

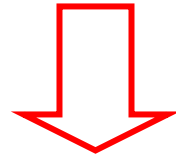
# Atmospheric Circulation Trends, 1950 - 2000: The Relative Roles of Sea Surface Temperature and Atmospheric Radiative Forcing

Clara Deser and Adam Phillips

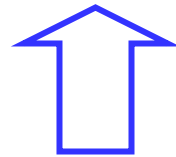
CVWG meeting, CCSM Workshop, June 20 2007

# *Atmospheric Radiative Forcing*

*(Greenhouse Gases, Ozone, Volcanic and Sulfate Aerosols, Solar Output)*



**ATMOSPHERIC CIRCULATION**

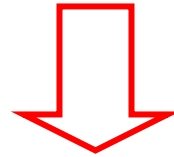


*Sea Surface Temperature/Sea Ice Forcing*

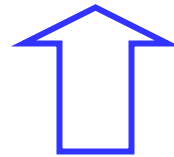
*Note: Both forcing agents contain natural and anthropogenic components*

# *Atmospheric Radiative Forcing*

*(Greenhouse Gases, Ozone, Volcanic and Sulfate Aerosols, Solar Output)*



## **ATMOSPHERIC CIRCULATION**



*Sea Surface Temperature/Sea Ice Forcing*

### **Atmosphere-Only Model Runs (CAM3; CVWG Allocation)**

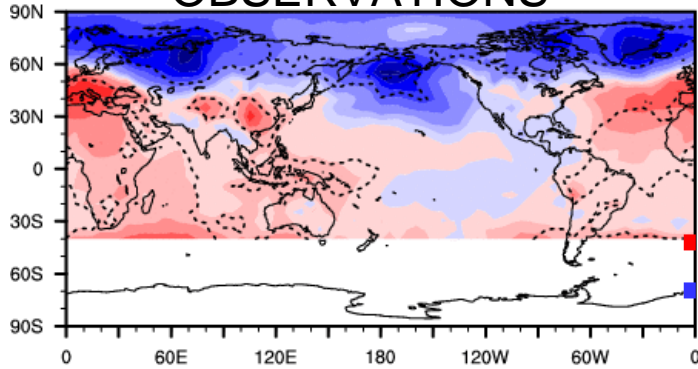
5 runs at T42 + 5 runs at T85, 1950-2000

Forced by:    1) *Global SST* + *Atmospheric Radiative Forcing*  
                  2) *Global SST*

# Sea Level Pressure Trend 1950-2000 DJF

## OBSERVATIONS

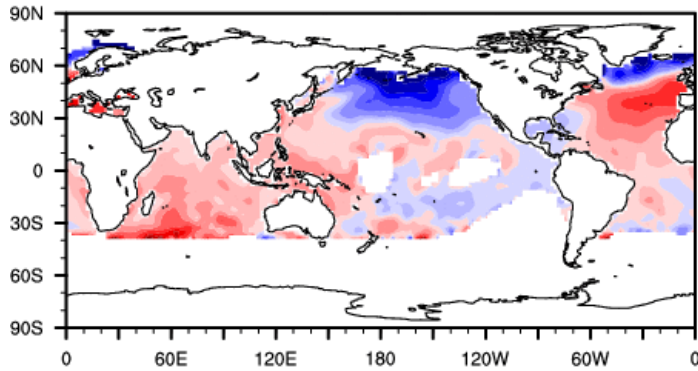
HadSLP2



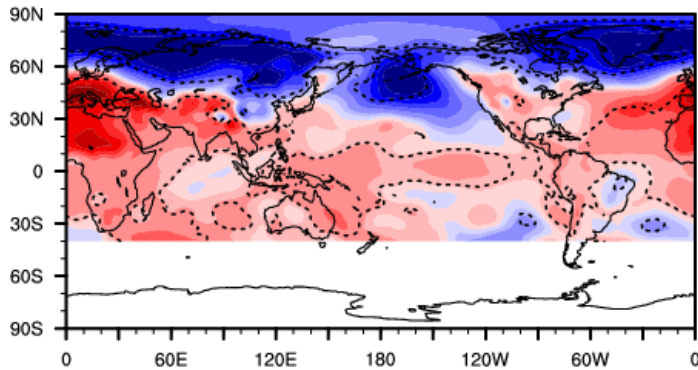
+1.9  
-2.9

6 station average 1957-2000  
(Marshall, J. Climate 2003)

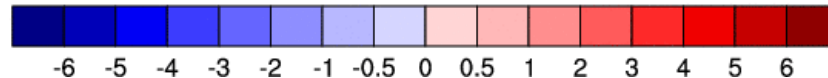
COADS



NCEP Reanalysis



- - - 95% significance



hPa per 51 years

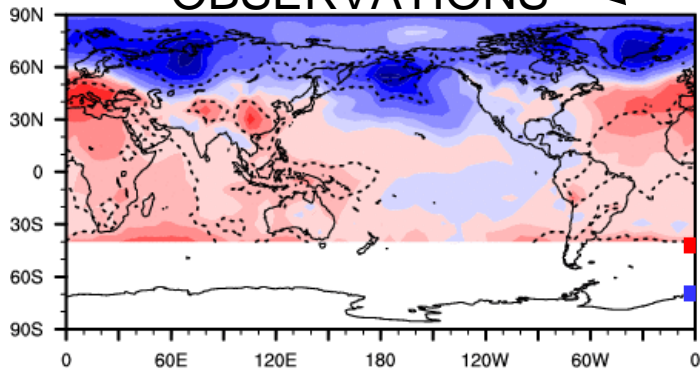
# Sea Level Pressure Trend 1950-2000 DJF

OBSERVATIONS

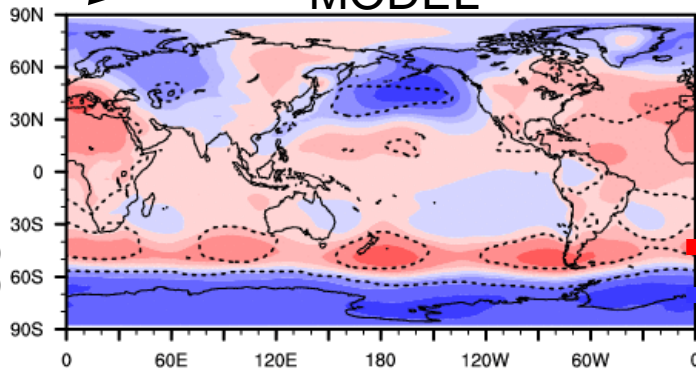
0.73

MODEL

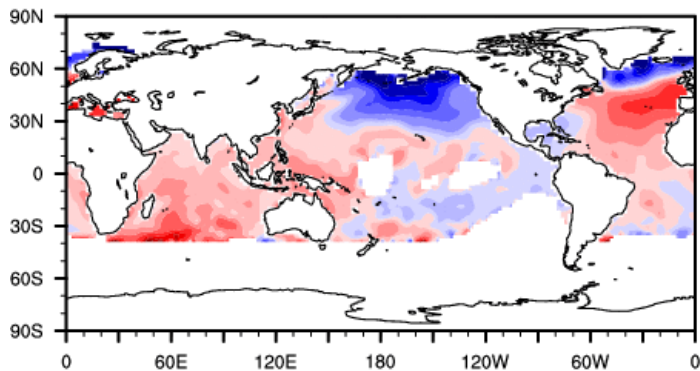
HadSLP2



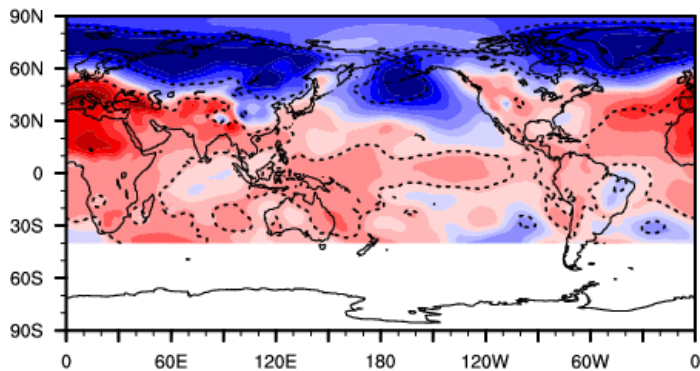
SST + ATM



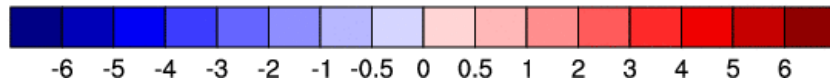
COADS



NCEP Reanalysis



- - - 95% significance



hPa per 51 years

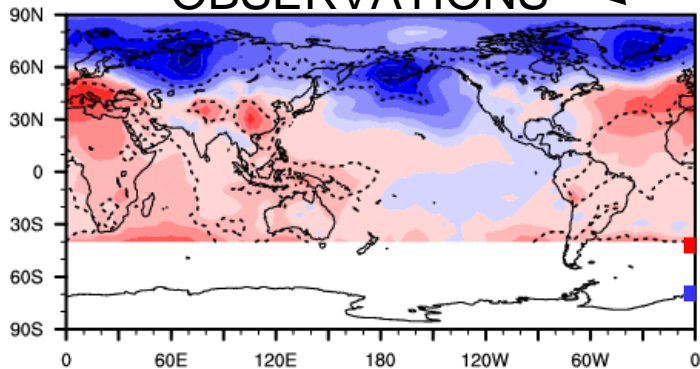
# Sea Level Pressure Trend 1950-2000 DJF

OBSERVATIONS

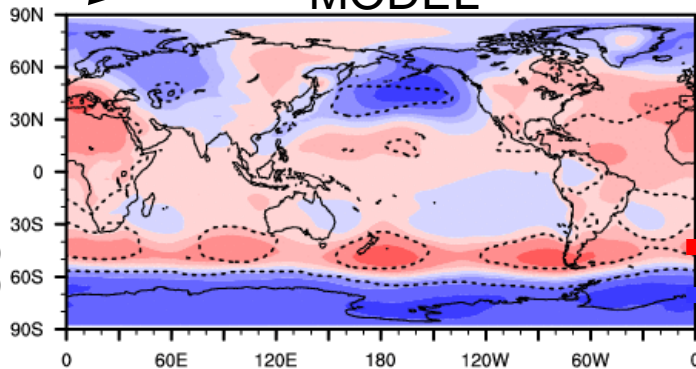
0.73

MODEL

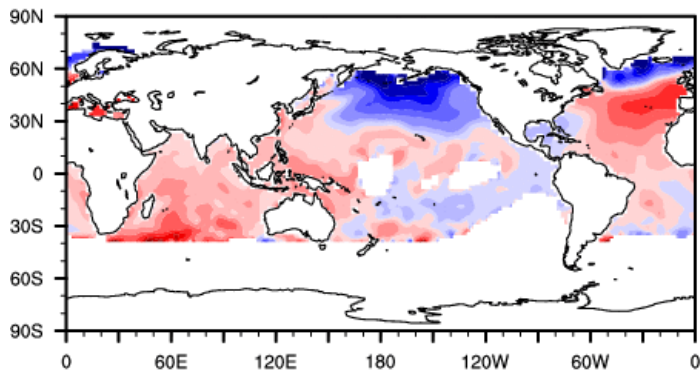
HadSLP2



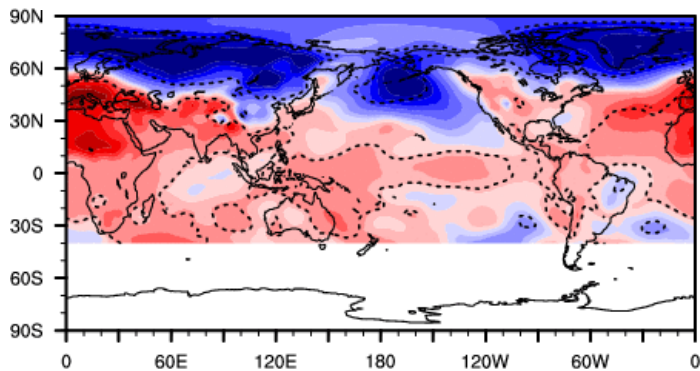
SST + ATM



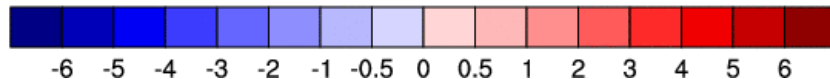
COADS



NCEP Reanalysis



- - - 95% significance



hPa per 51 years



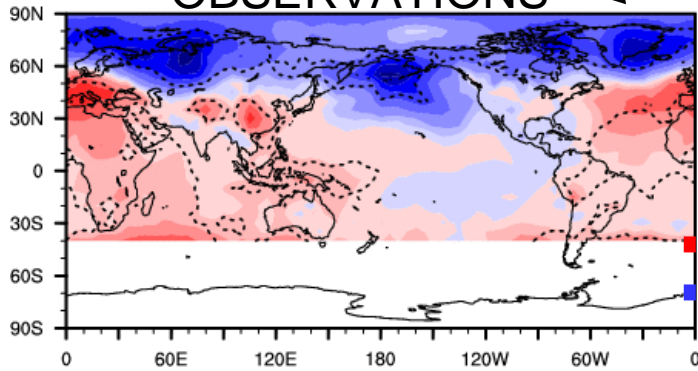
# Sea Level Pressure Trend 1950-2000 DJF

OBSERVATIONS

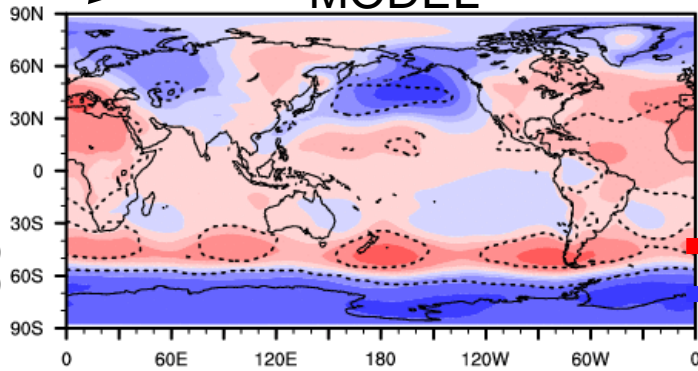
0.73

MODEL

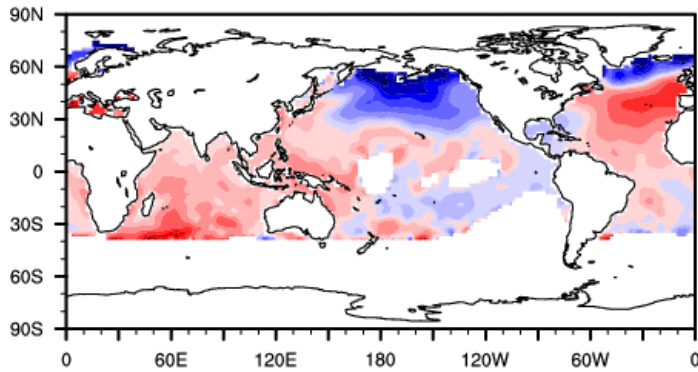
HadSLP2



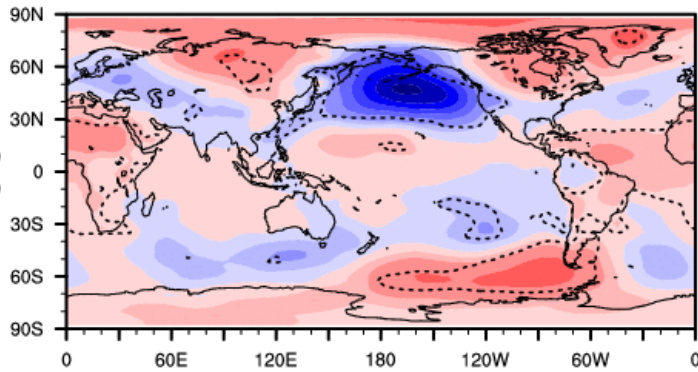
SST + ATM



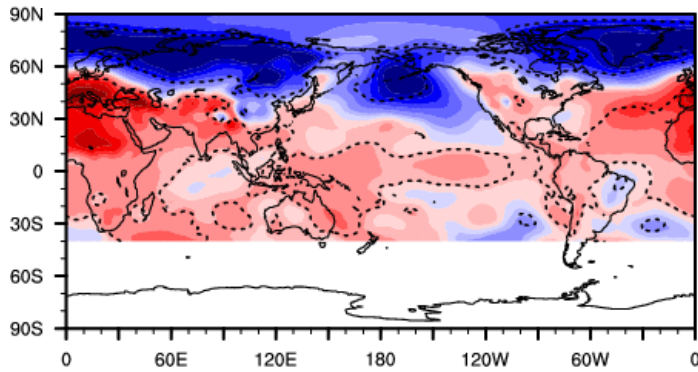
COADS



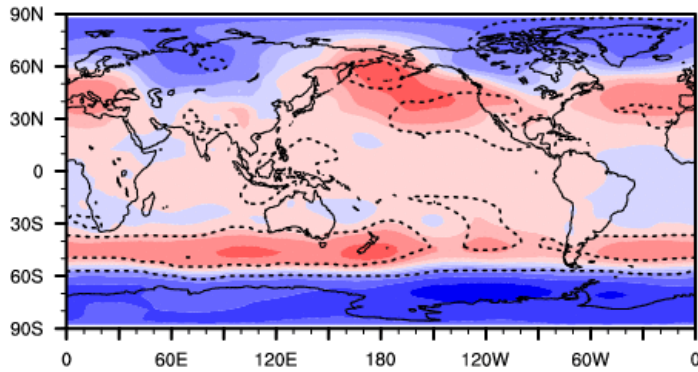
SST



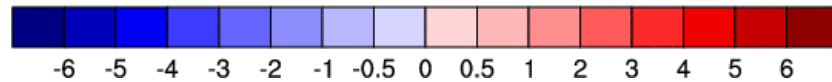
NCEP Reanalysis



"ATM"



- - - 95% significance



hPa per 51 years

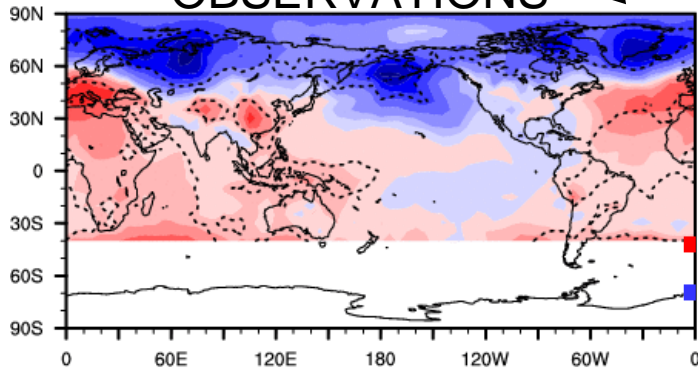
# Sea Level Pressure Trend 1950-2000 DJF

OBSERVATIONS

0.73

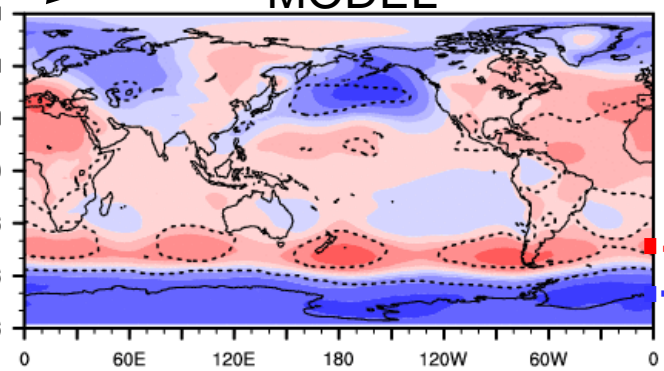
MODEL

HadSLP2



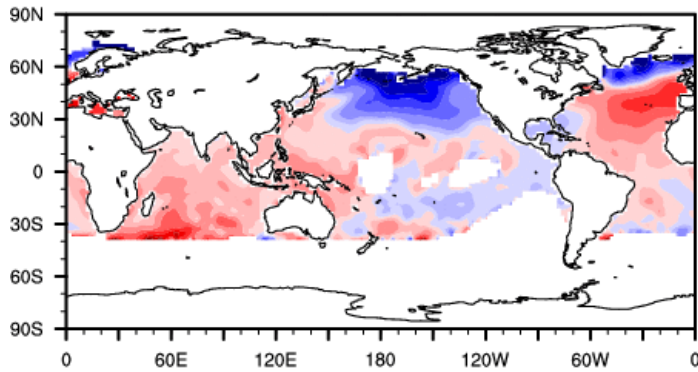
+1.9  
-2.9

SST + ATM

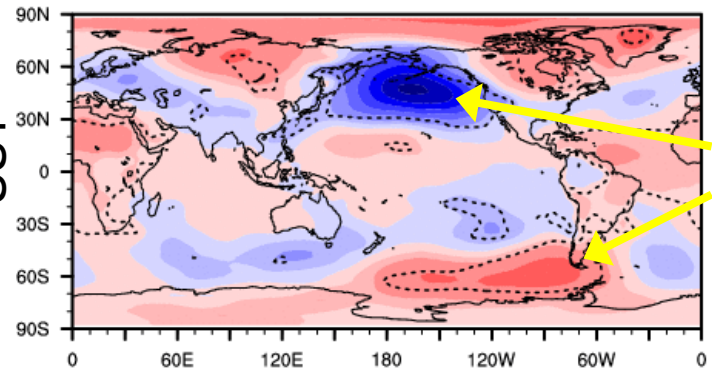


+1.6  
-4.2

COADS

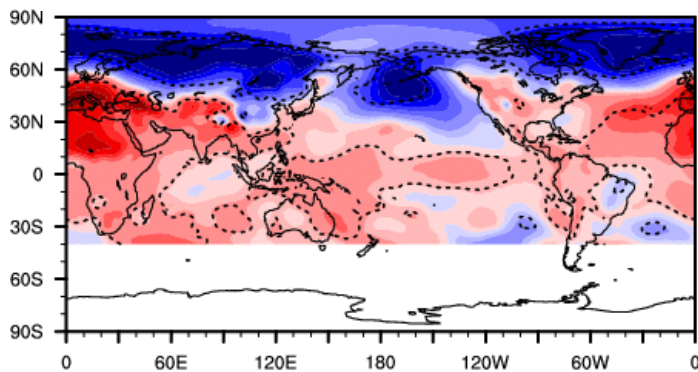


SST

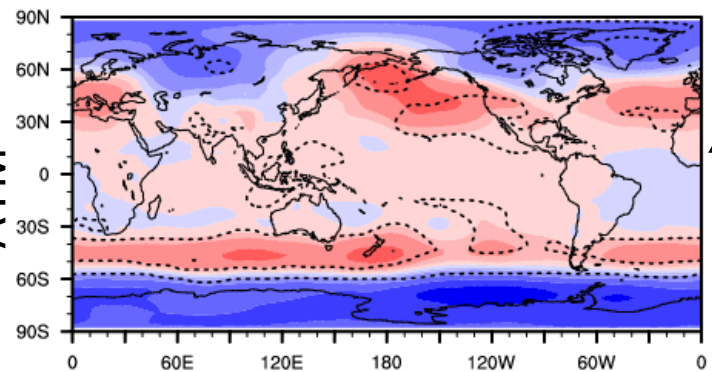


Pacific

NCEP Reanalysis

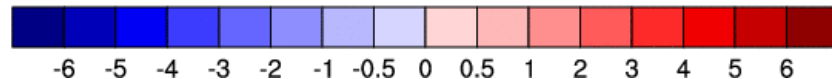


"ATM"



Annular Modes

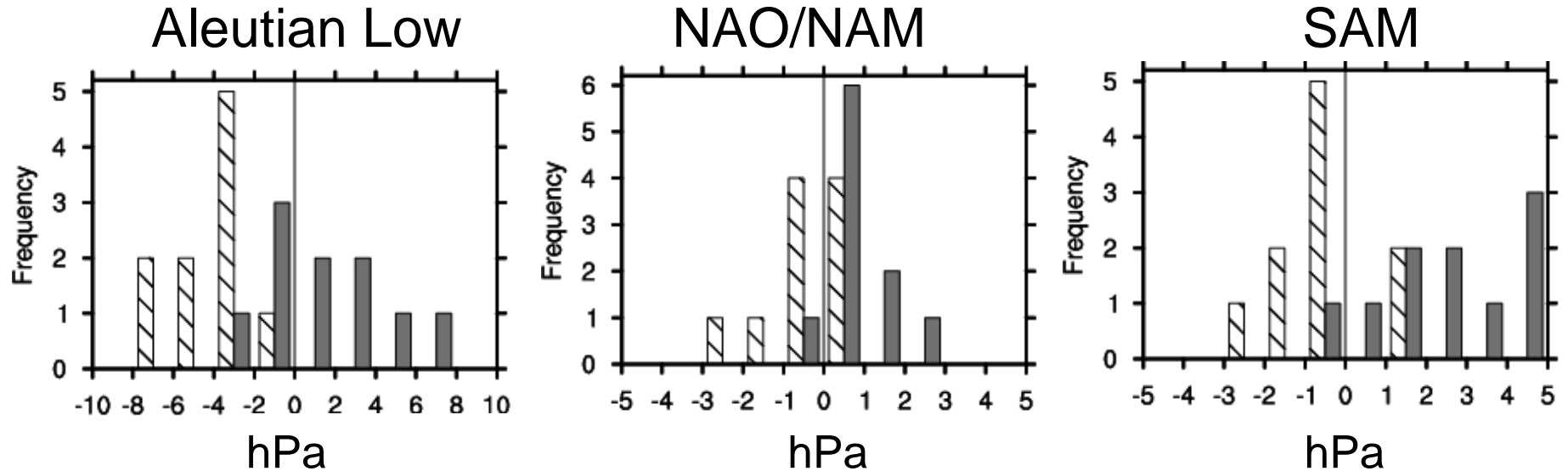
- - - 95% significance



hPa per 51 years



# SST vs. Atmospheric Radiative Forcing: Regional SLP Trends

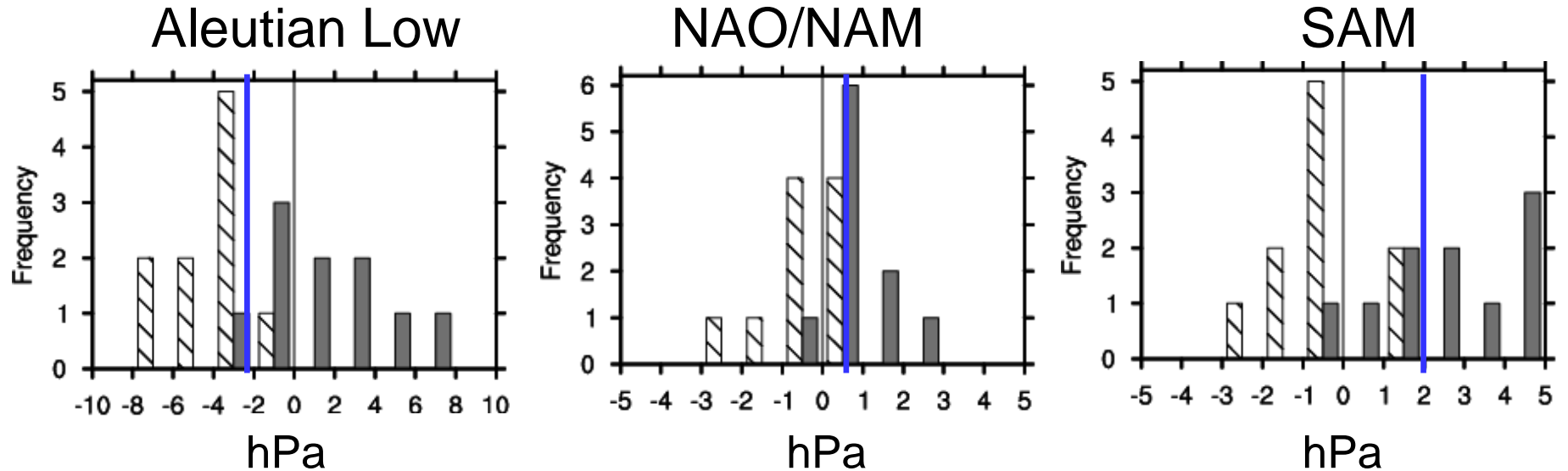


 *Atmospheric Radiative Forcing*

 *SST Forcing*

*Opposing Effects*

# SST vs. Atmospheric Radiative Forcing: Regional SLP Trends



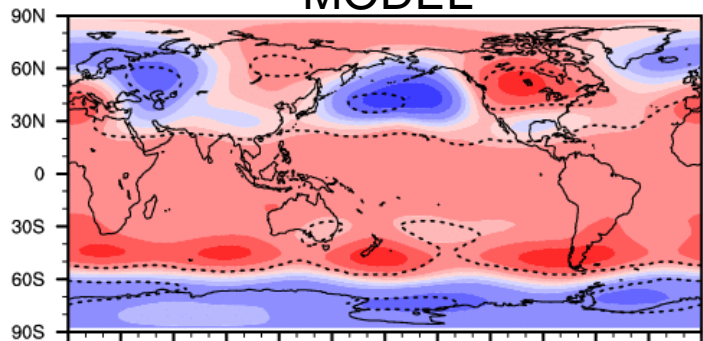
 *Atmospheric Radiative Forcing*

 *SST Forcing*

 *Atmospheric +SST Forcing Ensemble Mean*

# Z500 Trend

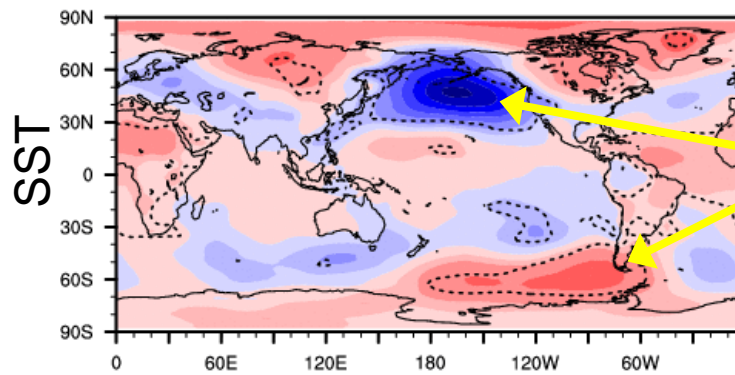
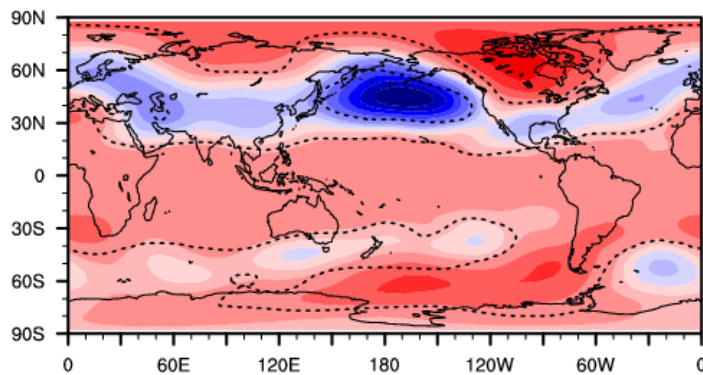
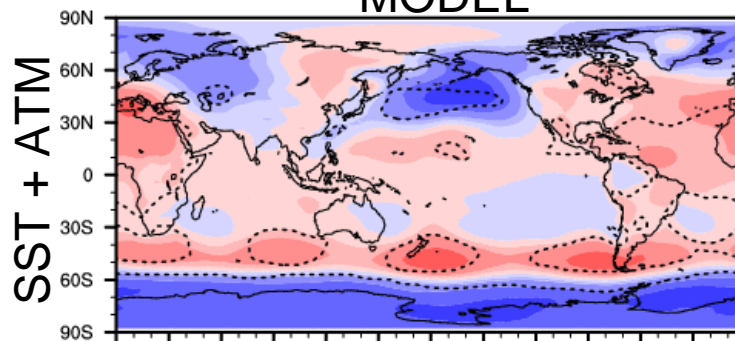
MODEL



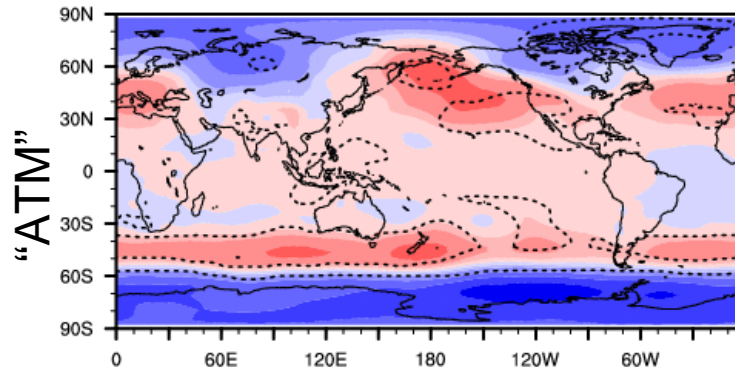
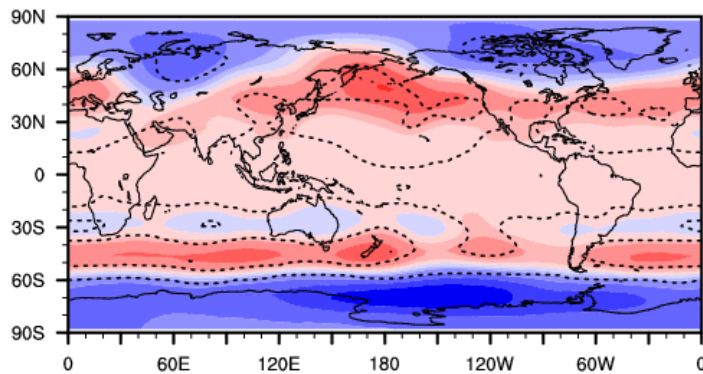
# DJF

# SLP Trend

MODEL



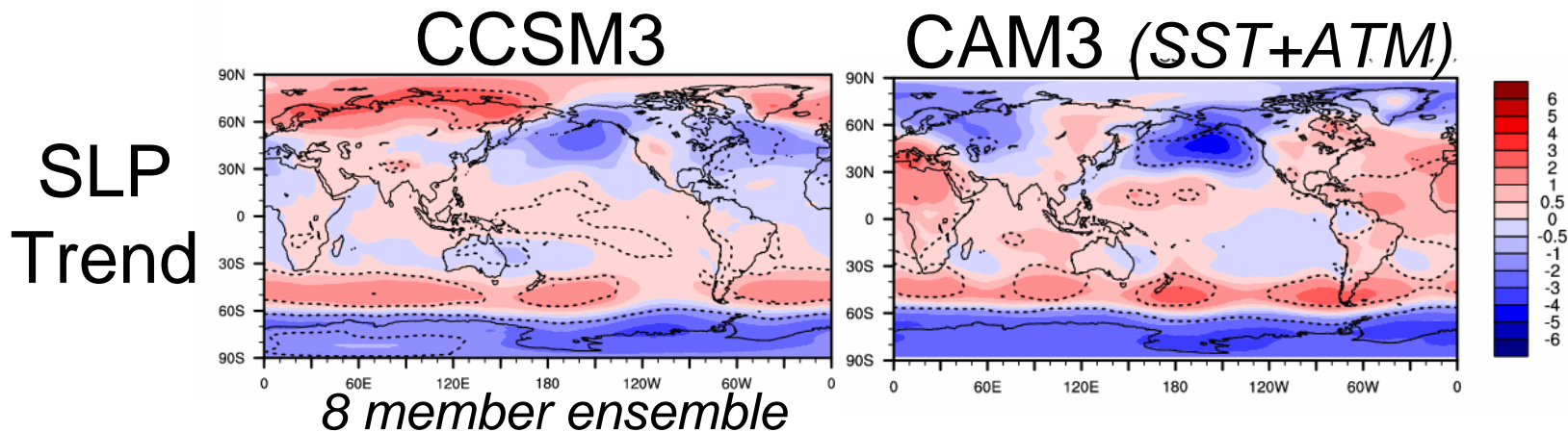
*Pacific*



*Annular Modes*

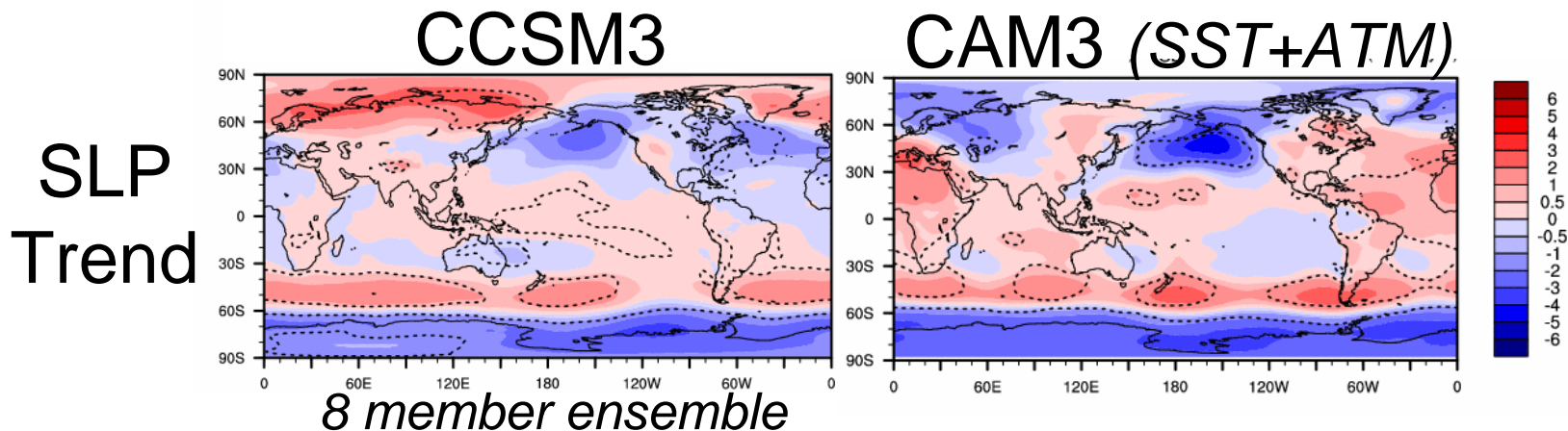
- - - 95% significance

# CCSM3 “20<sup>th</sup> Century Ensemble” vs. CAM3 (Identical Atmospheric Radiative Forcing)



*Correlation = 0.47*  
*(0.19 for CCSM3 with observed trend)*

# CCSM3 “20<sup>th</sup> Century Ensemble” vs. CAM3 (Identical Atmospheric Radiative Forcing)

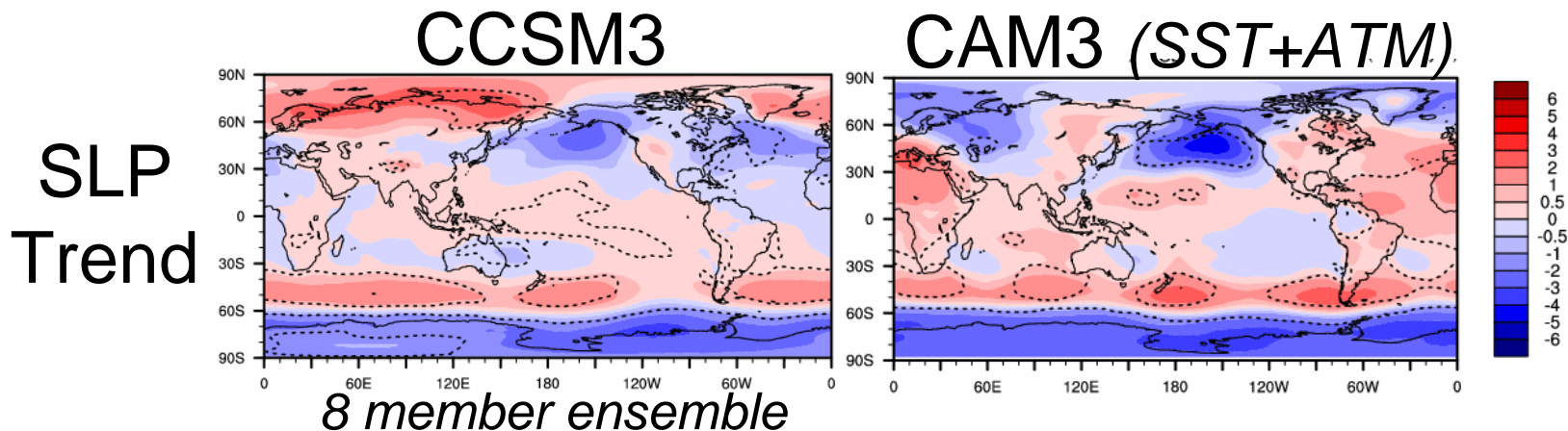


*Correlation = 0.47*  
*(0.19 for CCSM3 with observed trend)*

- Similar SAM
- Opposite NAO/NAM
- Weaker Aleutian Low in CCSM3
- Opposite Tropical Atlantic and Eastern Pacific



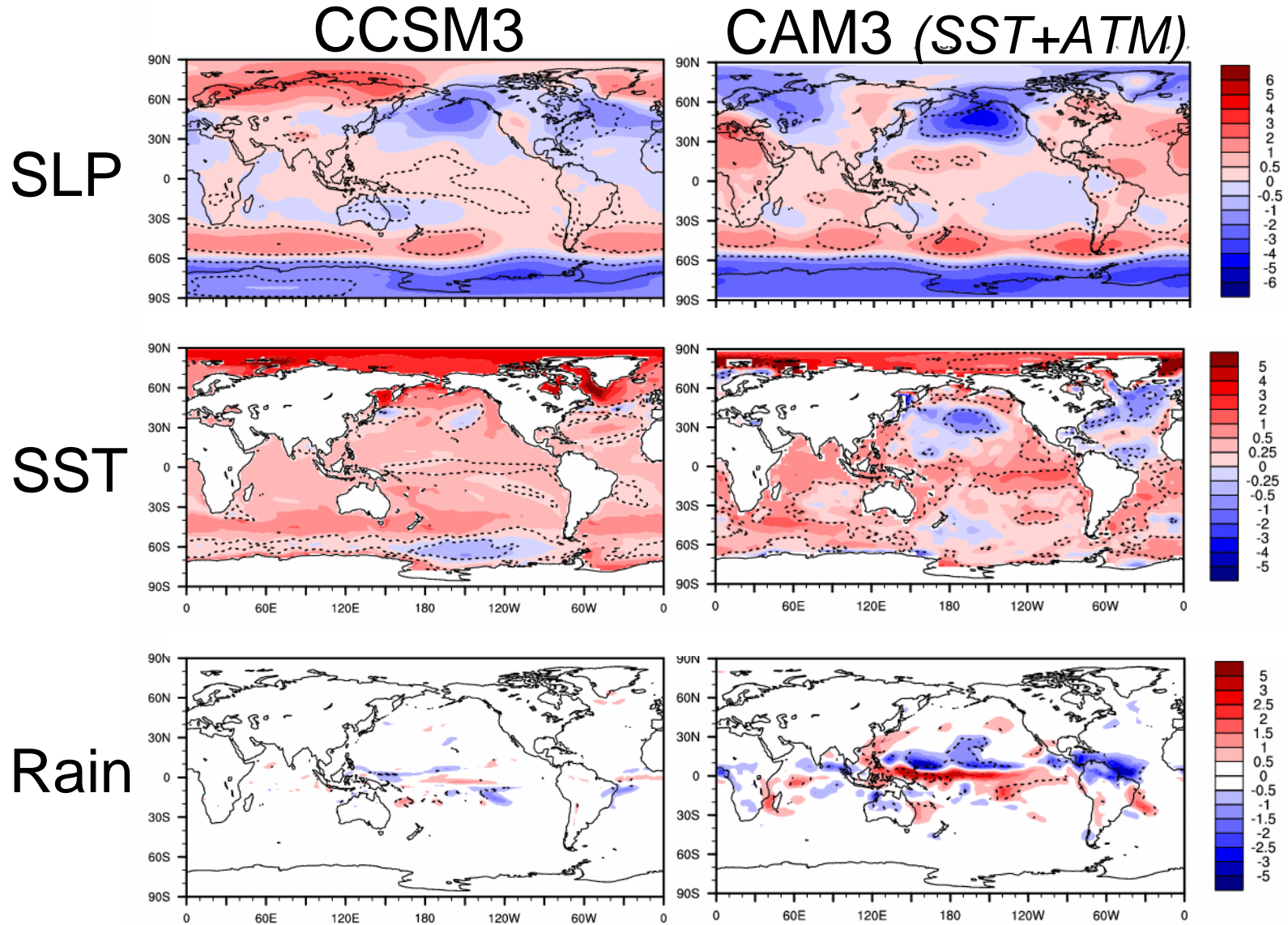
# CCSM3 “20<sup>th</sup> Century Ensemble” vs. CAM3 (Identical Atmospheric Radiative Forcing)



- ATM forced in CAM3*
- Similar SAM
  - Opposite NAO/NAM

- SST forced in CAM3 (tropical SST)*
- Weaker Aleutian Low in CCSM3
  - Opposite Tropical Atlantic and Eastern Pacific

# CCSM3 "20<sup>th</sup> Century Ensemble" vs. CAM3 (Identical Atmospheric Radiative Forcing)



# Summary

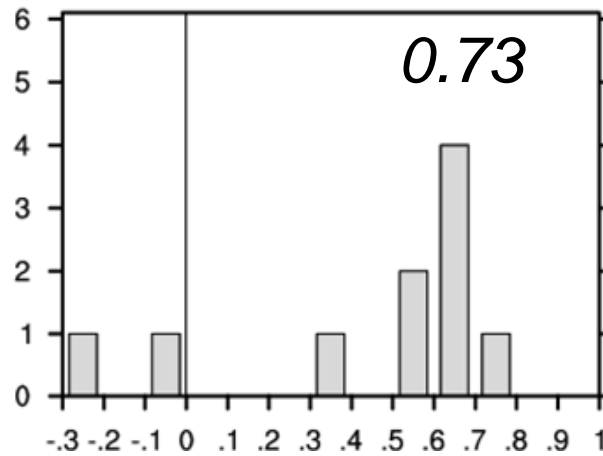
- CAM3 forced with SST+ATM simulates well the observed pattern of DJF atmospheric circulation trends 1950-2000, although weaker in amplitude
- ATM forcing responsible for positive trends in the annular modes of both hemispheres
- SST forcing responsible for the deepening of the Aleutian Low (also South Pacific)
- ATM and SST forcing produce opposite-sign circulation trends in extra-tropics
- *CCSM3 20<sup>th</sup> century ensemble mean*: anthropogenic warming of the tropical oceans weaker than actual warming, and thus atmospheric teleconnections to the extratropical Pacific weaker than observed

Extra

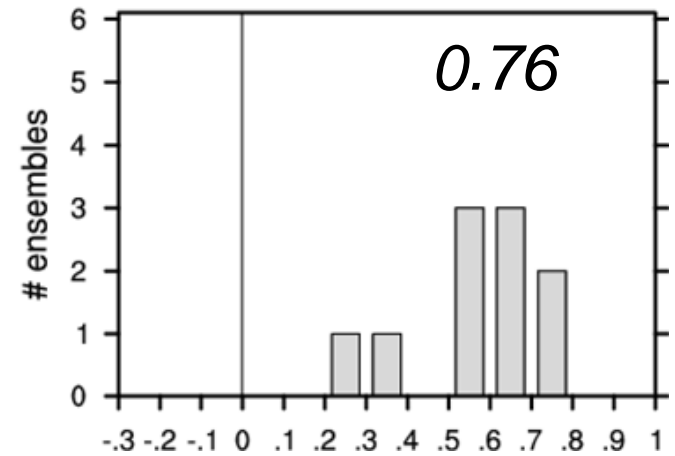
# Sampling Distribution of Pattern Correlations

*Individual Model  
Runs with  
Observations*

## SLP



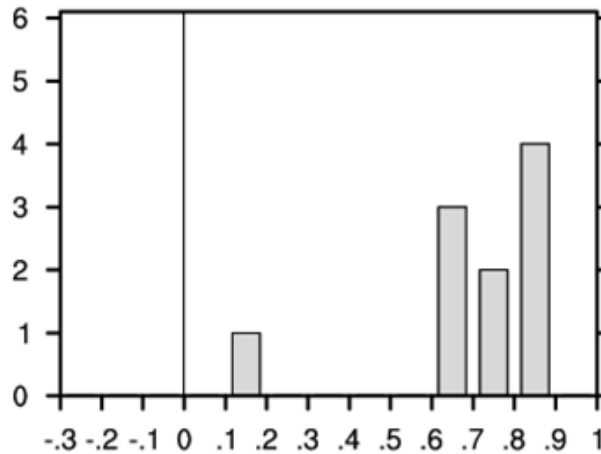
## Z500



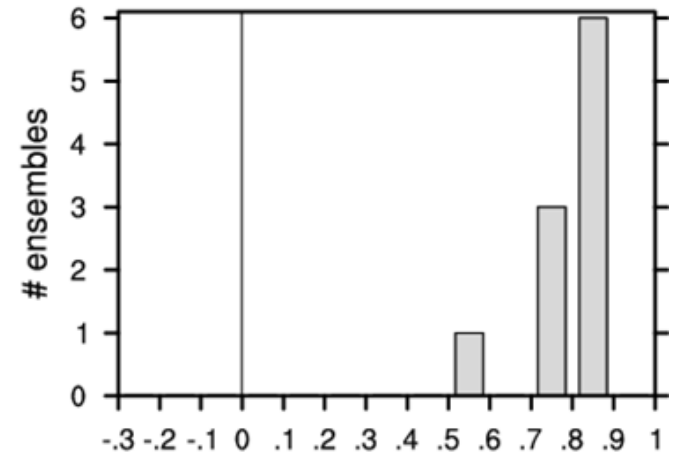


# Sampling Distribution of Pattern Correlations

## SLP

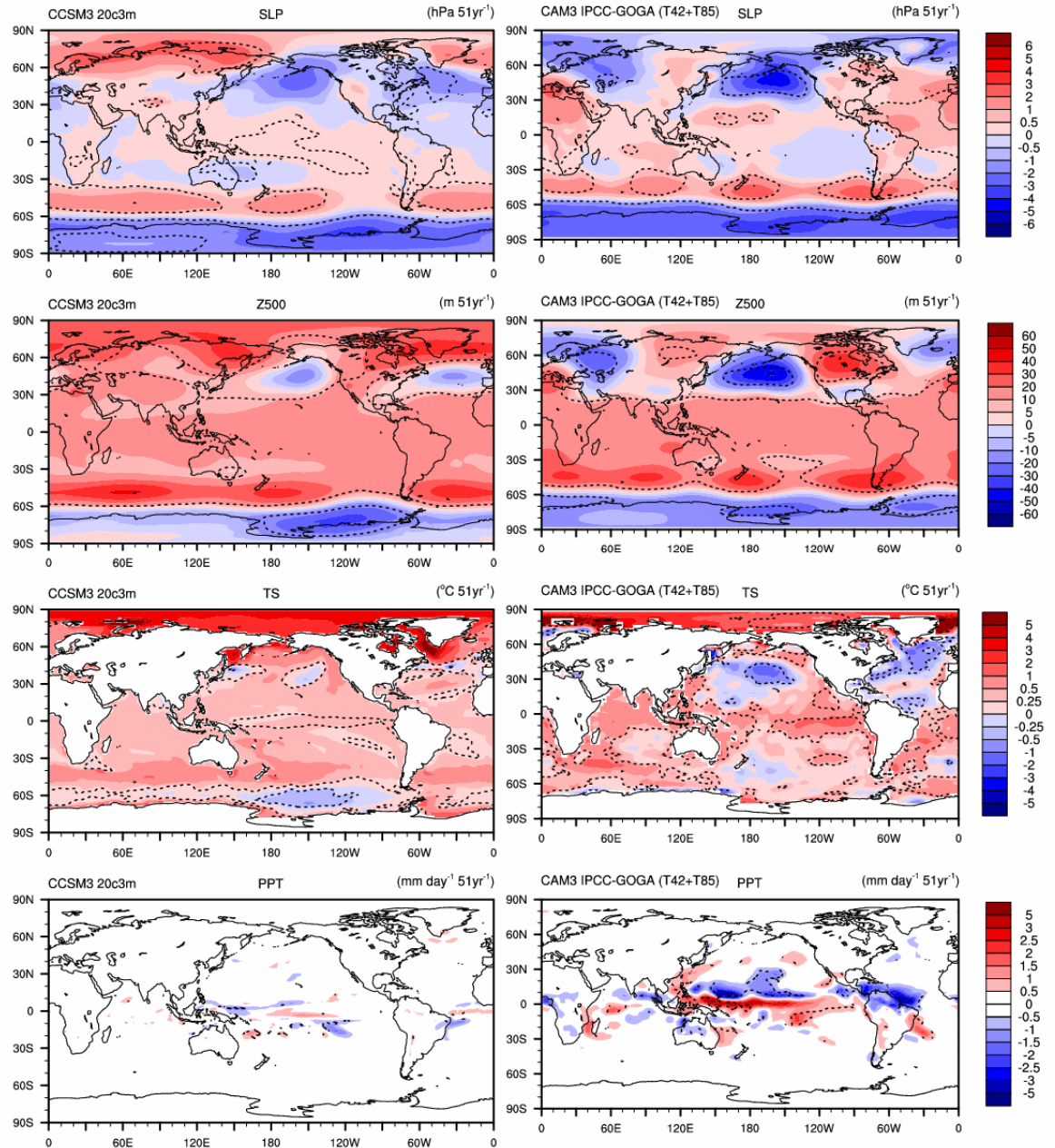


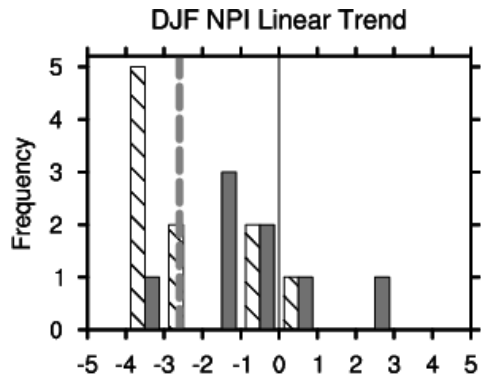
## Z500



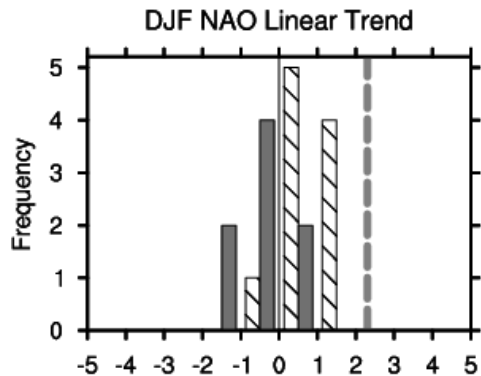
*Individual Model  
Runs with  
Model Ensemble  
Mean*

# Linear Trend, 1950-1999

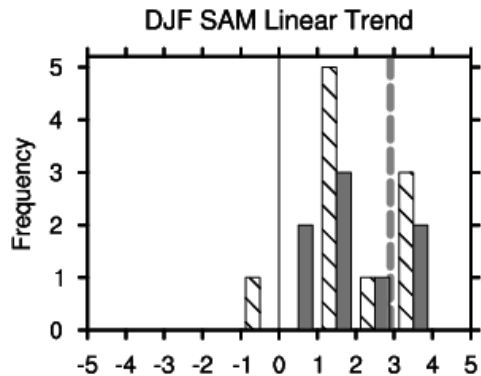





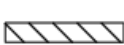
CAM3: -2.23  
 CCSM: -0.86  
 OBS : -2.6





CAM3: 0.55  
 CCSM: -0.45  
 OBS : 2.3

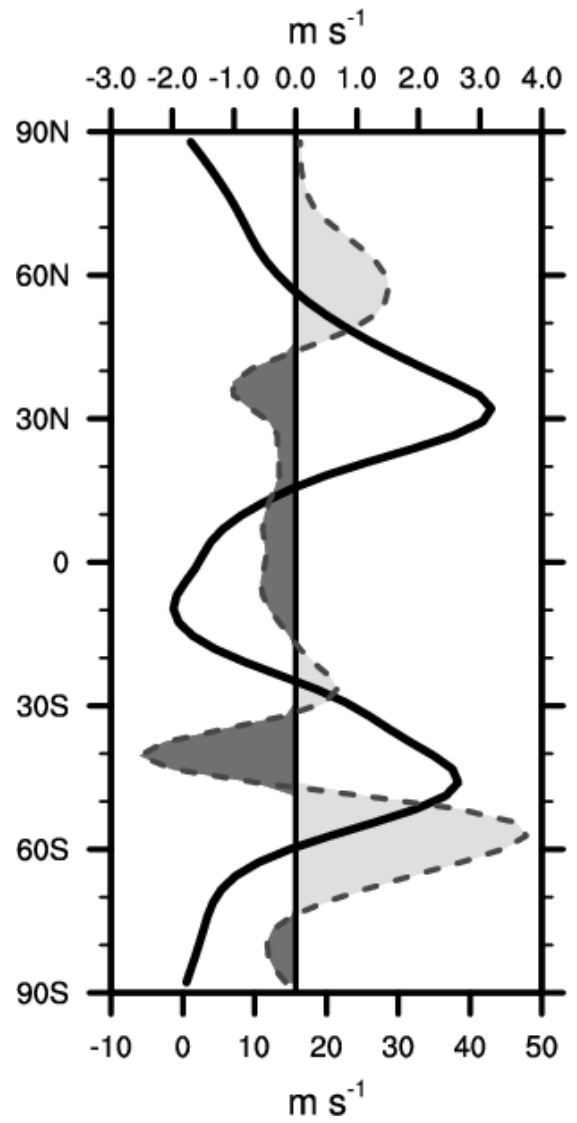


CAM3: 1.93  
 CCSM: 1.98  
 OBS(M):2.9

 CCSM 20c3m  
 CAM3 "SST+ATM"

 CCSM 20c3m  
 CAM3 "SST+ATM"

# U200

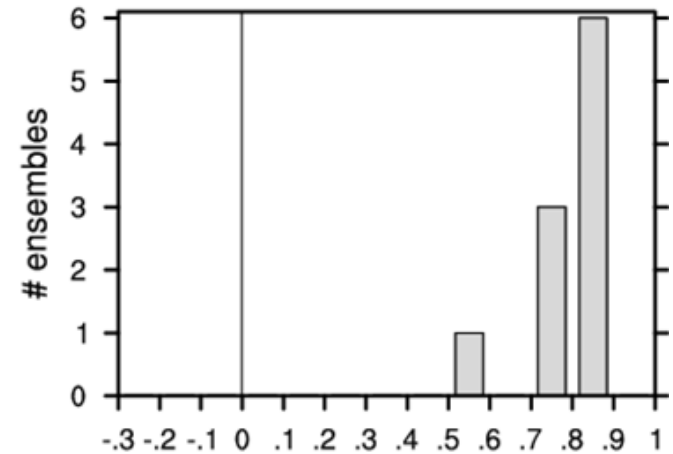
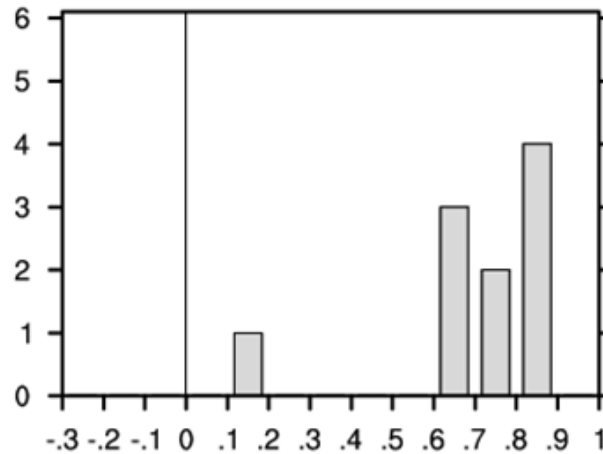


# Sampling Distribution of Pattern Correlations

SLP

Z500

*Individual Model  
Runs with  
Model Ensemble  
Mean*



*Individual Model  
Runs with  
Observations*

