Analysis of Multi-Decadal Satellite Observations for Signs of Cloud Feedback

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Long-Term Satellite Data Records Need Correction To Derive Cloud Trends

Satellite cloud data records now exceed 25 years in length. This is long enough that trends contained in the data might be the result of long-term climate change, rather than internal variability.

However, data stability is a major problem with satellite cloud data records and corrections are needed. In this study, corrections have been applied to the following two satellite datasets spanning the years 1983-2008:

International Satellite Cloud Climatology Project (ISCCP)

AVHRR Pathfinder Atmospheres Extended dataset (PATMOS-x)

Here, we examine trends in the adjusted data and consistency with climate model simulations.

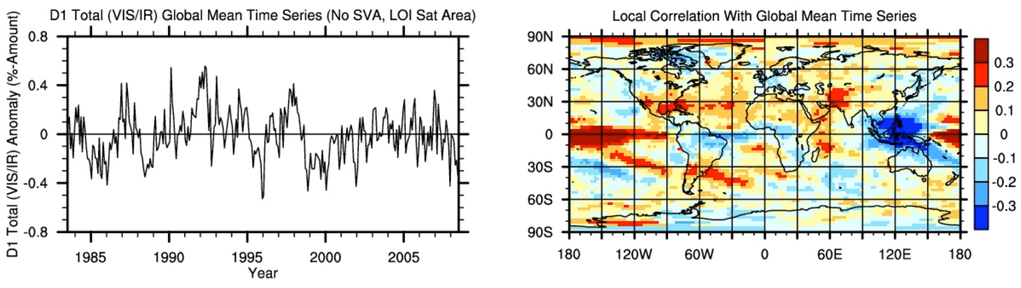
Removing Data Artifacts

A number of data artifacts can lead to spurious trends in satellite cloud data records. Sometimes, the sources of artifacts are known, such as drifts in the crossing times of polar-orbiting satellites, improper calibration of successive satellites, changes in the satellite view angle due to switching between geostationary and polar-orbiting satellites.

However, sometimes the sources of artifacts are unknown. Thus, artifact correction requires a combination of approaches, some of which are ad-hoc. Here, the corrections are applied to daily anomalies in total cloud amount by linearly regressing out time variations in satellite view angle and the mean cloud amount anomalies averaged over the viewing area of a given satellite (but separately for land/ocean/and ice-covered regions). These steps may remove some true variability in cloud cover, particularly for area-averages over the domain of view of a given satellite.

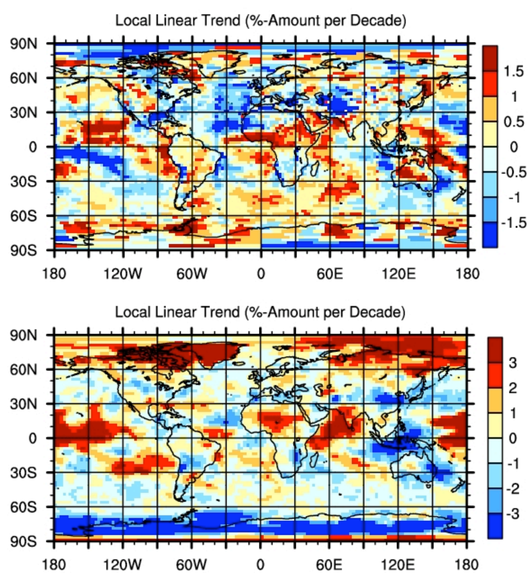
The plot below illustrates that for ISCCP, the corrections leave a time series of global mean cloud cover that is not dominated by a spurious interdecadal trend. but is well-correlated with natural (ENSO) variability.

Adjusted ISCCP Cloud Cover



Satellite Cloud Trends

ISCCP Cloud Cover Trend (1983-2008)



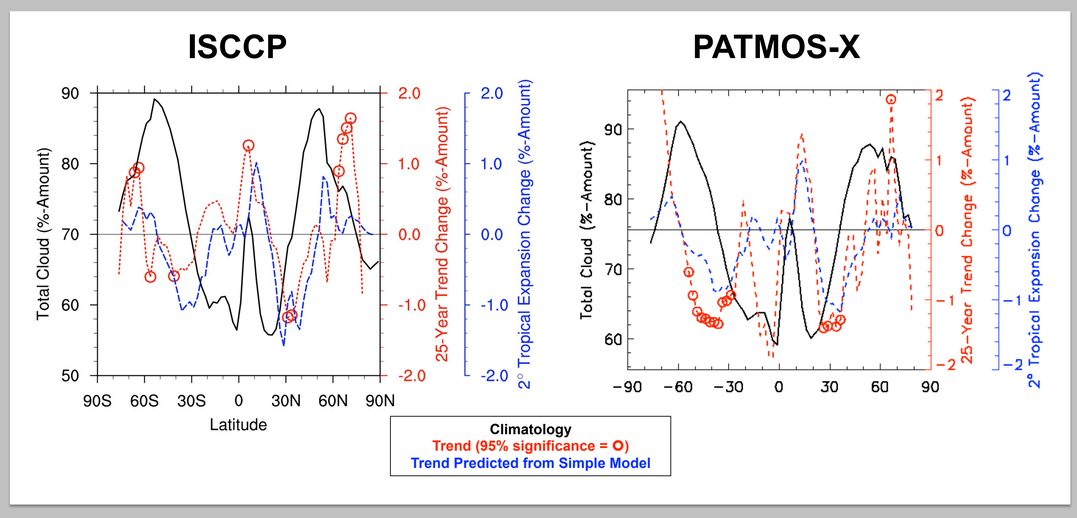
PATMOS-X Cloud Cover Trend (1983-2008)

Cloud cover trends for 1983-2008 do not exhibit a pattern which is easily interpretable in the context of known natural variability or predicted long-trends.

Interestingly, an increasing trend, more prominent in ISCCP data, exists in the marine stratocumulus regions off the coasts of North and South America and Southern Africa. However, Eastman, Warren and Hahn (*J. Climate*, submitted) found a *decreasing* trend in stratocumulus for these same regions for the years 1954-2008.

PATMOS-X cloud cover trends are in rough agreement with ISCCP.

Tropics Expansion is Apparent

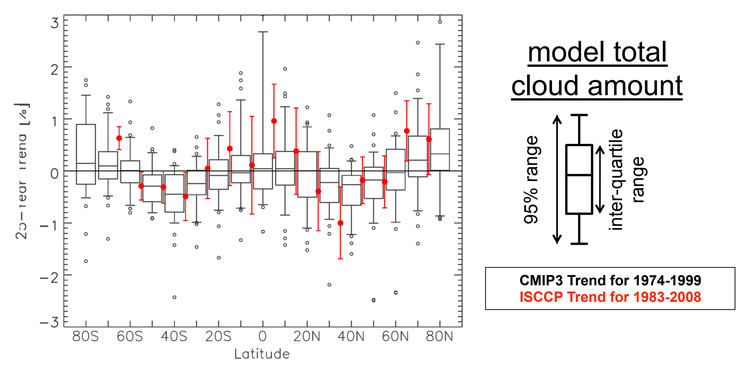


Although the regional pattern of cloud trends is hard to interpret, zonal mean cloud trends show clear signs of the expansion of the tropics which others have recently commented upon (Seidel et al. 2008, Johanson and Fu 2009). In particular, cloud cover has decreased at latitudes between 20° and 55° in both hemispheres and increased at latitudes greater than 55°. This is consistent with a poleward shift of the boundary between the clear subtropics and cloudy midlatitude storm tracks.

These zonal mean cloud trends closely match those predicted from a simple model of tropical expansion which in each hemisphere shifts the cloud cover climatology poleward 1° at 30° latitude. In this model, the latitude shift is linearly interpolated to zero at the equator and poles.

Can Climate Models Simulate These Cloud Trends?

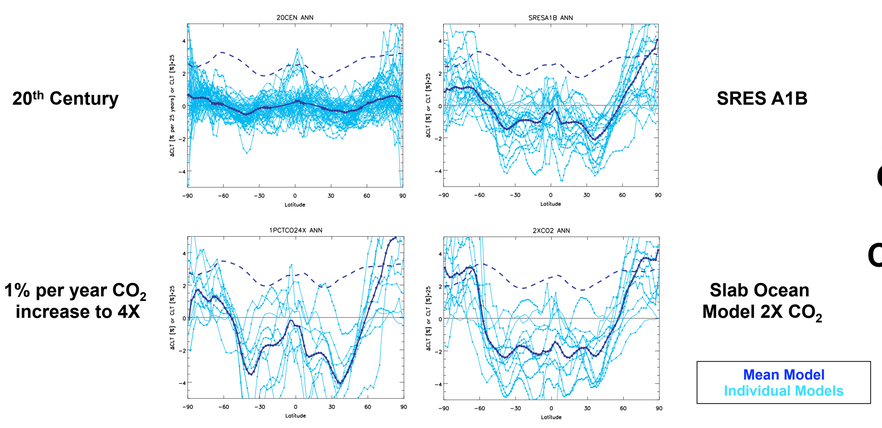
Zonal Mean Trends: ISCCP vs. CMIP3 Models



Similar to observations, climate models simulate on average a trend of decreasing cloud cover at between latitudes 25° and 55° and a trend of increasing cloud cover poleward of 55°. Model trends are a little low though, and tropical cloud cover trends differ between models and observations.

Regardless of scenario, climate models simulate reduced cloud cover at latitudes less than 55°, and increases poleward of 55° in response to increases in greenhouse gases. *Is the observed cloud cover trend the first evidence of a greenhouse-gas forced climate change signal in cloud cover? (It's too soon to say.)*

Zonal Mean Cloud Cover Trends in CMIP3 Models



Take Home Messages

- Cloud cover trends for the period 1983-2008 are consistent between two mostly-independent artifact-corrected satellite datasets
- Cloud cover trends are negative at latitudes 25° to 55° and positive at latitudes greater than 55°
- Cloud cover trends are consistent with an approximate 1° expansion of tropics
- Climate models, in the mean, reproduce the sign of cloud cover trends at latitudes poleward of 25° in the last 25 years of their 20th century simulations
- Attribution studies will be necessary to separate the role of greenhouse gases from other agents such as aerosols and ozone in forcing the observed cloud cover trends and tropics expansion. Such studies are necessary in order to attribute the observed trends to long-term cloud feedback.

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