

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)

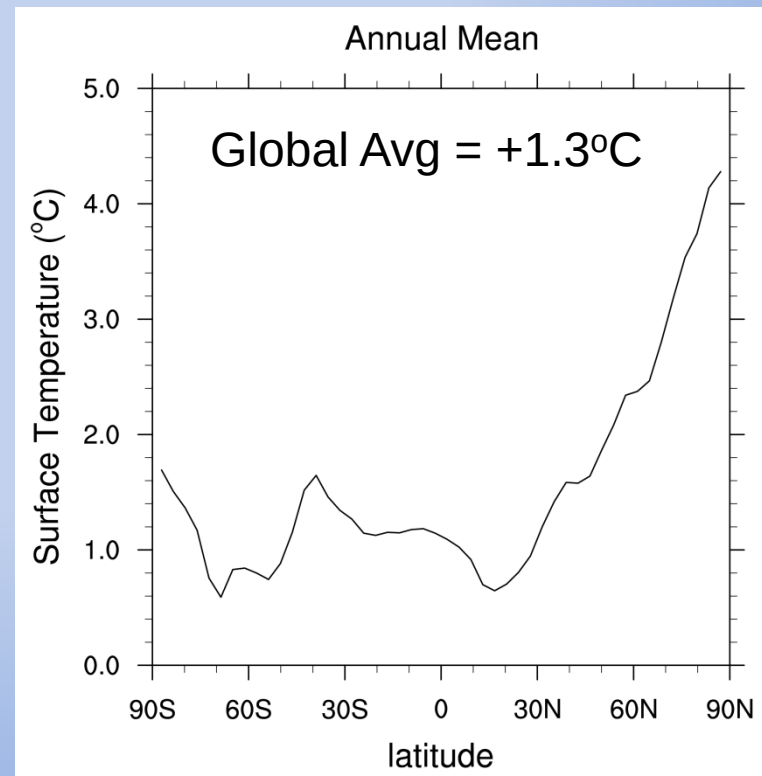
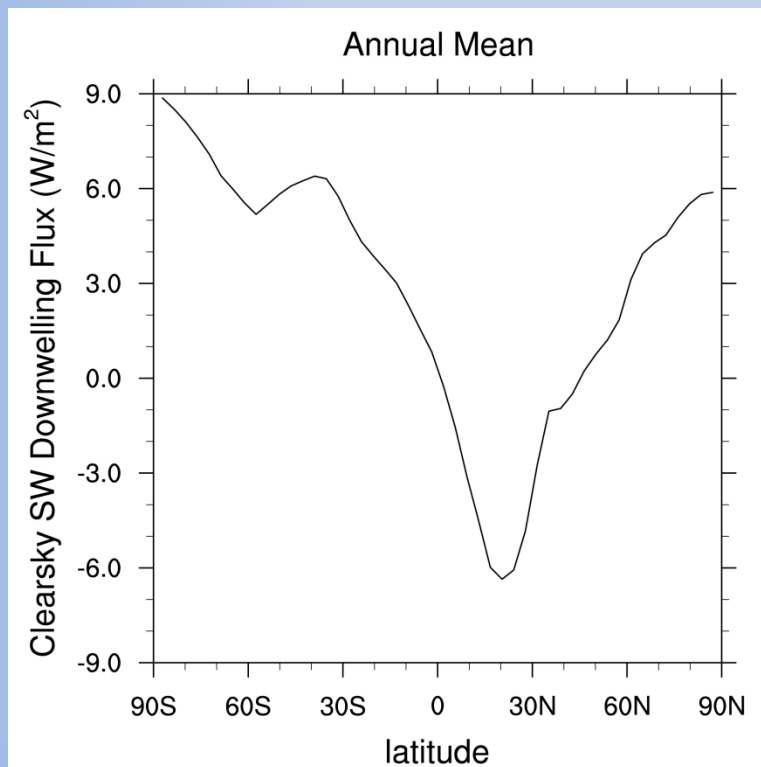
Paleo

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

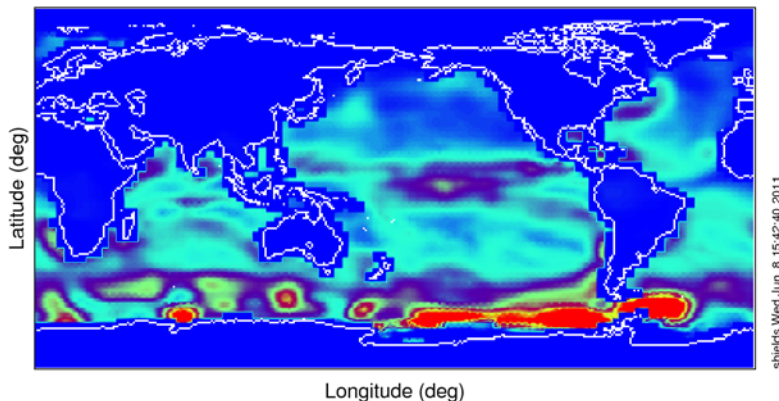
Oxides, dust, SO_2 , SO_4 , black carbon, organic carbon, and DMS.

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

Example DMS Forcing File:

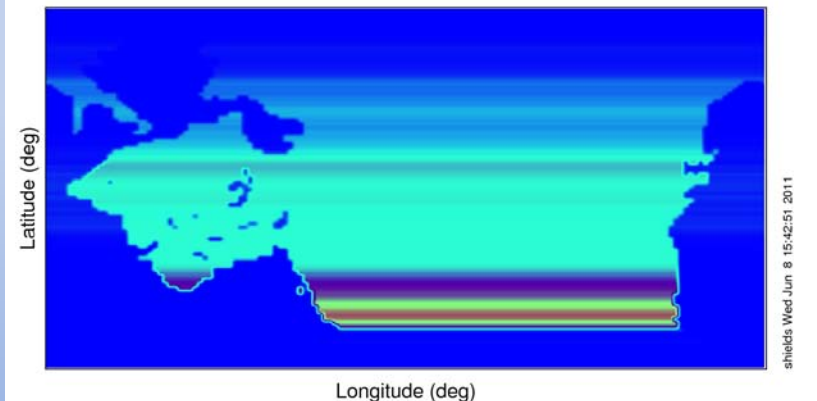
January Modern

DMS emissions (molecules/cm²/s)



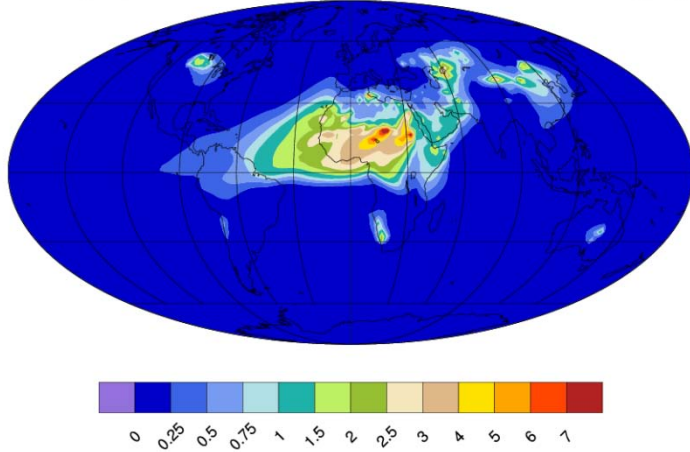
January P/T

DMS emissions (molecules/cm²/s)

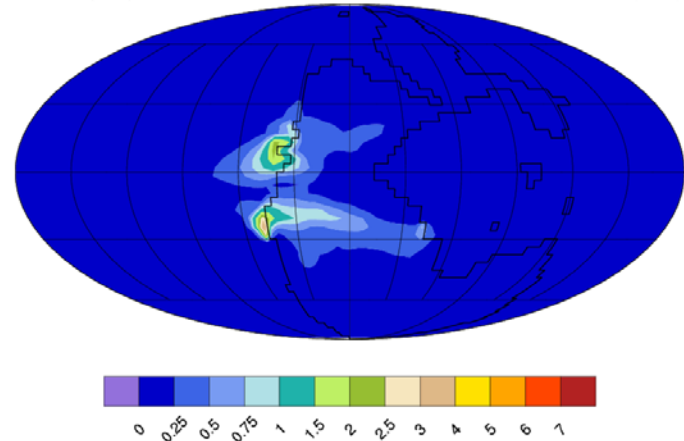


PROCEDURE: Example from Prescribed Aerosol Forcing File

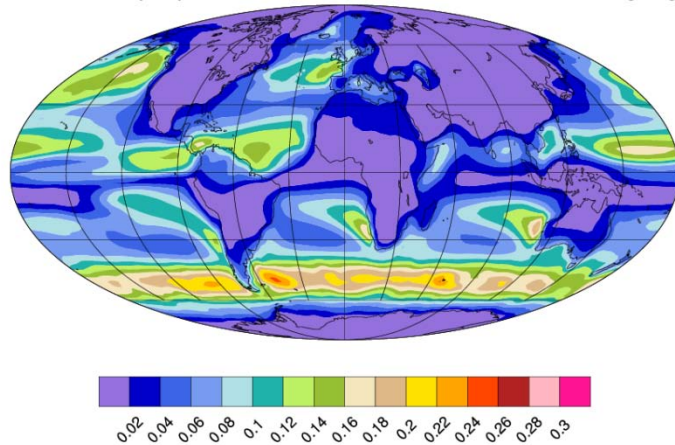
January FV2deg Default
Dust (01) $1e5 \times \text{g/kg}$



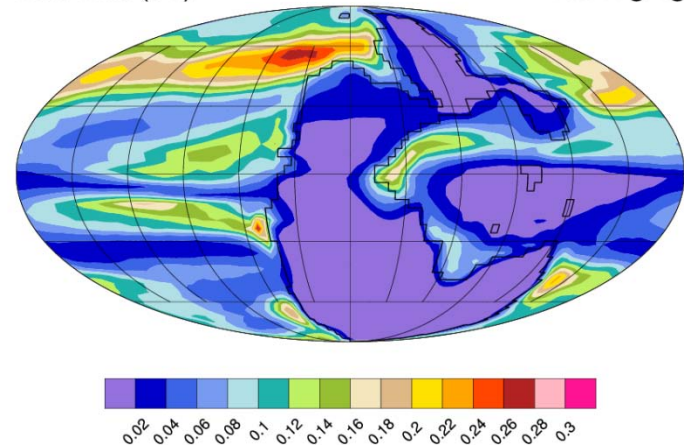
January Permian (250Ma)
Dust (01) $1e5 \times \text{g/kg}$



January FV2deg Default
Sea Salt (01) $1e5 \times \text{g/kg}$



January Permian (250Ma)
Sea Salt (01) $1e5 \times \text{g/kg}$



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

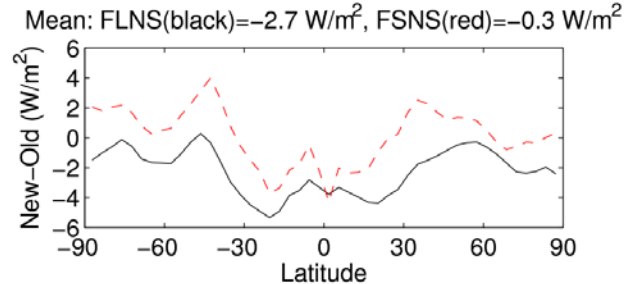
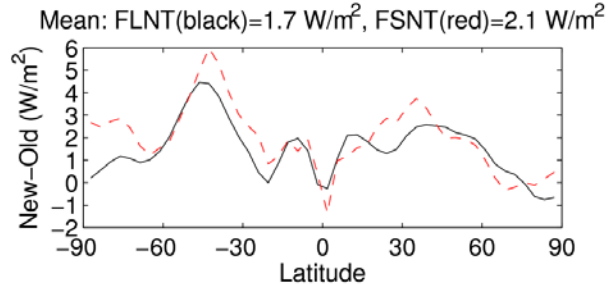
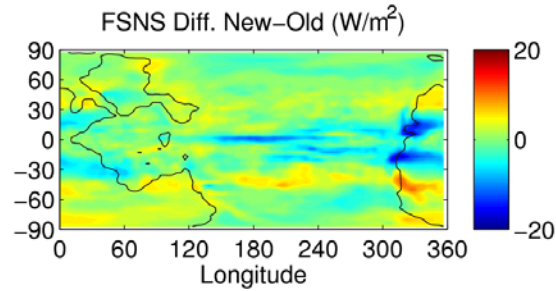
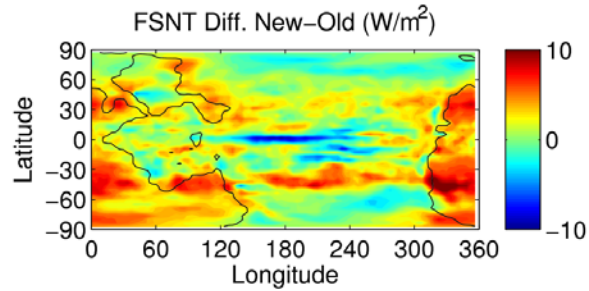
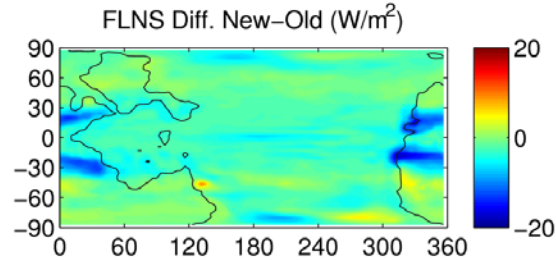
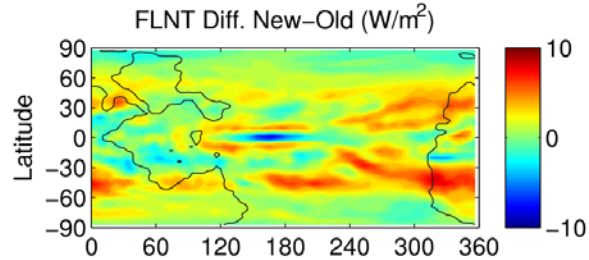
Control (“OLD”):

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

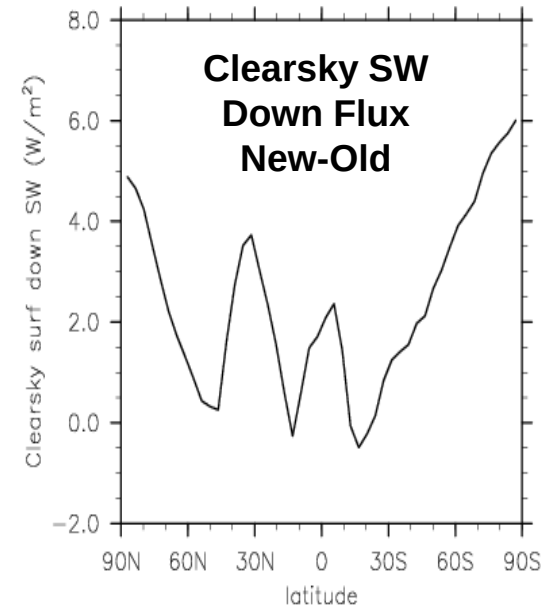
Sensitivity (“NEW”):

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

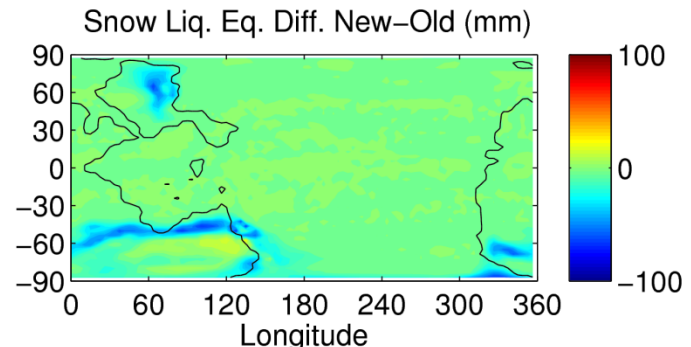
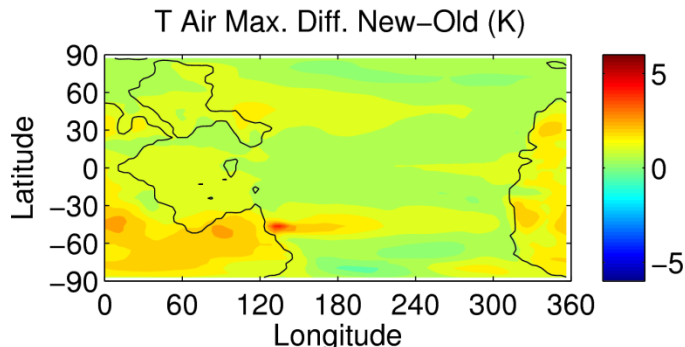
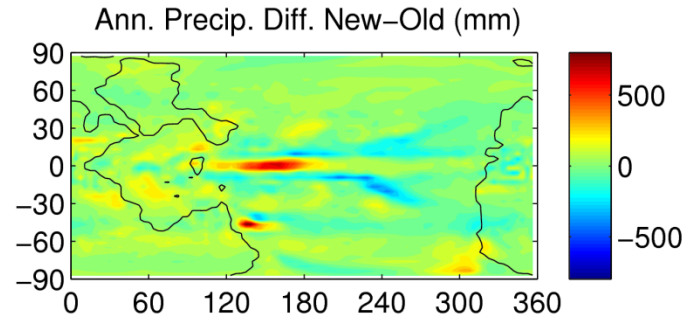
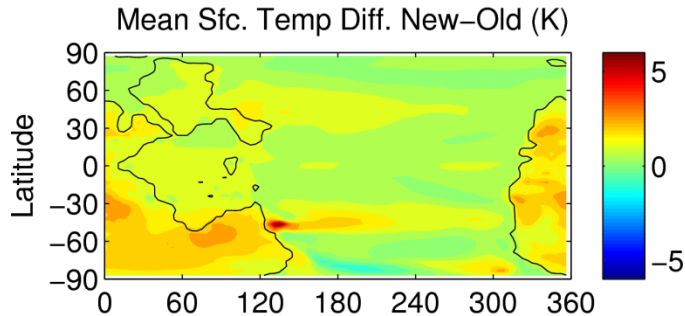
Sensitivity Results



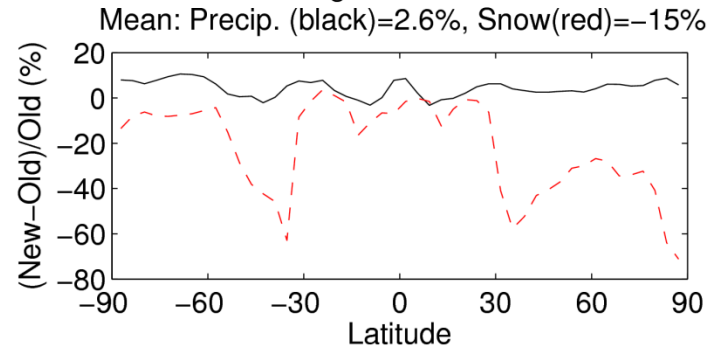
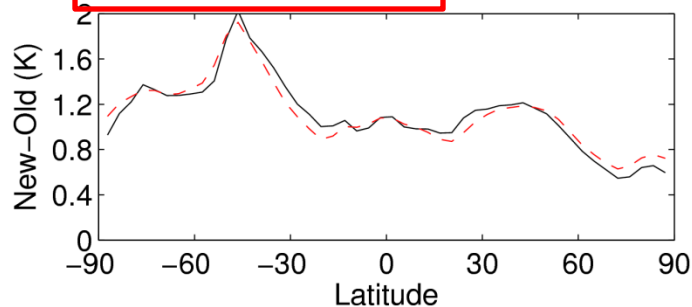
(Courtesy N.Heavens)



Sensitivity Results



Mean: Sfc. T(black)=1.1 K, T Max. (red)=1.1 K



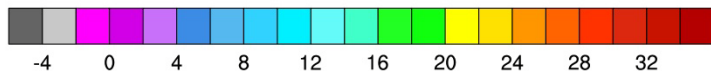
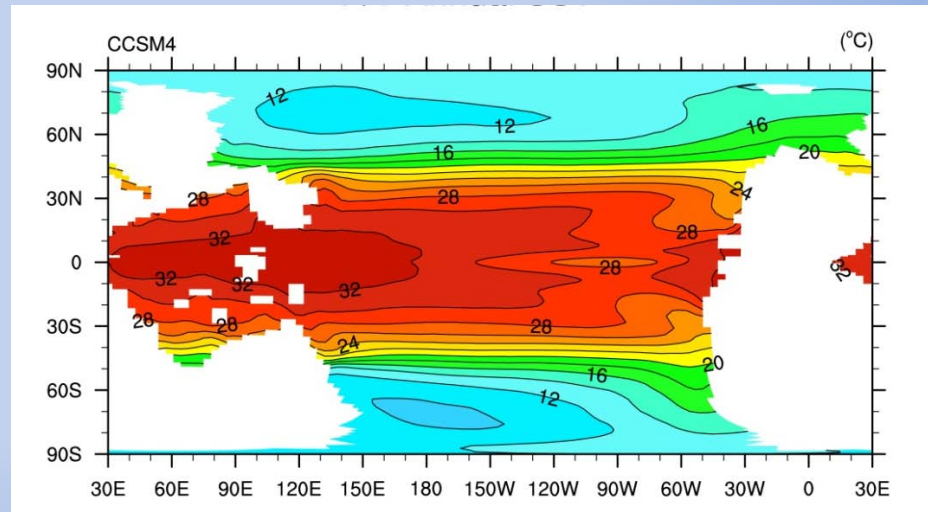
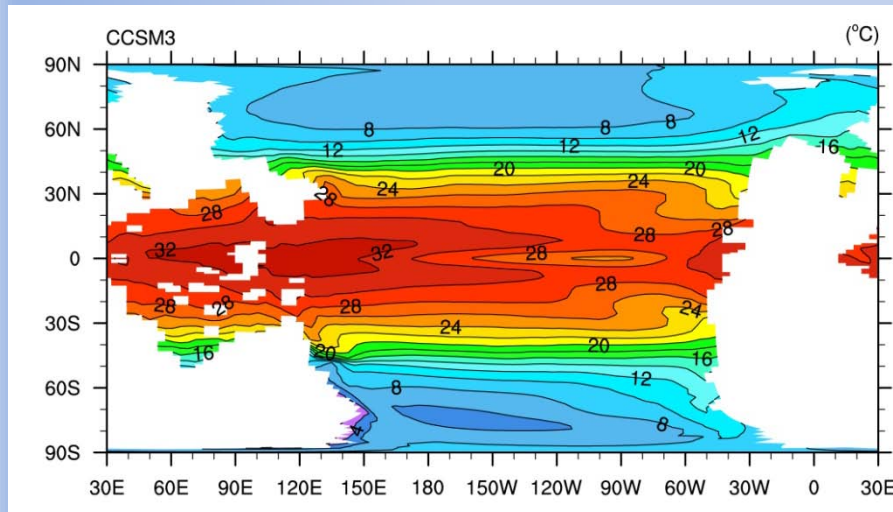
(Courtesy N.Heavens)

CCSM4 P/T Results

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

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

Annual SST



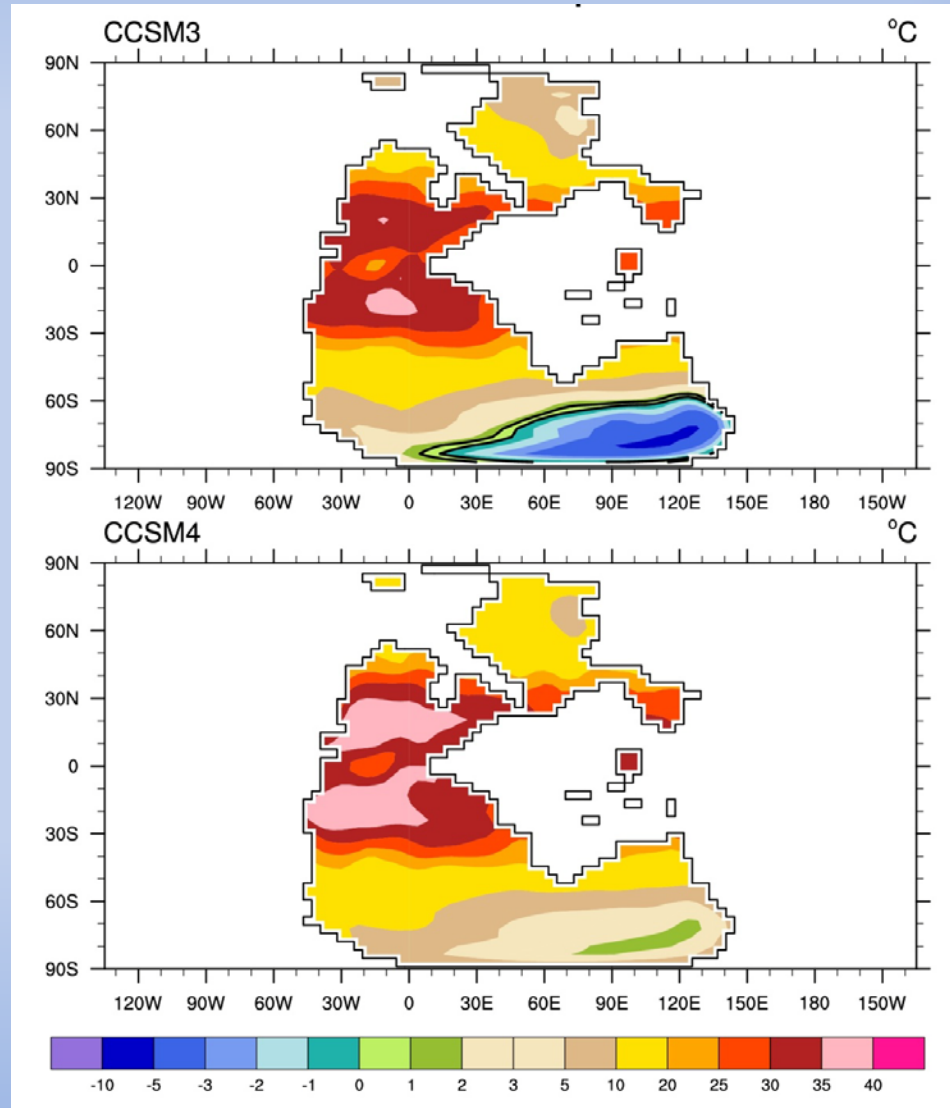
Global Avg CCSM4-CCSM3 SST Difference
2.4°C

CCSM4 P/T Results

Annual Continental Surface Air Temperature

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

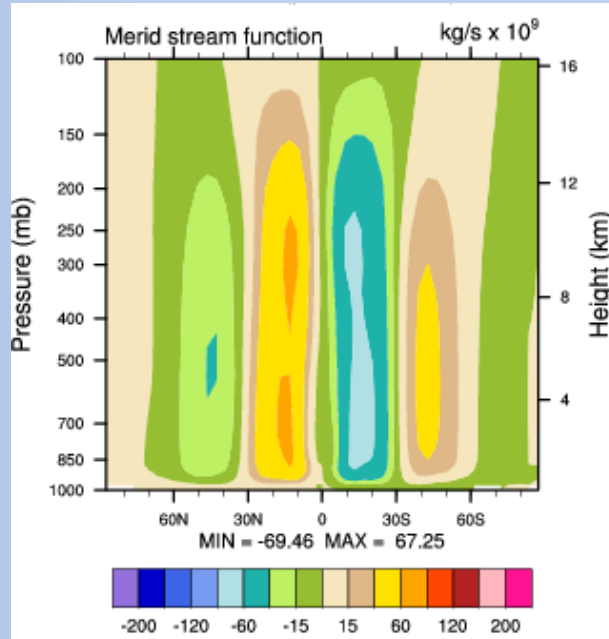
Global Average
CCSM4-CCSM3
TREFHT
(ocean+land)
Difference
2.8°C



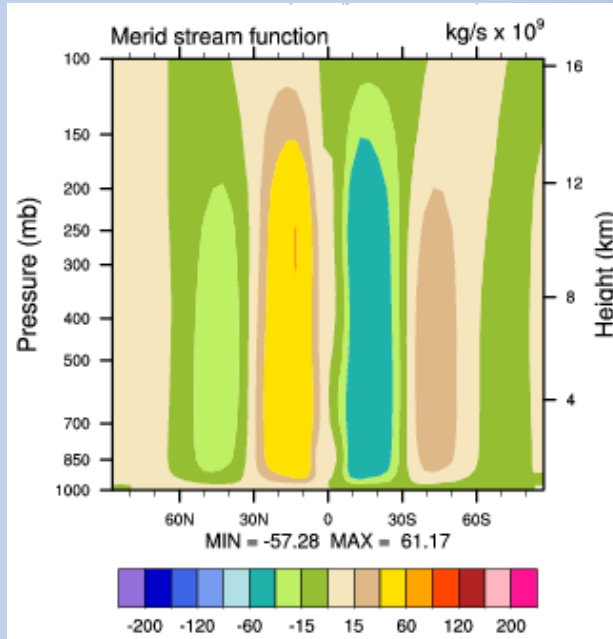
CCSM4 P/T Results

Annual Atmospheric Meridional Streamfunction

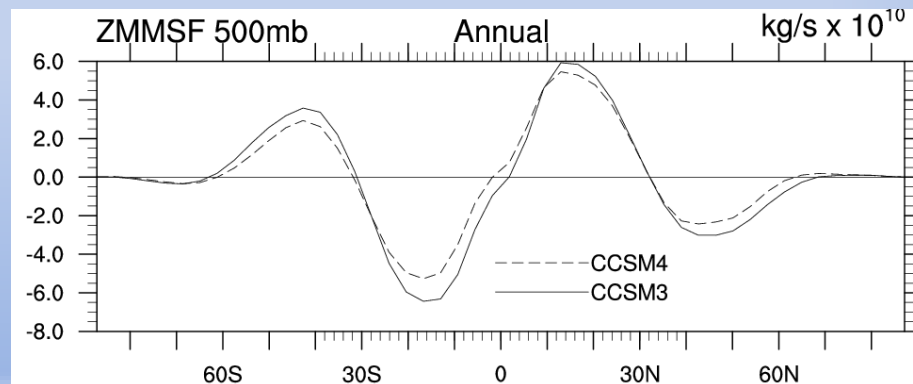
CCSM3



CCSM4

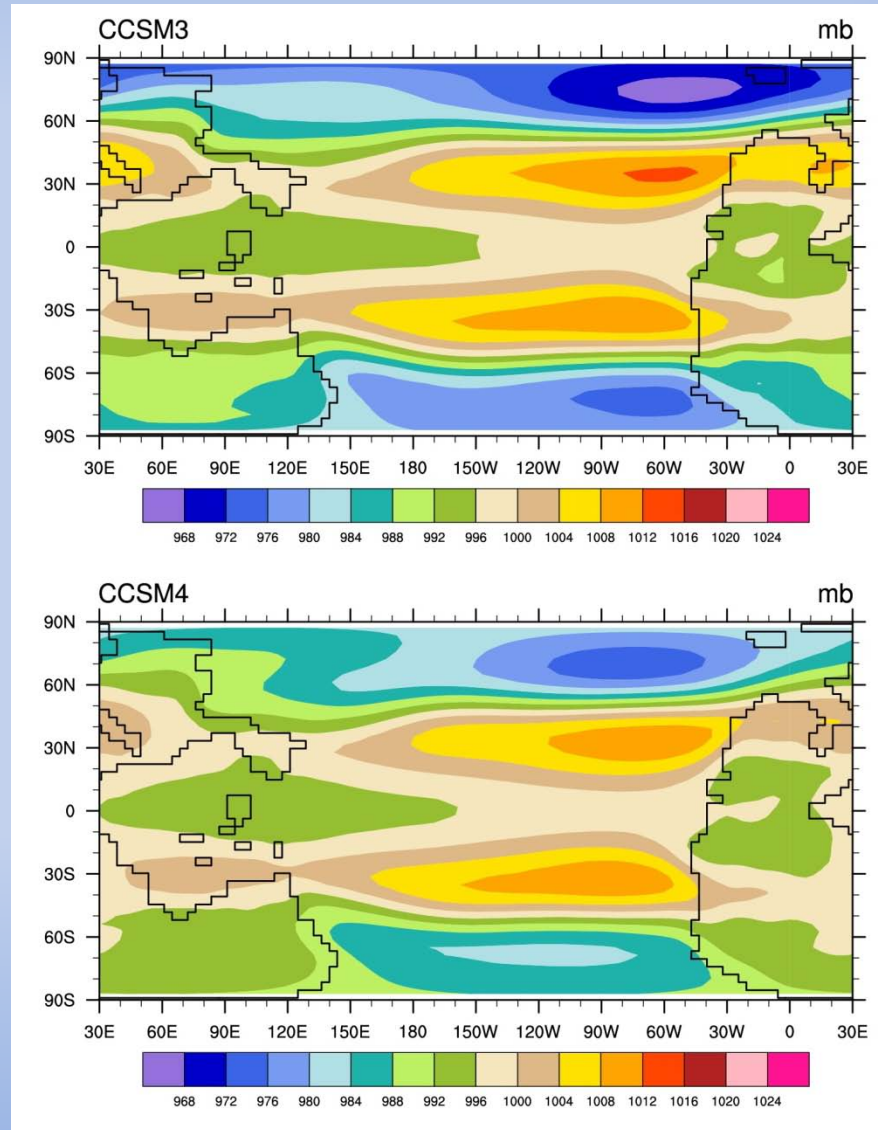


500mb
cross-
section



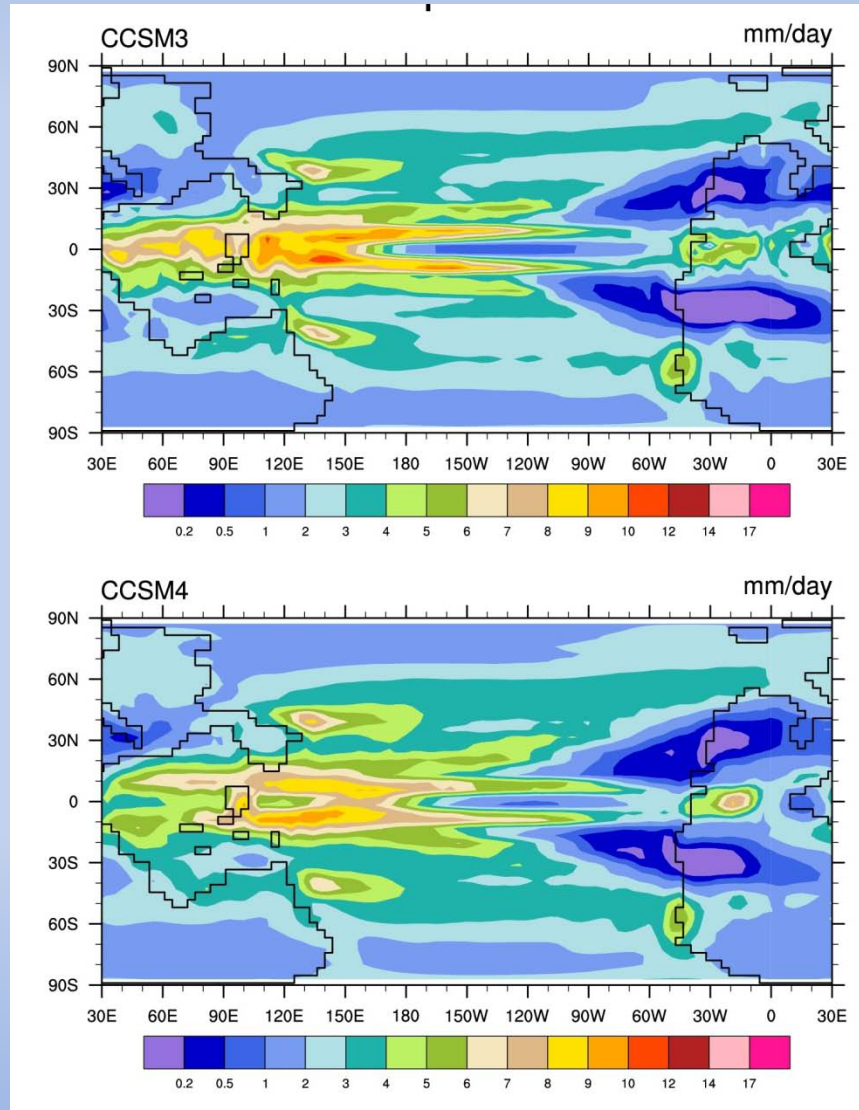
CCSM4 P/T Results

Annual
Sea
Level
Pressure



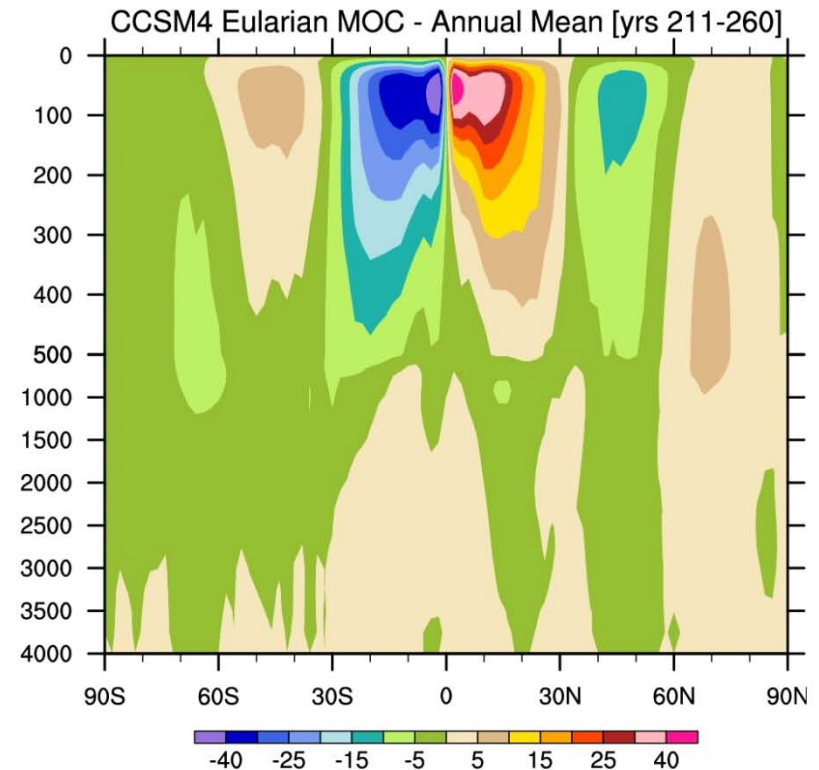
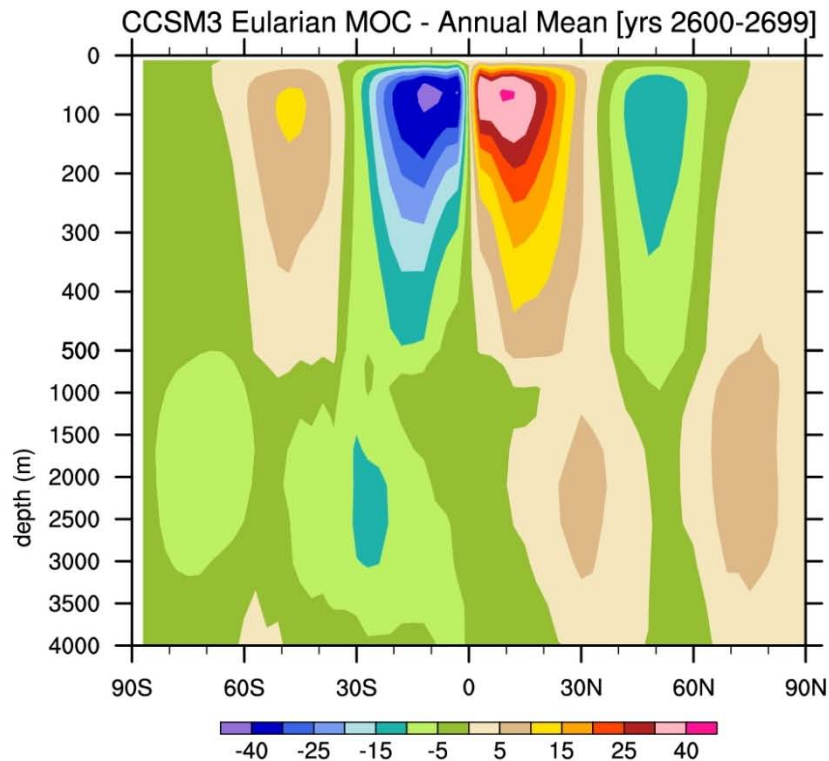
CCSM4 P/T Results

**Annual
Precipitation
Rate**



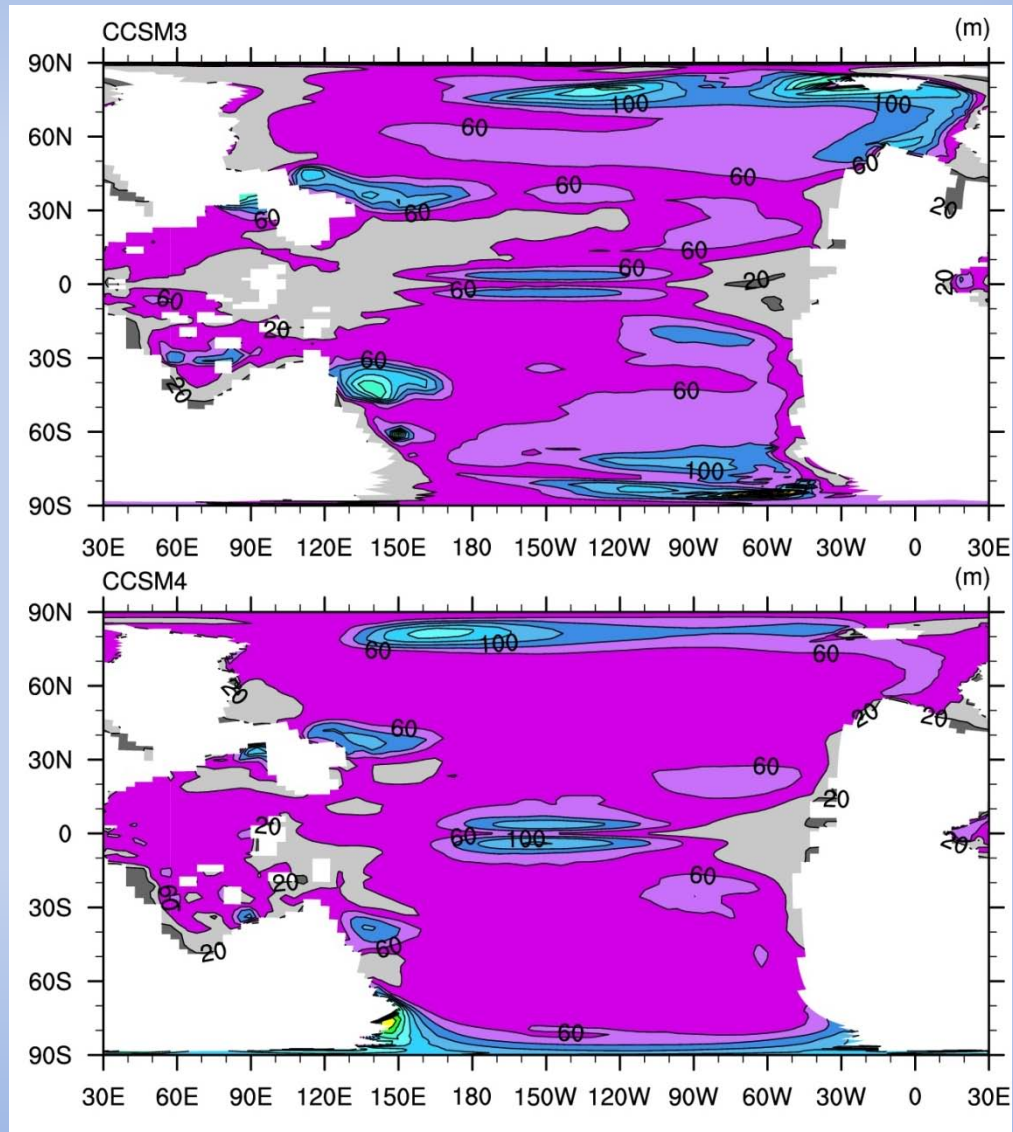
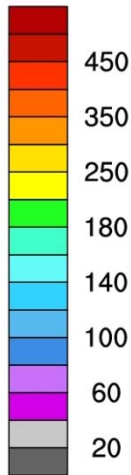
CCSM4 P/T Results

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

