8.2 ON THE RELATIONSHIP BETWEEN TROPICAL MEAN RADIATION AND SST

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1. INTRODUCTION

Recent study based on the earth's radiation budget observations during 1980's and 1990's indicates that decadal variations of tropical mean radiation fields are much larger than expected and far beyond the simulated decadal variabilities found in current general circulation models (Wielicki et al. 2002).

Since the tropical surface temperature was slightly higher during 1990's compared with 1980's, there would be an increase of atmospheric emission associated with the temperature increase and convection change. This study compares the observed decadal Earth Radiation Budget Satellite (ERBS) nonscanner radiation anomaly with theoretical calculations of radiation changes caused by sea surface temperature (SST) anomalies from blackbody emission and 1-D radiative-convective models. Furthermore, the prediction of the Iris hypothesis (Lindzen et al. 2001) was tested using the observed anomalies. Some studies (Lin et al. 2002; Chambers et al. 2002) have already clearly demonstrated that there are no evidences in satellite data in supporting the Iris hypothesis. This study further confirms the conclusion.

2. DATA SETS

The decadal tropical mean radiative anomaly fields of the Earth Radiation Budget Satellite (ERBS) during 1985 to 1999 (Wielicki et al 2002) are used in this study. The ERBS satellite measures broadband shortwave (SW) and total radiation. Longwave (LW) values are the differences between the two broadband measurements. The net outgoing radiation is obtained from the difference of outgoing LW and net incoming SW radiative values. The anomaly fields are constructed from the mean radiation values of the tropics (within ±20° latitudes) and referenced to 1985 to 1989 period. To remove the temporal aliasing effect caused by the slow drift of the ERBS orbit, the tropical mean radiative anomalies are calculated based on the full 72-day precession period of the ERBS satellite.

In order to investigate the effects of SST on clouds and radiation fields, the SST dataset from National Center for Environmental Prediction (NCEP) reanalyses for the same period as the ERBS radiation data is analyzed. The SST anomalies are constructed using the 72-day means obtained in the same manner as the ERBS radiative anomalies. Observations of tropical ocean surface temperature reveal that the 1990s were slightly warmer than the 1980s. Figure 1 shows the time series of the 72-day averaged tropical mean SST anomalies from the NCEP reanalysis. In decadal time scale, the tropical mean SST during the 1990s was about 0.14K higher than its value during the 1980s. There are no statistically significant SST trends during these periods due to large SST fluctuations caused by some extreme events such as El Nino and volcanic eruption.

3. RESULTS

The time series of tropical mean outgoing LW anomalies from ERBS nonscanner observation (red curve), along with the model-calculated anomalies based on the tropical mean SST anomalies and the Iris hypothesis are plotted in Fig. 2. Different γ values in the Iris calculations represent different assumed coupling conditions between tropical dry and moist areas. There are some gaps in the ERBS LW anomaly time series that are caused by spacecraft battery system anomaly problem (e.g. 4 months in late 1993). Compared with the NCEP SST anomaly (Fig. 1), the ERBS LW anomalies have very similar seasonal to inter-annual variations.

Figure 3 shows the relationship between ERBS outgoing LW anomalies and SST anomalies. The two data sets without the values for the Pinatubo eruption period (Fig. 3a) are statistically significantly correlated (correlation coefficient 0.563; note that ERBS SW and Net are also correlated with SST). The regression slope of the LW with SST is about 4.6 $W/m^2/K$, which is similar to the theoretical increase of LW due to blackbody emission (~4 $W/m^2/K$), and much larger than the predictions (~2.3 $W/m^2/K$) from 1D radiative-convective models with fixed relative humidity. Without ERBS decadal LW anomalies, the regression slope drops to ~2.1 $W/m^2/K$ (Fig. 3b), indicating the tropical climate system may be close to the radiative-convective equilibrium in seasonal to interannual time scales.

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The decadal ERBS measured outgoing LW and incoming SW radiation anomalies between the 80's and the 90's are about 3.1 and 2.4 W/m^2, respectively (Table 1). The ERBS LW anomaly is much larger than the calculated changes in blackbody emission (~0.58 W/m^2) resulted from the small decadal variations of tropical mean SST. These observed LW changes are also larger than those predicted by the radiative-convective equilibrium models (~0.33 W/m^2). As shown in Table 1, most of the observed LW anomaly, however, is balanced by net incoming SW radiation, resulting in the net outgoing radiation (0.65 W/m^2) closer to the theoretical values. On the decadal time scale, the LW and SW predictions of the Iris hypothesis are significantly smaller than ERBS observations (Table 1). The net outgoing radiation of the hypothesis is much larger than observed value due to the strong negative feedback of the Iris hypothesis.

4. CONCLUSIONS

The outgoing LW variations of tropical climate system show close relationship with the blackbody emission and radiative-convective equilibrium processes in the seasonal to interannual time scales. Theoretical calculations (such as blackbody emission) may also represent the net radiation of the system on longer time scales. On the decadal time scale, the ERBS measurements are generally significantly different from those of the Iris predicted tropical mean radiative flux anomalies, and do not support the strong negative feedback of the Iris effect (Table 1; Fig. 2).

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Table 1 Averaged tropical mean radiative flux anomalies (W/m^2) during the 1994-1997 period from the ERBS observations and the Iris hypothesis.

	ERBS	Iris	
		$\gamma = 0$	$\gamma = 1$
LW	3.05	1.434	2.066
SW	2.40	0.382	0.382
Net	0.65	1.052	1.684

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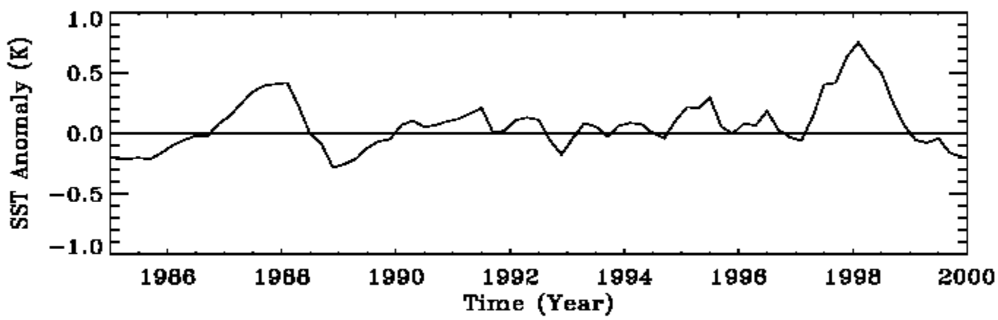


Figure 1 Time series of NCEP tropical SST anomalies.

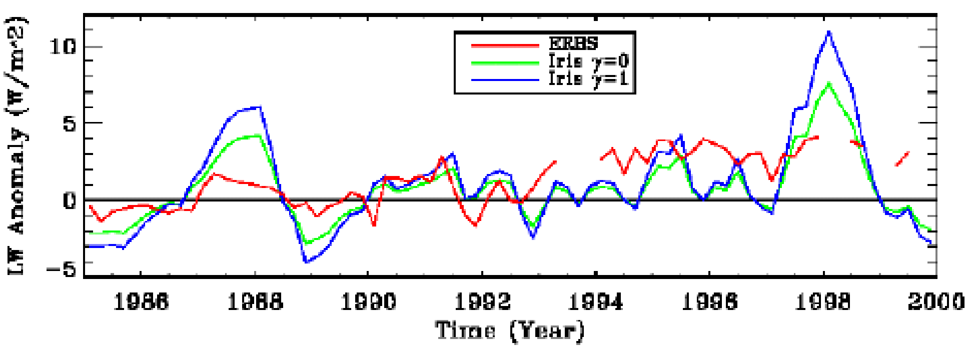
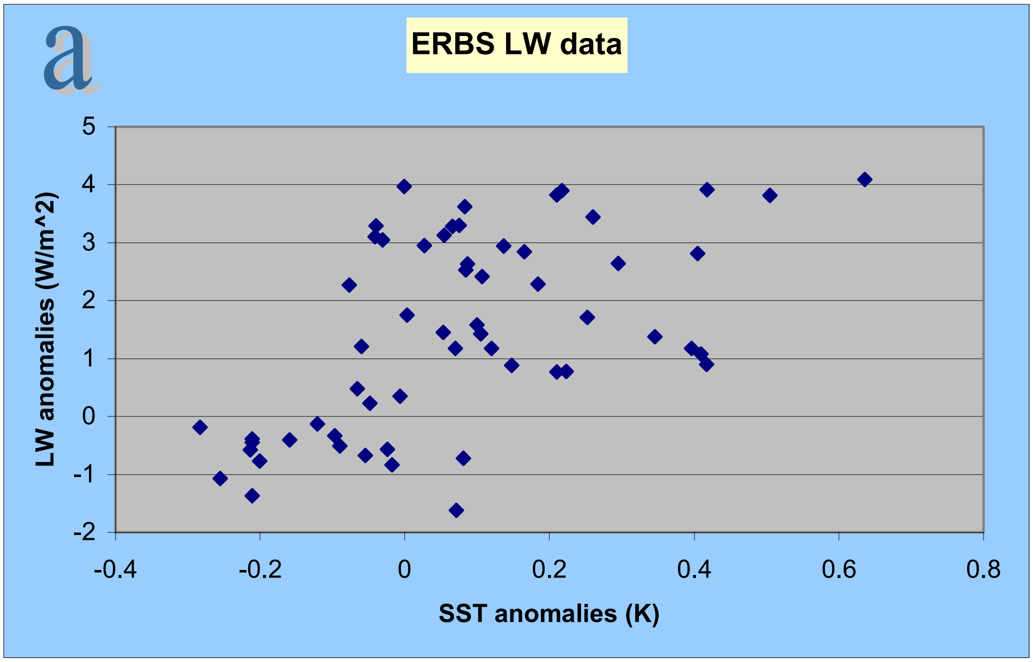


Figure 2 Time series of outgoing LW radiative anomalies from the ERBS and Iris hypothesis.



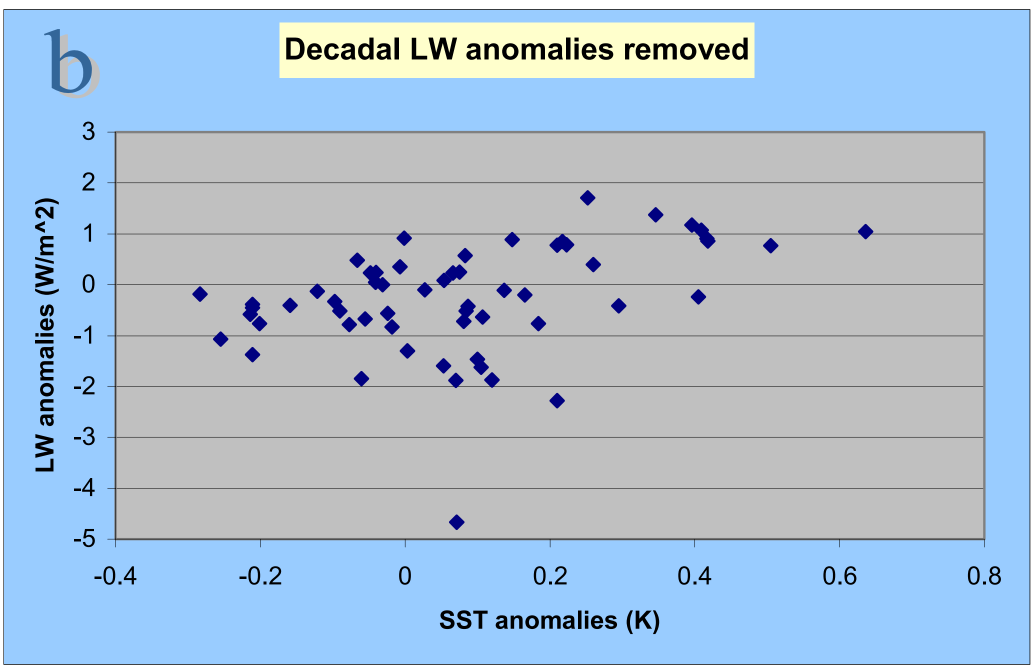


Figure 3. Scattering plots of outgoing LW with SST for ERBS data (a) and the ERBS data after ERBS decadal LW anomaly signal removed (b).