Analysis of the Time Development on Release and Reconstruction of Barotropic Instability Field in the ITCZ in the Eastern Pacific Ocean

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The intertropical convergence zone (ITCZ) in the Eastern Pacific Ocean is well known for occasional breakdowns of cloud bands that sometimes bear tropical cyclones. Previous studies show that these events have aspects of the barotropic instability with numerical simulations, but there are few quantitative observational studies to understand their processes. In this study, we performed a potential vorticity (PV) budget analysis by using observational data and tried to quantify the temporal evolution of the breakdown and reconstruction processes of the ITCZ instability.
We used the ECMWF reanalysis data, ERA-interim (ERA-I, every 6 hours), three-dimensional diabatic heating data (SLH ver.7) estimated from precipitation radar data of the Tropical Rainfall Measuring Mission (TRMM) satellite, and GSMaP surface precipitation data (every one hour). Horizontal resolutions of ERA-I, TRMM SLH, and GSMaP are 0.75 degrees in lat/lon, about 5 km, and 0.1 degrees in lat/lon, respectively.
Since the sampling of SLH data is limited in PR’ s narrow swath, we developed a look-up-table (LUT) method to estimate 3D diabatic heating. First, we divided the TRMM PR precipitation intensity into three classes according to its strength, and, for each class, created LUTs from SLH that give a vertical profile of diabatic heating for a specified vertical velocity at 500 hPa. Then, we utilized GSMaP precipitation, ERA-I vertical velocity at 500hPa, and the LUTs to obtain the diabatic heating in the ITCZ region. Finally, the PV budget analysis in the ITCZ region was carried out by quantifying the PV generations from estimated profiles of diabatic heating, together with the dynamic variables from the ERA-I.
First, we analyzed an event from July to August 1988, which is often cited as an example of the ITCZ breakdown, using ERA-I, separating the disturbance field from the basic field. It was confirmed that the initial state of the high PV band satisfied the necessary condition of the barotropic instability, and then, the instability was removed as disturbances developed after the breakdown.
Second, we analyzed events that occurred in August 2003. We observed a large amount of diabatic heating near the altitude of 2 km probably associated with congestus clouds in the ITCZ region. The heating reached the maximum in the early stage of the breakdown. We could also capture a stage in which as disturbances are detached from the ITCZ region and moved to higher latitude, the amount of heat calmed down and the field gradually recovered toward the initial stage.
Finally, the amount of the PV generation by the diabatic heating of the lower troposphere was quantitatively estimated, and the PV budget in the ITCZ region was investigated. As a result of the PV budget analysis on the 850hPa surface, it was found that the PV production due to the diabatic heating in the lower level was much larger, compared to either the inflow from the outside of the ITCZ region or the local PV tendency at 850 hPa. Since it was considered that the PV formed in the lower level was transported to the upper troposphere, a PV budget in the vertical direction was performed. We selected the 300 hPa surface and the 500 hPa surface to represent the upper level and the middle level, respectively. It was confirmed that the excessive PV generated in the lower level at the early stage of the breakdown event was transported to the upper levels. It is suggested that the PV generated in the lower troposphere helped strengthen the PV in the middle / upper levels. Such large vertical transport of PV could not be detected in the process of the field recovery, suggesting that ,at that stage, the PV generated in the lower level was used for the recovery on the spot.

In the future, we will also consider the uncertainty of the data used for the analysis of this research.

Keywords: Intertropical Convergence Zone, Barotropic Instability, Analysis of the satellite data, Diabatic Heating

