Attribution of Atmospheric Circulation Trends: an AGCM Approach

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Simulations conducted by the CCSM Climate Variability and Climate Change Working Groups

A few science results
1) 20th Century Simulations (1950-2000)

**Observed Direct Atmospheric Radiative Forcing**
(Greenhouse Gases, Ozone, Volcanic and Sulfate Aerosols, Solar Output)

From Meehl et al. 2006

**Atmospheric GCM Experiments**
CAM3 T42&T85, 10 member ensembles each
Time-evolving forcing specified

**Observed Sea Surface Temperature Forcing**

From Hurrell et al., 2008
DJF Sea Level Pressure Trend 1950-2000

Combined Direct Radiative Forcing & SST Forcing

- 0.73 correlation with observed pattern

Aleutian Low
SST Forcing Only

- 0.54

Southern Oscillation

NAO
Direct Radiative Forcing Only

- 0.52

Southern Annular Mode

- - - 5% significance
DJF Sea Level Pressure Trend 1950-2000

**COMBINED FORCING**
Direct Radiative & SST

**SUM**
Direct Radiative Forcing & Tropical SST Forcing

Deser and Phillips  
J. Climate

- - - 5% significance
Trend in Latitude of Edge of Tropics
Metric: Daily Tropopause Pressure (WMO defn)

1957-2000 GFDL AM2.1 10-member ensemble means

Lu, Deser and Reichler, GRL
Trends in PDFs of Daily Tropopause Pressure (DJF) from GFDL AM2.1 Simulations 1957-2000

Climatology is contoured; trends are shaded (# days/decade)
How well does an AGCM approach work for the coupled system?

Test with 21st century simulations (2000-2060)

30-member CCSM3 (T42) ensemble under SRES A1B
(same ocean initial conditions for each member, different atmospheric initial conditions)

10-member CAM3 (T42) ensembles forced with:
1) Direct radiative forcing and CCSM3 SST
2) CCSM3 SST only
3) Direct radiative forcing only
3) CCSM3 Tropical SST only
DJF SLP Linear Trends 2005-2060

a) Coupled Model

b) CAM forced with SST+Anthro

hPa per decade
Linear Trends 2005-2060

CCSM3 CAM3

SLP DJF

a) Coupled Model

b) CAM forced with SST+Anthro

c) CAM forced with Anthro

d) CAM forced with SST

e) c+d

f) CAM forced with TropSST

g) c+f

hPa per decade
Sea Level Pressure Trend 1950-2000

**OBSERVATIONS**
HadSLP2

**MODEL**
CAM3 "SST+ATM"

- **OBSERVATIONS**
  - 0.73
  - +1.9
  - -2.9

- **MODEL**
  - +1.6
  - -4.2

--- Linear trend significantly different from zero (0.05 P)
Expansion of the Tropics
Annual Means

Width: 0.71° / decade (Model), 0.70° / decade (ERA)
Simulated Trends: T42 vs. T85

SLP

T42

T85

Z500

.72

.86