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Propagation characteristics for vortex Rossby waves in the inner core region of an idealized tropical cyclone

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Tropical cyclone (TC) is a cyclonic vortex system having strong wind and heavy rain. In the mature stage, TC almost maintains in a quasi-steady state as an axisymmetric structure. To estimate the maximum intensity (i.e. maximum wind speed), the theoretical models have been developed in the assumption of two-dimensional axisymmetric structure for TC, which a TC tangentially has uniform structure. However, observations indicate that TCs have non-axisymmetric structures, such as polygonal eyewall and rainband, in the mature stage. Wang (2002) reported that a non-axisymmetric component contributes the TC's maximum intensity in the inner core in which TC has maximum wind speed in a three-dimensional model. A vortex Rossby wave is generated in the field with radial gradient of relative vorticity around the center in a large scale vortex, such as a TC. Wang (2002) showed that, in the inner core, non-axisymmetric component influence the TC's maximum intensity caused by redistribution of potential vorticity (PV) through the transport of PV by a vortex Rossby wave.

In this study, an identical experiment of a TC is performed utilizing with a three-dimensional non-hydrostatic model (CReSS) to quantitatively estimate radial and tangential propagating speed of non-axisymmetric component in the inner core region in a quasi-steady state. The estimated speed of the propagation in the model is compared with the theoretical speed of the propagation in the shallow water system.

This result indicates that non-axisymmetries of low wave number have rapid propagating speed, and the speed is close to the theoretical speed. We consider that the theoretical model for vortex Rossby wave in a shallow water system is helpful to understand the behavior of the waves in the three-dimensional core a TC in a stratified atmosphere.

Keywords: tropical cyclone, vortex, wave, non-axisymmetry