

# Paleoclimate modeling of Eocene and Miocene using different boundary conditions and resolutions in CESM1.0

Aaron Goldner, Matthew Huber, Nicholas Herold

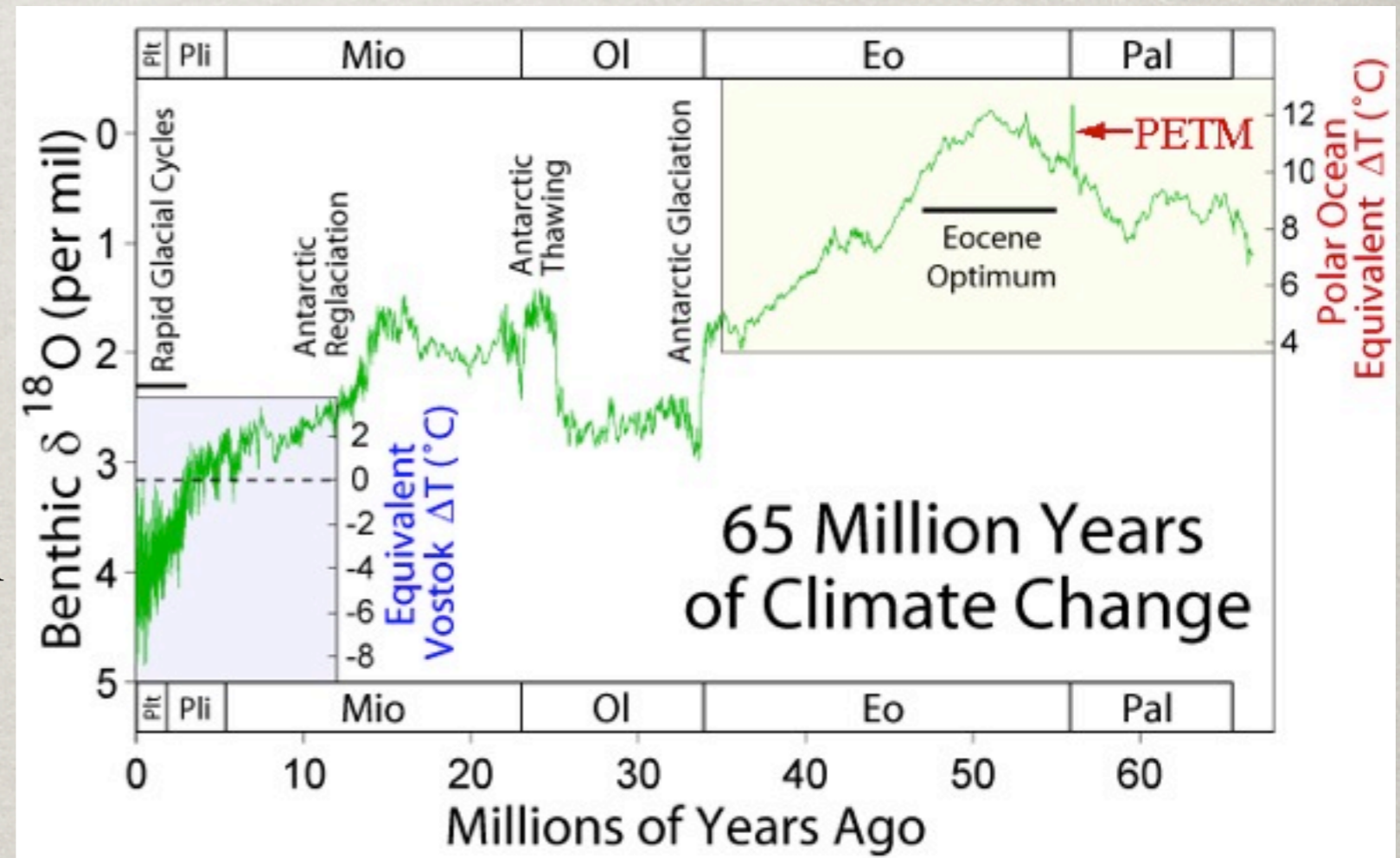
Purdue University, West Lafayette Indiana  
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This work is supported by NSF P2C2 grants ATM- 0902882 and ATM-0902780, and a GAANN Fellowship which supports the graduate student

# Motivation

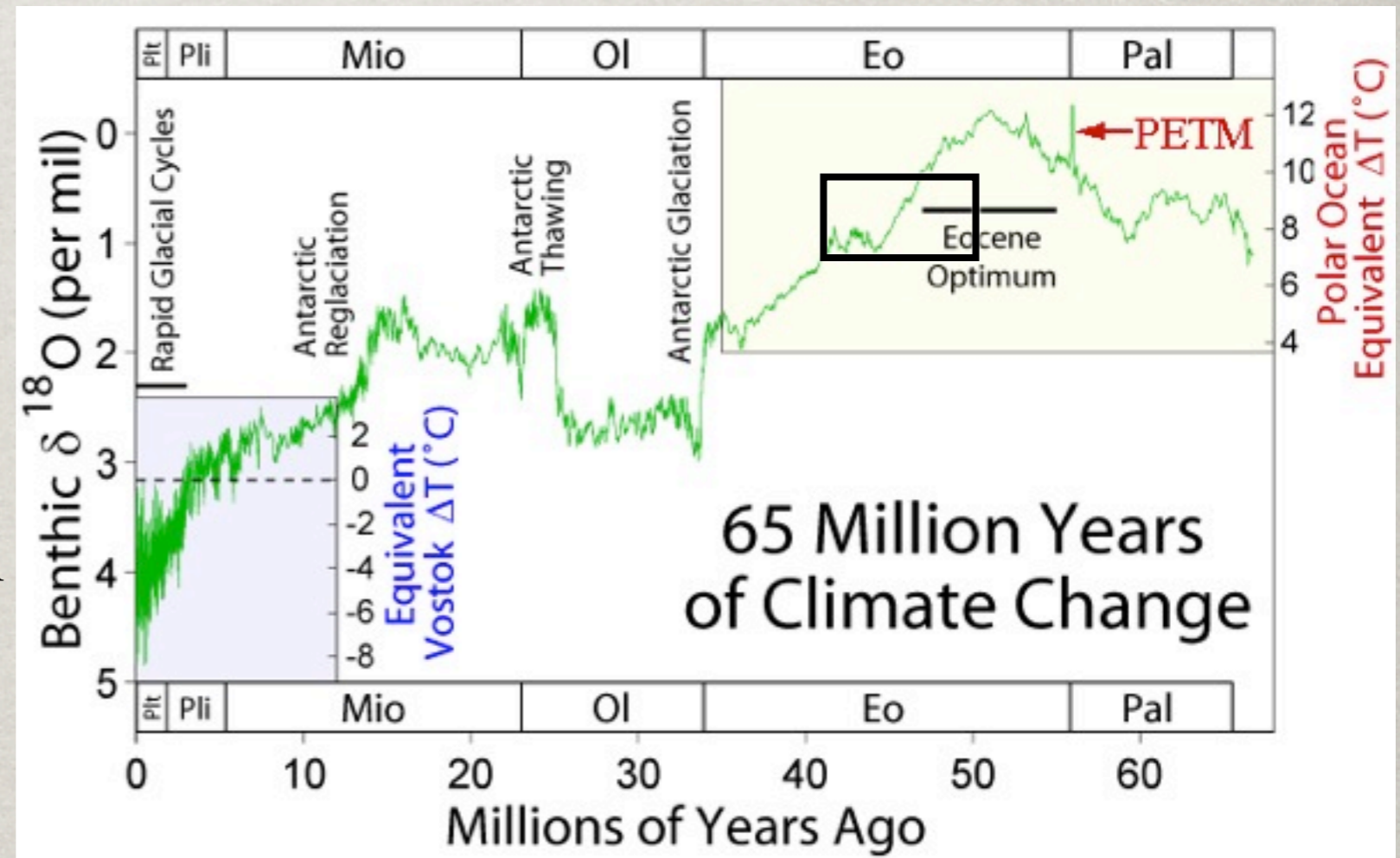
- Quantifying the temperature sensitivity between the CO<sub>2</sub> and non-CO<sub>2</sub> forcings important for Cenozoic climate intervals like the middle Eocene (~45 mya), Eocene/Oligocene Transition (~35 mya), and middle Miocene (~15 mya).



Zachos et al., 2001

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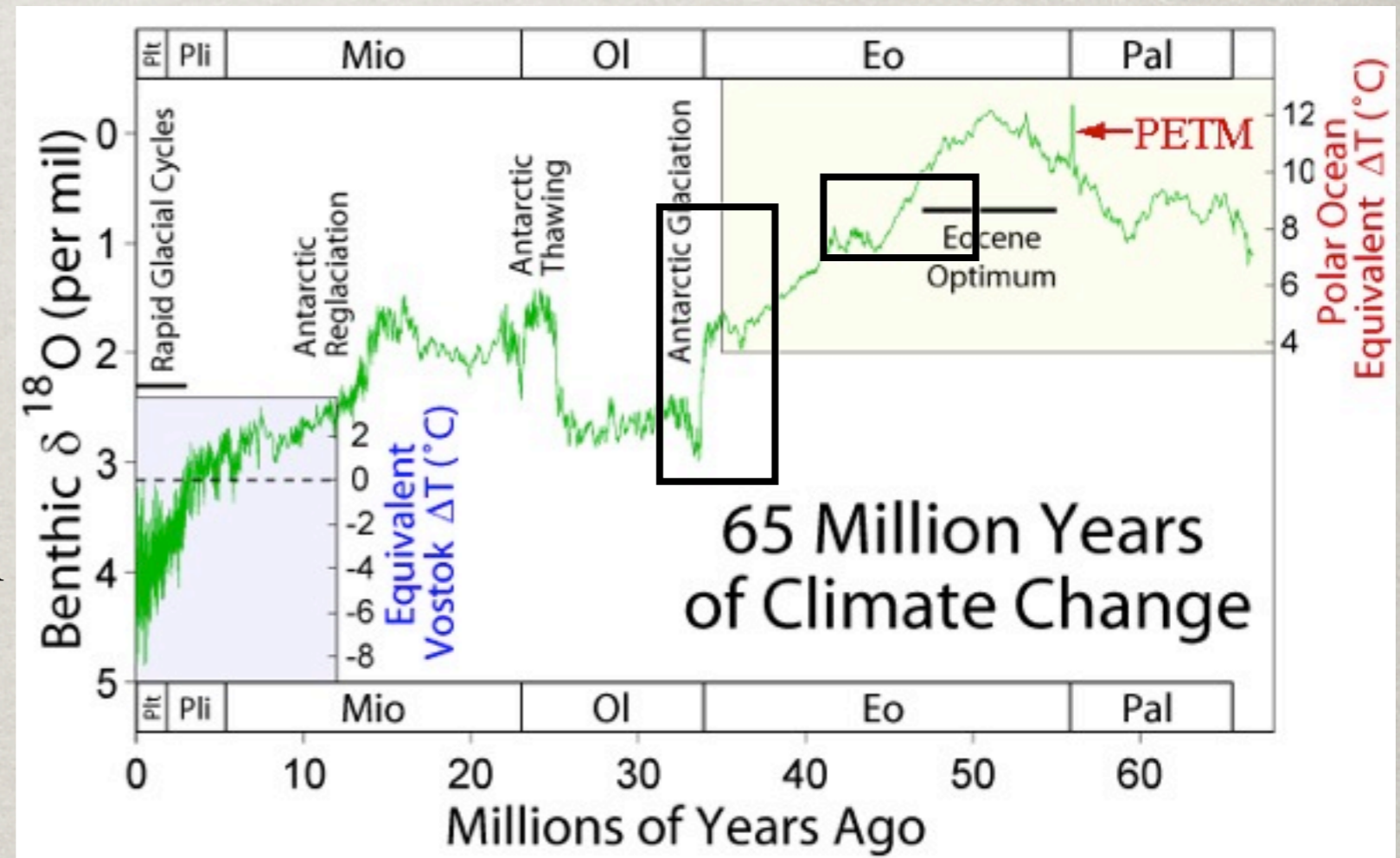
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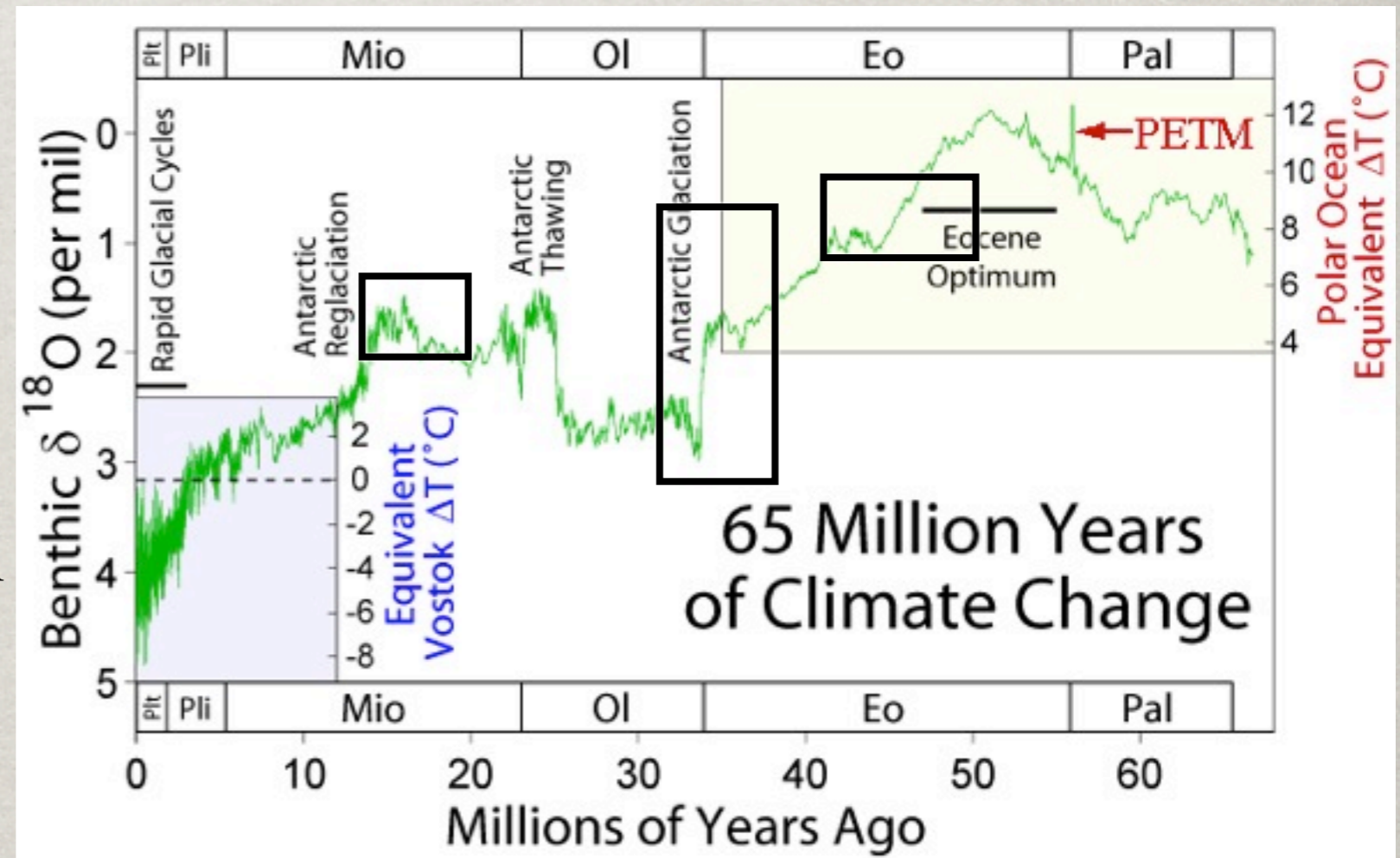
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Zachos et al., 2001

# NCAR CESM1.0.3

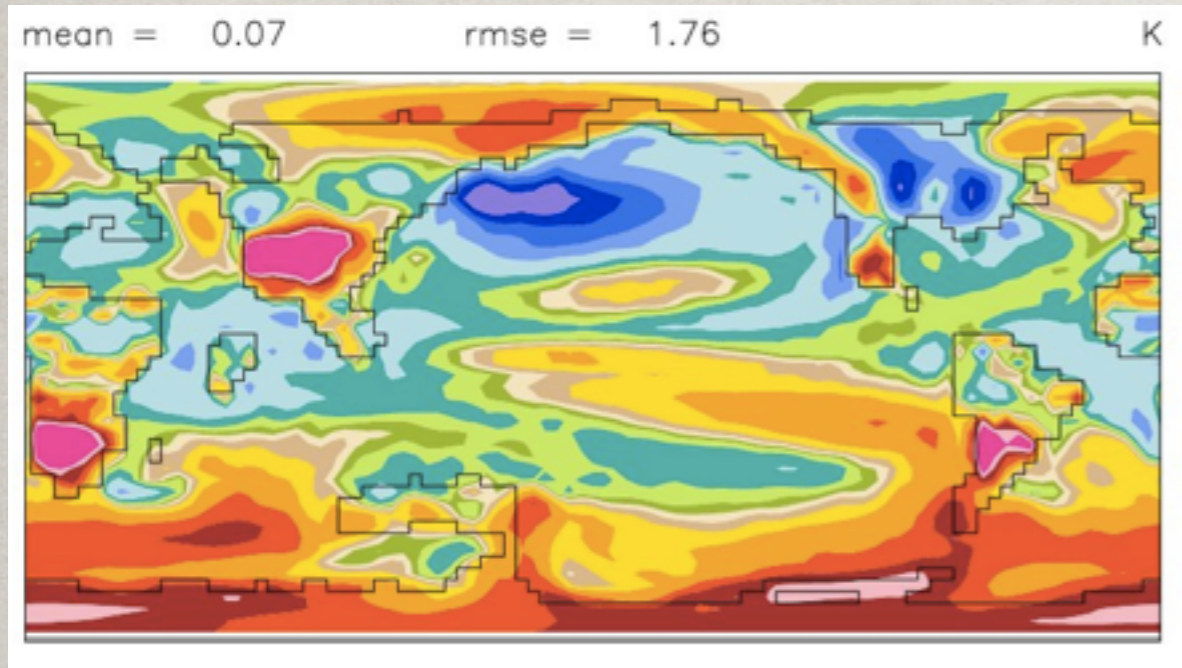
- We use the newest model released from the National Center for Atmospheric Research (NCAR), the Community Earth System Model (CESM1.0.3) (<http://www.cesm.ucar.edu/models/cesm1.0/>).
- We conduct a series of fully coupled and slab ocean simulations for the Eocene at varying resolutions.
- We conduct a series of slab simulations for the Miocene at 1.9x2.5 degree resolution.

# Completed Eocene Modeling Simulations

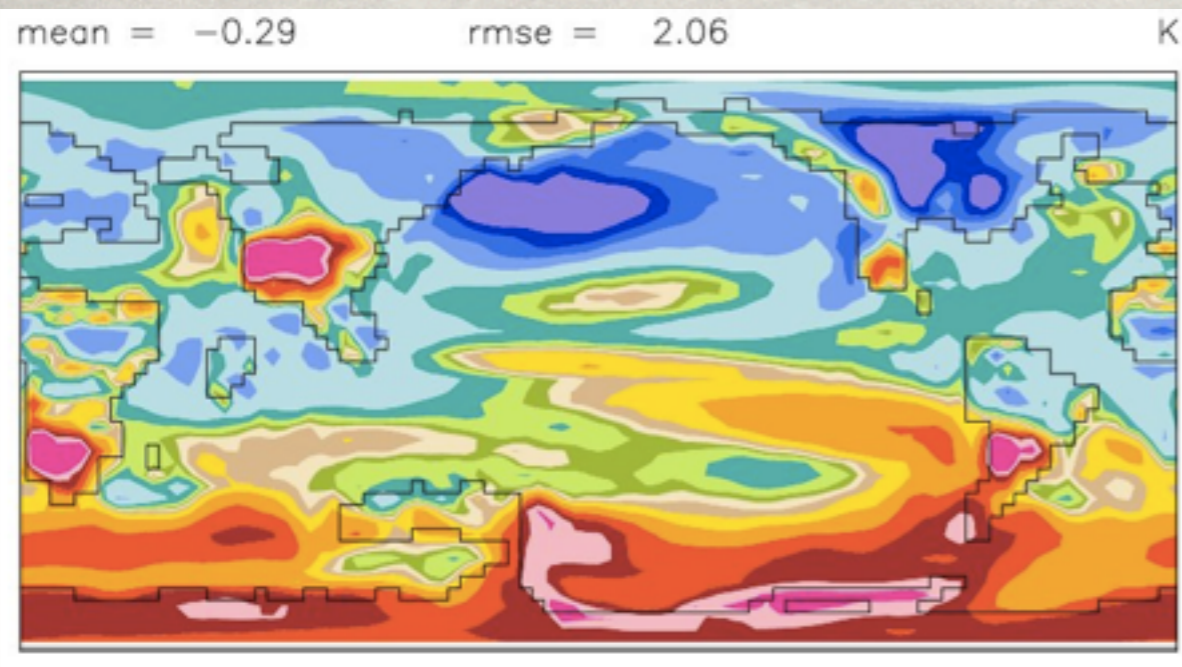
Compset	Resolution	CO2	Equilibrated?	Boundary Change
B (CAM4)	T31	560,1120,2240	>1700 years	Antarctic ice sheet
E (CAM4)	T31	560,1120,2240,4480	yes	Antarctic ice sheet
E (CAM4)	T85	1120	yes	Antarctic ice sheet
E (CAM4)	1.9x.25	560,1120,2240	yes	Antarctic ice sheet, aerosols, methane

# Eocene Coupled Model Comparison: CO<sub>2</sub>

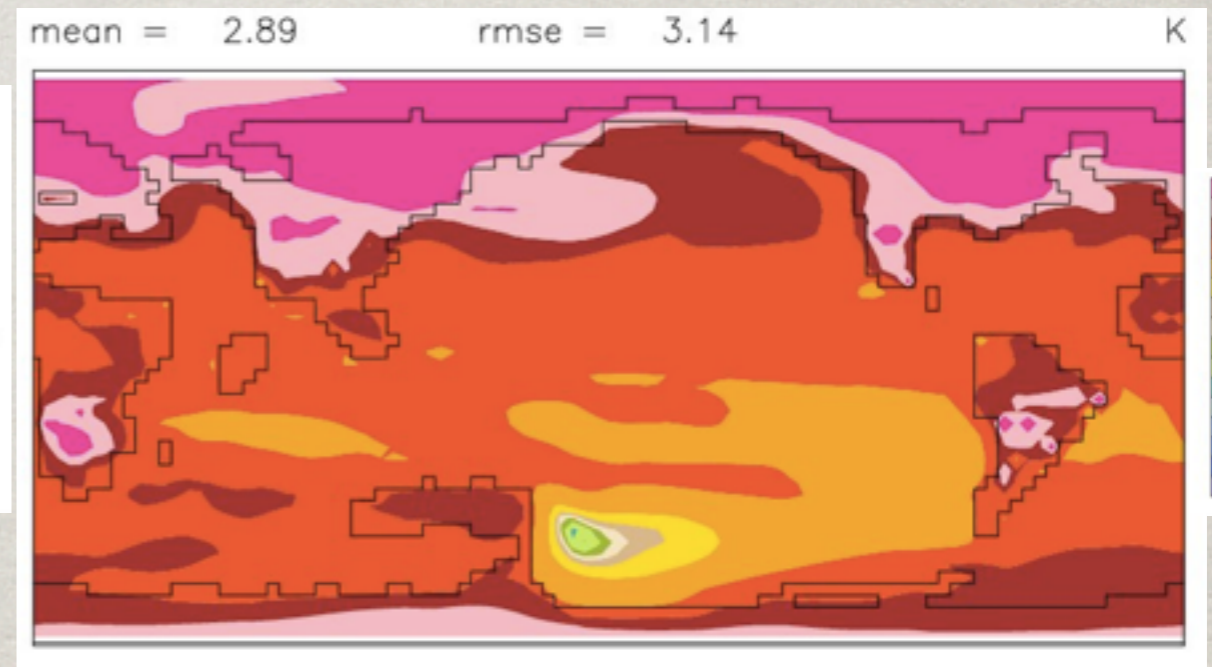
CESM1.0.3 versus CCSM3  
2240 ppm CO<sub>2</sub>



1120 ppm CO<sub>2</sub>



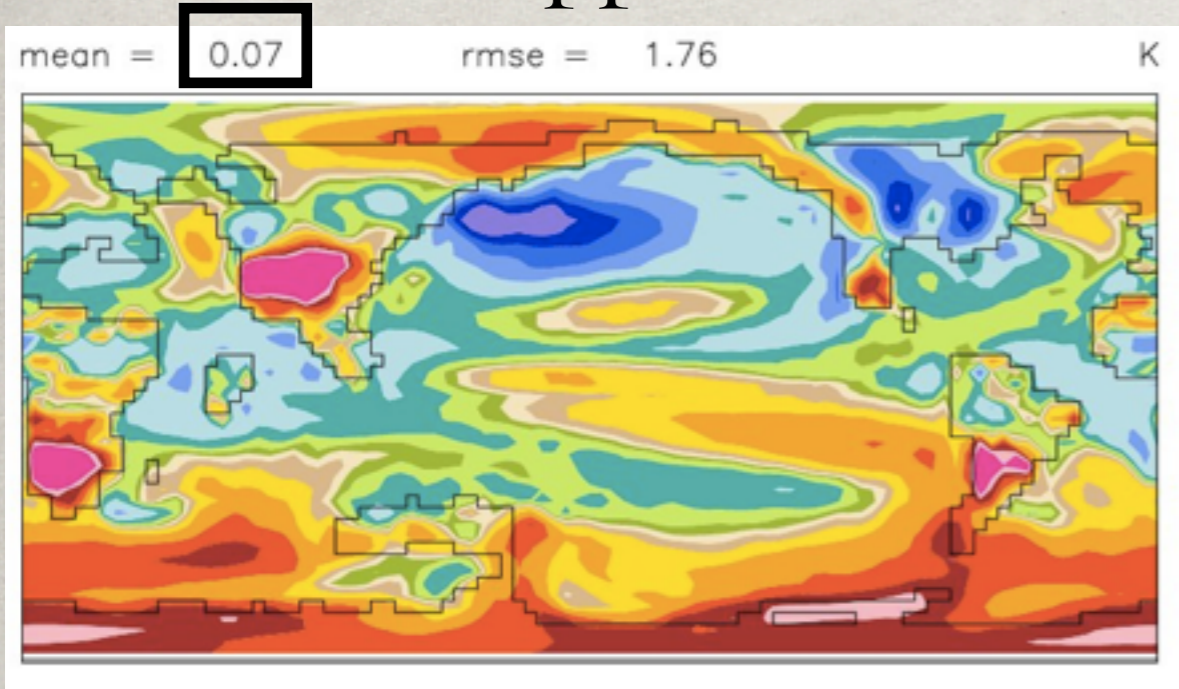
CESM1.0.3 Sensitivity  
2240 ppm - 1120 ppm CO<sub>2</sub>



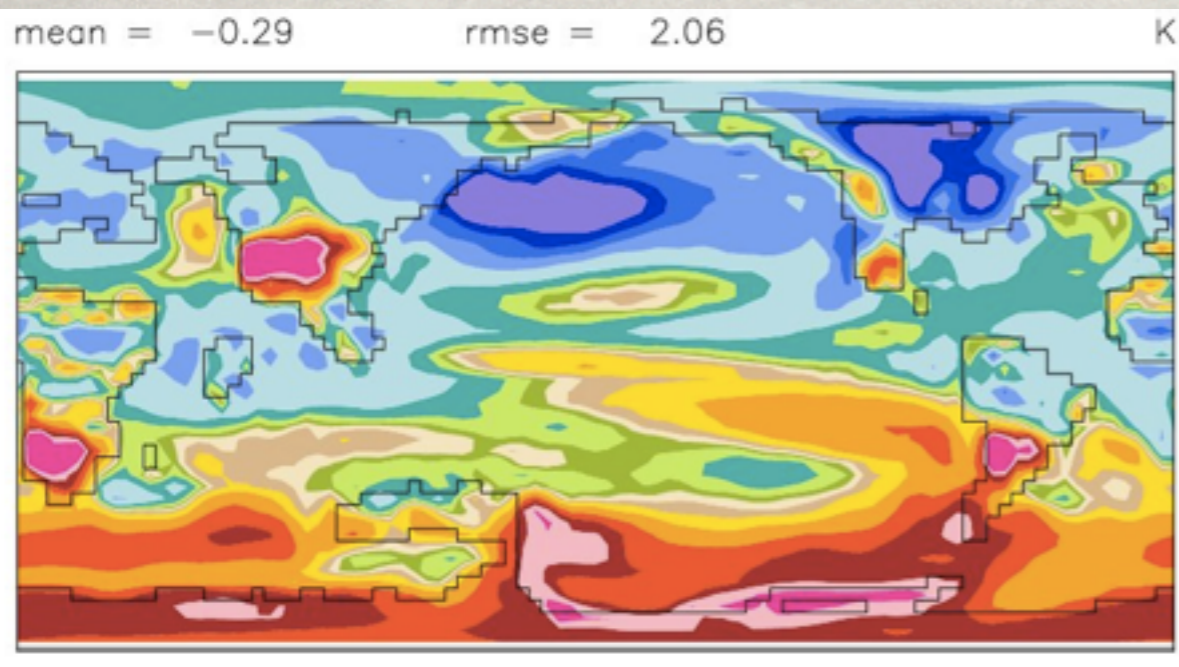


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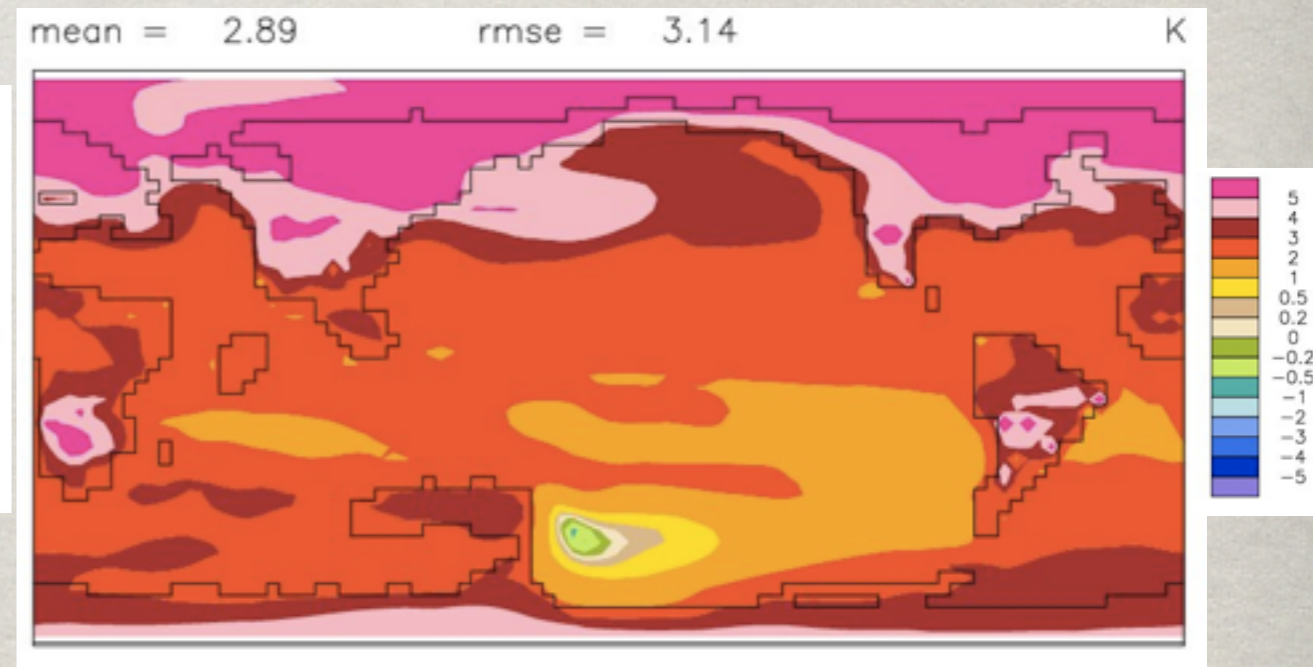
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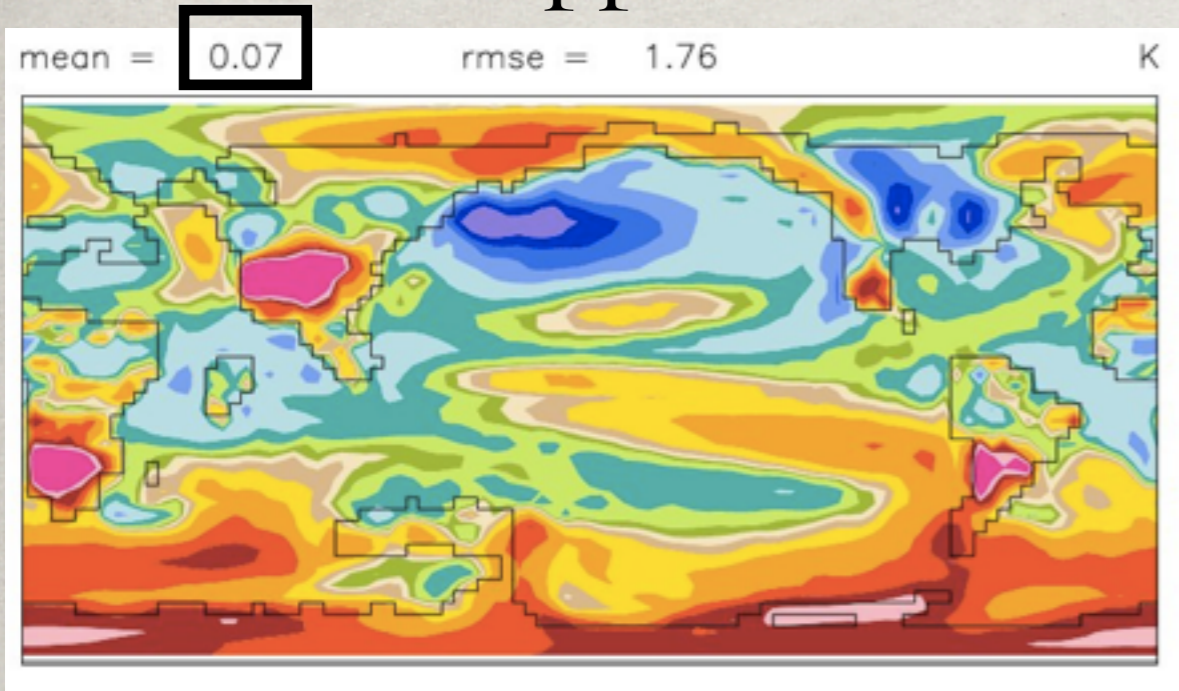


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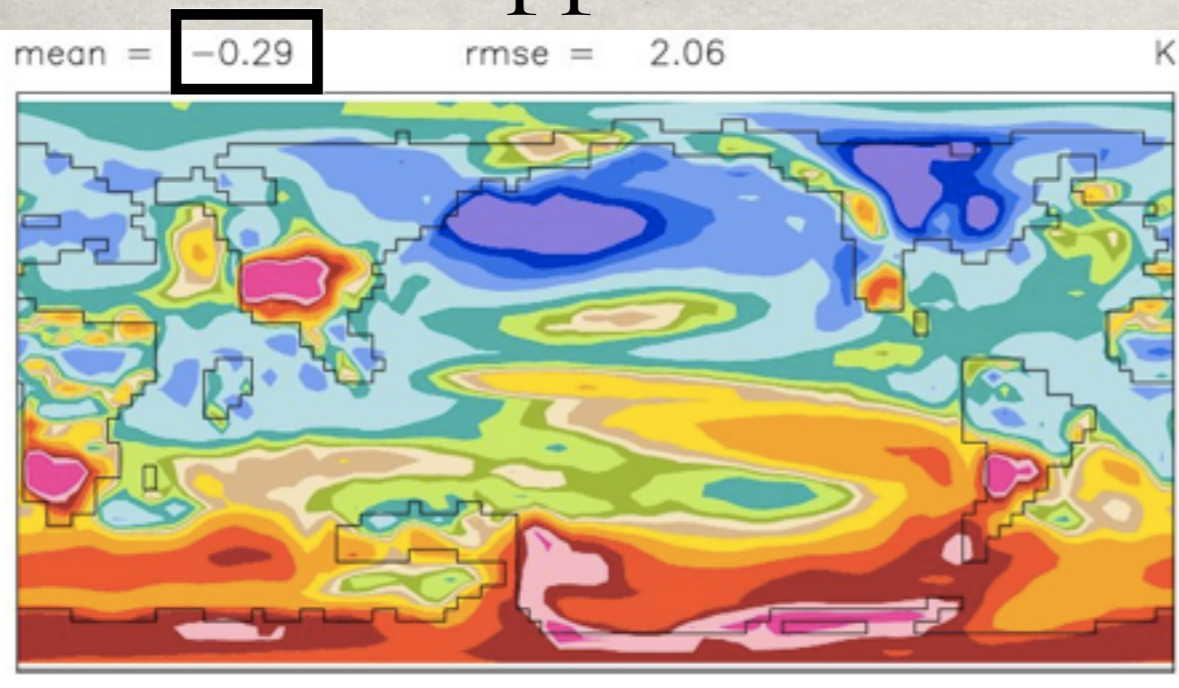


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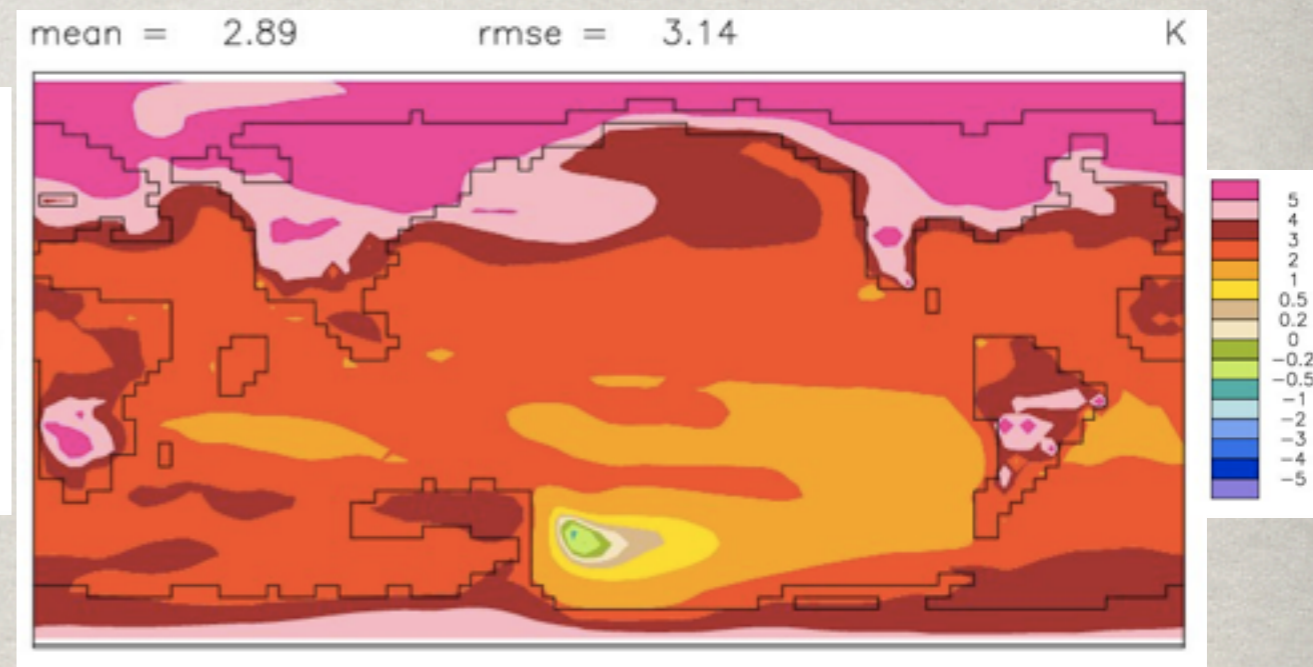
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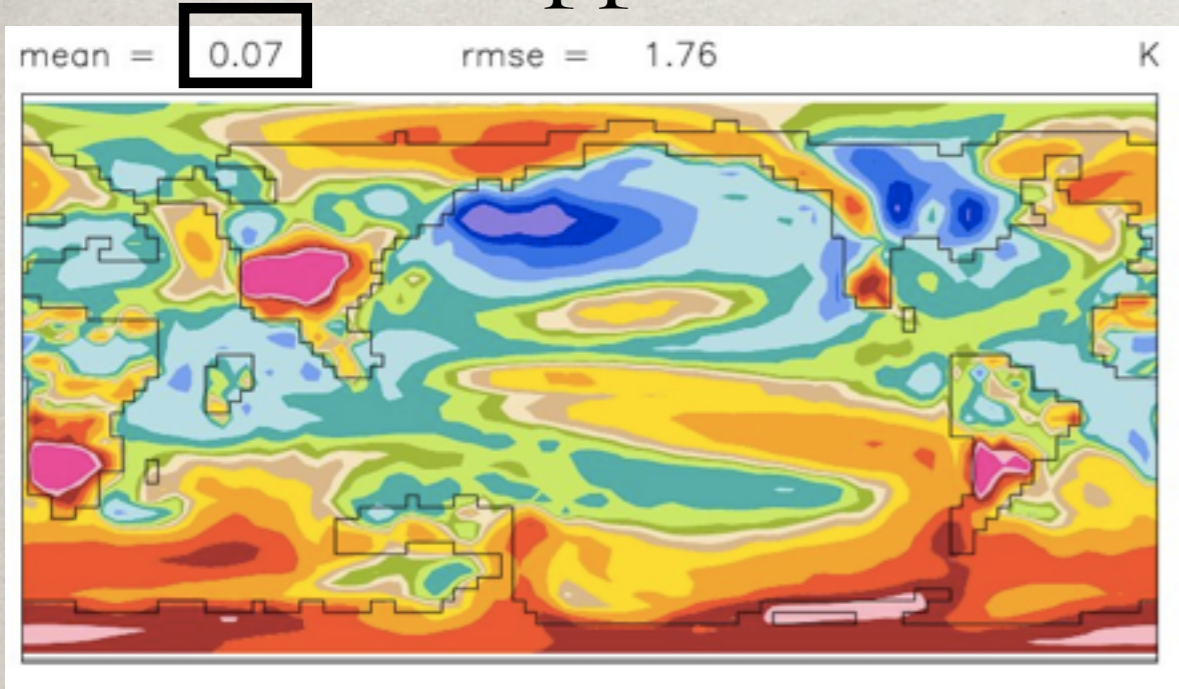


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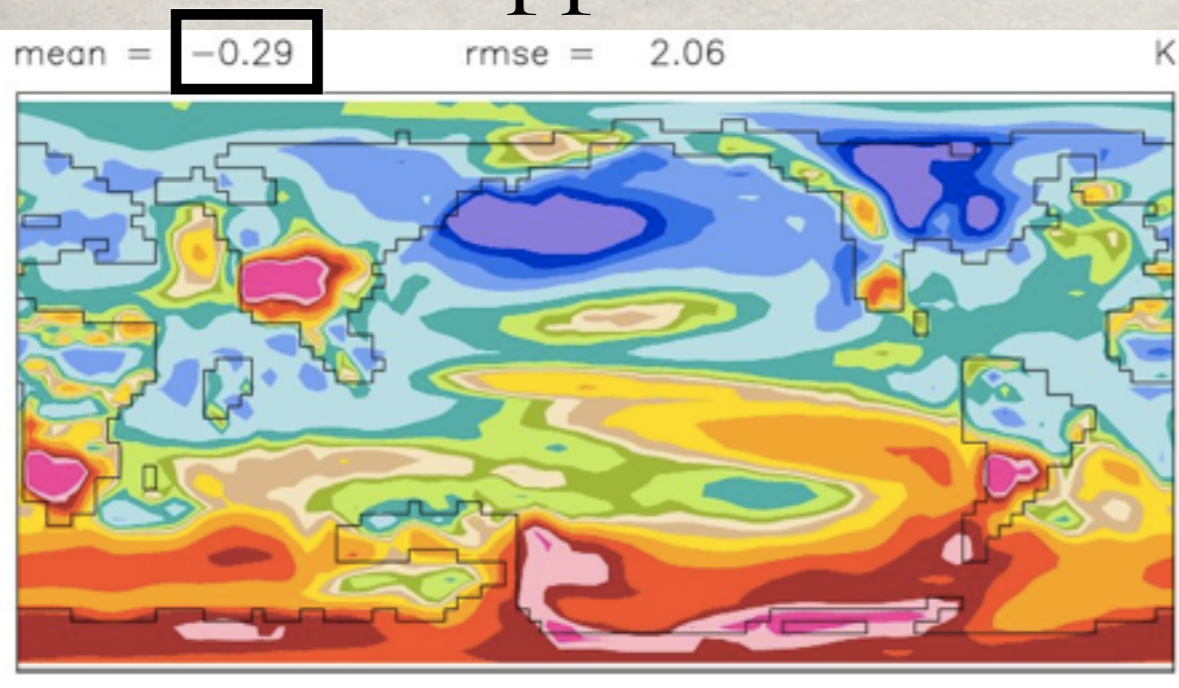


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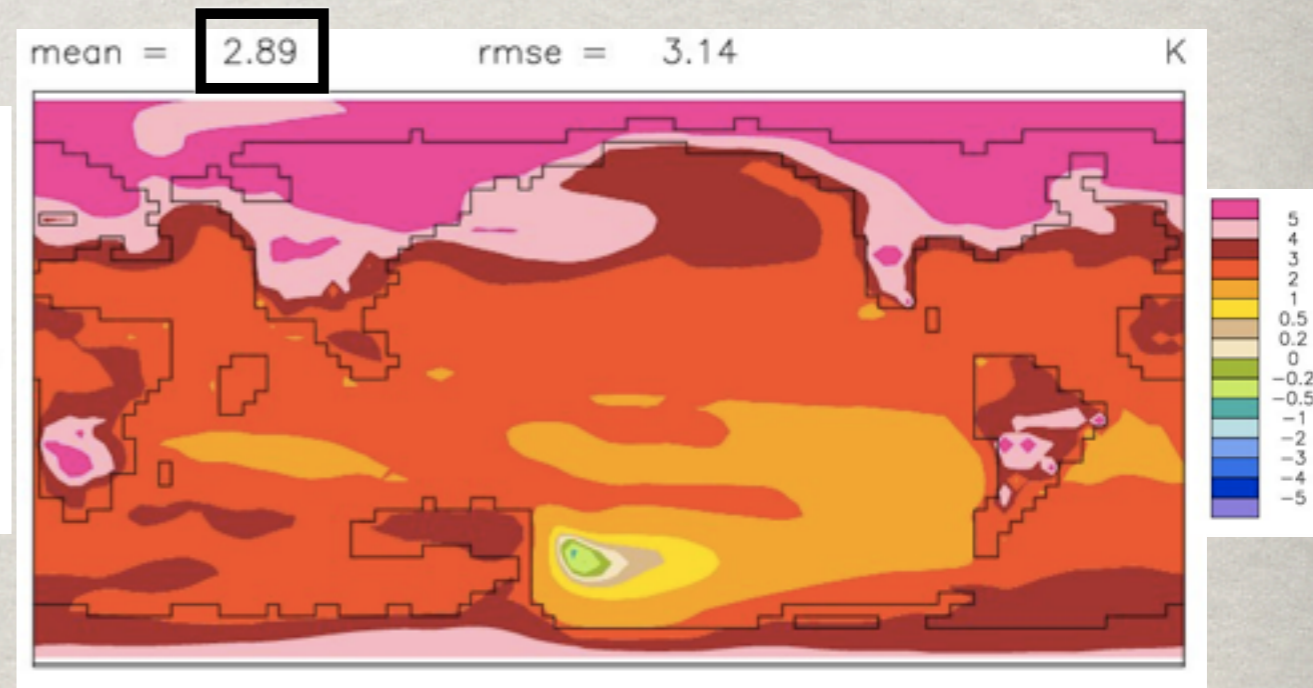
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2240 ppm CO<sub>2</sub>



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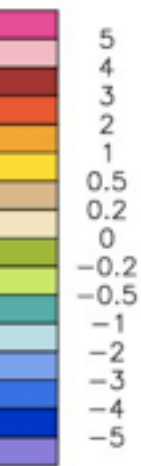
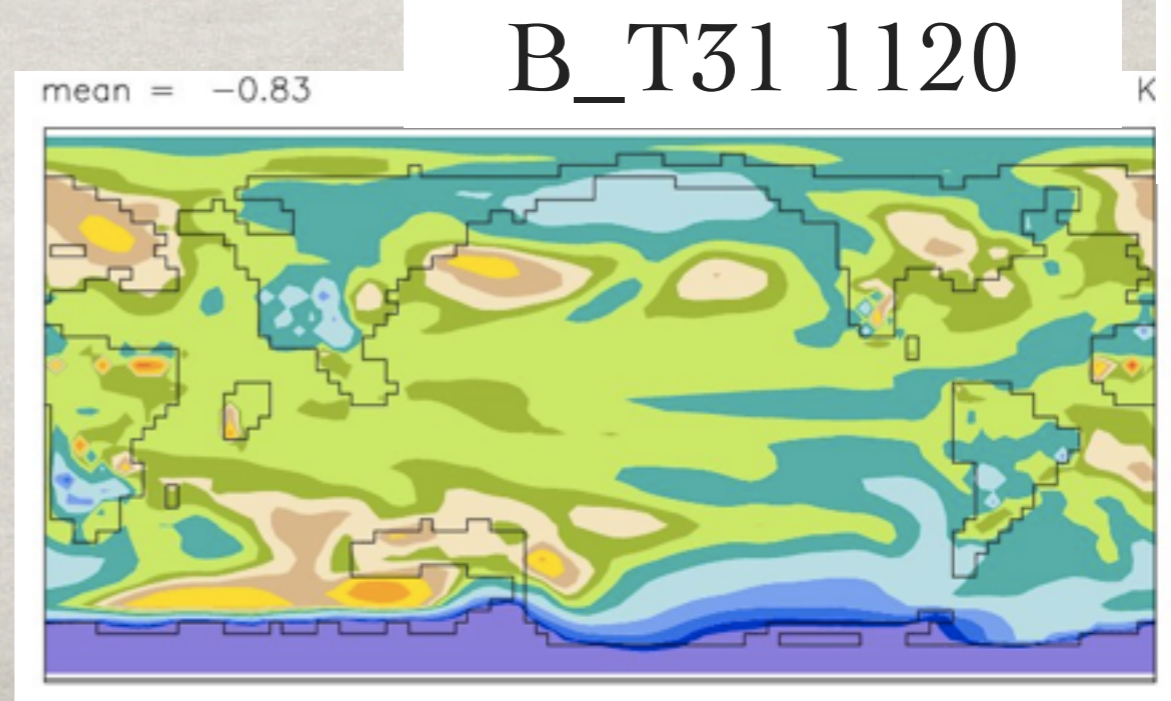
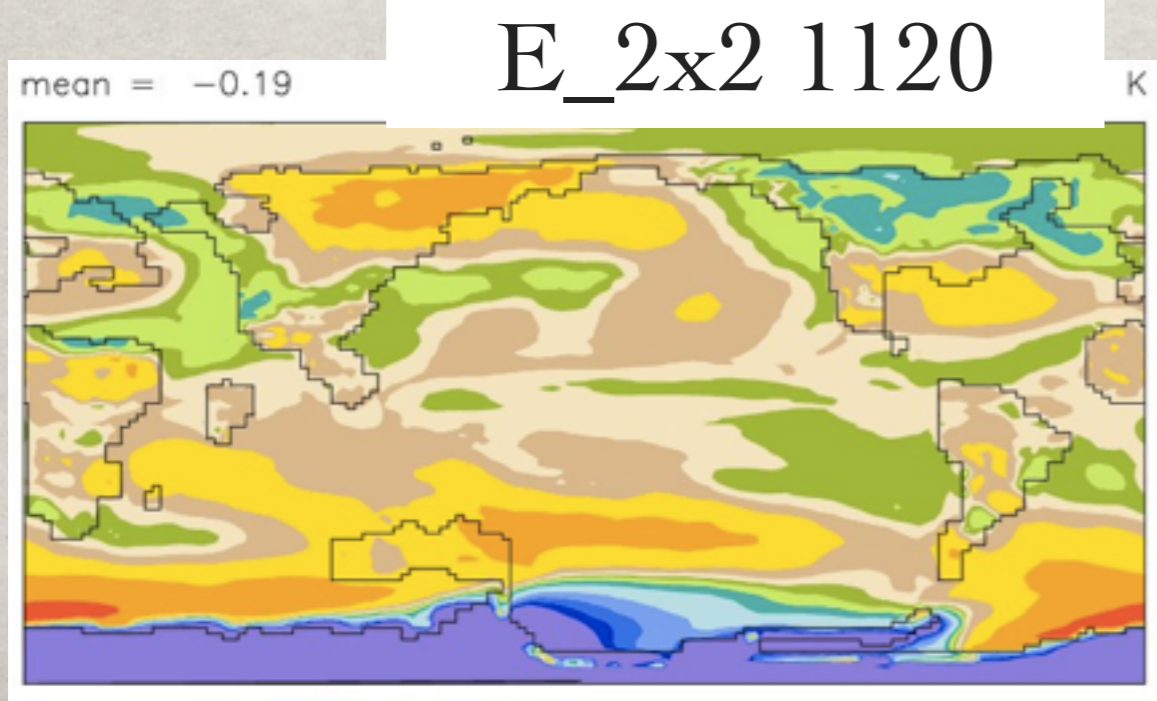
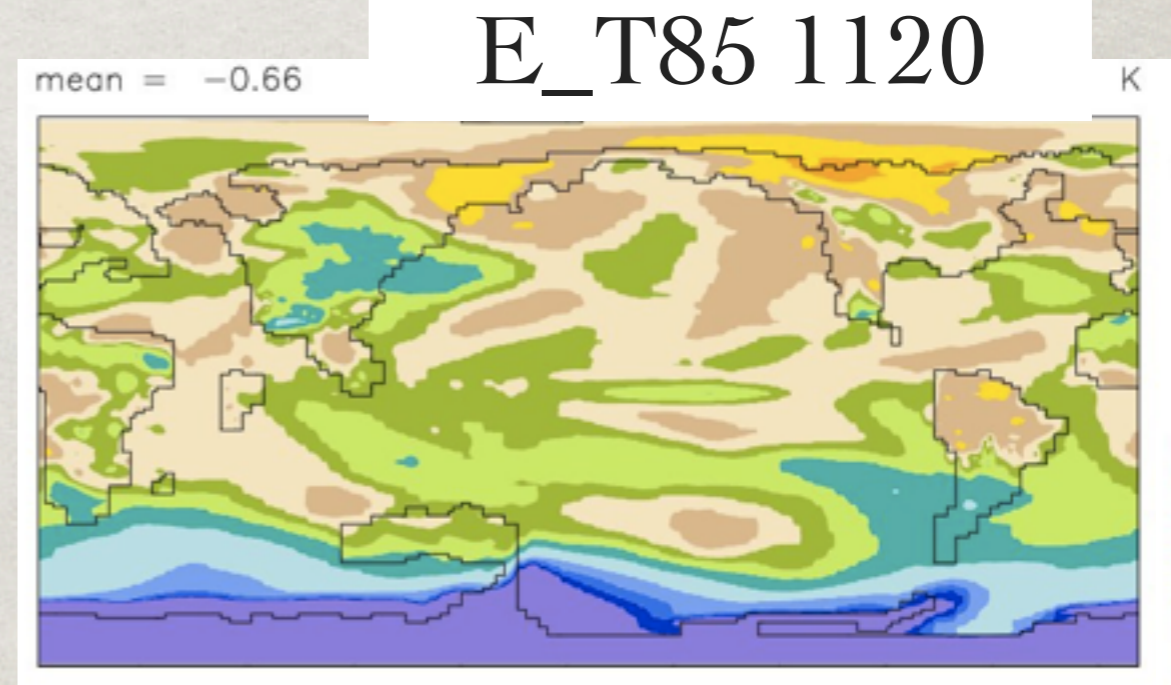
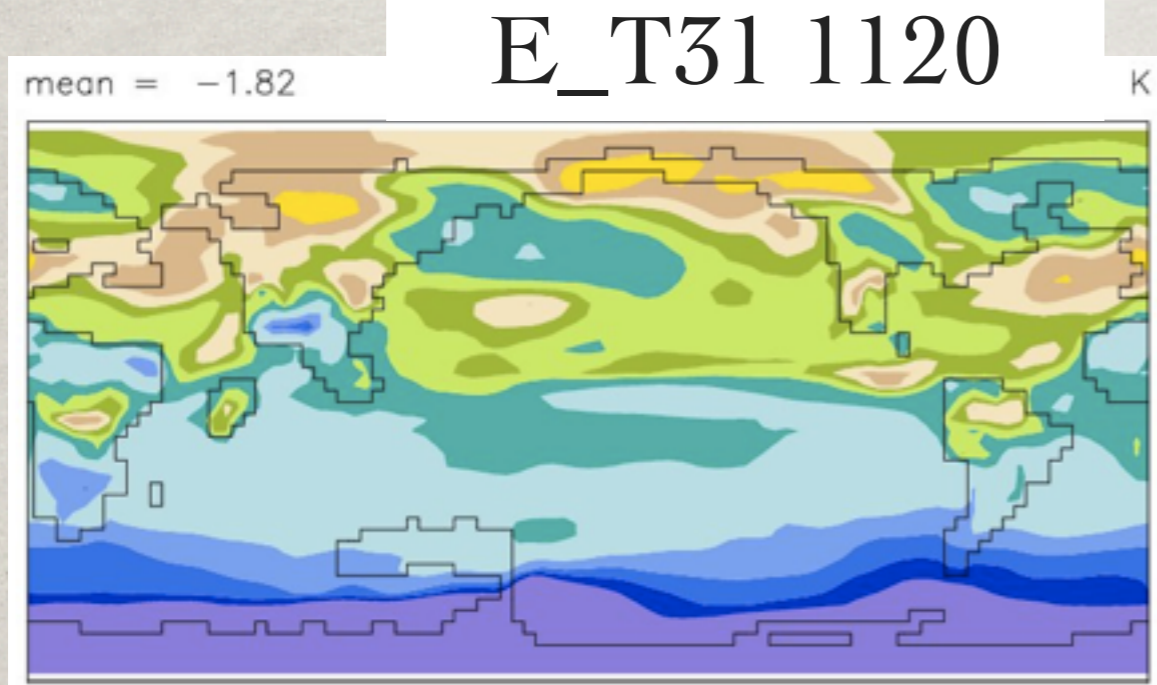
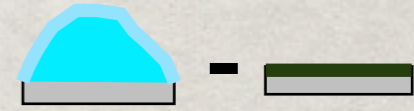


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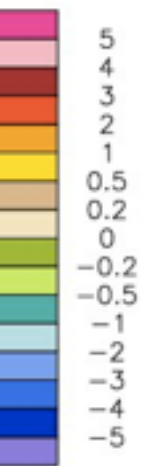
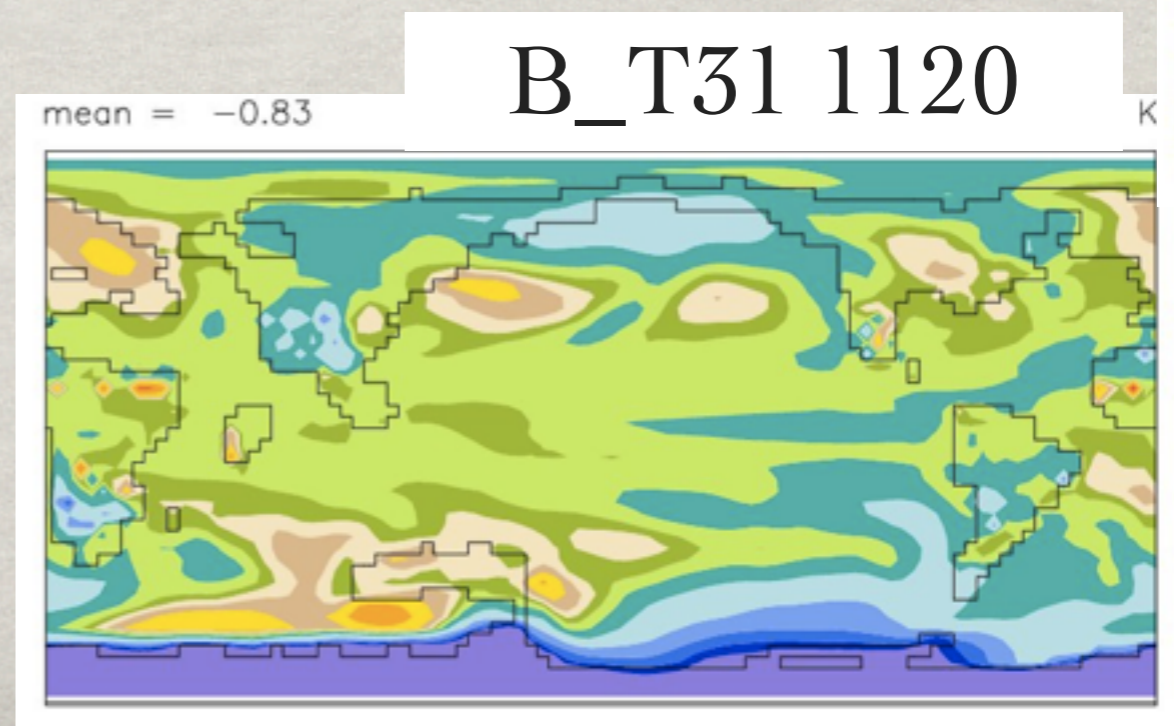
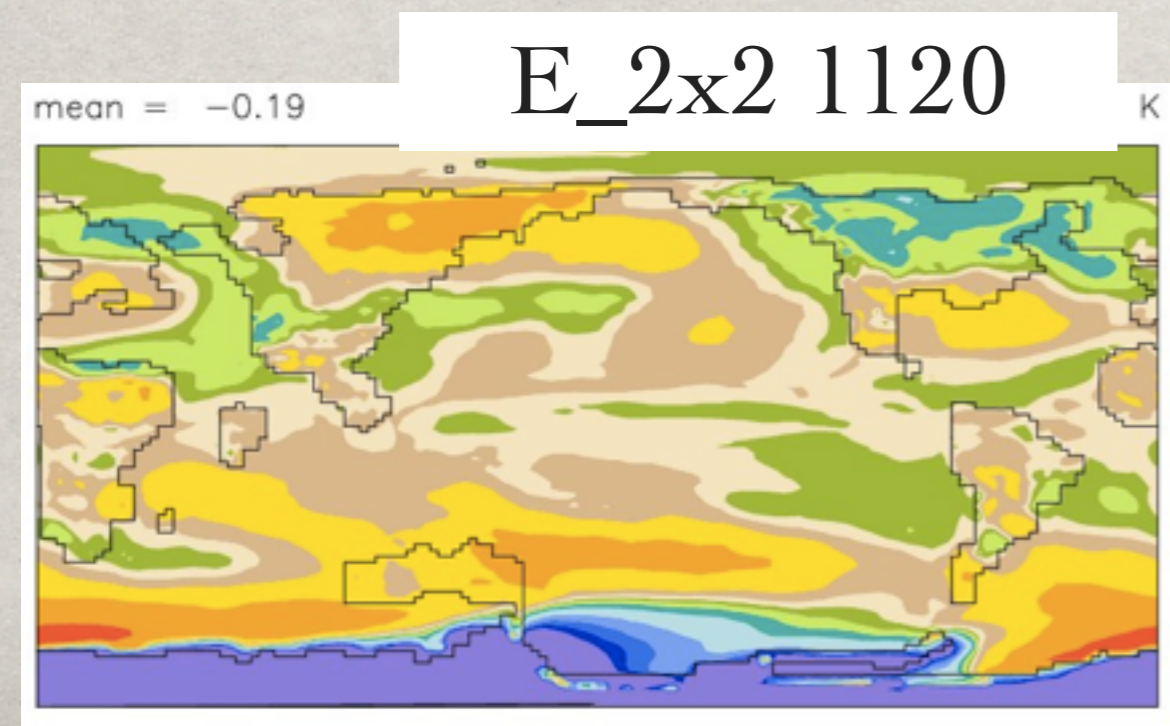
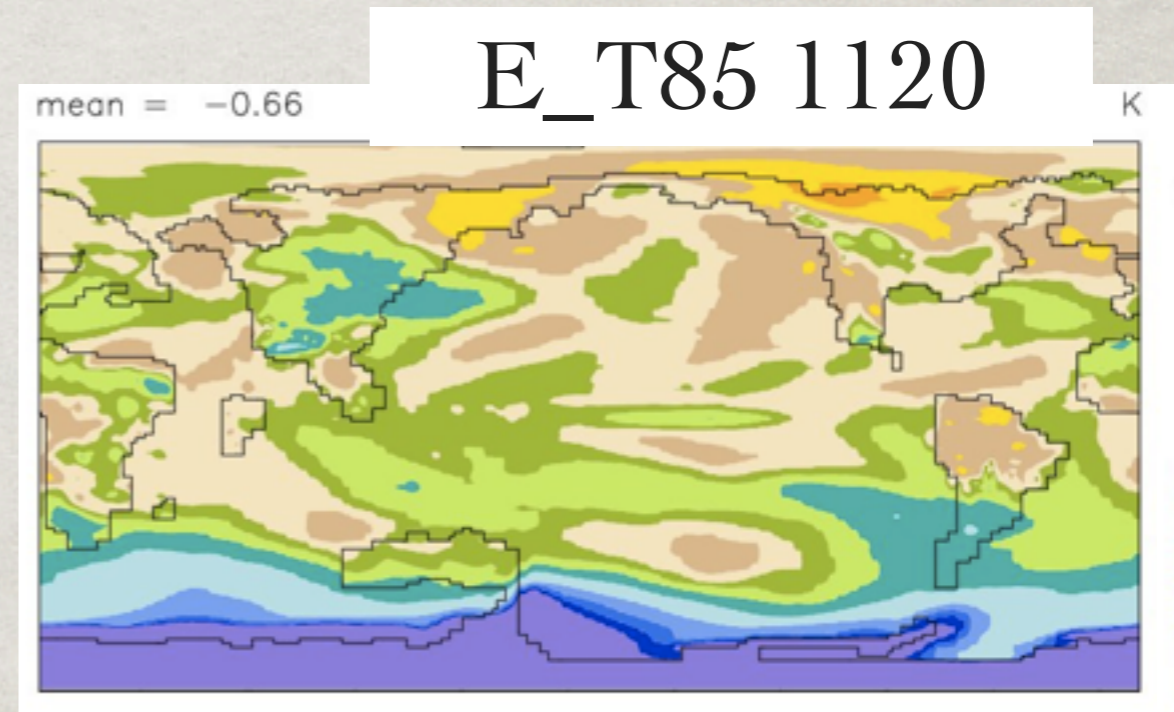
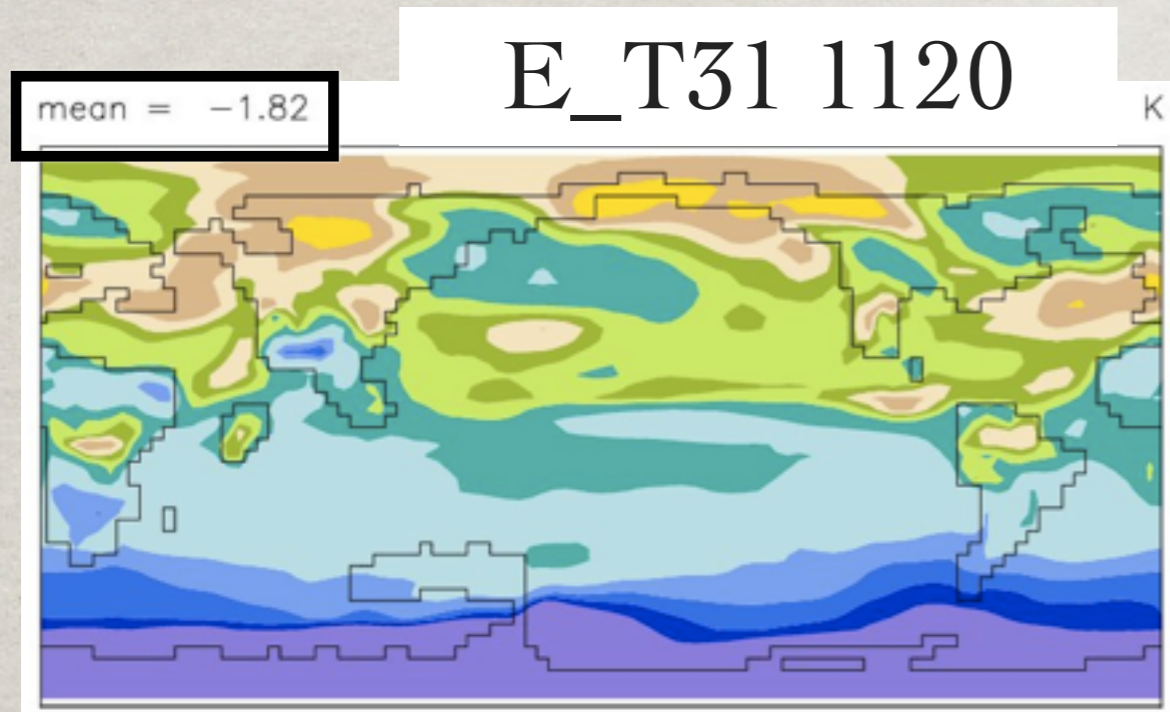
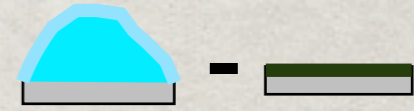
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- Place a modern size Antarctic ice sheet (topography, SGH30,SGH, and albedo) into Eocene control simulations. Below are Anomalies.



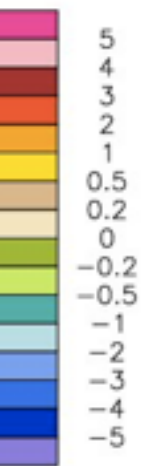
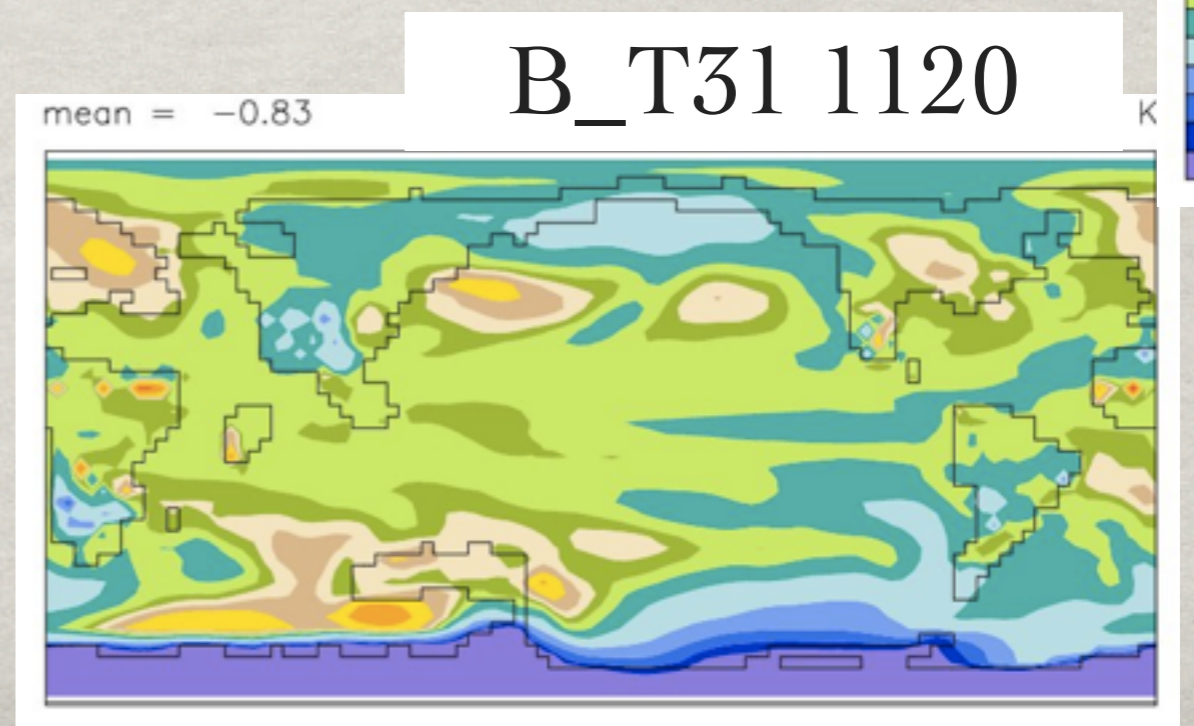
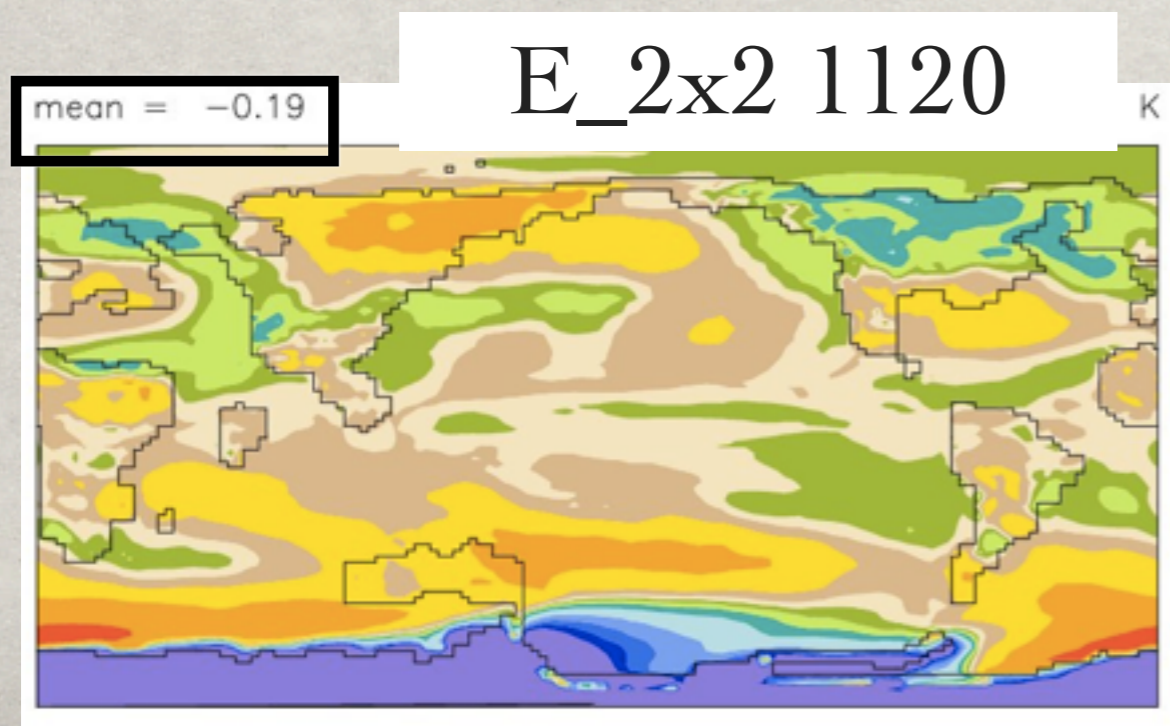
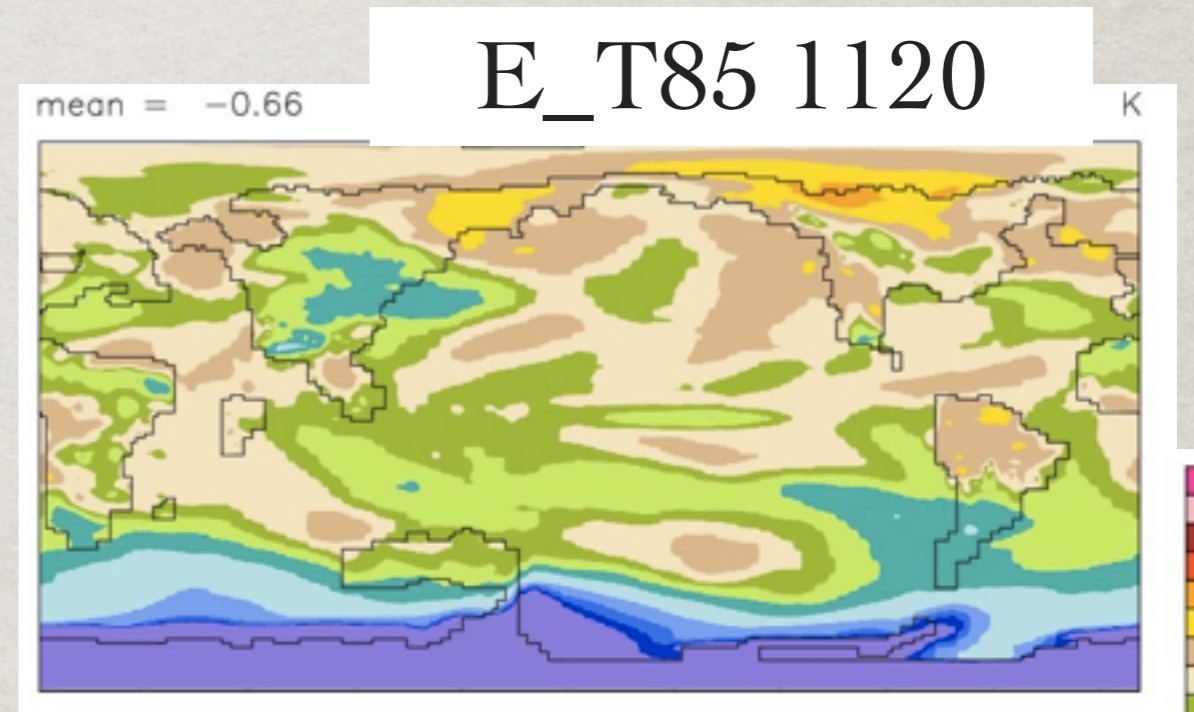
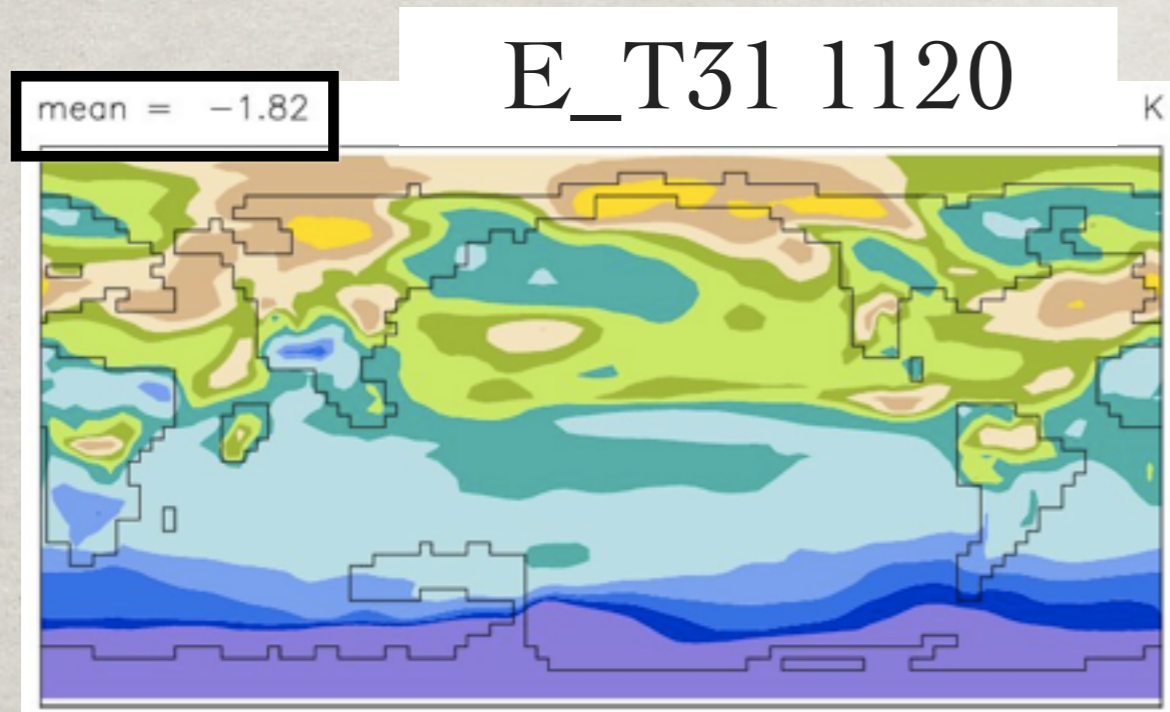
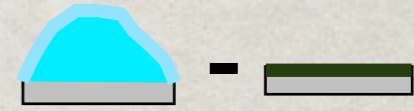
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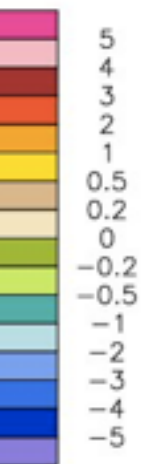
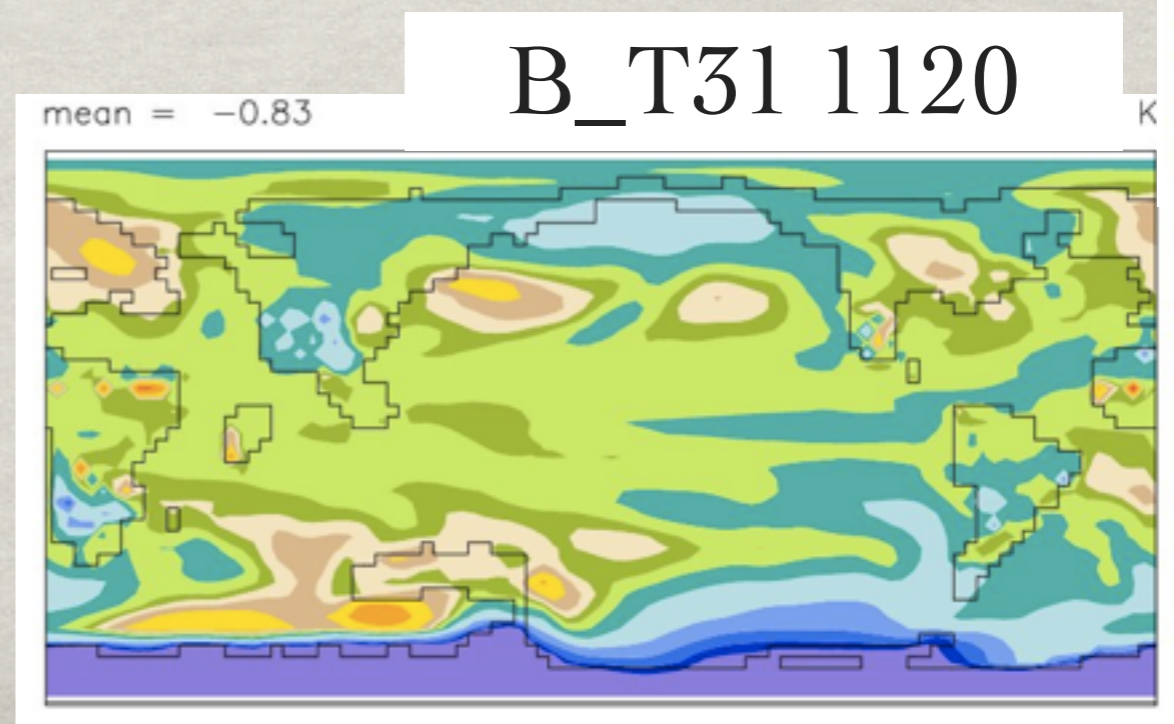
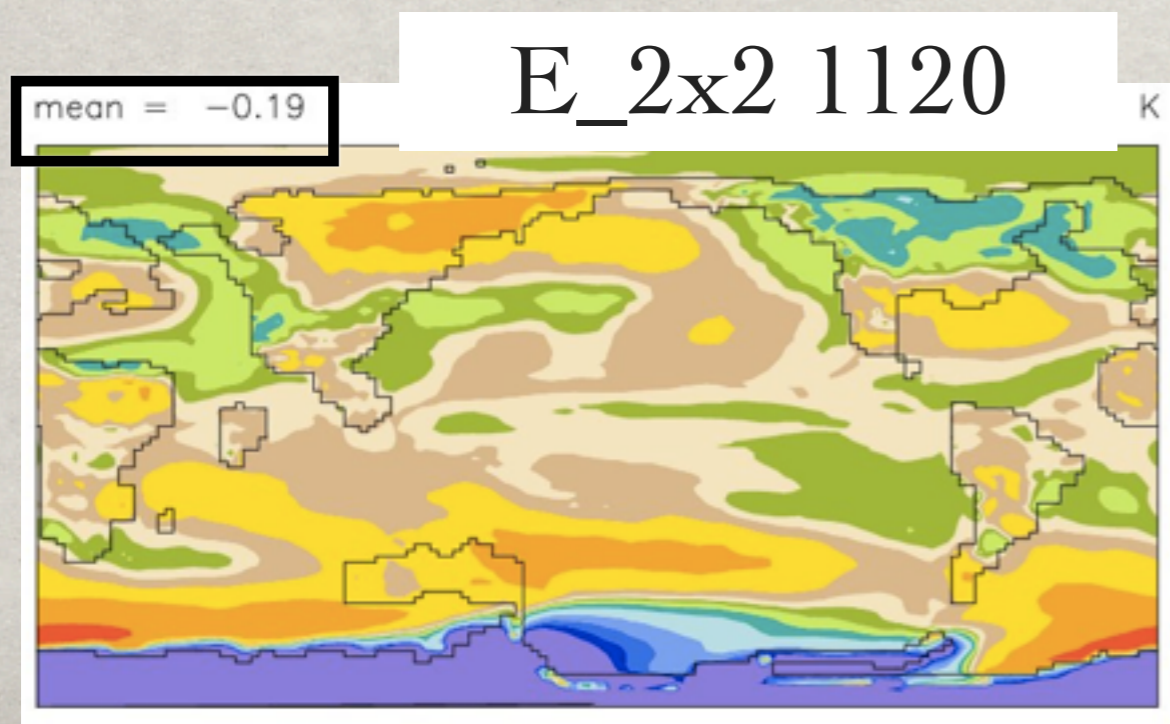
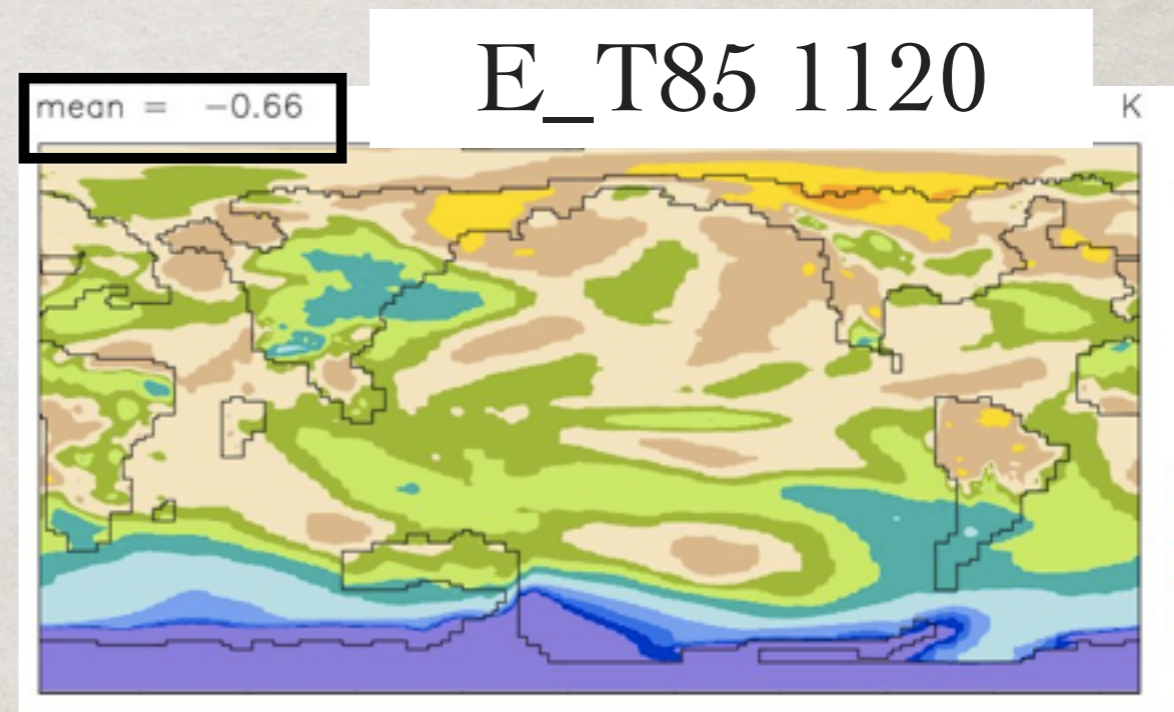
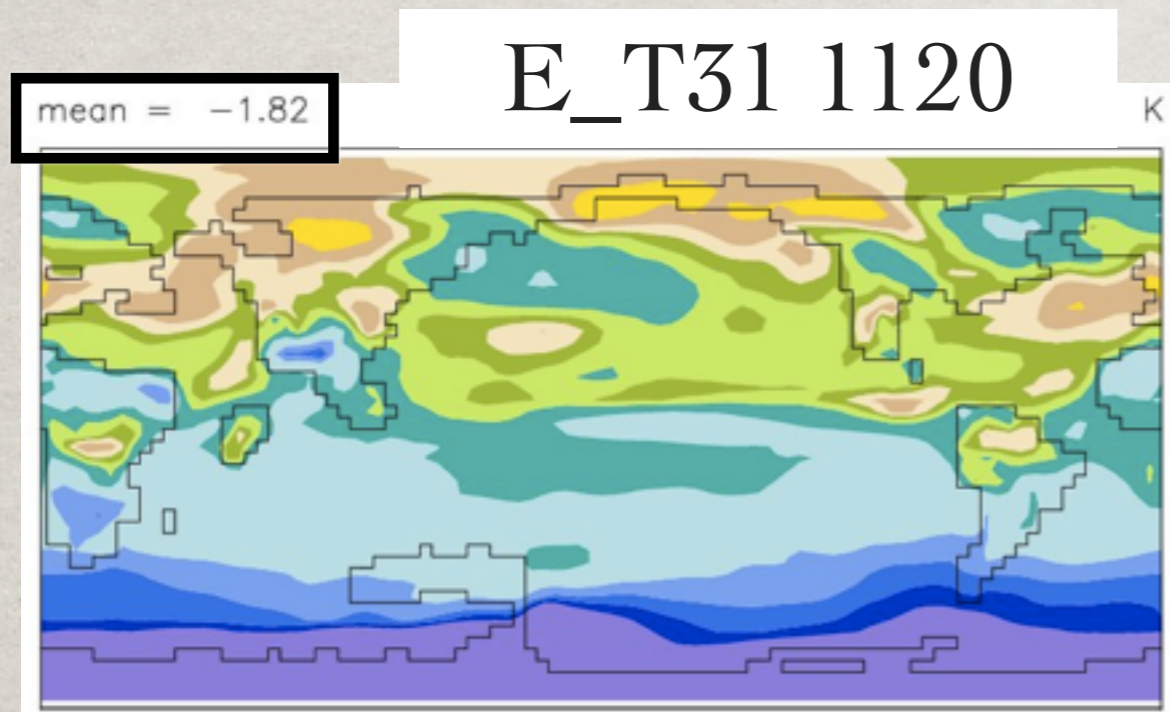
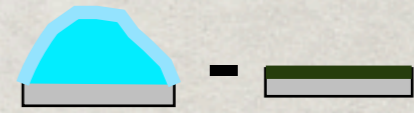
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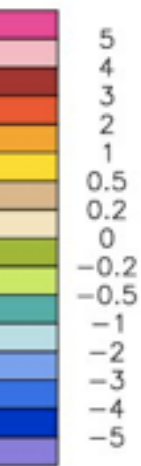
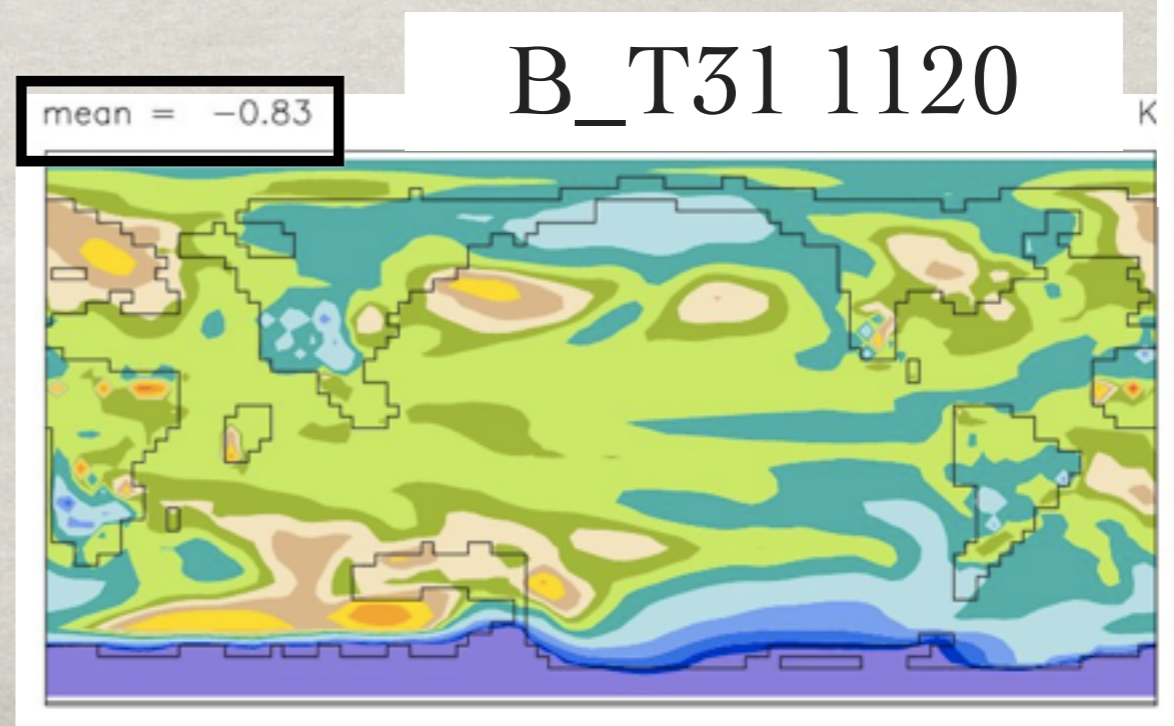
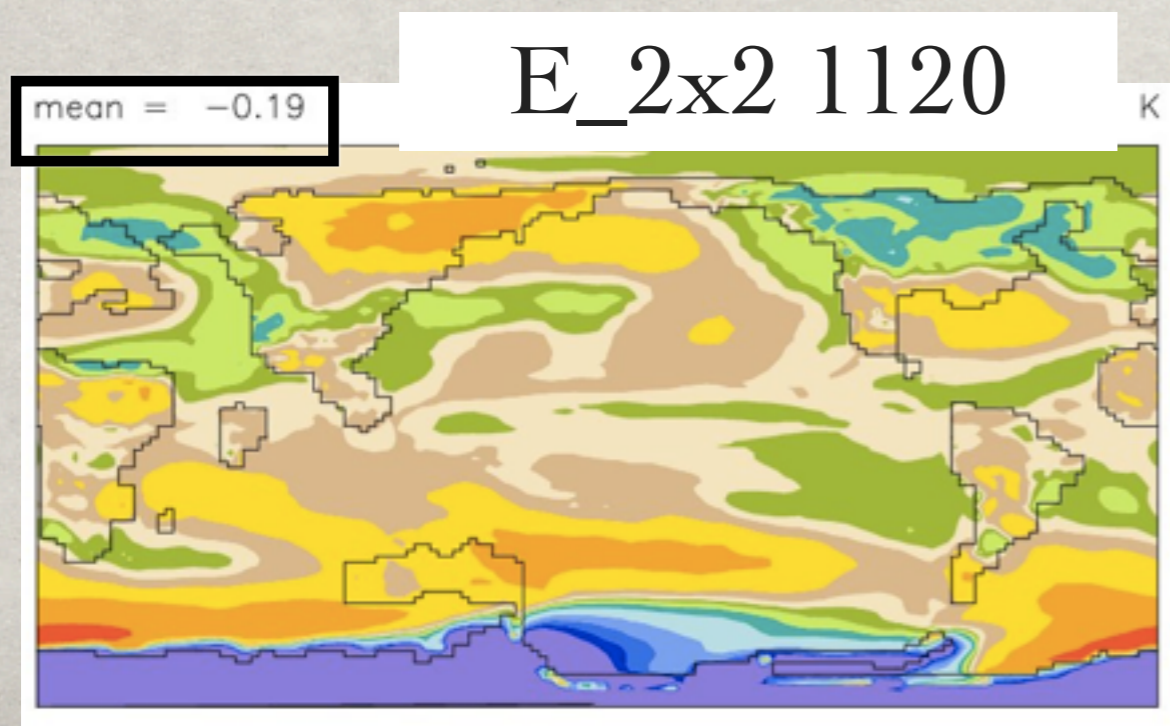
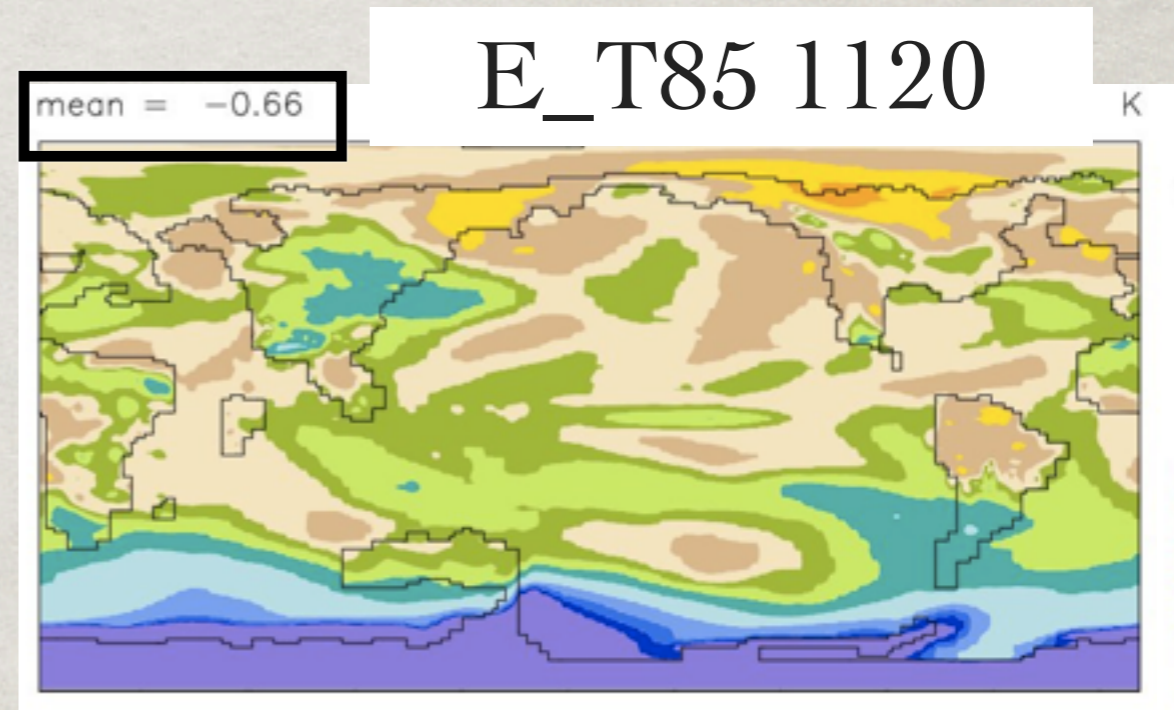
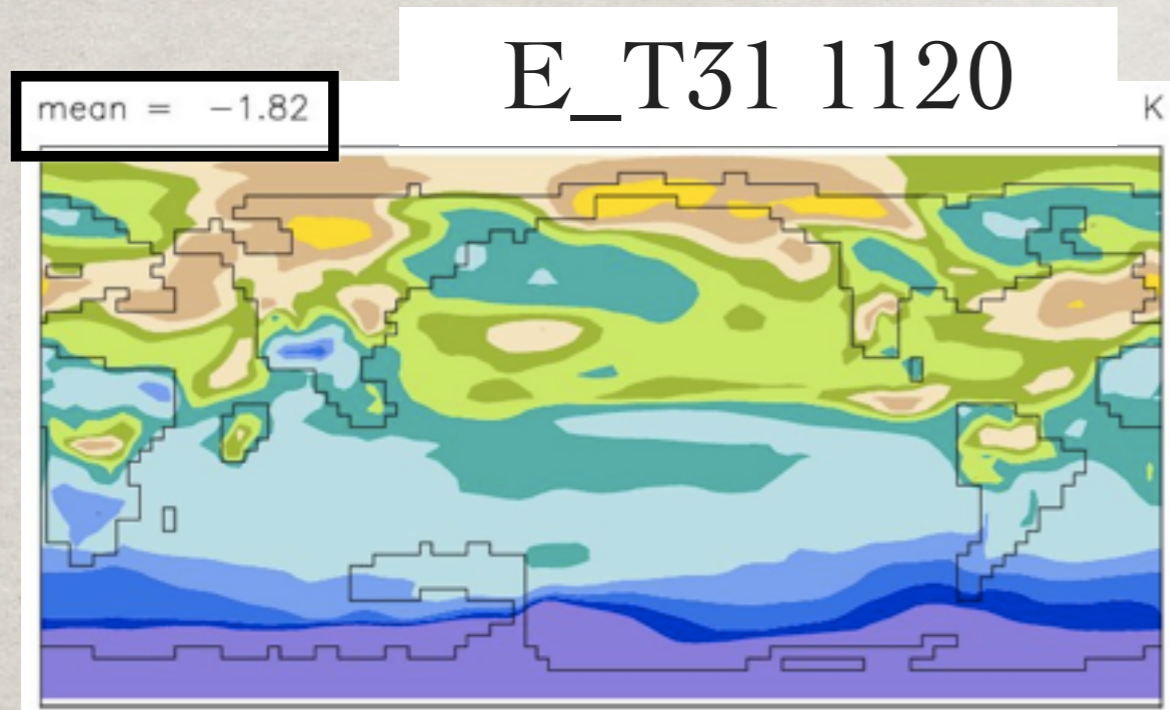
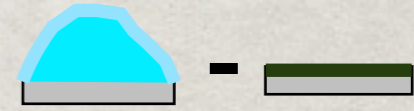
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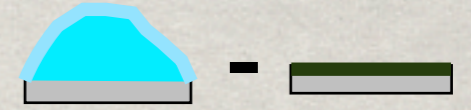
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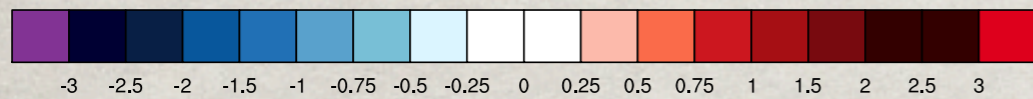
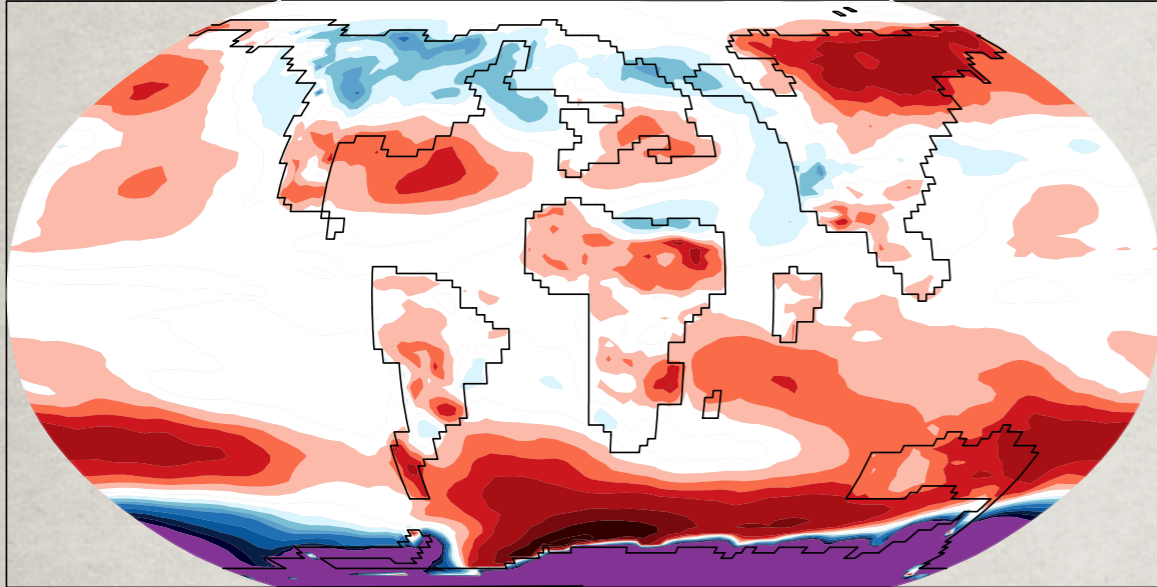




# Eocene Slab Model: Antarctic Glaciation



Surface temperature (radiative) -0.19 K



Total Cloud Forcing 1.26 W/m<sup>2</sup>

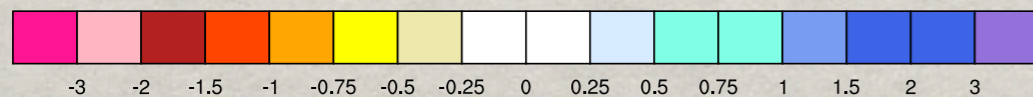
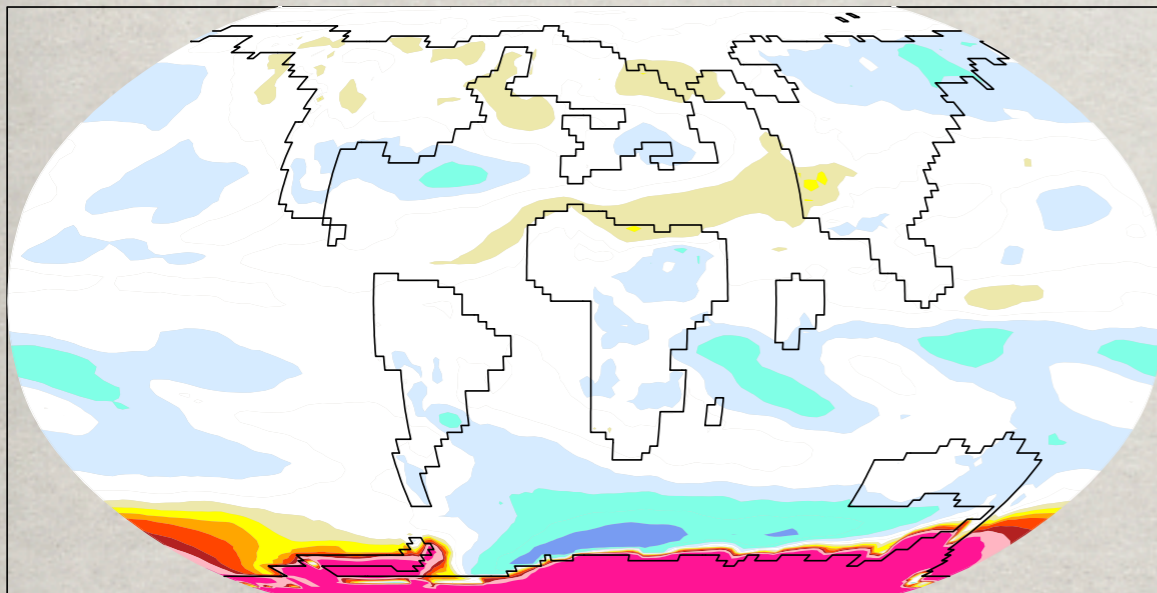
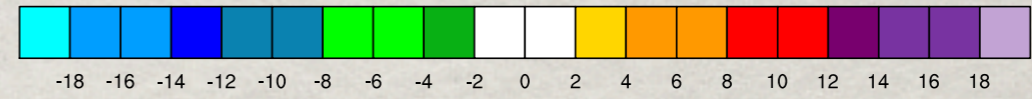
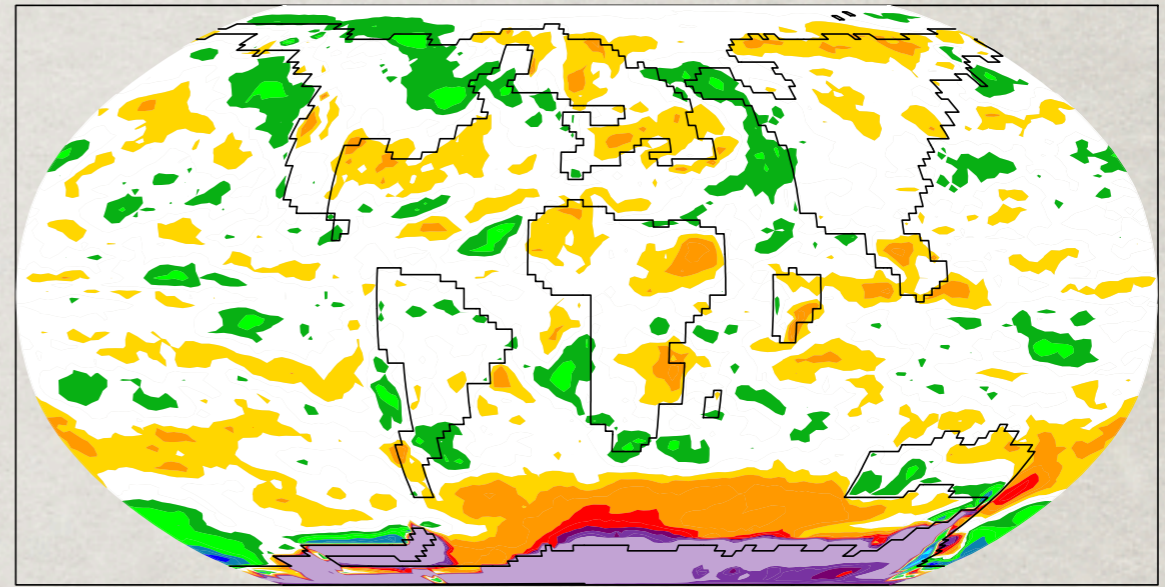
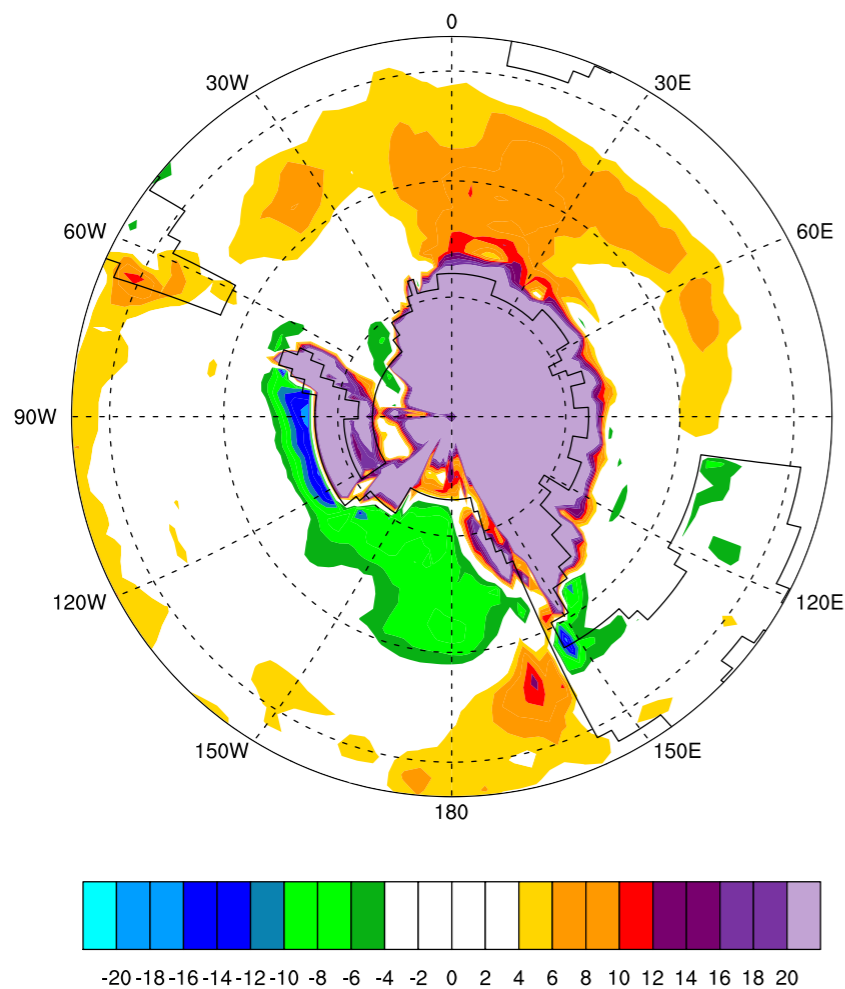


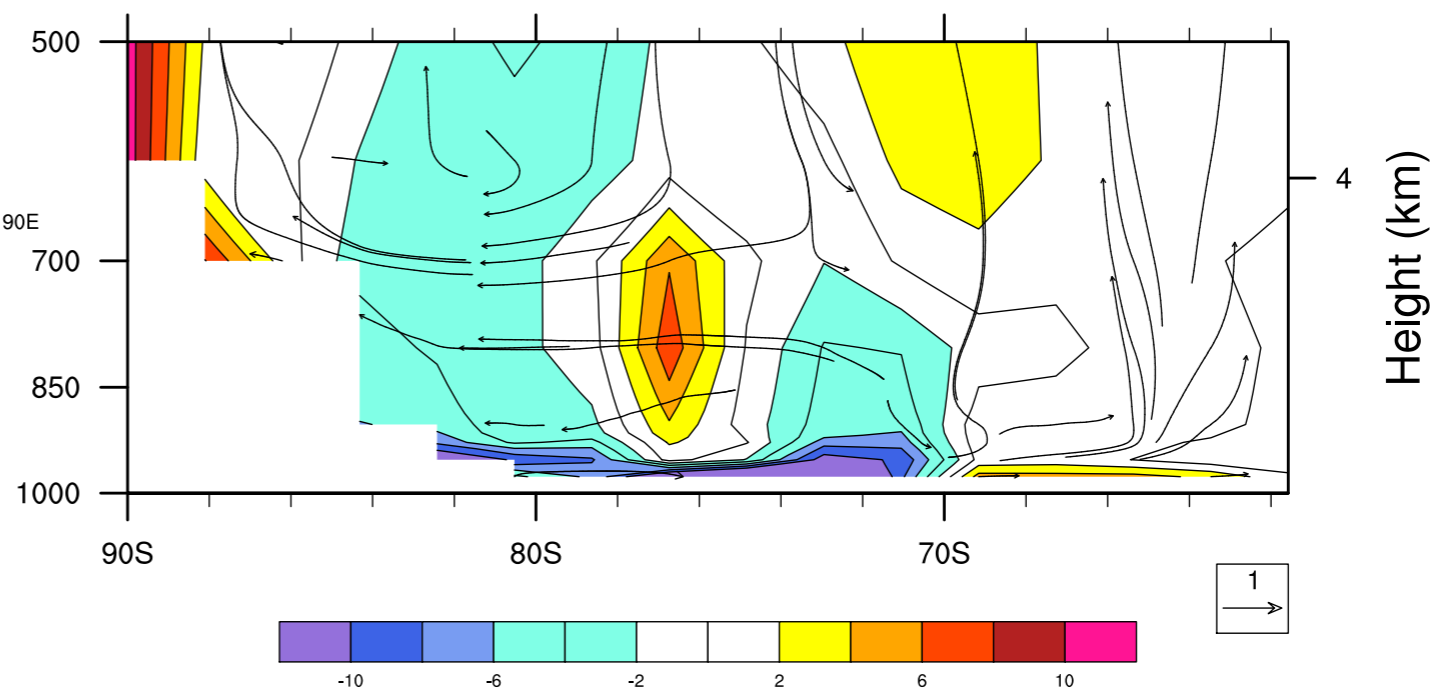
Figure 4. (a) Annually averaged surface temperature anomalies (K) and annually averaged total cloud forcing (longwave cloud forcing (LWCF)+shortwave cloud forcing (SWCF)) in W/m<sup>2</sup> (b), (c) normalized ga (greenhouse effect without clouds) anomaly in % .

# Eocene Slab Model: Antarctic Glaciation

## Shortwave Cloud Forcing Anomalies

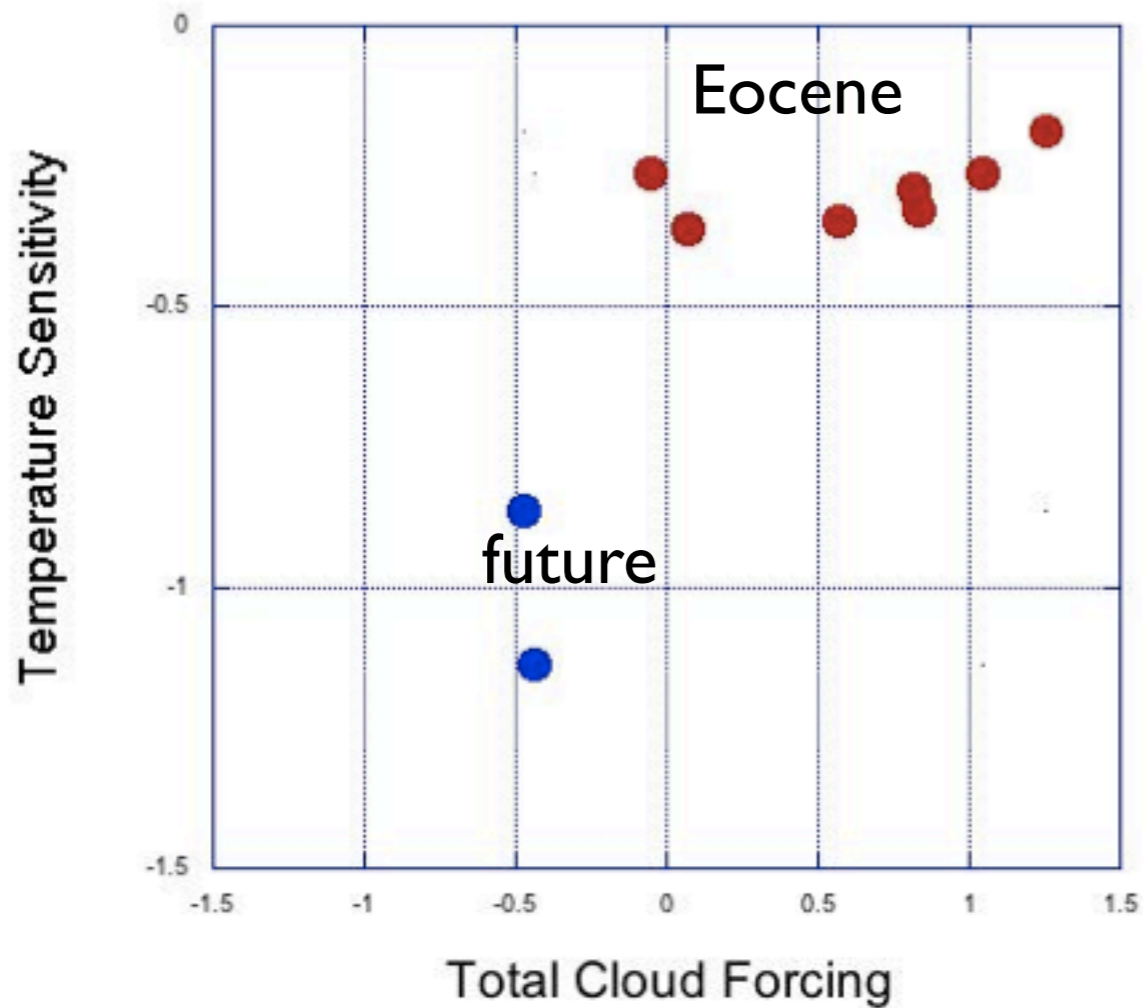


## Cloud fraction anomalies and uplift/subsidence regions around Antarctica

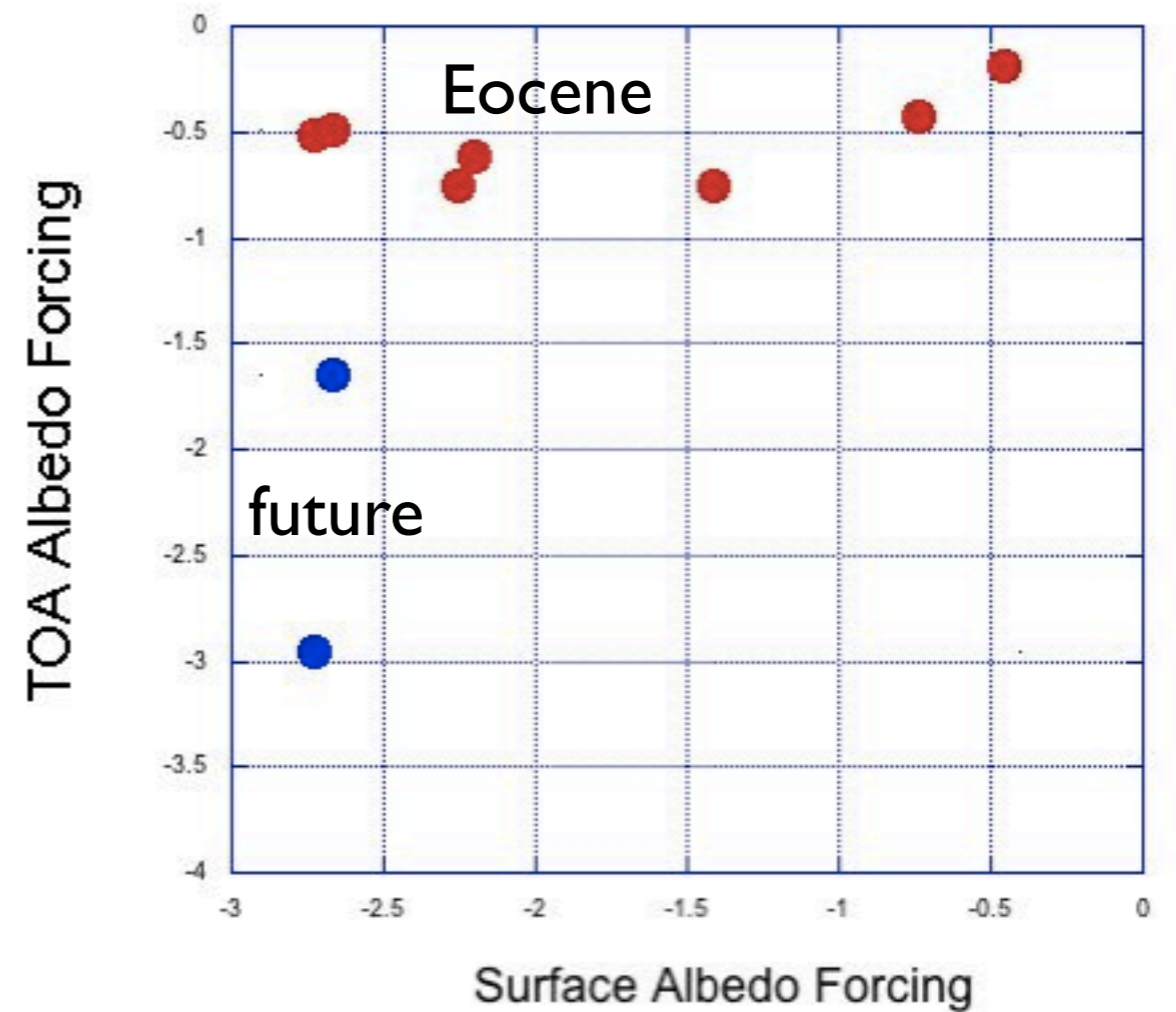


# Radiative Impact

Temperature Sensitivity versus Cloud Forcing



TOA Albedo versus Surface Albedo

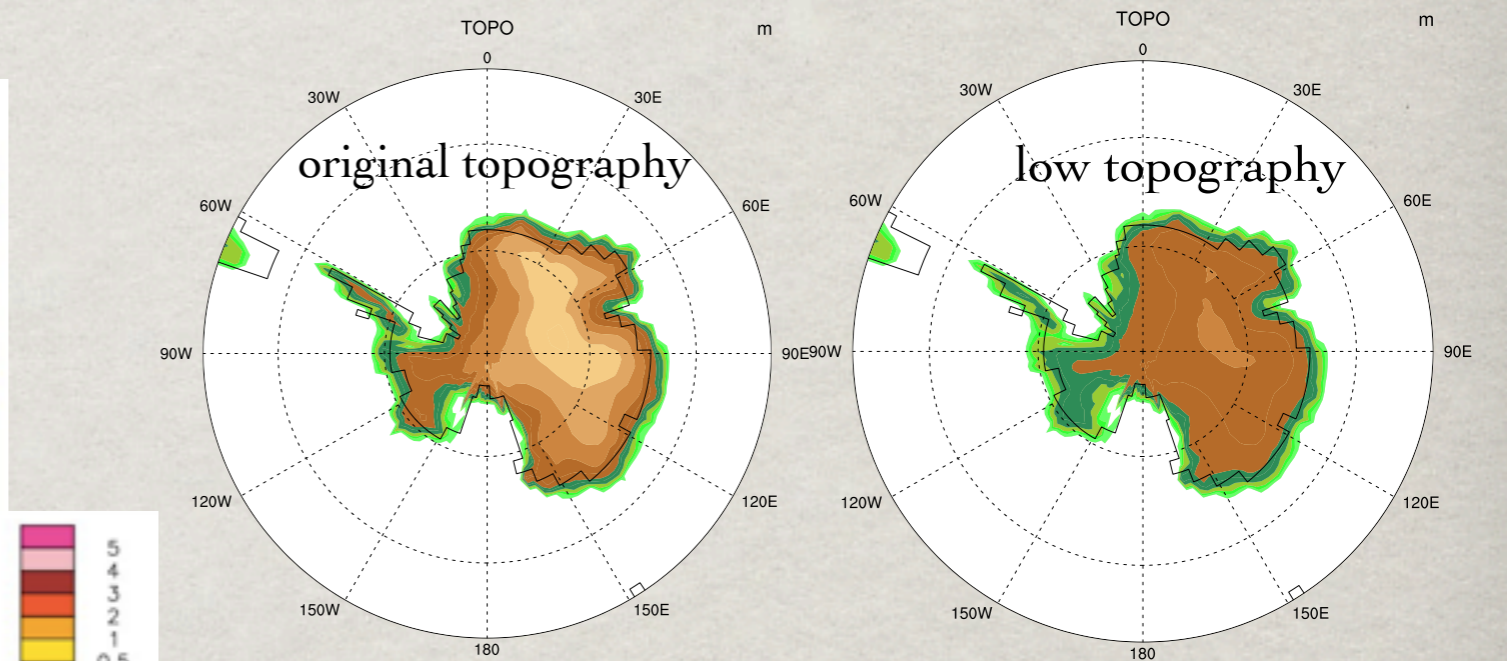
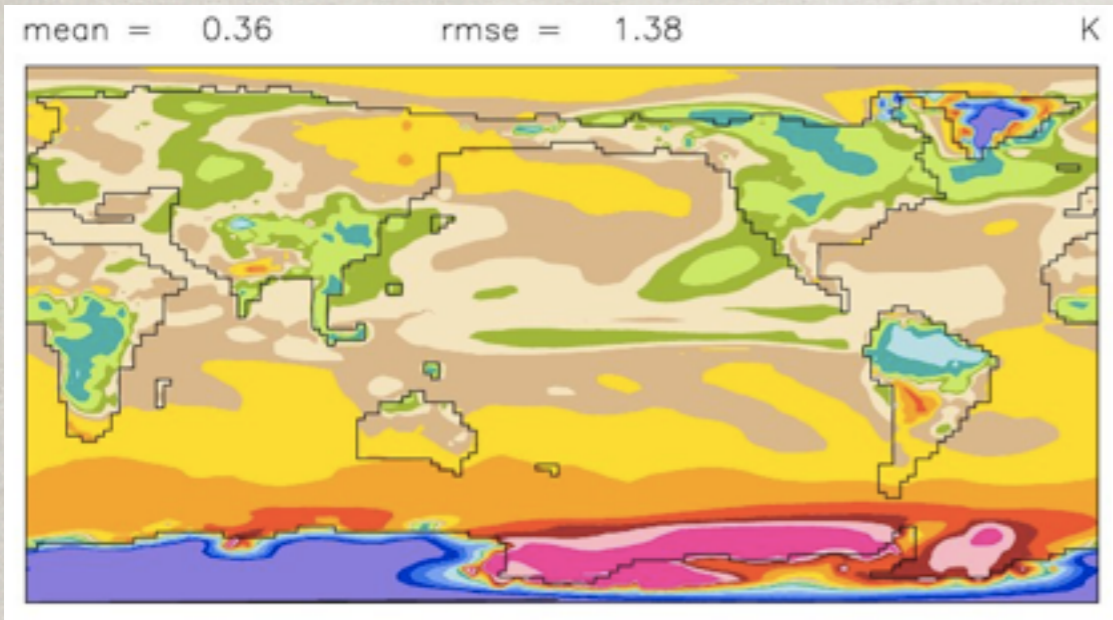


# Results Eocene CAM4/CAM5

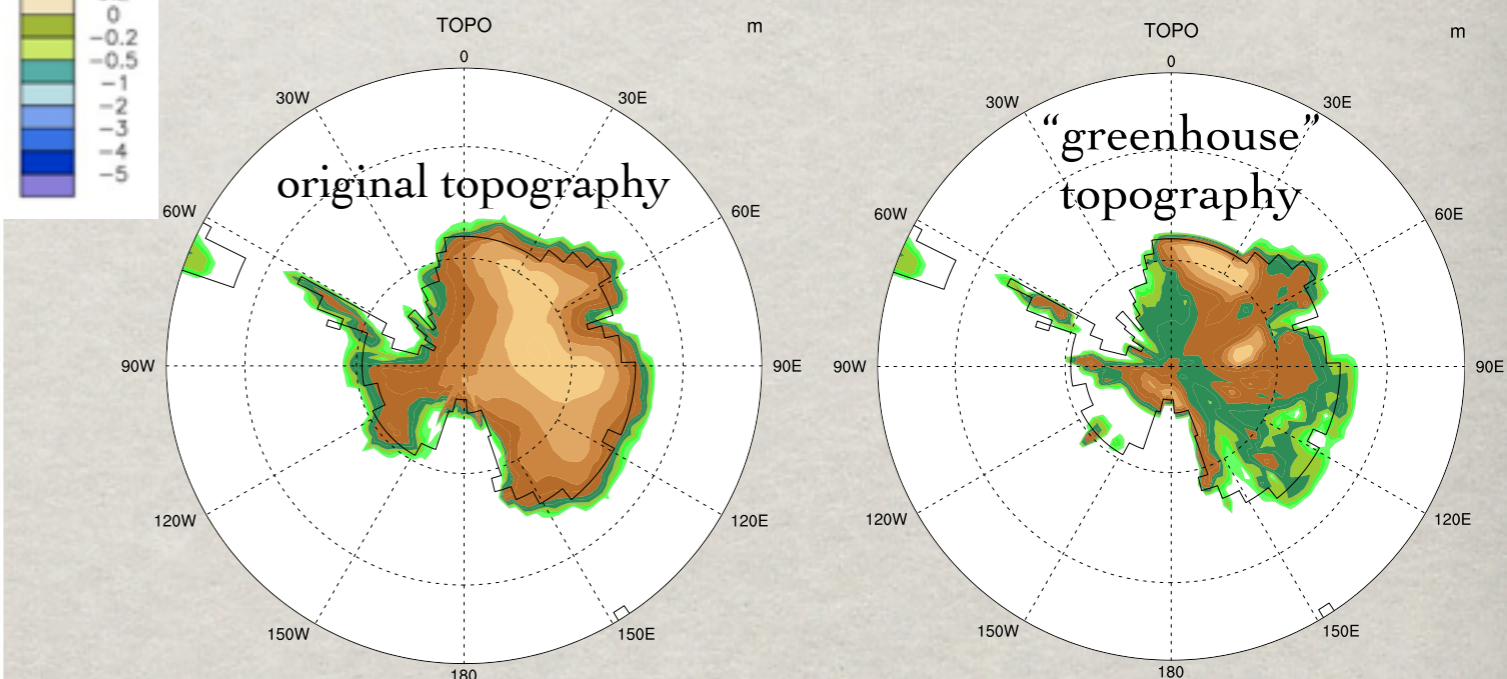
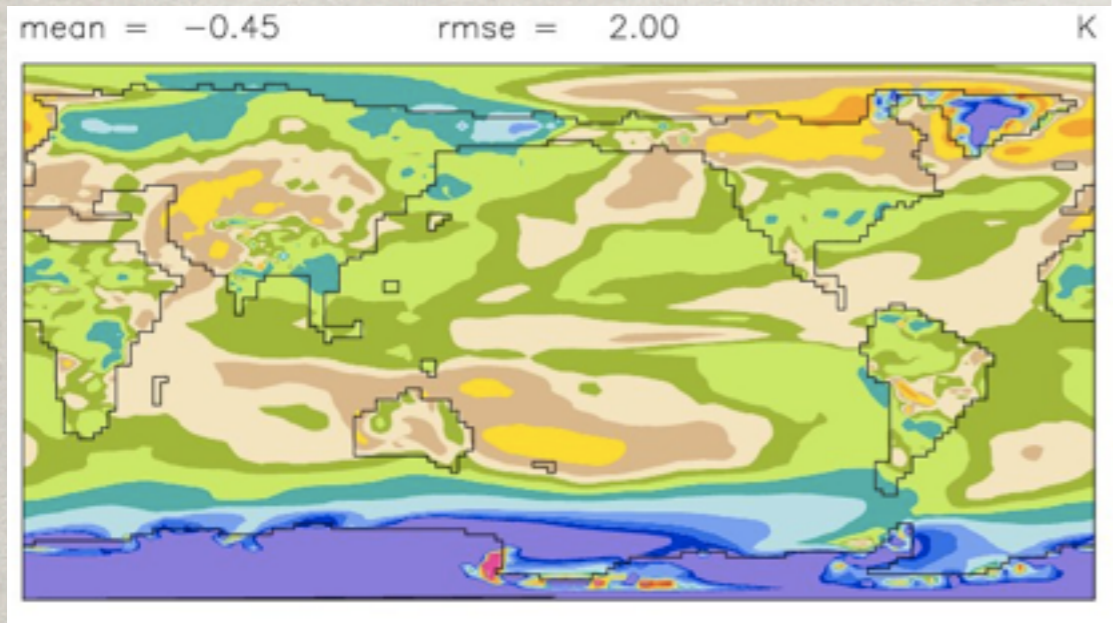
- Coupled model shows roughly a ~3K per doubling of CO<sub>2</sub> warming.
- Slab model using CAM4 has a 3.5K per doubling of CO<sub>2</sub> warming.
- Adding Antarctic glacier into Eocene induces a global cooling signal from (-0.19 to -1.8 K).
- Prescribed aerosols using bulk aerosol mode (BAM) approach warm the Eocene ~0.3K.

# Miocene Sensitivity: Topography

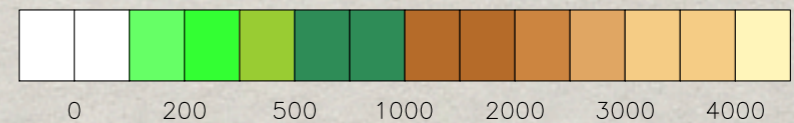
original topo minus low topo



original topo minus greenhouse topo

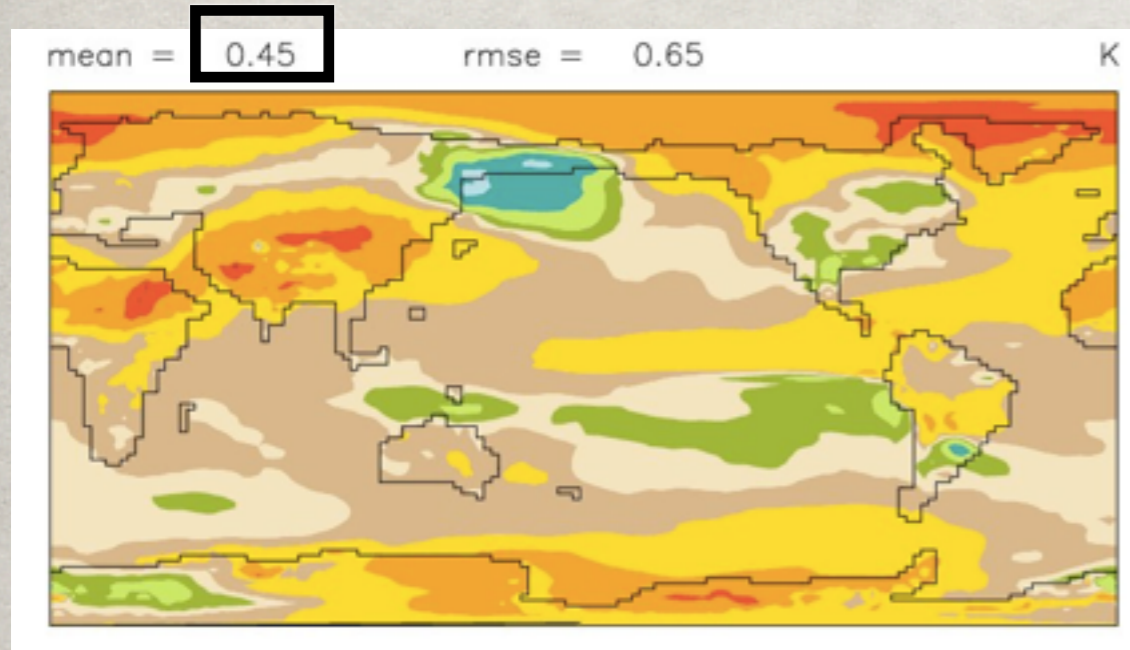


“Miocene greenhouse topography”-Pollard and DeConto, 2009



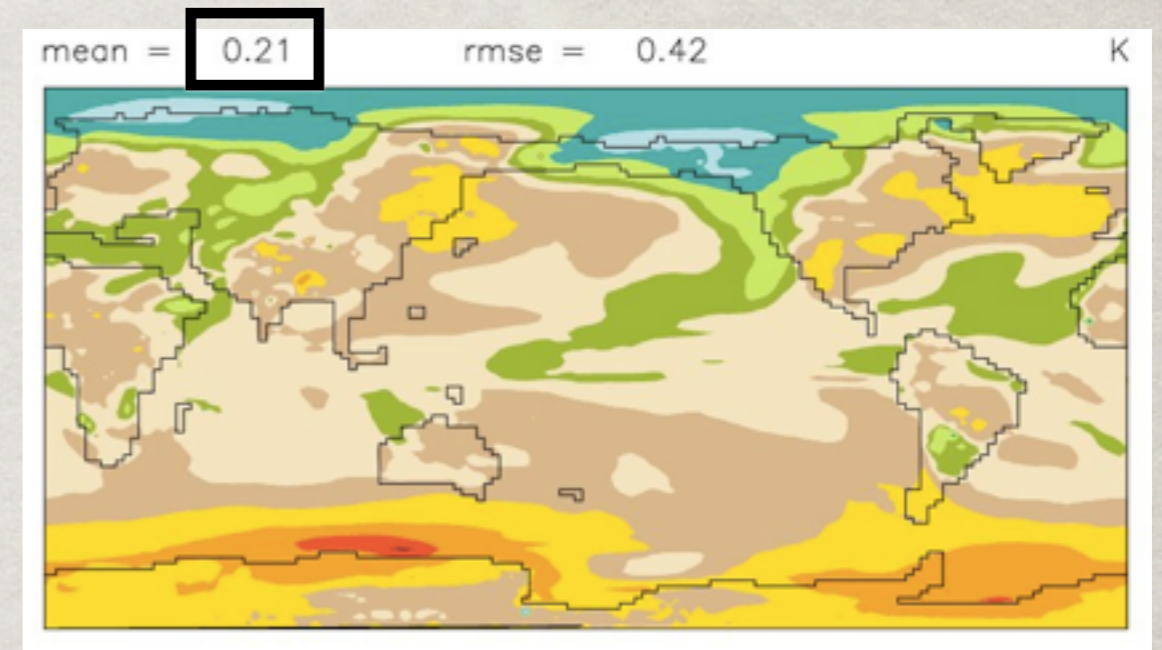
# Miocene Sensitivity

Aerosols



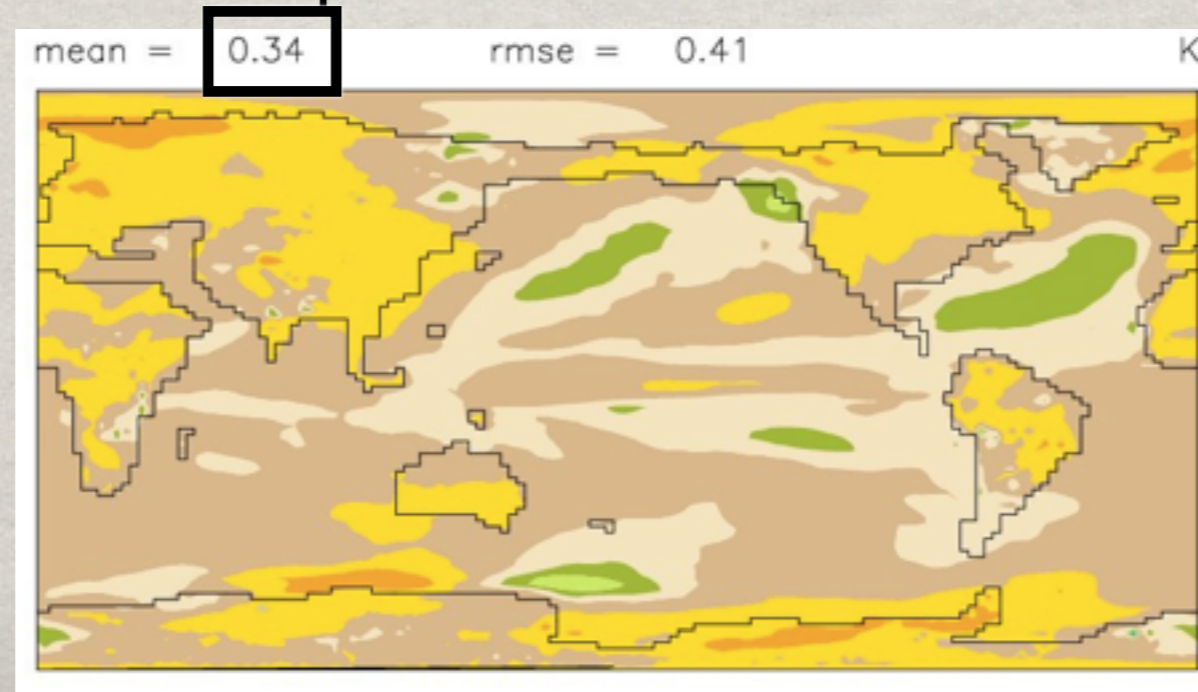
BAM prescribed Aerosols versus PI prescribed aerosols. Used workflow developed by Christine Shields

Less Antarctic Glacier



Miocene 560 “original-higher topography” minus “lower” topography and less glacier in Antarctica

2x pre-industrial CH<sub>4</sub>



# Special Thanks

- Matthew Huber
- Gabe Bowen
- Alex Gluhovsky
- Dorian Abbot
- Christine Shields
- David Bailey
- Nicholas Herold
- Rodrigo Caballero
- Jonathan Buzan
- Nan Rosenbloom
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- Purdue Climate Change Research Center
- NCAR paleoclimate working group
- Purdue University, Earth and Atmospheric Sciences
- Amanda Frigola

# References

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