A DEVELOPMENT PROCESS OF THE TROPICAL DISTURBANCE OBSERVED IN PALAU2010 FOR UNDERSTANDING TROPICAL CYCLOGNESIS

P1.29

Ryuji Yoshida*

DPRI, Kyoto University / Advanced Institute for Computational Science, RIKEN

1. INTRODUCTION

In this study, our interest is an organization process of a vortex embedded in tropical disturbance. A tropical disturbance is observed in Pacific Area Long-term Atmospheric observation for Understanding climate change (PALAU) 2010 field campaign. PALAU- 2010 focused on clarifies the mechanisms tropical cyclone (TC) genesis and summertime inter-seasonal variation in equatorial Pacific. The tropical disturbance was accompanied with a large cyclonic vorticity, and persisted for more than three days over the western North Pacific. However, the perturbation did not become tropical depression intensity.

Recently, the process of tropical cyclogenesis is gradually understanding by contributions of vigorous observations and numerical simulations. The early stage of the cycloegenesis seems to be reveled through the bottom-up hypothesis. It is important for understanding whole tropical cyclogenesis to compare the non-develop case with the develop case.

Zehr (1992) suggested four types of non-develop tropical disturbance based on the progress of TC genesis. He focused on the shapes of the cloud systems and the convection maximum. He suggested twice convective maximums, which can be found in a pre-TC disturbance before become TC. The well-organized cloud system is developed in the first convective maximum. In the second convective maximum, a cyclonic vortex is organized in the cloud system. Whether a cloud system can completes these two stages or not is the key-points in the early stage of tropical cyclogenesis. The details for collapse of cloud systems still have not known. Thus, in this study, the observed tropical disturbance is numerically simulated by using NWP model, and the simulated process of vortex organization is investigated to understand what a fork is in the tropical cyclogenesis.

2. THE SIMULATED CASE AND NUMERICAL SIMULATION SETUP

2.1. The general feature of the disturbance

Figure 1 is images of geostational meteorological satellite (MTSAT-1R, JMA). From Fig. 1, we can identify the cloud area which is circular shape. This cloud area was developed from lager cloud region which does not have circular shape. At this cloud area, a positive vorticity area at lower troposphere can be identified from NCEP/FNL wind field, and moves westward along 11 deg North (not shown). In the NCEP/FNL horizontal wind field at 500 hPa, a positive vorticity area can be identified from 19th

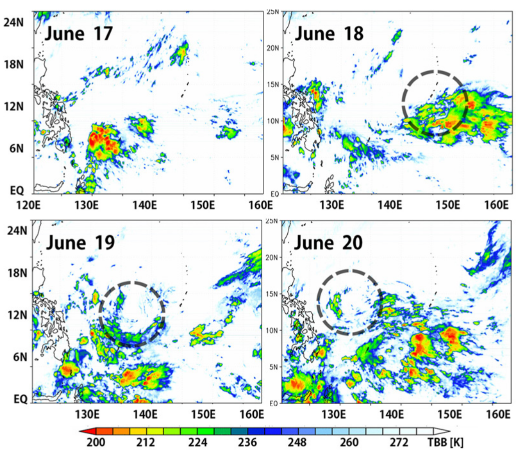

Figure 1. The distribution of black-body temperature of MTSAT-1R (infra-red channel); Broken-line circles show the locations of low-level circulation.

* Corresponding author address: Computational Climate Science Research Team, Advanced institute for Computational Sciece, RIKEN, Chuouku, Kobe, Japan, 650-0047; e-mail: ryoshida@riken.jp

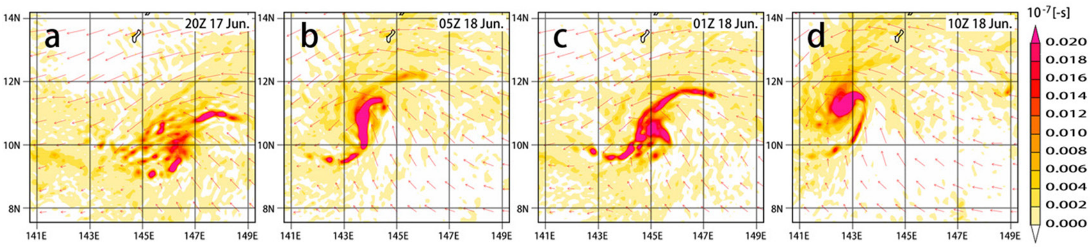

Figure 2. The horizontal distributions of vertical relative vorticity at 850 hPa height by using domain 2 data; vectors are horizontal wind field, and color shade is vorticity.

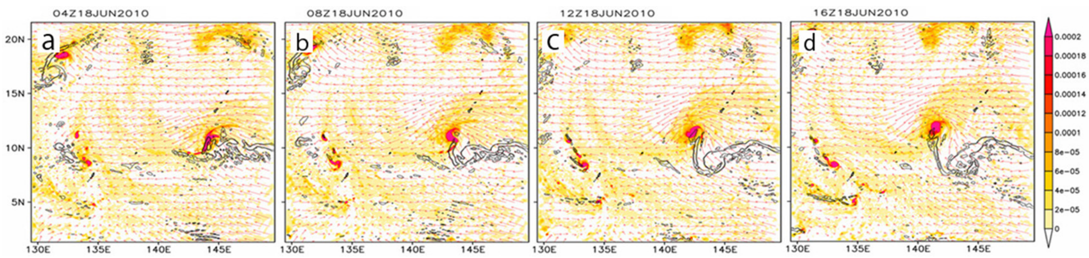

Figure 3. The horizontal distributions of vertical relative vorticity; color shade is vorticity at 850 hPa height, and contours are also same but at 500 hPa height. Vectors are wind field at 850 hPa height.

Jun. 2011. In addition, at upper troposphere, large scale cyclonic circulation locates to the west of lower vorticity area. This vortical disturbance can be followed by the low level vorticity until 23th Jun. 2011. The disturbance continues moving westward till dissipate, and never become intensity of tropical depression in the end .

2.2. The model and simulation setup

In order to investigate the development process of the disturbance, we numerically simulated this tropical disturbance with the Weather Research and Forecast (WRF) model-the Advanced Research WRF (ARW) version 3.2.1 (Skamarock et al. 2008). The computational domains are multi-nested in two levels in a two-way interactive mode. The two computational domains have grid dimensions of 130x277 and 100x285 with a grid spacing of 32 and 8 km, respectively. The model is initialized at 0000 Z 17 June 2010, 48 hours before observation, and is integrated for 4 days. NCEP/FNL data is used as initial condition and lateral boundary condition. A modified version of the Kain and Fritsch cumulus scheme is used in order to represent the effects of cumulus convection. The cloud-microphysics schemes used here was the WRF Single-Moment 5-class scheme (WSM5) containing five classes of hydrometeors. The turbulence mixing of the planetary boundary layer (PBL) is parameterized by the Yonsei University scheme. For long-wave and short-wave radiation, the Rapid Radiative Transfer Model (RRTM) scheme and Dudhia shortwave radiation scheme are used, respectively.

3. SIMULATION RESULTS

The simulated disturbance has similar cloud pattern with that of observed by the geostationary meteorological satellite (figure is not shown). A mid-tropospheric circulation seen in NCEP/FNL wind field is also simulated correctly. The simulated disturbance does not develop into “tropical depression” intensity in the integration period. The important feature in this simulations the disturbance did not develop into the TC even the core vortex was organized. The mid-tropospheric cyclonic circulation can be found in the NCEP/FNL at the start time of time integration, and the circulation is also resolved in the simulation. The mid-tropospheric circulation has MCV like features, and it is organized during the first convective burst. At that time, the synoptic scale trough exists below the MCV. In the trough region, multiple mesoscale vorticies are diagnosed by the horizontal wind field at the surface, and these are shown in Fig. 2. These multiple vortices appear after the completion of MCV at the mid-troposphere. These merge each other, and become an intense vortex finally. This merging process is found in the TCG process of develop case reported by Fuquing Zhang (2010). When the one intense vortex is organized, the middle level vortex and low level vortex seem to be couple each other. A vortex which is elongated from lower troposphere to upper troposphere can be made in this simulation. This vortex can be identified as the initial vortex of TC, thus the initial vortex is organized successfully. However, the initial vortex was not able to sustain for long time. The figure 3 shows locations for low-level vortices and a mid-level vortex. The location of these vortices are superposed at the earlier time (Fig. 3a), but the locations of these vortices are separating during Fig.3b to Fig.3d. After that, this disturbance is dissipated by 23th Jun. 2011.

4. THE DISCUSSION OF THE DISTURBANCE DISSIPATION

The important feature in present simulation is a dissipation process of the core vortex. The main reason for dissipation of the disturbance may be the collapse of the core vortex. The core vortex was tilting gradually, and torn in two vortices at different height finally. Then, it is a key-point for the disturbance dissipation what is a cause of the collapse of the core vortex. Two possibilities, these are vertical shear and dry intrusion, are considered here.

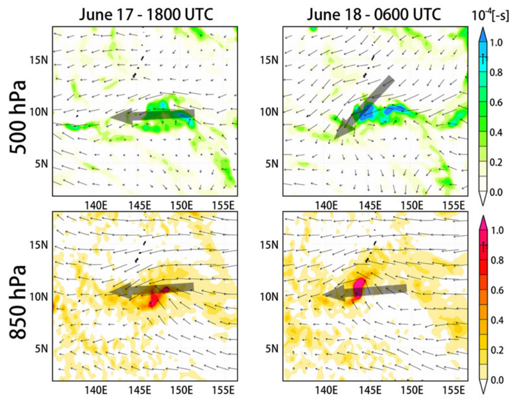

Figure 4. The horizontal wind distributions at 500 hPa and 850 hPa height; vectors show horizontal wind component, and color shade is relative vorticity.

4.1. Vertical Shear

The one possibility is vertical shear. The figure 4 shows wind fields of simulated disturbance at 500 hPa and 850 hPa height. Figure 4a and 4c are at 1800 UTC 17th July, and 4b and 4d are at 0600 UTC 18th. Comparing these two time, it is found that vertical shear from low-level to mid-level became stronger at 0600 UTC 18th. It is easily understand that strong vertical shear destroy the initial vortex. Because strong vertical shear breaks active convection in the low-level vortex. In other words, when vertical shear is too strong, there is not enough time to generate complete tropical cyclone features such as eye wall. However, in the simulated disturbance case, moisture condition is also unsatisfactory of environmental condition.

4.2. Dry intrusion

When the core vortex was torn, it is known that the

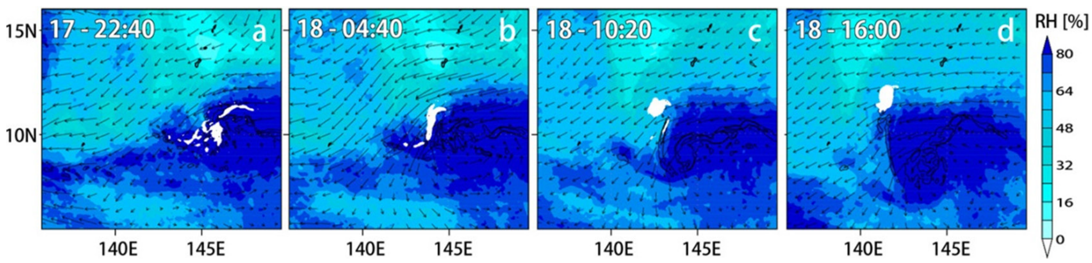

Figure 5. The horizontal distributions of relative humidity and relative horizontal vorticity; color shade is relative humidity, and vectors are wind field at 500 hPa height. White colored region is the area that has high vorticity at 850 hPa height, and also contours are relative vorticity but at 500 hPa height.

dry air was intruded from northern part of the disturbance from both NCEP/FNL and simulated relative humidity field. This dry intrusion occurred mainly at middle level. Thus, convection at the core vortex was suppressed, and was not able to sustain itself. Before the organization of the core vortex, both the middle and low level vortices were in high relative humidity area. Figure 5 shows the distribution of relative humidity (RH) at 500 hPa height. In the Fig. 5, white area shows the location of low-level vortex, and contours shows mid-level vortex. At 2240 UTC 17th, both low-level and mid-level vortices located at relatively high humidity region. The amount of RH is less at the north-western region of disturbance than other region, and the lesser RH region extends toward the location of low-level vortex gradually. At 1020 UTC 18th, the low-level vortex located at relatively dry region. Thus, moisture needed for sustainability to the active convection is not sufficient in this case. If convection at the low-level vortex cannot sustain its activity, cloud area above the low-level vortex might move away.

5. SUMMARY

In conclusion, the simulated cloud system which was not able to become tropical cyclone had a core vortex. The structure and organization process of the core vortex were similar to that of the initial vortex of tropical cyclone. However, the core vortex was not sustained for a long time, and collapsed finally. The reason for this collapsing may be vertical wind shear and dry air intrusion. From current simulation results, it is suggested that the suitable environments to sustain the core vortex for a long time is one of key point in the tropical cyclogenesis process. The suitable environments are weak vertical wind shear and/or moist air existence. It is also important that such suitable environments are sustained for a long time enough to organize steady TC core vortex.

ACKNOWLEDGMENTS.

The authors thank Drs. Hirohiko, Ishikawa, Tetsuya Takemi, for valuable discussions; anonymous reviewers for constructive comments. The current study was carried out by using data of JAMSTEC PALAU2010 project.

REFERENCES

Fang J., and F. Zhang, 2010: Initial Development and Genesis of Hurricane Dolly (2008). J. Atmos. Sci., 67, 655–672.

Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, M. G. Duda, X.-Y. Huang, W. Wang, and J. G. Powers, 2008: A description of the Advanced Research WRF Version 3, NCAR Tech. Note, NCAR/TN-475+STR, pp.113.

Zehr, R. M., 1992: Tropical cyclogenesis in the western North Pacific. NOAA Tech. Rep. 567 NESDIS, 61, 1–181.