On the diurnal variation of precipitation associated with tropical cyclone and its intensity

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1. Introduction

Diurnal variation of cloudiness associated with tropical cyclone (TC) was reported by previous studies. Kossin (2002) identified a significant diurnal variation of cloudiness beyond a radius of 300 km without the diurnal variation near the storm center using IR images. He hypothesized the spatial variation of cirrus canopy is caused by radiatively driven subsidence. Fovell et al (2010) remarked that the microphysics parameterization modulates vertical motions and outer core wind speed through cloud-radiation feedback at the anvil using idealized simulations. From these studies, cloud-radiation feedback might produce temporal changes of TC structure and intensity through diabatic heating related to the diurnal variation of cloudiness. However, these are still not clear. Thus, cloud-resolving simulations of TC under an idealized condition are performed in order to examine a relationship between diurnal variation of precipitation and intensity change.

2. Model description and experimental design

A model used here is Japan Meteorological Agency Non-Hydrostatic Model (JMA-NHM, Saito et al., 2007). The model setting and experimental design are almost same as Sawada and Iwasaki (2010). The horizontal grid spacing of 3 km is used. The integration is done for 192 hours. Start time of simulations is 0900 local time (LT).

3. Time evolution of simulated TC

Figure 1 shows time evolution of central sea-level pressure (CSLP), area-averaged

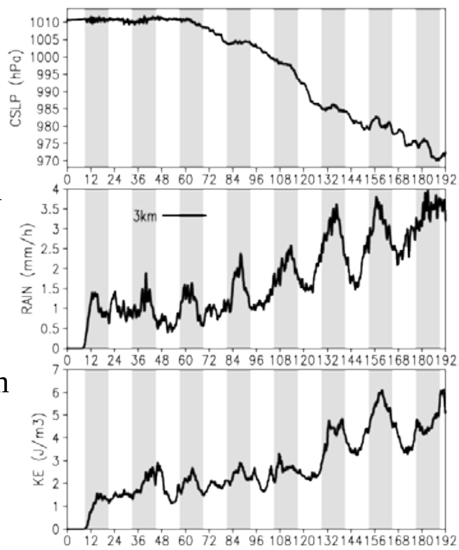

Fig. 1. Time series of CSLP, area-averaged precipitation, area-averaged eddy kinetic energy. Gray shadings indicate night time (18–06 LT).

precipitation within a radius of 300 km and area-averaged eddy kinetic energy. The CSLP begins to decrease at T = 60 h and it reaches 970 hPa at T = 189 h. The area-averaged precipitation has a significant diurnal variation with maximum at 21–03 LT and minimum at 06–12 LT. The diurnal variation is evident outside the eyewall. This variation is attributed to outward propagating rainband. The timing of rainband propagation is closely related to the cloud-radiation feedback. The rainband generates asymmetric structure, which causes the weak diurnal variation of eddy kinetic energy.

4. Secondary circulation and diabatic heating

Precipitation by rainband provides large amount of condensation heating outside the eyewall, which enhances secondary circulation. To see the temporal change in secondary circulation, the azimuthally averaged mass stream function is examined in the daytime and night time in Fig. 2. The secondary circulation outside the eyewall becomes stronger in the night time than in the daytime. The stronger secondary circulation transport absolute angular momentum from the outer side around the mid-troposphere, resulting in amplification of outer core wind speed. At the inner core, low-level inflows become slightly weaker in the night time than in the daytime, reducing tangential wind in the night time. This reveals that the response of wind speed in the inner and outer core to the diurnal variation is quite different.

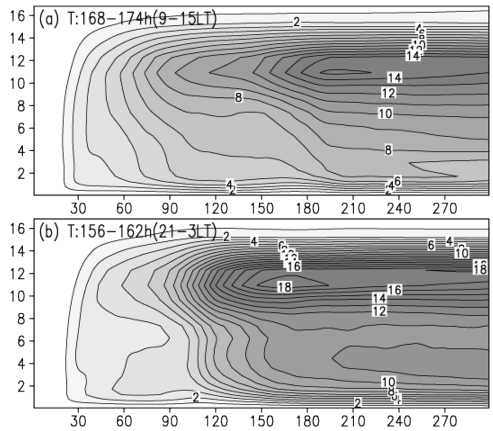

Fig. 2. Vertical structure of azimuthally averaged mass stream function at (a) T = 168-174 h (daytime) and (b) T = 156-162 h (night time).

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