5B.3 A study on variations of deep-rain properties with the sea surface temperature over the tropics utilizing TRMM PR2a25 and TMI data

Yukari N. Takayabu
Center for Climate System Research, University of Tokyo, Tokyo, Japan

1. Introduction

The infrared iris hypothesis proposed by Lindzen et al. (2001; LCH2001) suggested the possibility of negative feedbacks of tropical cloud systems through reducing the moist air attributing to the increase of cumulus rain. However, there are some ambiguities left; if we can clearly separate cumulus clouds from high stratiform clouds with GMS infrared data, if the sea surface temperature (SST) used there is truly representative of cloudy area SST, besides the subtropics contamination problem in their analysis as pointed by Hartmann and Michelsen (2002).

With TRMM (Tropical Rainfall Measuring Mission) satellite, we can obtain the 3D rain structure from the space-born radar measurements, which provides not only clearer classification of stratiform rain from convective rain, but also the precipitation top height (PTH). Moreover, from the TMI (TRMM microwave imager) data, which is on the same satellite, we can obtain the simultaneous SST data. Utilizing this opportunity, we approached the issue by statistically examining the variation of tropical rain characteristics associated with SST. Although what we see with PR is the rain and not the cloud, we can expect the deep stratiform rain cover would be in a positive correlation with the deep stratiform cloud cover.

2. Data and Methodology

All path data of PR2a25 version 5 for the three-year period from January 1998 to December 2000, except for January 1999 and September to November 1999 where data were missing, were utilized in a pixel by pixel basis. Classification between the convective rain and the stratiform rain depends basically on the rain flag provided by the PR2a23 data set. Warm isolated rain pixels were reclassified from the stratiform to convective rain, following the suggestion by Schumacher and Houze (2003). PTH for each pixel was identified with a threshold of 0.3mm/hr. With these rain flags and PTH, we determined deep convective rain (PTH>8km; DCR) and deep stratiform rain (PTH>5km; DSR).

Before the statistics, daily gridded rain data were made into 2.5deg x 2.5deg longitude-latitude grids. Only the ocean pixels were treated utilizing the surface information for each pixel. The 3-day running mean gridded TMI-SST provided by JAXA were utilized for SST. Next, we binned the daily 2.5degx2.5deg rain data into 1degC SST bins for the same day and same rainy grid. Then we made statistics of the coverage, amount, and intensity of DCR and DSR over ocean in relation to rainy-SST for four tropical regions as shown in Fig.1 (Region B: 30N-30S, 130E-170W, GMS region in LCH2001, Region D: 15N-15S, 125E-90W, North Pacific ITCZ, Region E: 5N-10S, 60E-100E, equatorial Indian Ocean, Region F: 20N-20S, 0-360E, entire tropics). Counted rainy 2.5deg grid numbers are 212599, 115650, 48888, 646099, for regions B, D, E, F, respectively. The averaging was performed carefully to consider the coverage of PR path over each rainy grid correctly with the area-weight.

3. Results

Figures 2 show the percent coverage of DCR and DSR, respectively. First let us examine the SST range between 25C and 30C, relatively warm water, which is examined in LCH2001. Both DCR cover and DSR cover significantly increase with SST, except for over the Indian Ocean. DCR and DSR amounts show very similar behavior with coverage (not shown). It clearly indicates that over most tropical region (see region F), DSR coverage increases with SST associated with the increase of the DCR amount. Over the Indian Ocean, on the other hand, SST is more sensitive to the solar flux and decrease with increasing stratiform cloud cover as suggested by previous works. Over the colder SST in the GMS region (region B here), DSR negatively correlates with SST. It supports the Hartmann and Michelsen (2002)'s criticism that the negative correlation of the anvil cloud cover with the cloud weighted mean SST in LCH2001 is an artifact by the contamination of the subtropics.

Next we examine the ratio of DSR cover to DCR cover (Fig.3a), which corresponds to LCH2001's 'cirrus coverage normalized by cumulus coverage'. We find that these values have significant negative correlation over warmer (>25C) SST. The decrease rate of DSR-cover/DCR-cover is 10%/1degreeC, in agreement with what suggested by LCH01. Values of DSR-cover/DCR-amount and DSR-amount/DCR-amount also decrease with SST (not shown). It is notable that these DSR properties normalized by DCR show very similar behavior in relation to SST independent of the regions.

Interestingly, intensities of DCR and DSR have a tendency to decrease with SST over the warmer water (Fig.3b). However, its decreasing rate is not very large, and therefore total rain amount almost follows the rain cover.

4. Conclusion

Although the DSR-cover/DCR-cover decreases with SST in concert with LCH2001, it was shown that DSR-cover itself increased significantly with SST. Therefore, when we assume the moist air in proportion with DSR-cover, the iris hypothesis is not expected to work over the average situation of the warm water. However, we have to note that there exist complicated atmosphere-ocean interactions, as suggested by the different behavior of the Indian Ocean. On the other hand, very robust relationship of DSR properties normalized by DCR values, free from regional differences, is suggested. These relations may become a clue to the variation of rain properties associated with the climate change in future studies. The physical reason of decreasing tendency of DCR and DSR intensity with SST should also be considered.

References:

Hartmann, D. L., and M. L. Michelsen, 2002: No evidence for iris. *Bull. Amer. Meteor. Soc.*, **83,** 249-254.

Lindzen, R. S., M. D. Chou, and A. Y. Hou, 2001: Does the earth have an adaptive infrared iris? *Bull. Amer. Meteor. Soc.*, **82.** 417-432.

Schumacher, C., and R. A. Houze, Jr.: The TRMM precipitation radar's view of shallow, isolated ran, *J. Appl. Meteor.*, **42,** 1519-1524.5

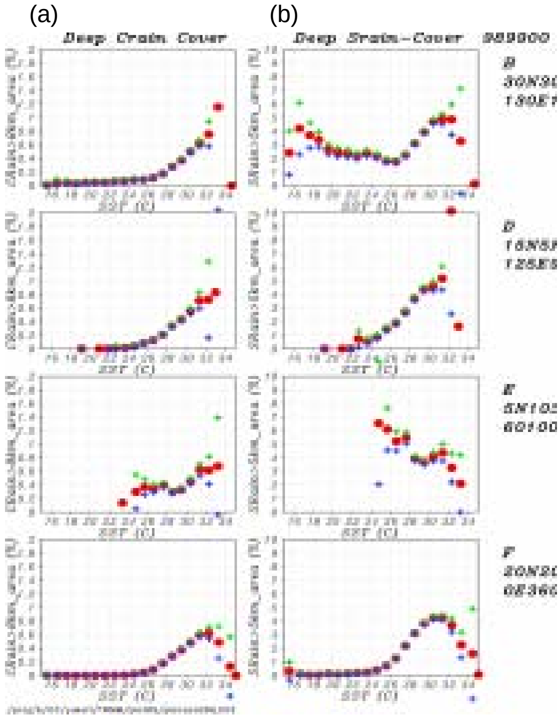
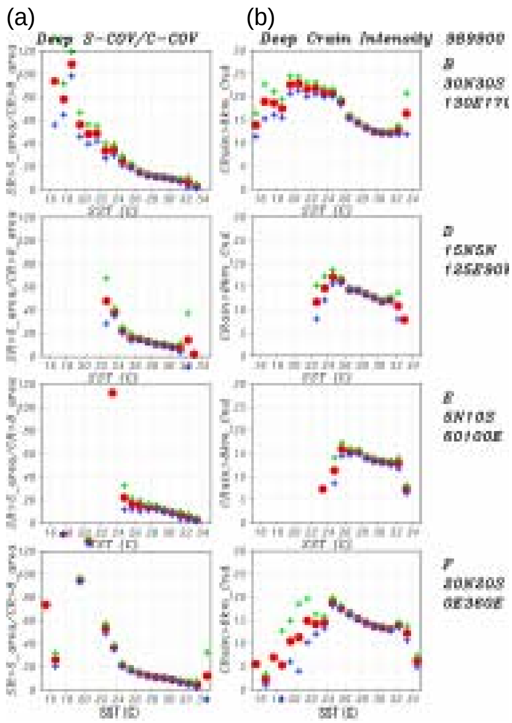


Fig.2: Average values of (a) DSR-coverage and (b) DSR-coverage binned to rainy SST for regions B, D, E, and F, from top to bottom. Crosses shows the 95% significant limits. See the text for details.



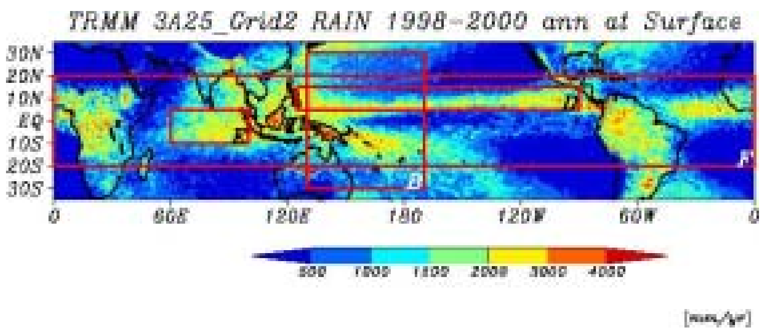


Fig.1 TRMM average surface rain and analysis regions (B, D, E, F).

Fig.3 Same as Fig.2 but for (a)DSR-coverage/DCR-coverage and for (b) DCR intensity.