The Potential Vorticity Budget of Typhoon Nari (2001)

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(manuscript received 7 November 2011 ; in final form 23 March 2012)

ABSTRACT

Tropical cyclone (TC) is a warm-core low pressure system with strong tangential wind and active convective clouds. Potential Vorticity (PV) is a quantity that combines both dynamic and thermodynamic information, and it is conserved under the adiabatic and frictionless condition. In recent years, there have been considerable studies between TCs and the PV. However, only a few studies used the PV budget to analyze a real TC case. In this study, we can improve our understanding of the dynamical and thermodynamical evolution during the TC's landfalling stage from the PV budget analysis.

A compressible nonhydrostatic PV budget equation, based on Pedlosky (1987) and Schubert et al. (2001), is used here to gain insights into the PV budget evolution of a typhoon from its oceanic stage to landfall stage. The budget is conducted using high spatial resolution (2-km horizontal grid size) MM5 outputs (CT experiment) from Yang et al. (2008). Two terrain-sensitivity tests, by removing Taiwan topogrpahy (NT) and substituting the Taiwan island with ocean (OC), are conducted to examine the effect of Taiwan's topography and the ocean surface fluxes on PV budget of Typhoon Nari.

In the CT experiment, its PV distribution exhibited the typical feature in a mature oceanic TC. At the time of landfall, its eyewall was contracted and convection was intensified by the topography. From the budget perspective, PV was redistributed cyclonically with TC circulation by horizontal advection and entered the inner core region with the radial inflow. The low-level PV generated by sensible heat flux and latent heat release will be transported upward through vertical advection. Latent heating term accounted for major PV generation in lower levels during the oceanic and early landfall stage. It also acts as a major PV sink term at mid-upper levels. The friction term included both effects of eddy mixing and surface friction; hence, it did not just act as a PV sink term.

In the terrain-sensitivity experiments, if the Taiwan topography was removed (NT), the friction term

reduced PV over Taiwan in lower levels, opposed to that for the full-terrain run. As a result, the existence of Taiwan topography could enhance the vertical eddy mixing. Both the Taiwan topography and surface friction are prone to trigger convection, releasing more latent heat and leading to the increase of PV. Turning off the ocean fluxes (NT vs. OC) will cause the dissipation of the PV ring. The asymmetric latent-heating effect in the NT run (occurred on the land-sea interface) not only contributed to the formation of this new PV ring, but also make this new PV ring become polygonal. This PV phenomenon may be a reason to cause the typhoon to move in a trochoidal manner afterward.

Key Words: Potential vorticity budget, Typhoon Nari, MM5