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°S to 40°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 $\Delta R$ denote the radiative response to that forcing. Also let $\Delta ASW$ 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, $\Delta R$ 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 $\Delta NET$. 
Surface-atmosphere emissivity

\[
\text{Emissivity} = \frac{\text{OLR}}{\sigma T_s^4}
\]

A decrease in emissivity corresponds to an increase in the greenhouse effect, and vice versa.
The graph shows the changes in surface temperature ($\Delta T_s$) and emissivity ($\Delta(\text{Emissivity})$) over the years 1985 to 1999, with notable events such as the Pinatubo eruption and El Nino years marked on the x-axis.

- **Surface Temperature ($\Delta T_s$)**: The graph indicates a steady increase in surface temperature over the years, with a significant rise post-Pinatubo and El Nino events.

- **Emissivity**: The emissivity data shows a consistent trend of increase over the years, with a notable dip around 1989.

- **Cloud Fraction**: The cloud fraction data displays a declining trend from 1985 to 1999, indicating a decrease in atmospheric cloud cover over time.

- **OLR and ASW Changes**: The graph also illustrates the changes in OLR and ASW, with OLR showing a decrease and ASW an increase over the years.
Cloud Fraction Change: A Trend or Periodic?

**Continental USA: Detrended**

![Graph showing detrended cloud fraction changes from 1900 to 1980 with 3-year smoothing.]

**USA cloud cover 1900 - 1987**

![Graph showing power spectrum with a peak at 24 years.]

**6-MONTH MEANS**

![Graph showing cloud fraction changes from 1983 to 1999 for ISCCP 40°S to 40°N.]

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).