Potential vorticity mixing and rapid intensification in numerically simulated Supertyphoon Haiyan (2013)

Satoki TSUJINO
(Department of Atmospheric Sciences, National Taiwan University)

Full understanding of rapid intensification (RI) in tropical cyclones (TCs) remains a big issue. RI can be controlled by environmental conditions such as sea surface temperature and vertical shear of large-scale flows, and internal processes such as convective bursts, strong boundary-layer inflow, and eye-eyewall interactions. In the intensification through the internal processes, convective-scale heating can be interacted with storm-scale flows. Then, potential vorticity (PV), which represents flows and mass (thermal) fields, is useful for the understanding of the internal processes in RI.

The present study examines a role of PV-mixing process around eye and eyewall on RI in Supertyphoon Haiyan (2013) simulated with a fine resolution. The PV field in the simulated storm indicates clearly elliptical and polygonal shapes in lower troposphere, and forms a PV hollow tower associated with an eyewall around a RI onset. Then, the PV changes to more monopole shape in the lower troposphere during the later period of RI. A PV budget analysis is diagnosed to quantitatively estimate contribution of the PV mixing to evolution of the PV field around the RI onset. The budget results show (1) the PV hollow tower generated by convective heating associated with the eyewall, and (2) radially inward advection of the PV associated with asymmetric flows along the inner edge of the eyewall (indicating the PV mixing). Around the RI onset, pressure falling associated with evolution of the PV field is diagnosed by a piecewise PV inversion technique. The diagnosed pressure falling is qualitatively consistent with actual pressure falling. Consequently, the PV mixing around the RI onset can induce deepening of the central pressure in the early stage of RI. The pressure deepening is related to increase of low-level inflow on an axisymmetric view. Eyewall updraft related to the increase of the low-level inflow is located in the inside of the radius of the maximum tangential wind speed. The enhanced low-level inflow suggests enhancement of tangential wind speed (i.e., RI) through inward advection of absolute angular momentum.