Changes in the Atmospheric Greenhouse Effect during 1985 to 1999

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Approach

Initially use the ERBE WFOV 15-year (1985-1999) measurements, with restriction to 40^{O}S to 40^{O}N, together with International Satellite Cloud Climatology Project (ISCCP) cloud fraction measurements.

But to better understand what we might anticipate, we first examine output from the NCAR Community Climate System Model for the last 29 years of a 1870-1998 simulation with increasing greenhouse gases.

Interpretation of the NCAR CCSM Results

Consider climate change induced by a radiative forcing G, and let ΔR denote the radiative response to that forcing. Also let ΔASW denote the change in absorbed SW radiation by the climate system. From a TOA energy balance applied to a closed system (global mean):

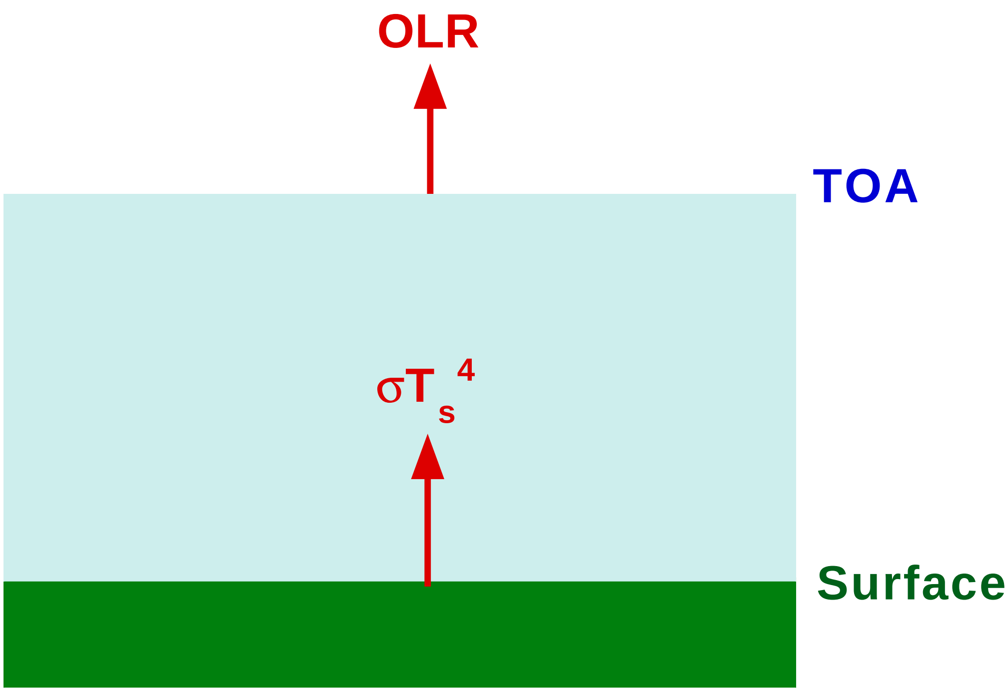
$$\Delta NET = \Delta ASW - \Delta OLR = G - \Delta R$$

For a change from one equilibrium climate state to another, $\Delta NET = 0$ and $\Delta R = G$.

But for a time-dependent forcing, ΔR lags G ($\Delta R < G$) because of the heat capacity of the oceans, and $\Delta NET > 0$.

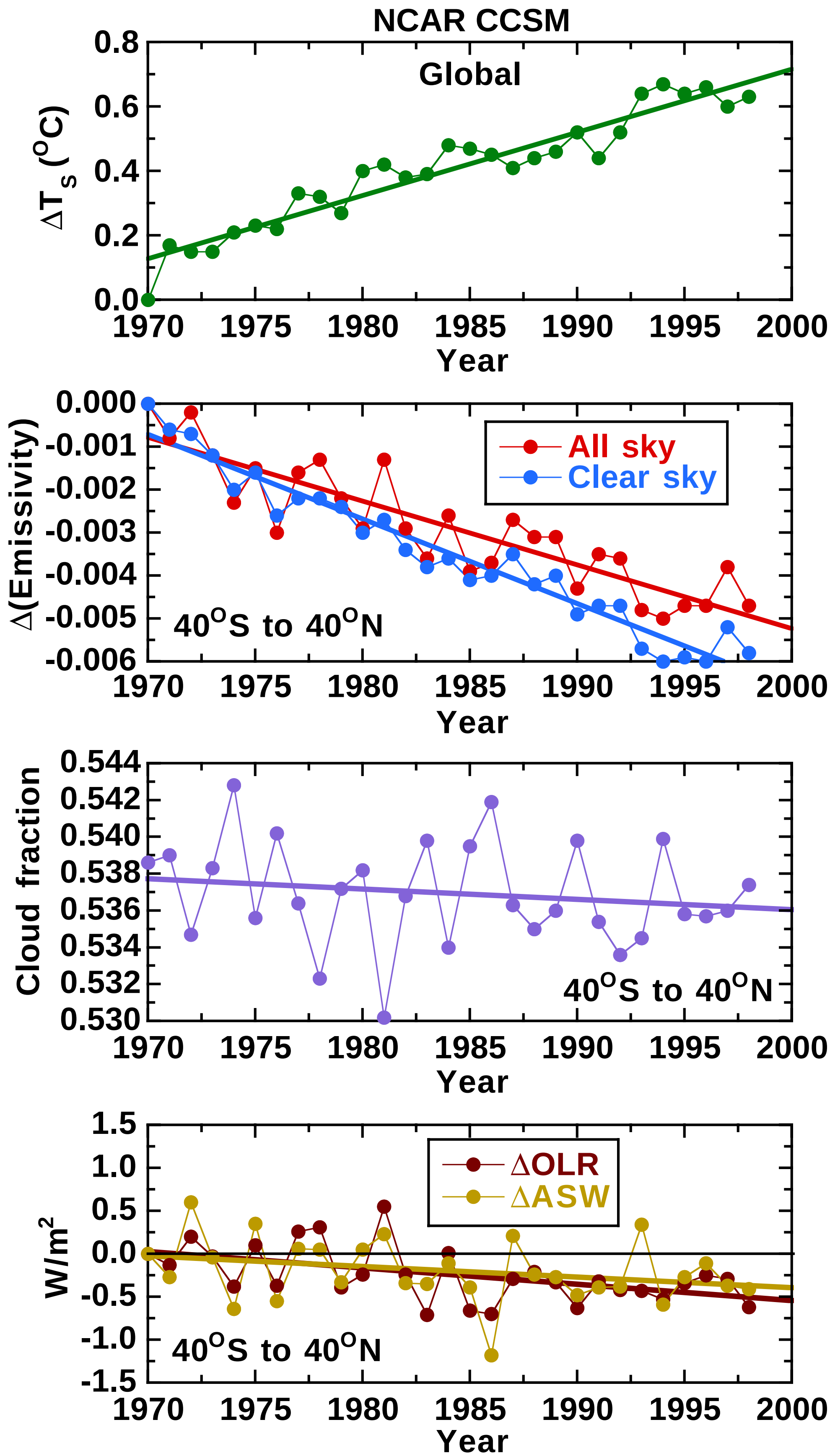
Caveat: When considering 40°S to 40°N, changes in poleward transport could impact ΔNET.

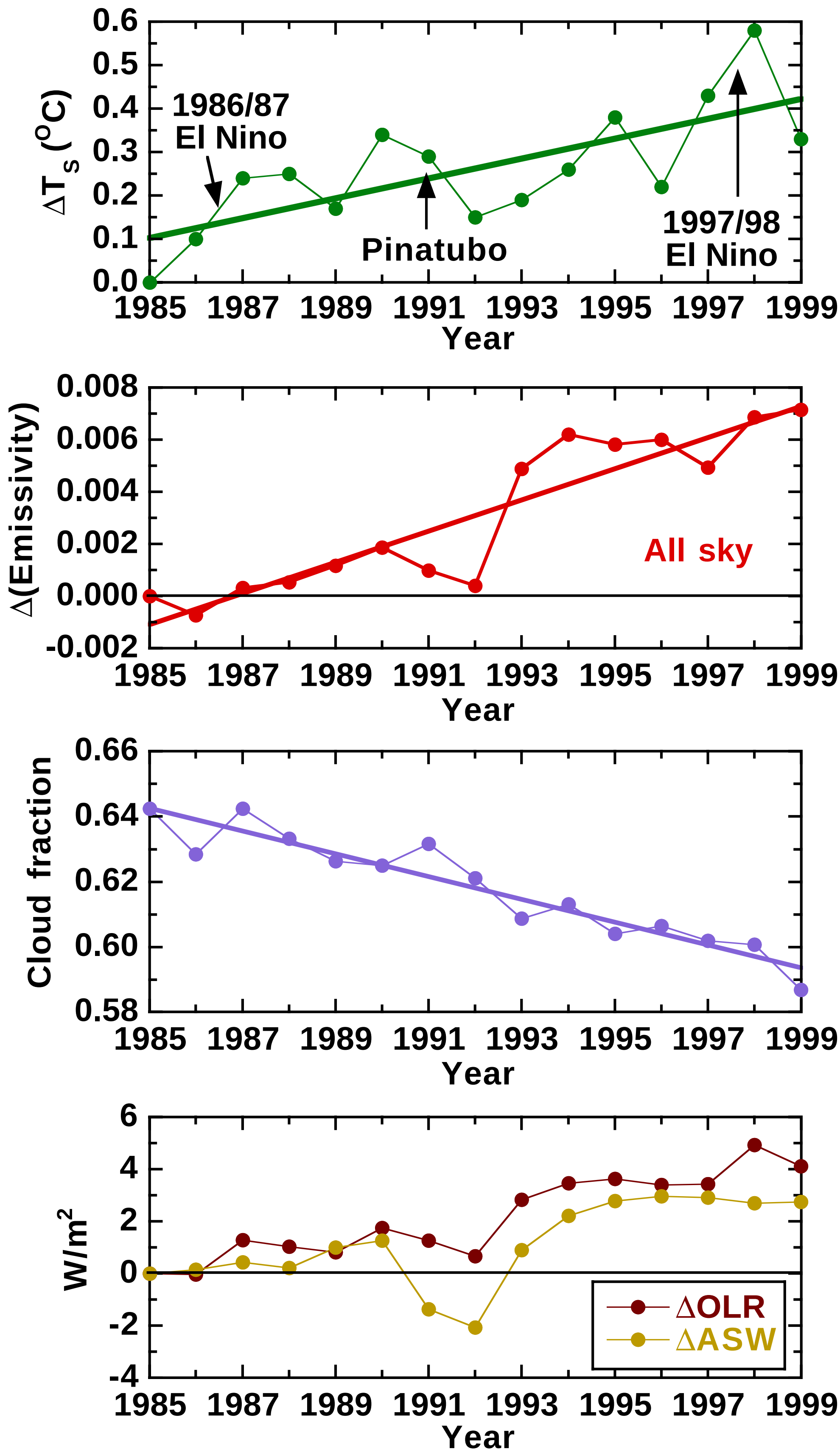
Surface-atmosphere emissivity



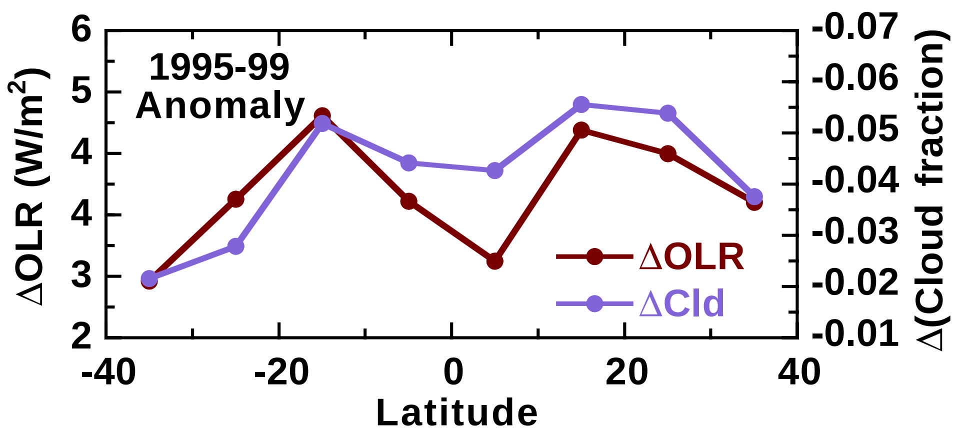
Emissivity = OLR/σT_s^4

A decrease in emissivity corresponds to an increase in the greenhouse effect, and vice versa.

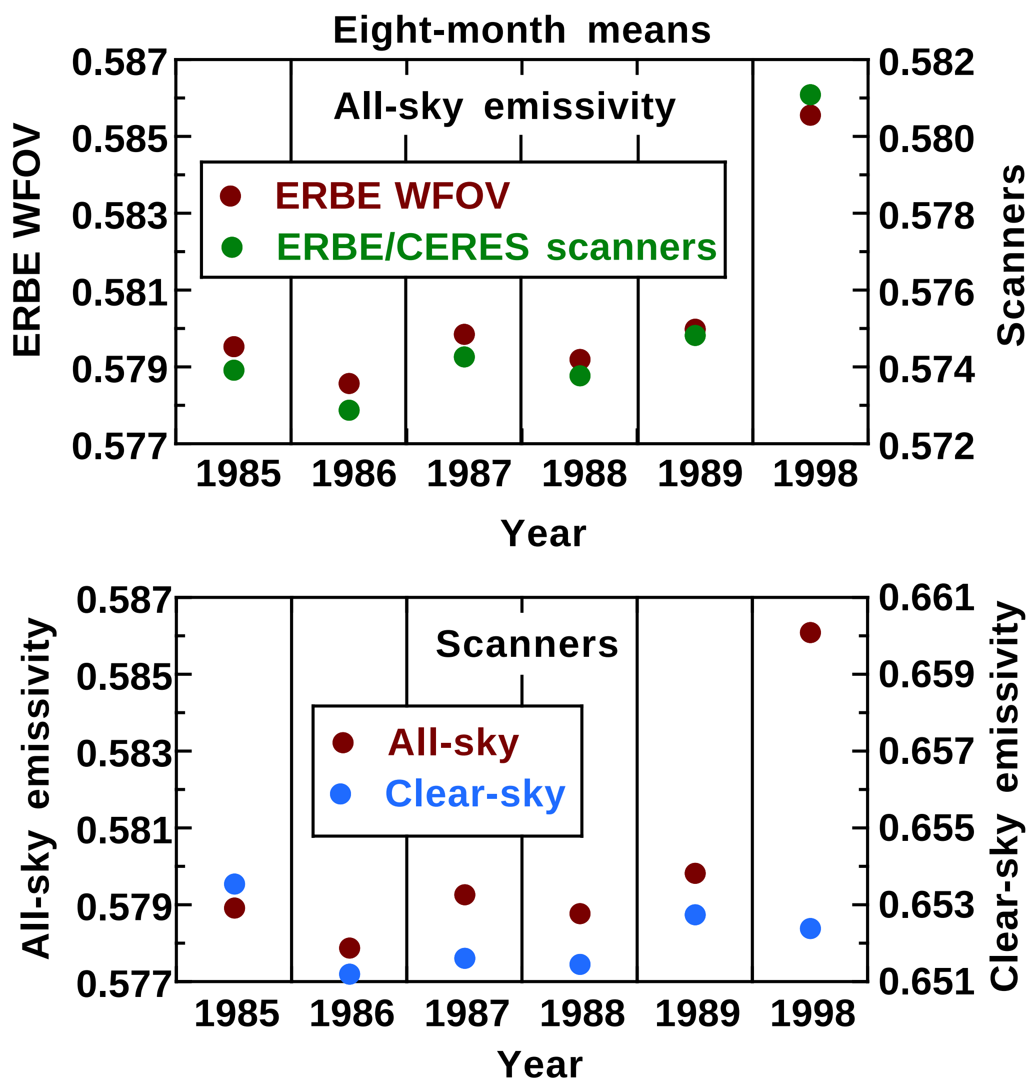

NCAR CCSM
Global
ΔT_S (°C)
Year
Δ(Emissivity)
All sky
Clear sky
40°S to 40°N
Year
Cloud fraction
40°S to 40°N
Year
W/m²
ΔOLR
ΔASW
40°S to 40°N
Year



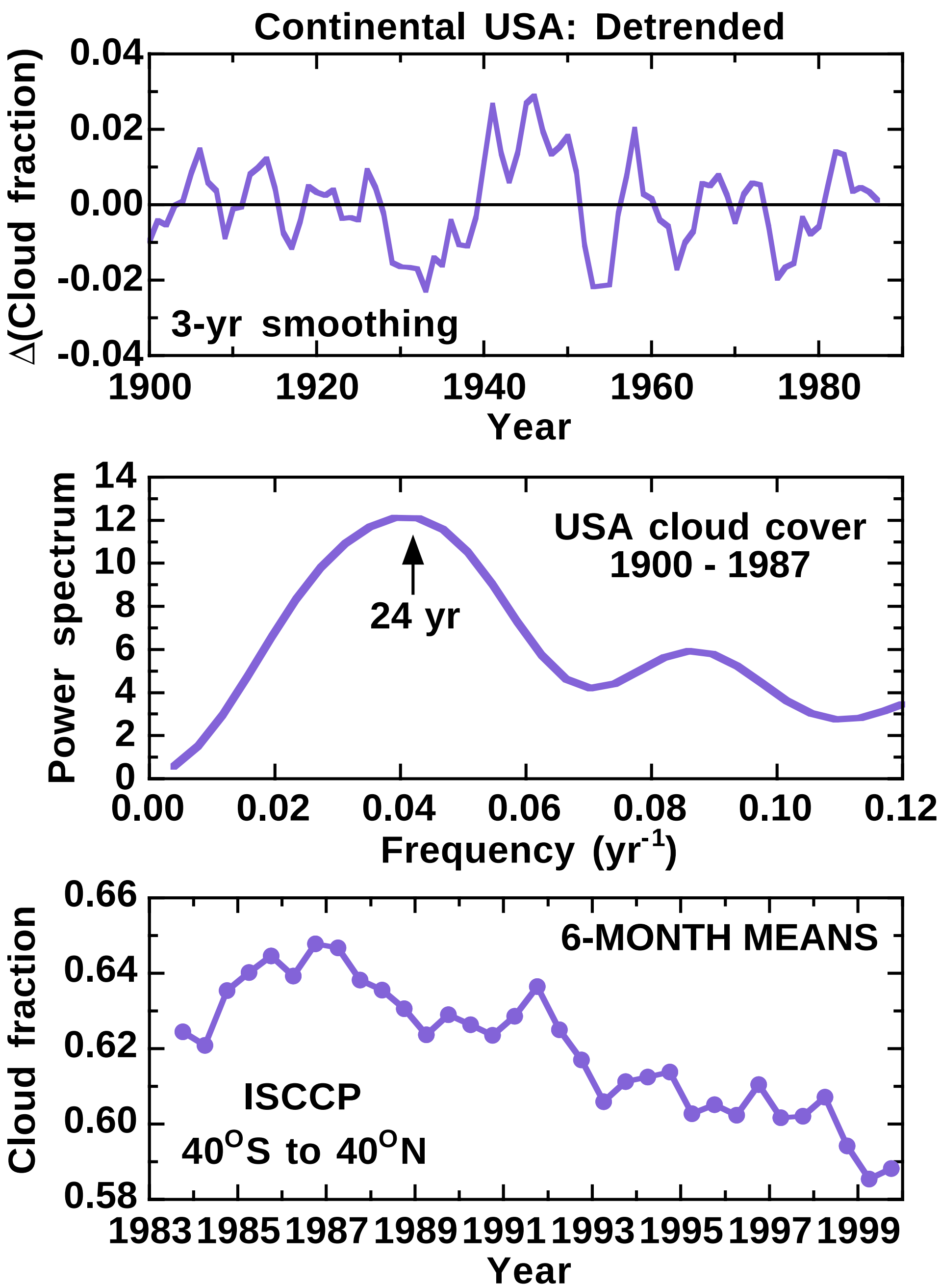
ΔT_s (^oC)
1986/87
El Nino
Pinatubo
1997/98
El Nino
Year
Δ(Emissivity)
All sky
Year
Cloud fraction
Year
W/m^2
ΔOLR
ΔASW
Year



1995-99
Anomaly
ΔOLR (W/m2)
Δ(Cloud fraction)
Latitude
ΔOLR
ΔCld
6
5
4
4
3
2
-0.07
-0.06
-0.05
-0.04
-0.03
-0.02
-0.01
-40
-20
0
20
40


Eight-month means
All-sky emissivity
ERBE WFOV
ERBE/CERES scanners
ERBE WFOV
Scanners
0.587
0.585
0.583
0.581
0.579
0.577
0.582
0.580
0.578
0.576
0.574
0.572
1985
1986
1987
1988
1989
1998
Year
Scanners
All-sky
Clear-sky
All-sky emissivity
Clear-sky emissivity
0.661
0.659
0.657
0.655
0.653
0.651
Year

Cloud Fraction Change: A Trend or Periodic?



Conclusions

The strong OLR anomaly appears to be real, and there is evidence that, to first order, it is caused by a related change in cloud fraction which could be the result of:

1. **A cloud response to greenhouse-gas warming (probably unlikely).**
2. **Or, a cyclical phenomenon (more likely).**

In either event, the NCAR CCSM (coupled atmosphere/ocean GCM) does not produce the OLR anomaly, nor do a suite of atmospheric GCMs that employ prescribed SSTs (Wielicki et al., 2002).