Aerosols for Deep Time CCSM4 Paleoclimate:

A Permian/Triassic Test Case

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OUTLINE

1. Review of aerosol treatment in CAM for deep time periods
2. Procedure to create period specific prescribed aerosols for CAM4
3. Results from a Permian/Triassic (P/T) sensitivity test isolating aerosol impacts alone
4. Results from a P/T CCSM4 test case

REVIEW

CCM3:

Globally uniform, visible optical depth, TAUVIS

CAM2:

Globally uniform, visible optical depth, TAUVIS

CAM3:

Modern

Climatological and spatially distributed forcing data for aerosols (sulfate, sea salt, dust, carbons)

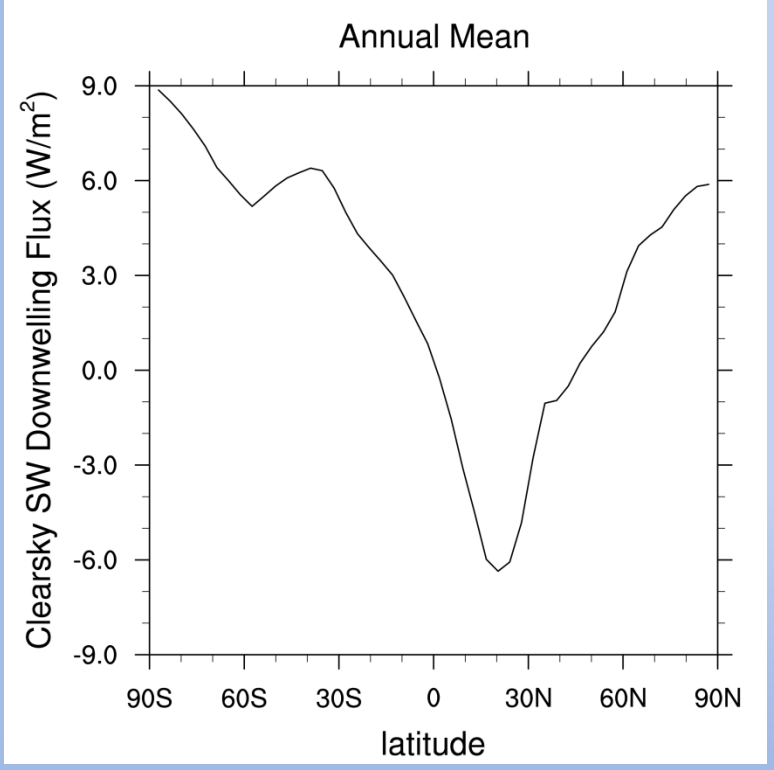
Paleo

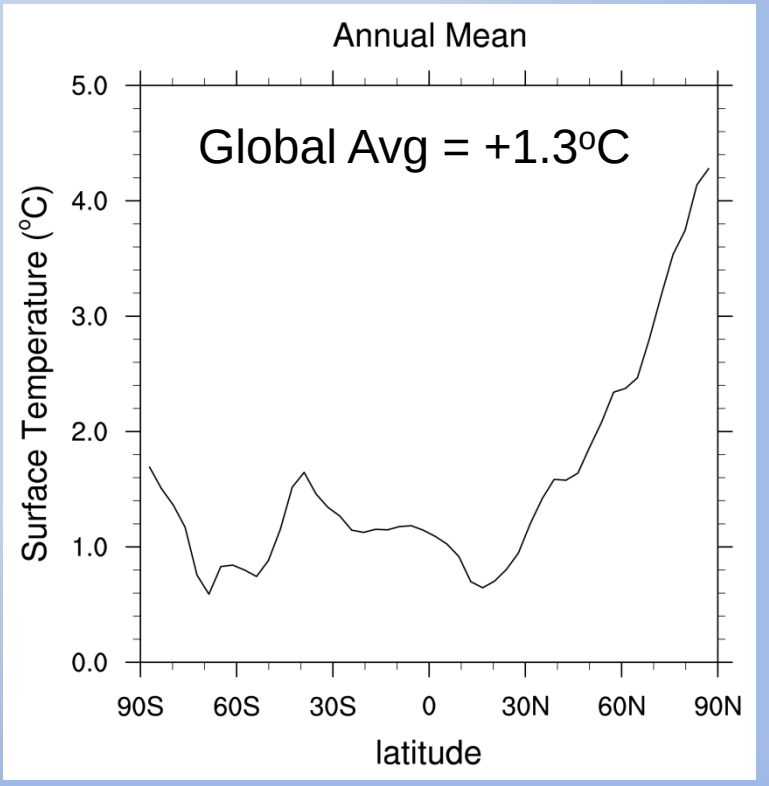
Globally uniform, aerosol optical depth, TAUBACK

REVIEW

CCSM3 impact of switch from TAUVIS/TAUBACK to prescribed aerosols for modern world…

Spatial - TAUBACK





REVIEW and PREVIEW

CAM4:

Modern and Paleo

Climatological and spatially distributed forcing data for aerosols (sulfate, sea salt, dust, carbons), aerosol deposition on snow and ice included.

CAM5:

Modern

Predictive aerosols

Paleo

Prescribed aerosol option, CAM4 treatment

CAM4 PROCEDURE

1. Run CAM4/CCSM4 with bulk aerosols (BAM) instead of default prescribed aerosols

   a. Create new, required BAM forcing files

   b. Generates geography-specific aerosols including dust and sea salt, primary aerosols for paleo periods.

2. Create CAM4 prescribed aerosol radiative forcing file from BAM output.

3. Create CAM4 prescribed aerosol deposition forcing file from BAM output.

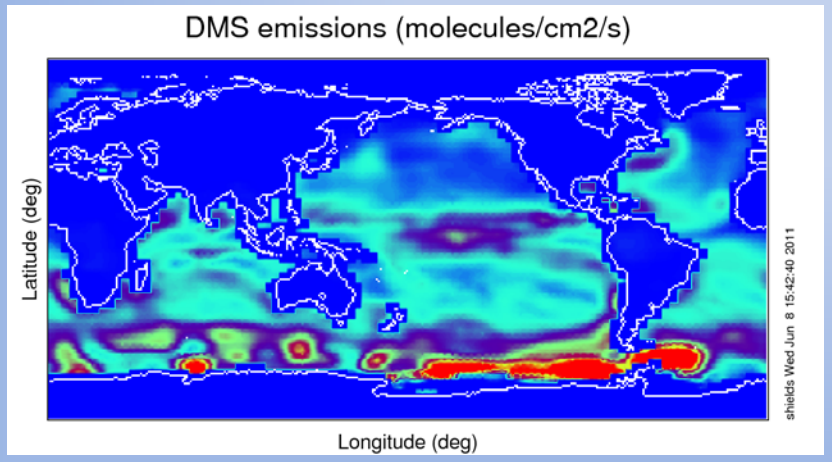
PROCEDURE: New BAM forcing files

Oxides, dust, SO_2, SO_4, black carbon, organic carbon, and DMS.

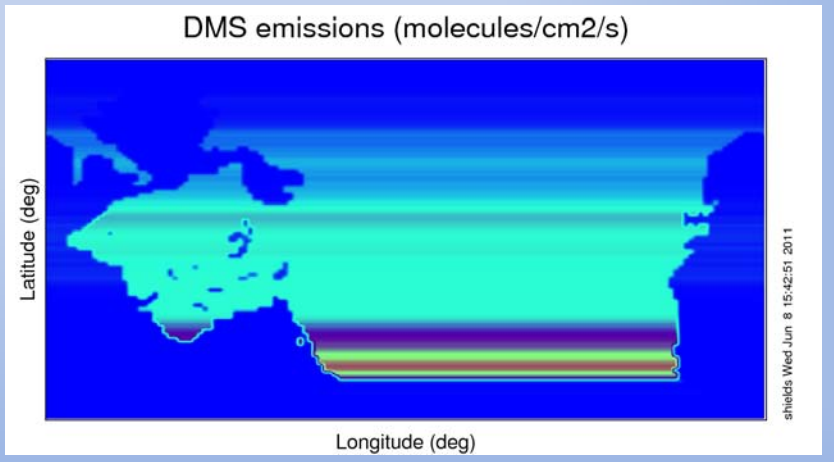
NCL scripts available: generic zonal average values for land and ocean assigned for natural, zero assigned for human-influenced.

Example DMS Forcing File:

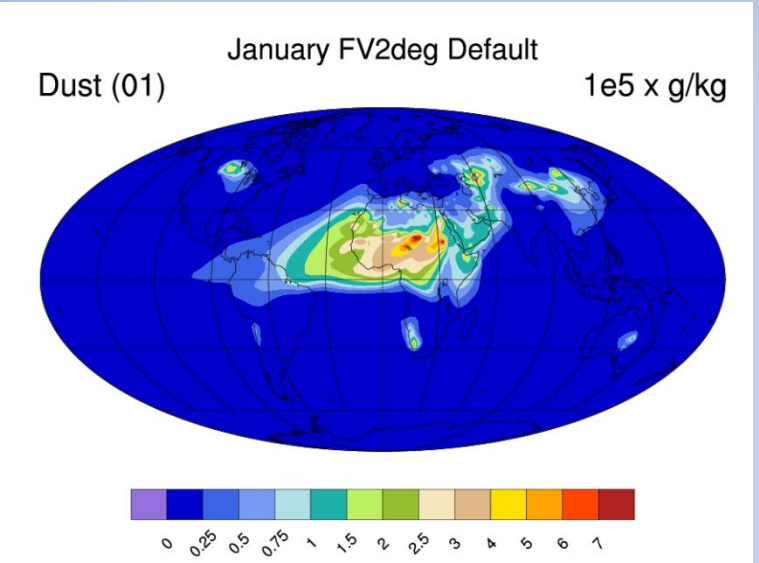
January Modern

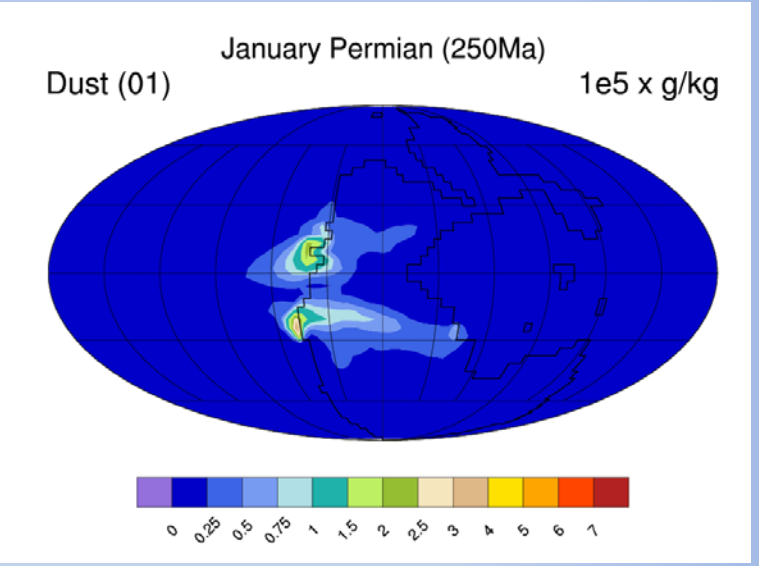


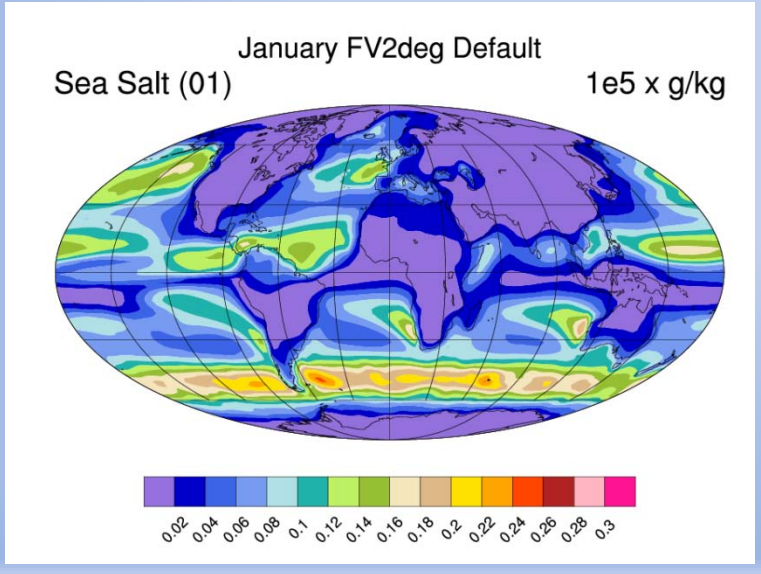
January P/T

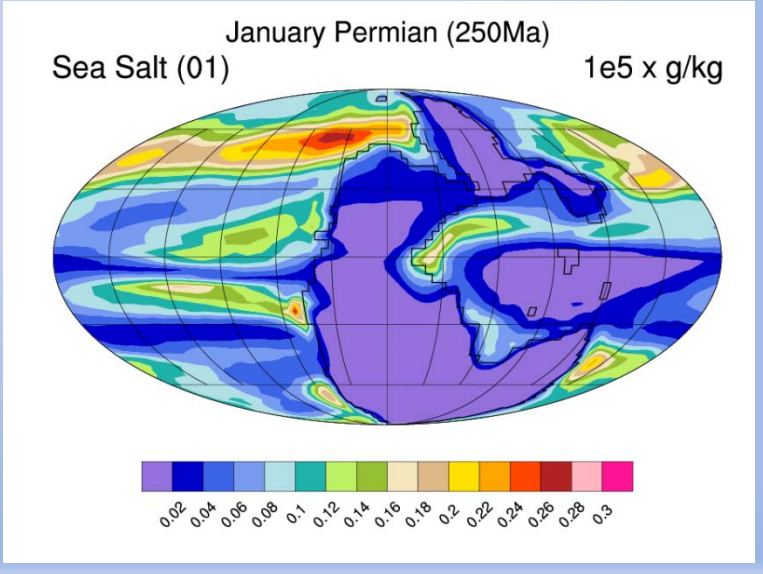


PROCEDURE: Example from Prescribed Aerosol Forcing File









Sensitivity Description

Model: CCSM3

Branch and Reference: P/T CCSM3 (Kiehl and Shields 2005)

Method:

N.Heavens (Cornell) retrofitted CAM4 P/T prescribed aerosols into CCSM3 to test aerosol sensitivity

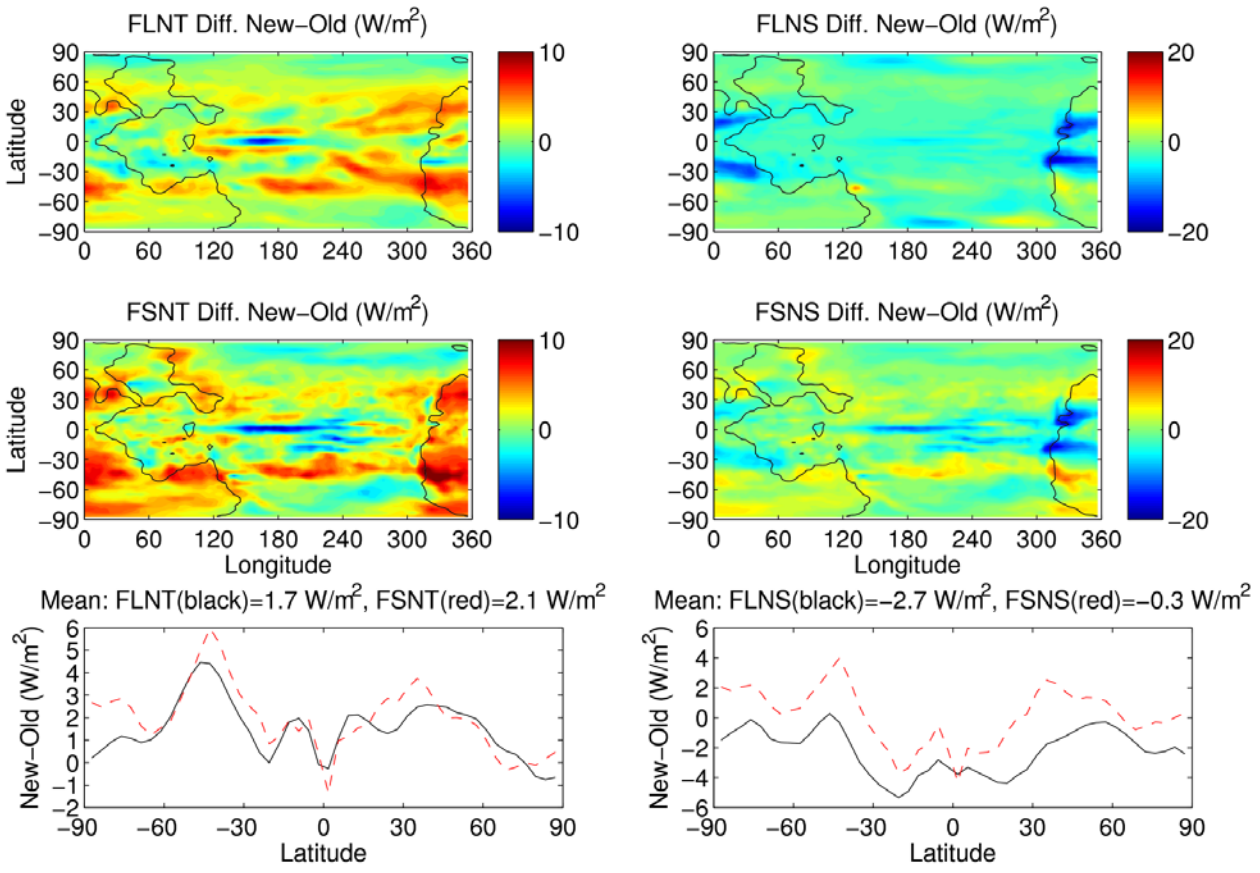
Control ("OLD"):

CCSM3 P/T branch from Kiehl/Shields case
TAUBACK ON, 100 years

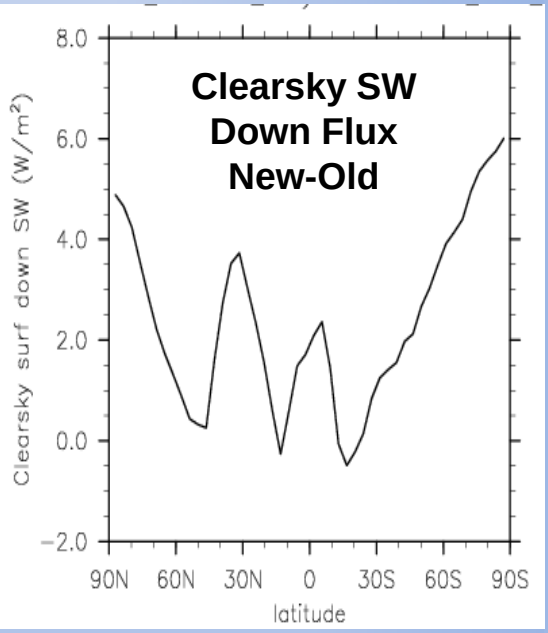
Sensitivity ("NEW"):

CCSM3 P/T retrofitted with CAM4 P/T aerosol data,
TAUBACK OFF, 100 years

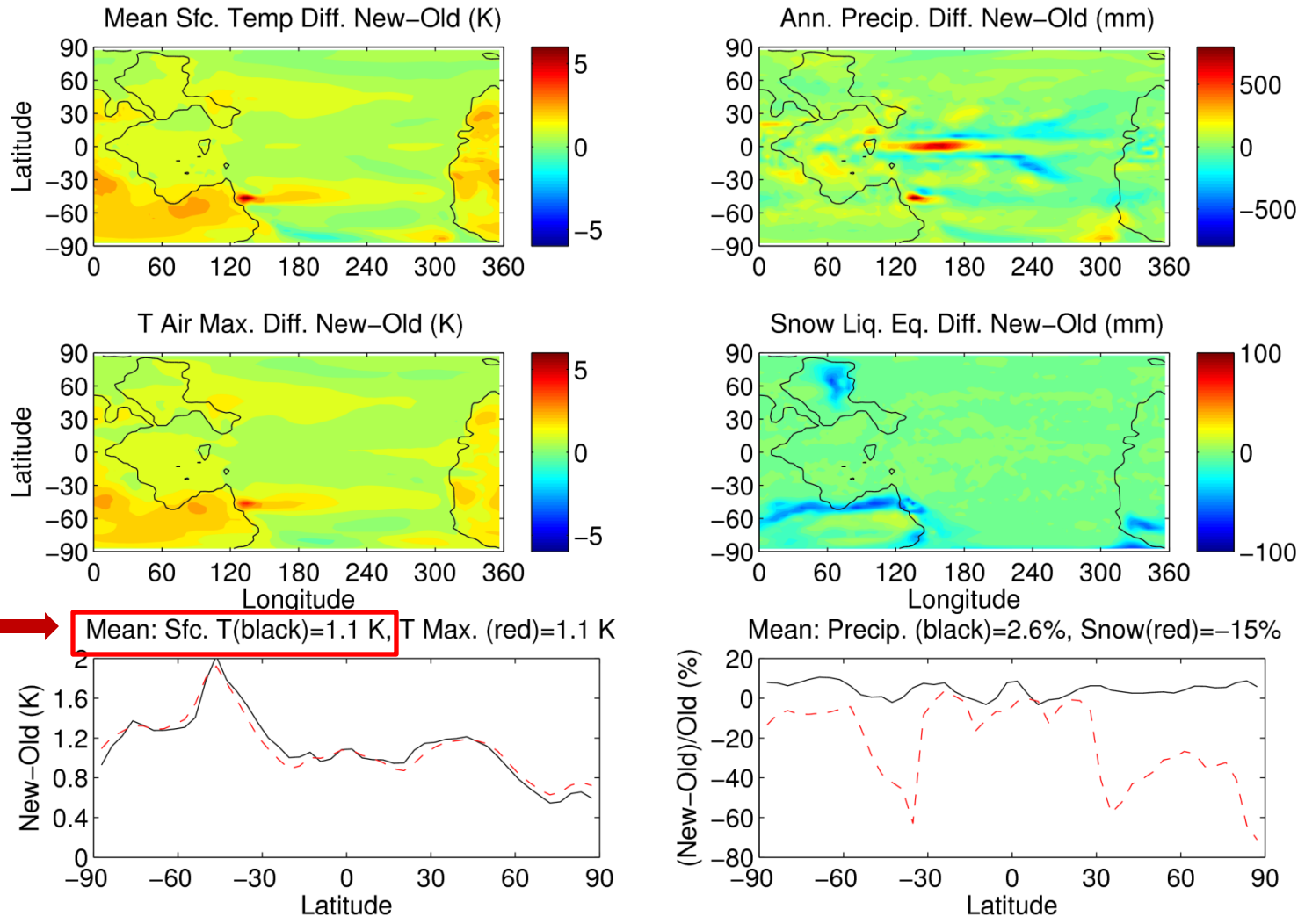
Sensitivity Results



(Courtesy N.Heavens)



Sensitivity Results



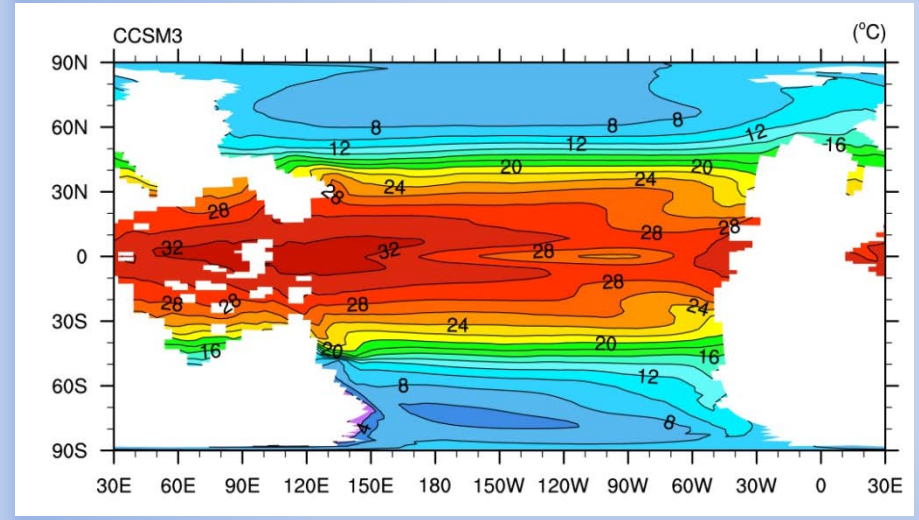
(Courtesy N.Heavens)

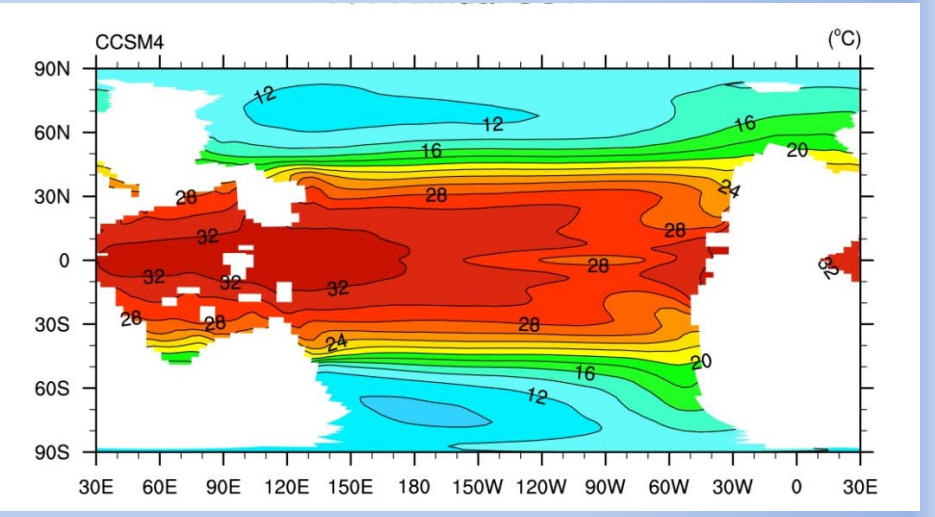
CCSM4 P/T Results

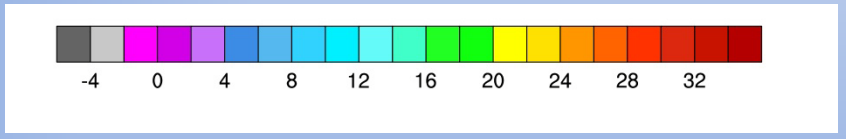
CCSM3: P/T Kiehl/Shields, 2700yr run, fully equilibriated, [last 100 yrs]

CCSM4: P/T Test case (w/prescribed aerosols), 260yr run, [last 50 yrs]

Annual SST







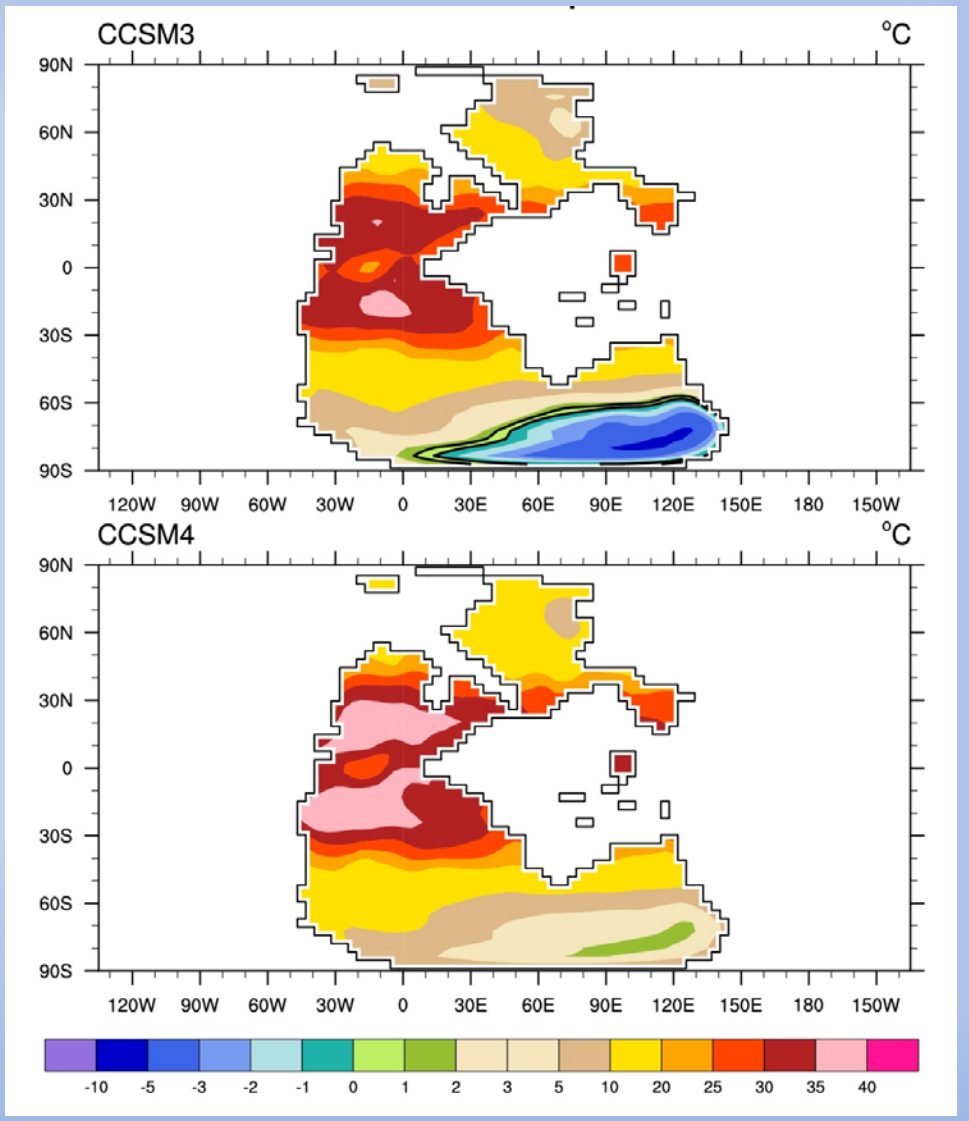
Global Avg CCSM4-CCSM3 SST Difference
2.4°C

CCSM4 P/T Results

Annual Continental Surface Air Temperature

Global Average CCSM4-CCSM3 Land-Only Difference 3.8°C

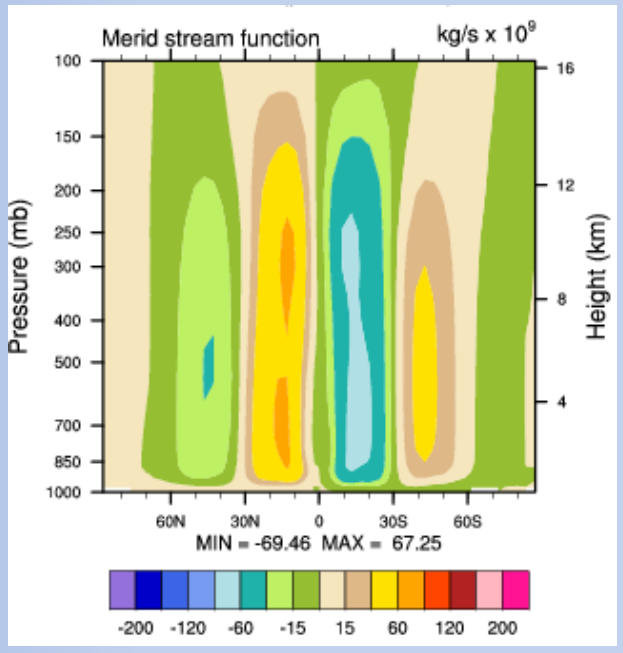
Global Average CCSM4-CCSM3 TREFHT (ocean+land) Difference 2.8°C

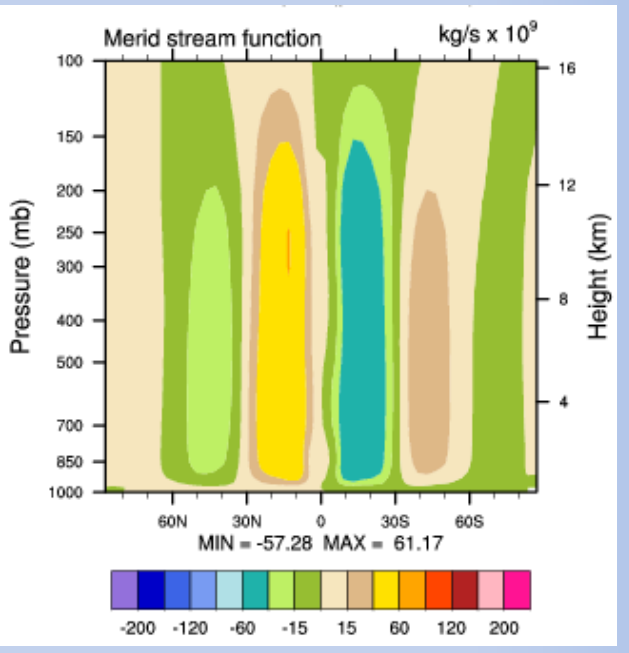


CCSM4 P/T Results

Annual
Atmospheric Meridional Streamfunction

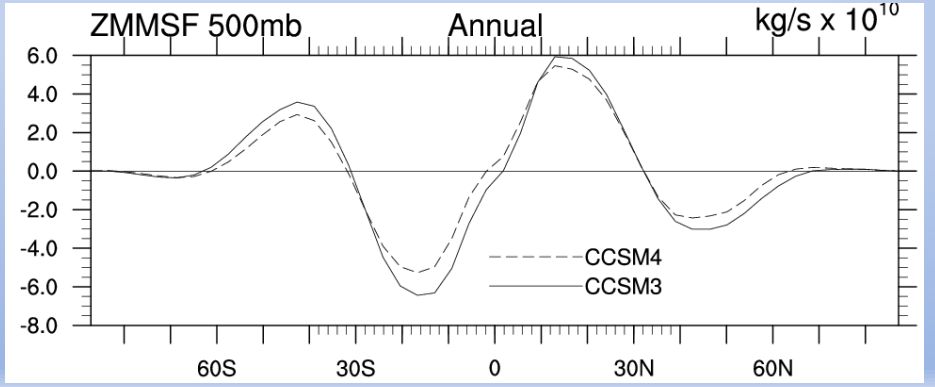
CCSM3





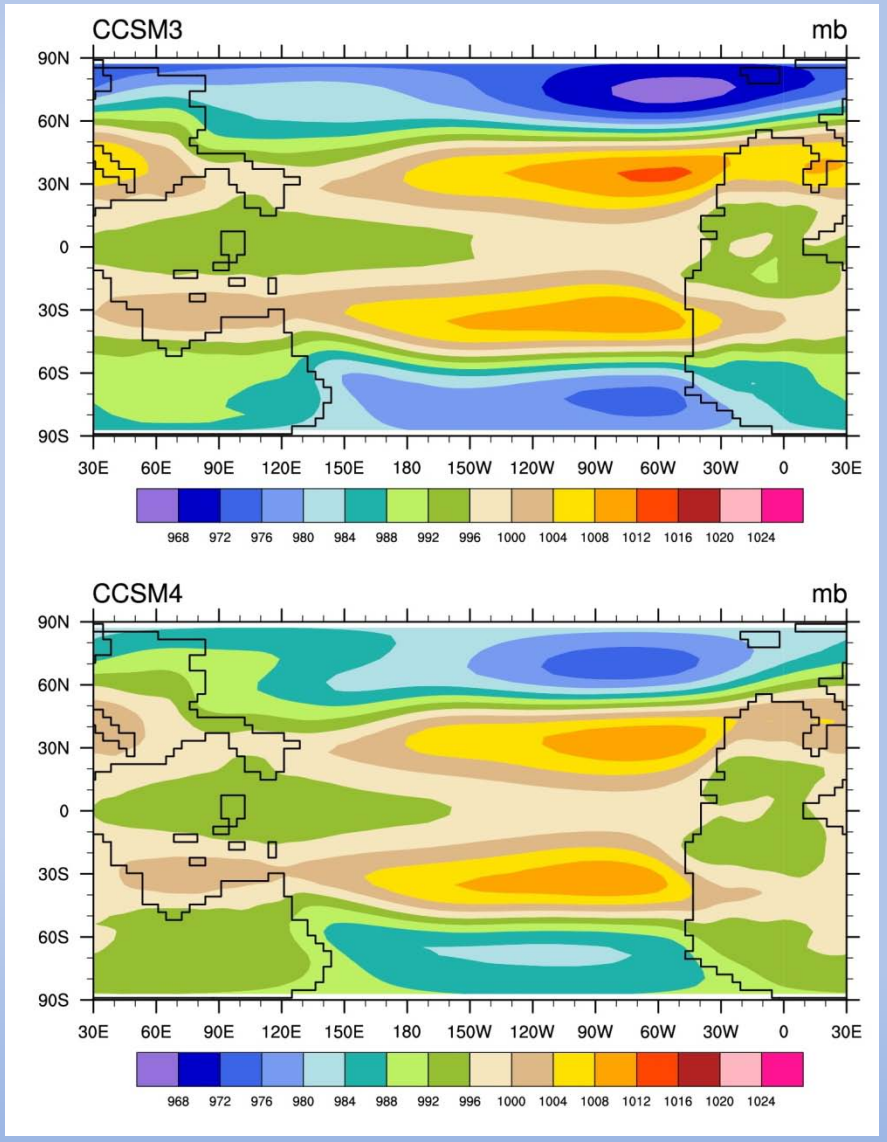
CCSM4

500mb cross-section



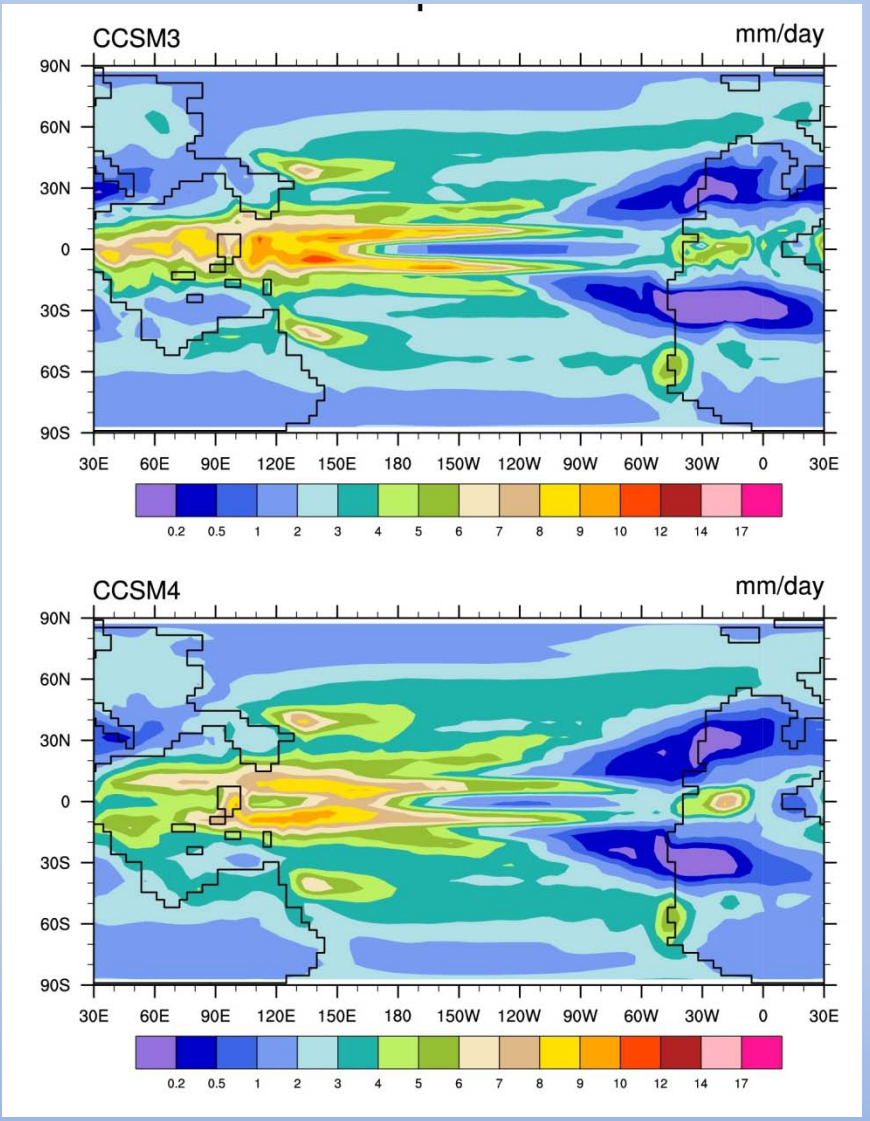
CCSM4 P/T Results

Annual Sea Level Pressure



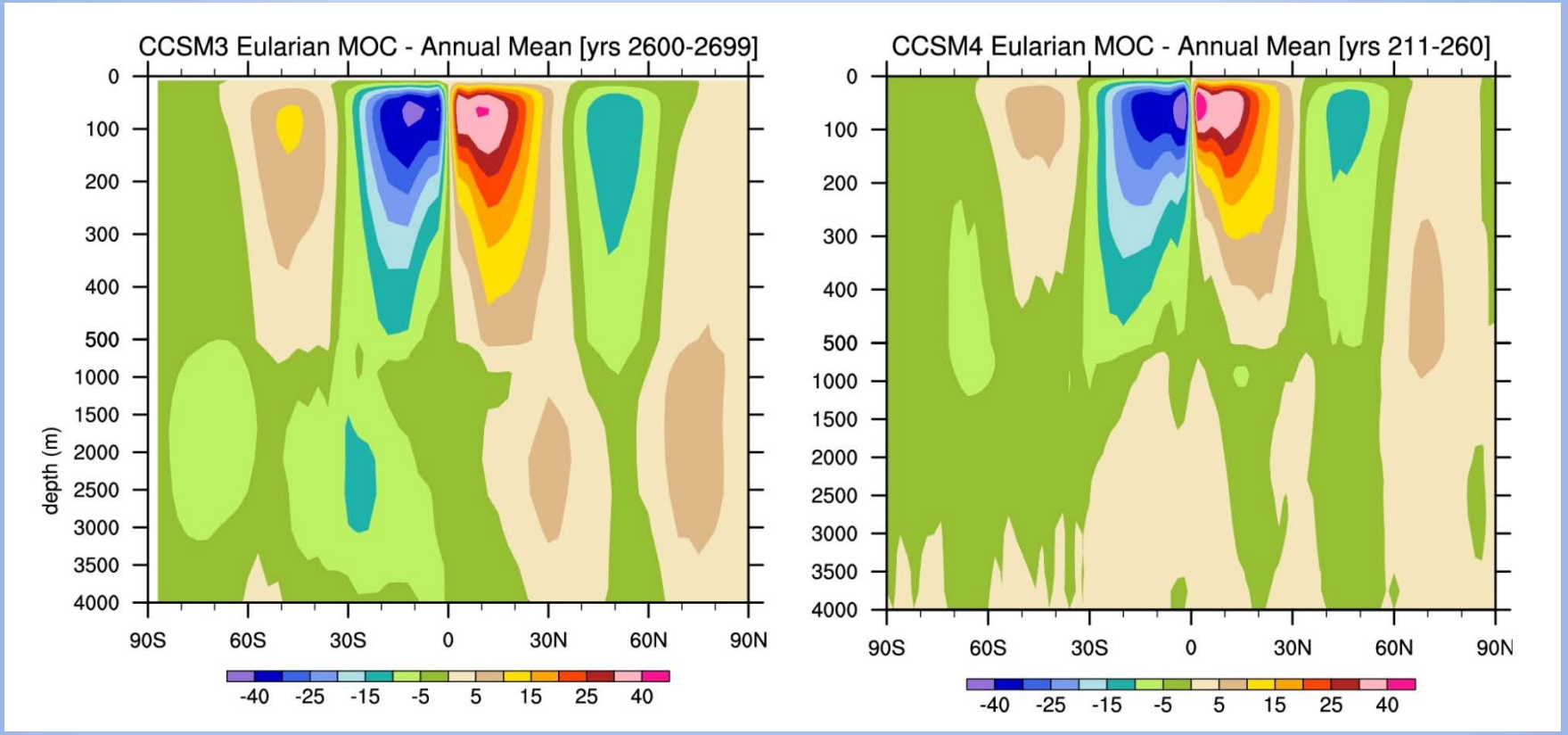
CCSM4 P/T Results

Annual Precipitation Rate



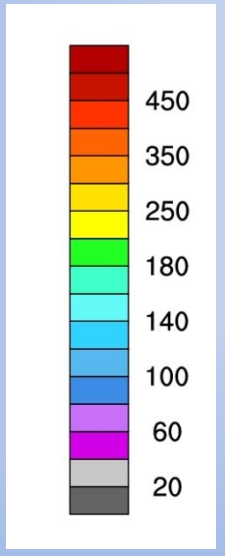
CCSM4 P/T Results

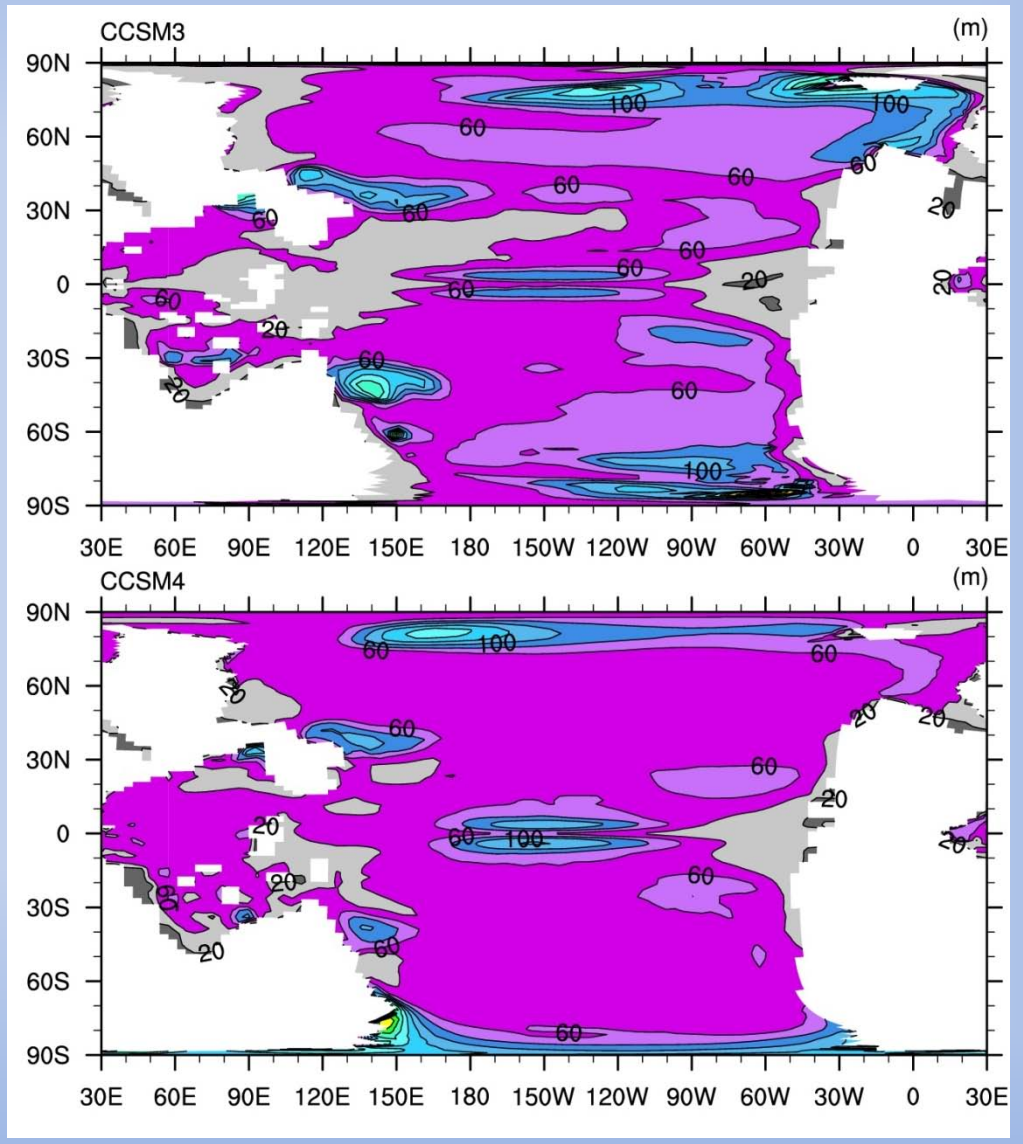
Annual
Global Ocean Meridional Overturning Circulation



CCSM4 P/T Results

Annual Ocean Mixed Layer Depth





Summary

1. A new technique to define aerosols for user-specified geography now developed for CAM4/CCSM4.

2. Implementing the new method has shown to be a positive forcing for a CCSM3 Permian sensitivity case. (Consistent with modern sensitivity case). Surface temperature ~1°C warmer with temporally and spatially varying aerosols.

3. A CCSM4 coupled P/T experiment implementing the new method was completed.

4. CCSM4 P/T is much warmer than CCSM3. This is likely due to a combination of aerosols (~1°C) and improvements in land and ocean components of the model.

Thank You