P1A.6

DIURNAL CYCLE OF DEEP CONVECTION IN THE SUPER CLUSTER EMBEDDED IN MJO

Tsuneaki Suzuki*
FRCGC/JAMSTEC, Yokohama, Kanagawa, Japan

1. INTRODUCTION

Tian et al. (2006) investigated the impact of the MJO on the diurnal cycle of the tropical deep convection cloud amount (DCC) using the ISCCP D1 cloud product. Their analysis indicated that the diurnal cycle of the DCC was enhanced (reduced) during the convectively active (inactive) phase of the MJO. They also showed that the diurnal phase of DCC was not so significantly affected by the MJO. Tian et al. (2006) mainly investigated the area-weighted mean “MJO diurnal cycle”, so that they did not identify the type of convective organization, i.e., the convectively coupled wave (large-scale organized deep convection) and isolated deep convection.

Nakazawa (1988) showed the distinct super clusters (SCs) which propagated eastward with the phase speed of 10–15 m/s during the active phase of MJO. When we observe the MJO by outgoing long wave radiation (OLR) or equivalent blackbody temperature (Tbb), MJO is often characterized by SCs which appear to be a kind of convectively coupled Kelvin wave. The diurnal variation of cumulus convection clearly associated with convectively coupled wave has not been studied minutely. In this study we investigate the diurnal cycle of deep convection in the SC using the global IR (i.e., Tbb) data.

2. DATA AND METHODS

To investigate the diurnal cycle of cumulus convection, we used the global half hourly IR (Tbb) data provided by the Climate Prediction Center (CPC)/NOAA. The spatial resolution of the Tbb data that we used is 0.5°×0.5° and we degraded temporal resolution from half hour to 1 hour by simple average. The period between the autumn of 2000 and the spring of 2005 was analyzed.

In addition, to select MJO events, we prepared the MJO-wave-filtered NOAA daily OLR in the same period as the Tbb data. Referring to the longitude–time diagram of the MJO-wave-filtered NOAA daily OLR averaged between 7.5°S and 7.5°N, we identified the boreal winter MJO events occurring from the autumn of 2000 to the spring of 2005. Based on this MJO identification, we chose 30 SCs (the phase speed of 5–13 m/s) embedded in MJO events using the longitude–time diagram of Tbb averaged between 7.5°S and 7.5°N.

* *Corresponding author address*: Frontier Research Center for Global Change, Japan Agency for Marine-Earth Science and Technology, 3173-25 Showa-machi, Kanazawa-ku, Yokohama, Kanagawa 236-0001, Japan; e-mail: tsuneaki@jamstec.go.jp

First, for the one SC event, we made the composite of Tbb data every 3 hours of local standard time (LST) along the line which corresponds to the SC in the longitude–time diagram of Tbb. Next, we collected all SC events and made the composite Tbb of 30 SCs (SC composite). We made the composite of SC for the four selected regions, i.e., the Indian Ocean (IO) (60°–95°E), ocean of the Maritime Continents (MCO) (100°–150°E), lands of the Maritime Continents (MCL) (100°–150°E), and the western Pacific (WP) (150°E–180°).

To compare SC case with the isolated (or weak organized) cumulus convection, we also made the composite of Tbb data every 3 hours of LST at each longitude during convectively suppressed phase of MJO (CSP composite). We selected different periods of convectively suppressed phase for each region [i.e.,

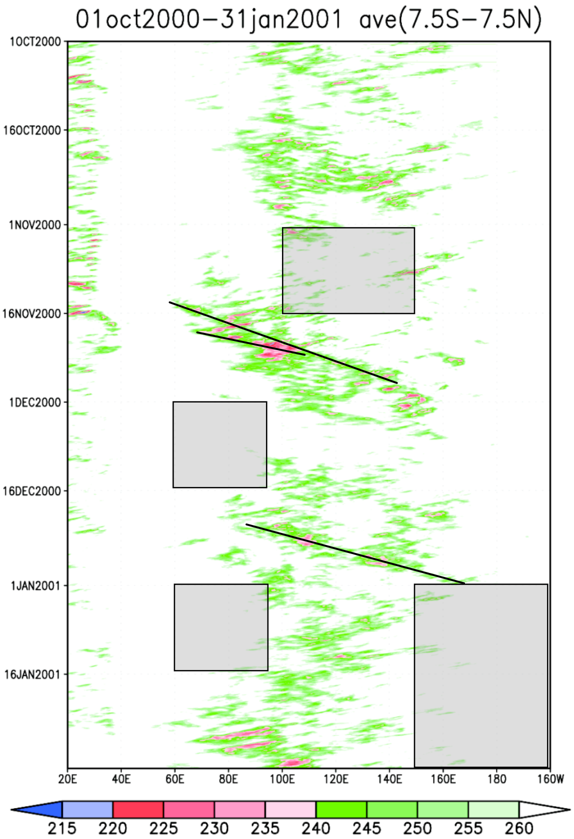

FIG. 1. Longitude–time diagram of Tbb (K) averaged between 7.5°S and 7.5°N. Solid lines show the super cluster events that we selected to make SC composite. Gray-shade regions indicate area in the convectively suppressed phase of MJO.

IO, MC (-O, -L), WP], referring to the longitude–time diagram of the MJO-wave-filtered NOAA daily OLR and raw Tbb.

When we made composite Tbb, we excluded the grid of which the temperature is higher than 270 K to remove the influence of surface emission.

3. RESULT

Figure 1 shows a example of the longitude–time diagram of Tbb in which we presented several SCs and convectively suppressed phase of MJO for each region. The composites for each LST were made using these selected Tbb scenes (i.e., Tbb data files for each GMT).

3.1 Diurnal Cycle of Composite Cumulus Convection in SC

Figure 2 shows the diurnal variation of SC composite in IO region. The LST shown in Fig.2 corresponds to the time at the relative longitude 0°. The relative longitude 0° corresponds to position on the SC line in the longitude–time diagram of Tbb at each LST, so that the lowest temperature area is expected to appear at the relative longitude 0°. However, the lowest temperature area existed about 7° east. One reason for this discrepancy is that the SC line may not capture the coldest Tbb position of the SC because the Tbb was averaged between 7.5°S and 7.5°N in the longitude–time diagram. The diurnal cycle of the cold area (deep convection) was consistent with previous studies (e.g., Janowiak et al. 1994). However, the cold area seemed to be maintained longer than previous reports; the relatively cold area (<240 K) was almost the same in 0300–1500 LST. The diurnal cycle of deep convection

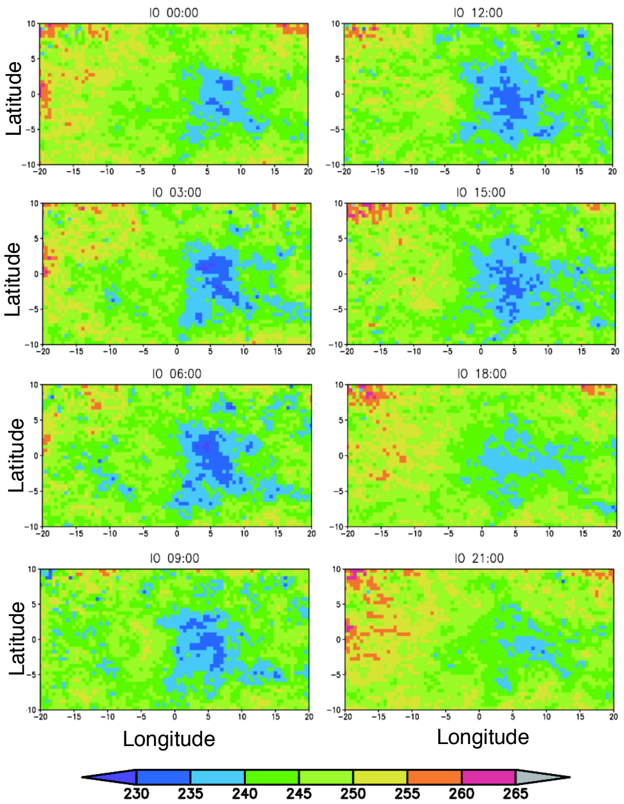

FIG. 2. Diurnal cycle of composite Tbb (K) of super clusters in the Indian Ocean (60°–95°E). Longitude 0° indicates the center of composite super cluster. The composite Tbb is shown every 3 hours.

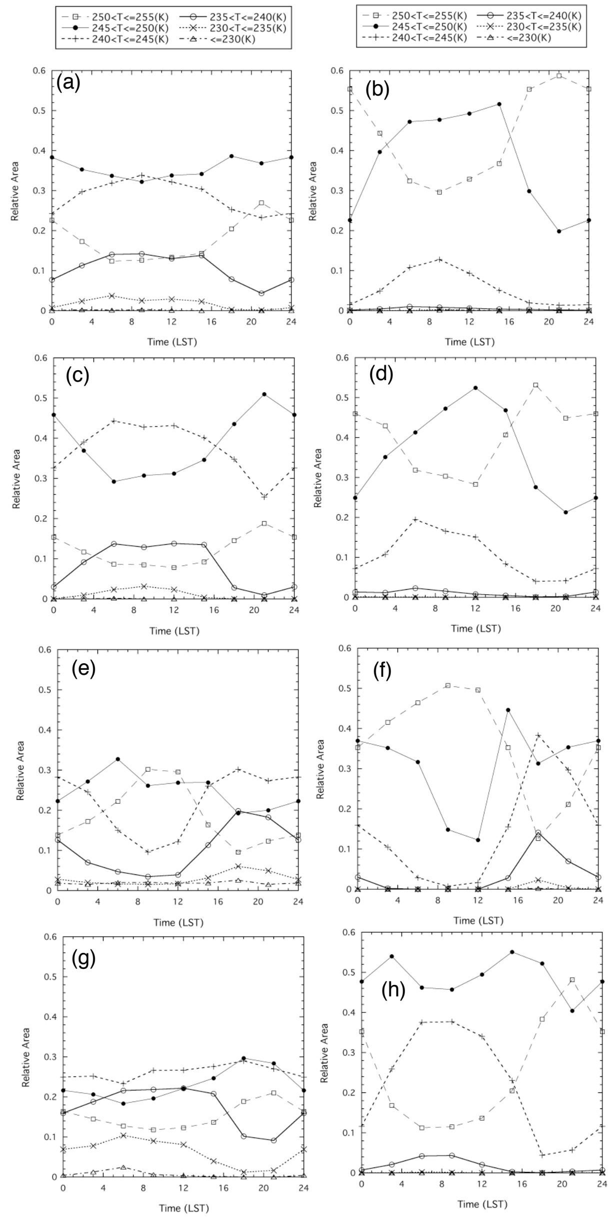

FIG. 3. Diurnal variation of relative area (see text) for each Tbb threshold. (a) and (b) The Indian Ocean, (c) and (d) oceanic region of the Maritime Continents, (e) and (f) lands of the Maritime Continents, (g) and (h) the western Pacific. Left column shows the composite of super clusters. Right column shows the composite of cumulus convection during convectively suppressed phase of MJO.

associated with SC seems to be modulated in comparison with that of averaged oceanic deep convection.

3.2 Comparison of Diurnal Cycle of Cumulus Convection in SC with that in the Convectively Suppressed Phase of MJO

To confirm the modulation of diurnal cycle of cumulus convection associated with SC, we examined the diurnal cycle of cumulus convection during the convectively suppressed phase of MJO. Figure 3 shows the diurnal variation of the relative area (the ratio of area within the Tbb threshold to total area) for different Tbb thresholds for both SC and CSP composites. Although the diurnal cycle of cumulus convection in three oceanic regions (IO, MCO, WP) showed slight differences, there were common features; the Tbb area colder than 240 K showed the diurnal cycle consistent with typical oceanic deep convection in SC composite, while the Tbb area colder than 245 K was consistent with typical oceanic deep convection in CSP composite. The amplitude of diurnal cycle in SC composite was smaller than that in CSP composite, and the cold Tbb area was maintained longer in SC composite than in CSP composite. The same relation of cumulus convection feature between SC and CSP composites also existed in the land region (MCL). The difference between the SC and CSP composites might be explain by the large-scale and mesoscale dynamic and thermodynamic processes as pointed out by Chen and Houze (1997). However, the differences between the two composites in oceanic region were similar to those in land region. This suggests that the difference of the diurnal cycle of Tbb in the two composites reflects simply the difference of the development and maintenance of outflow cloud deck from cumulus convection at upper troposphere.

4. SUMMARY

The main findings are as follows. 1) Both composite of super cluster (SC composite) and that of cumulus convection during convectively suppressed phase of MJO (CSP composite) showed the diurnal cycle of deep convection consistent with previous studies: maximum of deep convection occurred in late afternoon and early evening in land region, while maximum occurred in early or late morning in oceanic region. 2) However, the amplitude of diurnal cycle in SC composite was smaller than CSP composite, and the cold Tbb area was maintained longer in SC composite than in CSP composite. 3) The Tbb threshold with which we identify deep convection was higher for CSP composite than for SC composite.

Acknowledgments

The author thanks Yukari N. Takayabu and Kozo Nimoniya for their useful comments, and is grateful to John E. Janowiak and Yelena Yarosh for providing the 0.5°□0.5° CPC global IR data.

REFERENCES

Chen, S. S., and R. A. Houze Jr., 1997: Diurnal variation and life-cycle of deep convective systems over the tropical Pacific warm pool. *Quart. J .Roy. Meteor.Soc.*, 123, 357–388.

Janowiak, J. E., P. A. Arkin, and M. Morrissey, 1994: An examination of the diurnal cycle in oceanic tropical rainfall using satellite and in situ data. *Mon. Wea. Rev.*, 122, 2296–2311.

Nakazawa, T., 1988: Tropical super clusters within intraseasonal variations over the western Pacific. *J. Meteor.Soc. Japan*, 66, 823–839.

Tian, B, D. E. Waliser, and E. J. Fetzer, 2006: Modulation of the diurnal cycle of tropical deep convective clouds by the MJO. *Geophys. Res. Lett.*, 33, L20704, doi:10.1029/2006GL0277752.