A study on disturbances with wavenumber 2 in inner-core region of tropical cyclones.

*Yuki Kawata[1], Keita Iga[1], Sho Yokota[2], Eigo Tochimoto[1]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Meteorological Reseach Institute, Japan Meteorological Agency

While the development mechanisms of tropical cyclones (TCs) have been investigated based on axisymmetric theories, asymmetric structures such as spiral rainbands are also observed inside them. Such asymmetric structures are explained using vortex Rossby waves (Montgomery and Kallenbach, 1997).
Wang (2002) performed idealized numerical experiments, and indicated that these asymmetric structures can be understood as convectively coupled vortex Rossby waves and that the disturbances with wavenumber 1 and 2 are important. Some previous studies have suggested that asymmetric structures have an important role in intensity changes in TCs (e.g. Yang et al., 2007). While the disturbances with wavenumber 1 have been discussed using analytic models (e.g. Ito and Kanehisa, 2013; Nishimoto and Kanehisa, 2018), disturbances with wavenumber 2, which can be observed as elliptical vortices, have been analyzed only using radar reflectivity data (e.g. Kuo, 1999) observations; dynamic environments are not examined nor sufficient numerical experiments using non-hydrostatic mesoscale models.
In this study, we focused especially on the disturbances with azimuthal wavenumber 2, and the mechanisms of its generation and maintenance processes were examined by observational data analysis, and numerical simulations with idealized settings using a non-hydrostatic mesoscale model.
First, the observational data of Typhoon Maria (TC1808) was analyzed in order to investigate asymmetric structure of the actual case. This typhoon kept its inner eyewall with an elliptic structure for a long time, whose inner-core region was observed in detail with a Doppler radar in Ishigakijima, Japan. Retrieving the wind field at 2 km altitude of the TC from the Doppler velocity data using the GBVTD analysis (Lee et al., 1999), it was confirmed that the local region of the tangential wind maximum was formed around the long axis of the ellipse. A vorticity disturbance with wavenumber 2 persisted and from the local maximum regions extended the vorticity disturbance with a filament structure to the outer direction. The results of analyses of these observational data show that this disturbance satisfies the characteristics of vortex Rossby waves.
Second, idealized numerical experiments using JMA-NHM were performed in order to investigate the formation mechanism of the asymmetric structure of TCs, which reproduced successfully a long-lasting elliptical vortex similar to Typhoon Maria. The energy budget analysis using anelastic equations revealed that the shear production and convergence terms contributed mainly to generate the asymmetric structure in the lower layer, and the buoyancy term in the middle layer. Subdividing these effective terms, it was also shown that the term of asymmetric convergence due to radial wind in the boundary layer was dominant. For a period of elliptical vortex, the convergence in the boundary layer was strong at the long axis regions of the elliptical vortex, and the mixing ratio of rainwater was large there. From these results, it is suggested that the persistent horizontal convergence in the long axis regions and the PV generation caused by the latent heat release through the vertical wind due to this convergence are important to maintain the elliptical vortex.

Keywords: vortex Rossby waves, elliptical vortex, GBVTD analysis

