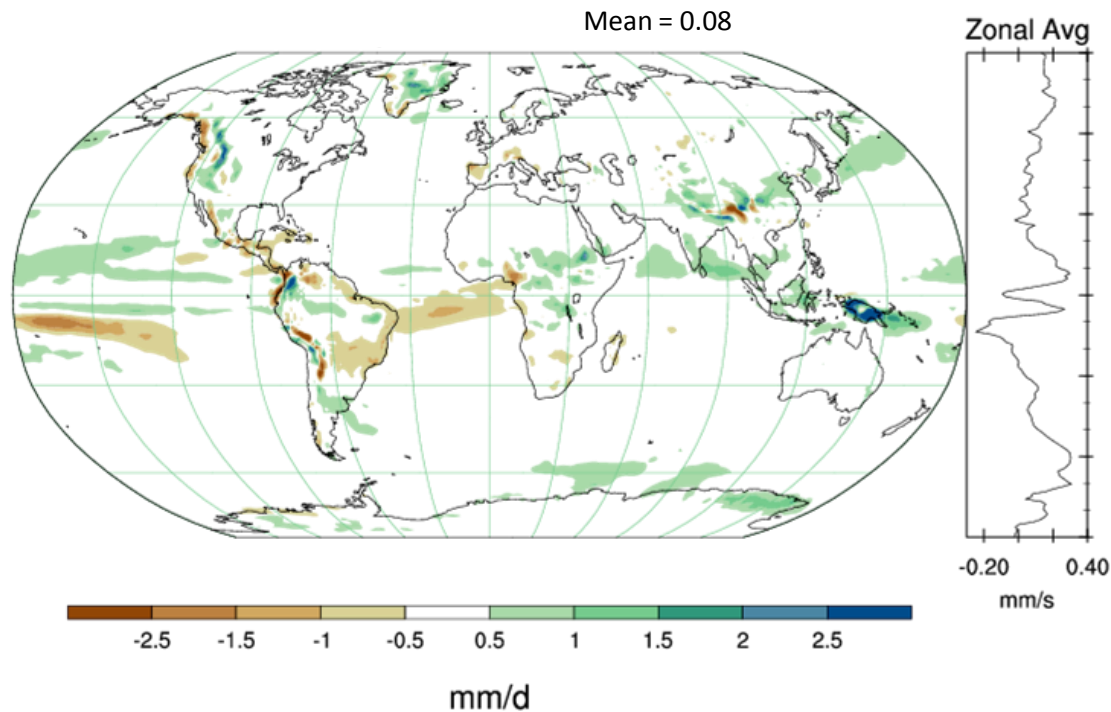
Control



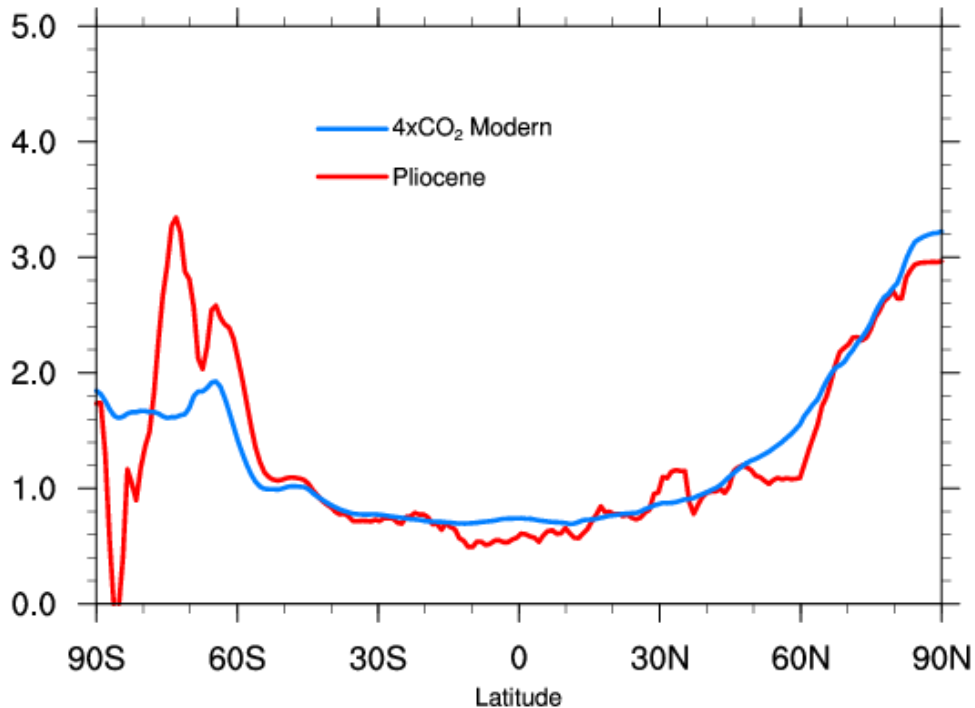
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Precipitation rate: Pliocene - 1850

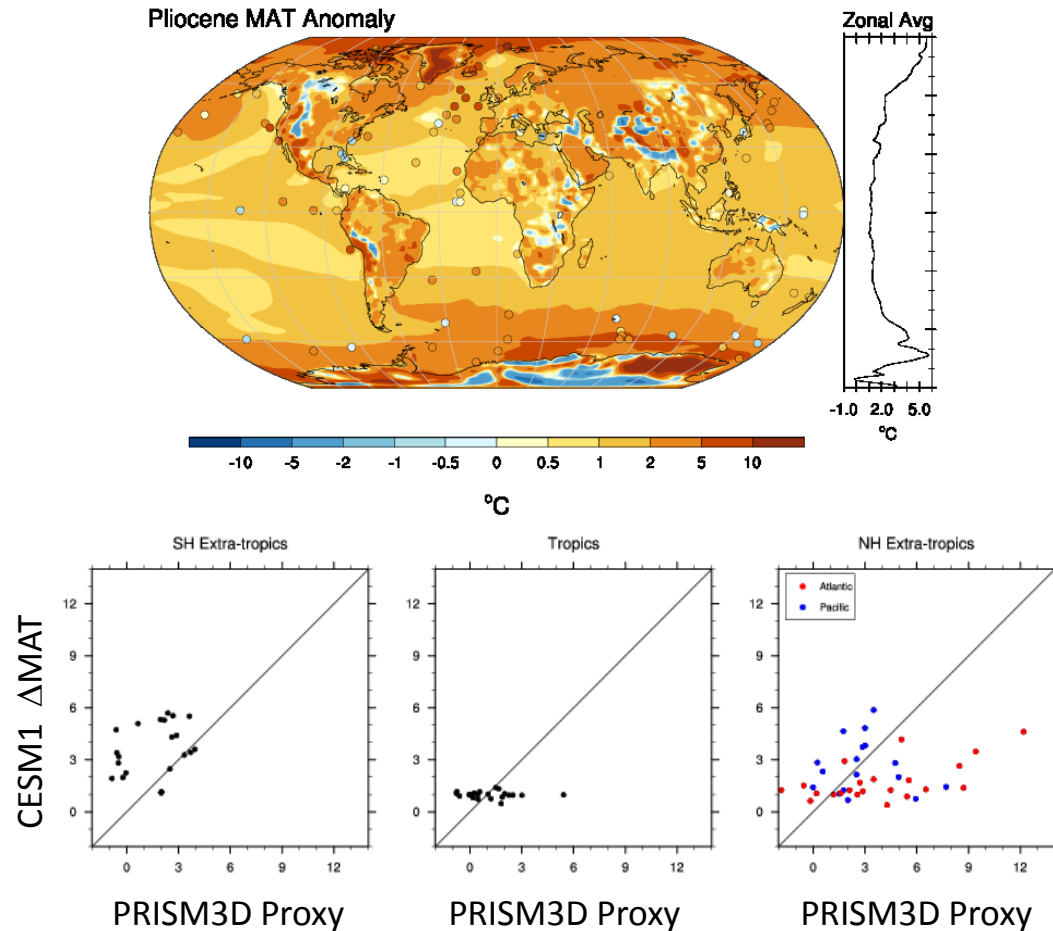


CESM1 Polar Amplification in a warm world



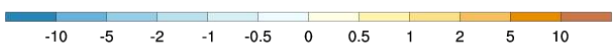
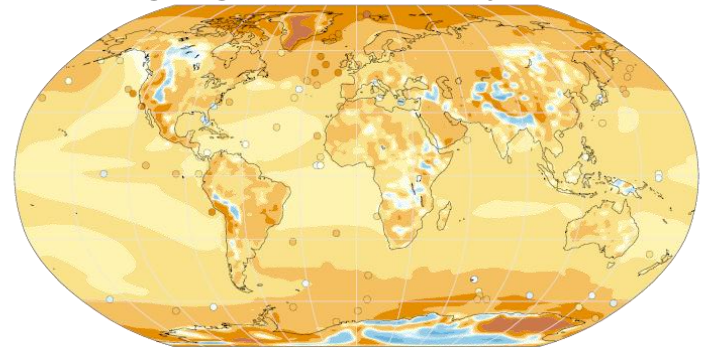
Zonally averaged MAT anomaly (WRT PI) normalized by the global MAT anomaly. The SH Pliocene response is strongly influenced by elevations changes to the EAIS (~85°S) and by removal of the WAIS (75°S)

Not enough warming in the North Atlantic



Closing the Bering Strait

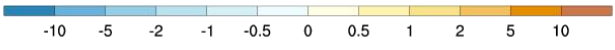
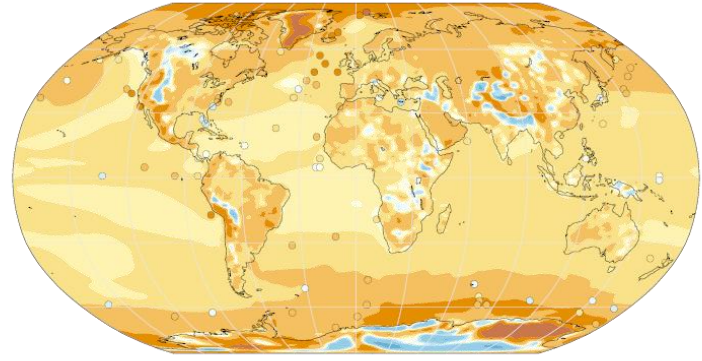
Closed Bering Straight Pliocene MAT Anomaly



°C

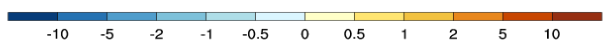
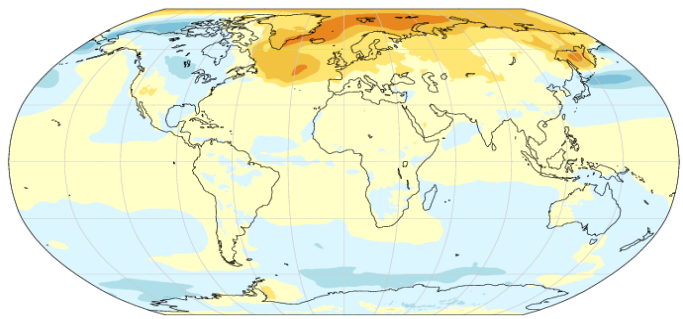
PlioceneBSC

Pliocene MAT Anomaly



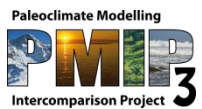
°C

Pliocene



°C

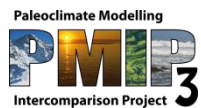
PlioceneBSC - Pliocene



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Thank you



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