Correlation between the Sea Surface Temperature and the frequency of Severe Storms in the Tropical Oceans using seven years of AIRS data.

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Abstract

Seven years of AIRS data were used for a daily count of Deep Convective Clouds with cloud top temperatures colder than 210K in the tropical oceans, which we define as DCC. In the past seven years the frequency of DCC has decreased in 30N to 0-30S tropical oceans, and the Sea Surface Temperature (SST) has decreased. If we interpret the ratio of the trend in the DCC count to the trend in the SST as a “DCC process sensitivity”, then the frequency of DCC increases 30±13% for each degree K increase in the SST. This result is consistent with previous work, where we used the correlation of the seasonal variation of the DCC count with the zonal mean SST to deduce a DCC process sensitivity of 45±12%/K. DCC as defined in our study have historically been associated with intense thunderstorms. Assuming continued global warming at the nominal rate of 0.13K/decade, the frequency of severe storms can be expected to increase at the rate of 4%/decade.

Introduction

One of the more elusive problems related to climate changes is the role of clouds. The ISCCP study (Rossow and Schiffer, 1999) found no change or a slightly decreasing high cloud frequency with time. This result disagrees with the most recent reanalysis of HIRS data between 1978 and 2003, which revealed no significant trend in low clouds, but a 2%/decade increase in the high cloud fraction (Wylie et al. 2005). The “high clouds” in the HIRS reanalysis covered about 40% of the tropical oceans. For the detection of climate change, the analysis of trends in the most extreme member of a population may be more sensitive than the analysis of trends in the mean value. The extreme case of high clouds are Deep Convective Clouds (DCC). If we select DCC to have cloud-top-temperatures below 210K, DCC cover less than 1% of the tropical oceans. Our analysis uses the daily count of DCC from the first seven years of Atmospheric Infrared Sounder (AIRS, Chahine et al. 2006) . Every AIRS footprint where the brightness temperature in the 1231 cm^{-1} atmospheric window channel is less than 210 K over non-frozen land or ocean is defined as a DCC. AIRS was launched into a 705 km altitude orbit on May 4, 2002 with a precisely maintained 1:30 PM ascending node. Based on current estimates of spacecraft consumables, AIRS data are expected to be available through 2016.

Results

Figure 1. shows the normalized daily count of DCC (red) and the zonal mean SST (blue) from 0-30N ocean. The overlay of the normalized data, (data-mean)/stdev(data), highlights the high phase correlation between the DCC count and the SST. The SST is obtained from the NCEP forecast (Thiébaux et al. 2003) and randomly sampled for the AIRS nadir track.

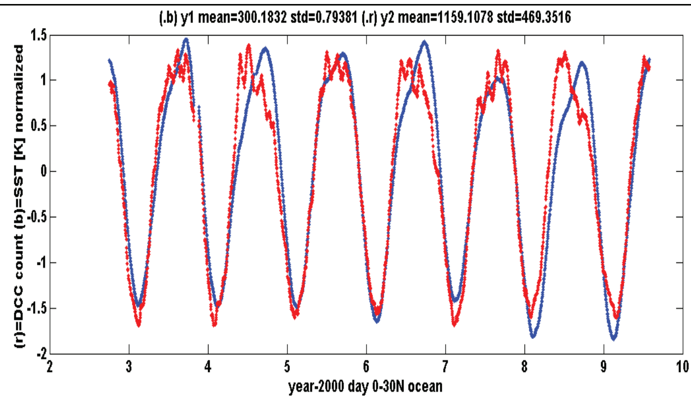

Figure 1.Normalized daily count of DCC from the 1:30PM (day) overpasses of the 0-30N (blue) and the zonal mean SST (red).

In order to evaluate the trend in the data we calculate the anomaly. The anomaly is defined as the difference between the data and the seasonal fit to the data

The seasonal fit is calculated using a linear combination of low order sine and cosine terms (Aumann et. al 2008).The results of the anomaly trend and trend uncertainty for the DCC count and the SST are summarized in Table 1 for the tropical oceans between 30N and 30S latitude. The trend is based on the anomaly and uncertainty includes a correction for the autocorrelation. Two other methods of estimating the trend and trend uncertainty, one using EMD another using LSQ fit bootstrap, produce similar trends, but slightly different trend uncertainties, without changing the overall result.

Tropical Ocean	Day	Night
SST trend mK/yr	-25±3	-28±3
DCC trend %/yr	-0.77±0.36	-0.95±0.37

Table 1. Summary of SST and DCC trends in the tropical oceans

Discussion

The SST trend, presumably related to multi-decadal oscillation, is significant. The DCC trends are significant, their day/night difference is not significant. Our count of DCC and the stability of the count with time depend solely on the stability and the accuracy of the AIRS absolute radiometric calibration. Accuracy at the 200 mK level, and stability at the better than 10 mK/year have been documented in the literature (Aumann et al. 2006). Since a change in the DCC threshold from 210 to 211 K increases the count by 10%, the 10 mK/yr upper limit in the radiance trend contributes less than 0.1%/yr to the DCC trend.

Any trend from only seven years of data has to be interpreted with caution in the context of climate. However, the combination of the trend observed in the SST and the DCC count can be used to derive a sensitivity of the DCC process to a change in temperature. The results are summarized in Table 2.

	Day	Night
Sensitivity %/K	+31±14	+29±12

Table 2. Change in the DCC frequency with SST in the tropical oceans.

The sensitivity of the DCC process to SST derived from seven years of AIRS is consistent with Aumann et al. (2008), who used the correlation between the seasonal variability of the SST and the DCC frequency to drive a +45±12%/K sensitivity. The consistency of the result from the two methods shows that the seasonal variability of at least some geophysical parameters can be used as a proxy to derive the response of the Earth Climate System to longer term trends. DCC colder than 210K have historically been associated with intense thunderstorms. Assuming continued global warming at the nominal rate of 0.13K/decade, the frequency of severe storms associated with DCC can be expected to increase at the rate of 4%/decade.

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