DIURNAL VARIATION DURING TOGA COARE

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1. Introduction

In many regions of the Tropics where local effects do not dominate, oceanic rainfall is characterized by a nocturnal to early morning maximum. The oceanic diurnal variation is significant during the disturbed periods but not during the undisturbed periods. The primary mechanisms that have been suggested include: (1) Mesoscale convective systems (MCSs) life cycle (Chen and Houze 1997). (2) Direct radiation-convection interaction (Kraus 1963 and Randall et al. 1991). (3) Day versus night radiation-subsidence (Gray and Jacobson 1977). (4) Large-scale radiative destabilization (Sui et al. 1997, 1998).

The purpose of this paper is to test the different mechanisms using the abundant observational data during TOGA COARE.

2. Data and Method

The datasets used include (1) TOGA COARE radar rainfall maps (Short et al. 1997). (2) Upper air temperature and specific humidity from the CSU gridded analyses over the IFA (Lin and Johnson 1996). (3) cloud fraction derived from the sounding data using relative humidity criteria and the radiative heating rate calculated using the CCM3 column radiation model. (4) The heat, moisture and moist static energy budgets calculated by Zhang and Lin (1997) from the sounding array during TOGA COARE.

Composite of diurnal variation are constructed separately for the disturbed periods and the undisturbed periods. Fourier analysis is applied to eliminate any nondiurnal signal.

3. Results

Fig. 1 shows the vertical structure of the convective heating and the corresponding surface precipitation. For the disturbed period (Fig. 1b), The anomaly field is obviously tilted with height. The convective precipitation is dominant from afternoon to midnight, while the stratiform component is dominant from midnight to early morning. This suggests that the tilt of the convective heating is mainly caused by the development and time-lag of the two components.

The cloud structure are quite different between the two periods. In disturbed periods, there is more midtop cloud, and the diurnal variation has much larger magnitude and thickness. For disturbed periods (Fig. 2b), the net radiation is dominated by the LW field. At night there is positive cloud base-top difference, while during the day, there is negative cloud base-top difference. This suggests that it is more unstable at night and more stable in the day.

Fig. 3 shows the vertical pressure velocity ω. In the undisturbed periods, Anomaly field of ω (Fig. 3a) shows distinct out-of-phase relationship between the lower troposphere and the upper level. This obvious two layered structure implies that the vertical velocity in the undisturbed region can not be caused by the nighttime radiational cooling alone. In that case, the whole troposphere should be subsidence at night. The observed situation suggests that there exists an interaction between the disturbed and undisturbed region, and the two layered structure maybe forced by the disturbed region (Fig. 3b).

The availability of saturation water vapor amount $-dq_s/dt$ (Fig. 4b) has different position of maximum comparing with convective heating $Q_1 - Q_R$ (Fig. 1b), and the magnitude is not large enough to explain all $Q_1 - Q_R$ variation. The maximum of vertically integration of $-dq_s/dt$ (shown below) is 0.2 mm/hr at 1900 LT, not in the midnight. It may contribute to convective precipitation maximum at 2000 LT, but can not be the mechanism for the stratiform precipitation maximum at 0100 LT.

4. Conclusion

Fig. 5 is the schematic of diurnal variation based on TOGA COARE analysis: Our result support the MCS life cycle and the direct radiation-convection interaction mechanism, but do not support the day versus night radiation-subsidence and the large-scale radiative destabilization mechanism.

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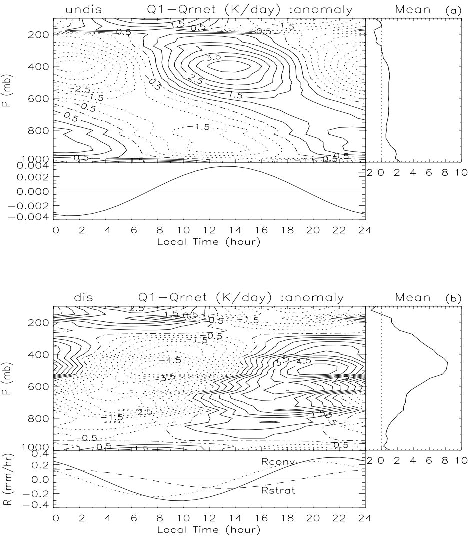

Figure 1: convective heating $Q_1 - Q_R$ (K/day).

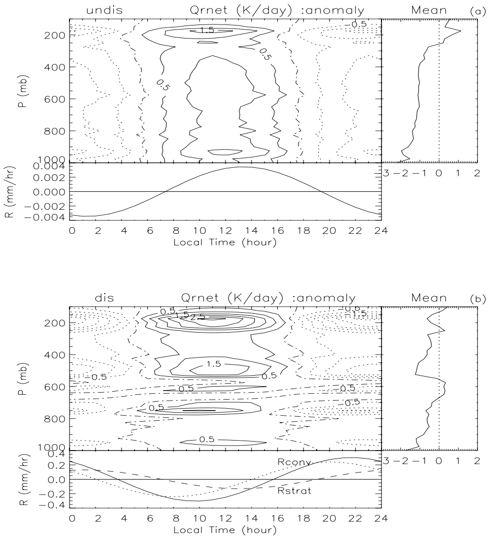

Figure 2: net radiation heating rate (K/day).

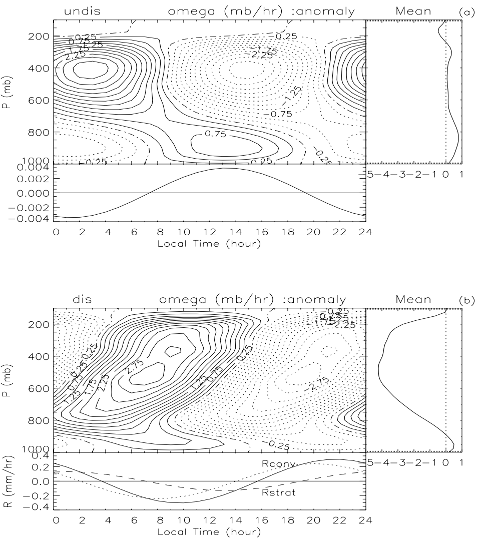

Figure 3: vertical pressure velocity (mb/hr).

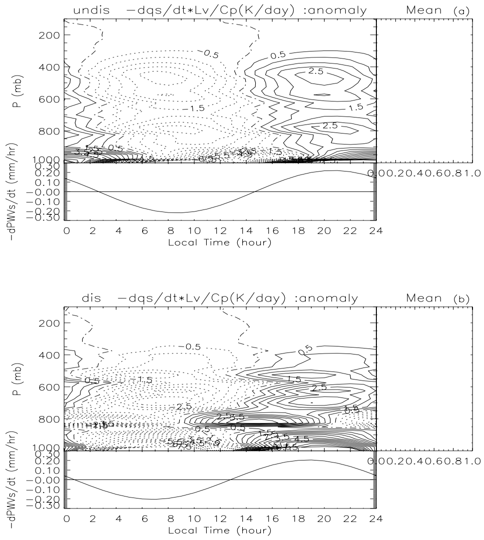

Figure 4: Time change of available saturated moisture (K/day).

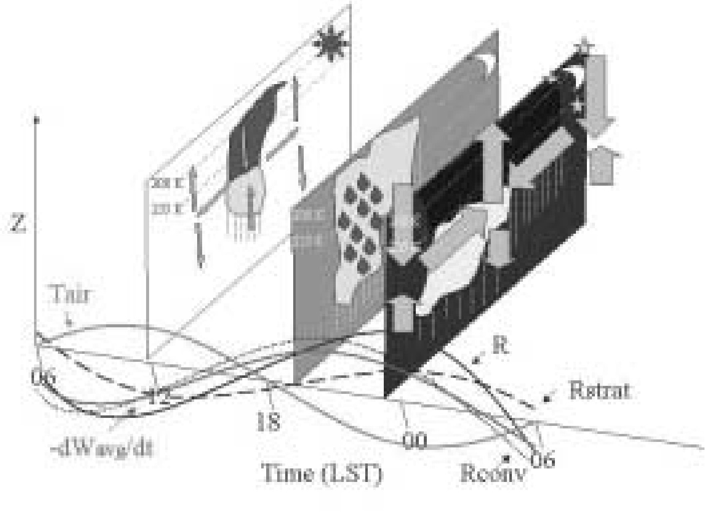

Figure 5: Schematic of the TOGA COARE results