Large-scale deformation of tropical cloud band in the ITCZ detected in NICAM simulations

*Noriyuki Nishi[1], Atsushi Hamada[4], Yohei Yamada[2], Tomoe Nasuno[2], Reona Satoh[5], Masaki Satoh[3]

1. Faculty of Science, Fukuoka Universtiy, 2. JAMSTEC, 3. AORI, University of Tokyo, 4. Graduate School of Science and Engineering for Education, University of Toyama, 5. Graduate School of Science, Fukuoka University

Over the central/eastern tropical Pacific, the Inter Tropical Convergence Zone (ITCZ) is detected in the northern side of the equator. In the ITCZ, we can sometimes observe drastic deformation of the cloud bands elongated zonally with several thousand-kilometer scale. The initial stage of the band, which is composed of deep convective systems, expands meridionally and separates into two or three parallel cirrus bands that keep alive one or two days (Hamada et al., 2013, JMSJ). These separation events cannot be well described in the objective analysis datasets, probably due to lack of the observations over the open ocean; investigation of their mechanism with the analysis data is difficult. In order to study their mechanism, we attempted to use the numerical simulation results of global cloud system resolving model NICAM (Satoh et al. 2014, Progress in Earth and Planetary Science) to find similar events in them. If we can find separation events in the results, we can examine the mechanism with many physical parameters including wind, various kinds of hydrometeors. We have already analyzed several numerical experiment results for different periods, resolution and physical schemes.

We found a similar separation event in an output of the simulation for one year from June 2004 and horizontal resolution 3.5 km. We examined the life cycle of the cirrus bands after separation. One interesting point is on the height of the cirrus clouds in the separated bands. The simulated cirrus clouds in the bands lie in the 13-14 km height level, while the height of the maximum meridional wind that contributes to the meridional movement of the cirrus bands is about 12 km. This difference of the heights means that the cirrus clouds were not just advected by meridional wind but were possibly developed in the course of the separation.

The trigger of zonally simultaneous separation of a long band is another our interest. Inertial instability may be a candidate since vertical exchange of zonal momentum by deep convection would occur in an original band and result in the large meridional shear of the zonal wind in the upper troposphere. We tried to confirm necessary condition for inertial instability by calculating geostrophic vorticity, following the general procedure. However, the position of the bands is too close to the equator (3-7N) to establish geostrophic relationship, and the spatial pattern of the geostrophic vorticity is too noisy to analyze. Therefore, we instead calculate simple absolute vorticity. We found that the absolute vorticity around the separated bands was almost negative. It suggests the possibility of the inertial (or similar kind of) instability.

We are now analyzing another numerical experiment including four kinds of runs using a cloud scheme with different cloud parameter settings. In the real atmosphere, a separation event occurred on 16-17 June 2008 at the just east of the date line. The event can be simulated in all of four runs at 36 hours from the initial time. It suggests that the basic mechanism of the separation is not sensitive to the detail of cloud systems. By analyzing the dynamical fields of these outputs, we are trying to find the key mechanisms to trigger the meridional separation of the cloud bands.

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