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Title: Formation Mechanism of the Elliptical Eye in Typhoon Herb

Abstract:

A rotating elliptical eyewall is occasionally observed in the mature stage of strong typhoons. The Elliptical eyewall keeps their rotation period and ratio constant for more than several hours. The previous studies revealed that the elliptical eyewall has a structure with wavenumber two. The formation process of such elliptical eyewall has been discussed with theoretical analyses of the linear stability. Those previous studies have revealed that the symmetric flow having large wind shear region is destabilized for the perturbation with wavenumber two. However, such theoretical analyses have used the idealized wind profile and they were not validated for real wind profiles. An elliptical eyewall was observed in Typhoon Herb during its passage around the Sakishima islands on 30-31 July 2004. In this study, we clarified the dynamic instability of symmetric tangential flow in Typhoon Herb and discussed the formation process of Herb's elliptical eyewall. At first, the linear stability analysis was performed for three-dimensional perturbation using the asymmetric balance model. The distribution of wind in Typhoon Herb was used as a basic flow in the analysis. An unstable mode with wavenumber two was found in our analysis. The eigenmode structure and the rotation period of the resulted unstable mode show good agreement with the observation. In the next step, to understand the early stage nonlinear evolution of this elliptical eyewall, we performed numerical experiments using the contour dynamics model. The basic flow in our experiments had the real-data-based vorticity gradient just outside the radius of maximum wind speed. The deformation of vortex from circular to elliptical shape became remarkable as the growth of the perturbation of wavenumber two, and then the circular vortex settled to a tripole structure. The behavior of this elliptical vortex resembled Typhoon Herb's elliptical eyewall in the radar and satellite data. These results confirmed that barotropic instability due to the radial shear of tangential wind is responsible for the formation of the elliptical eyewall in Typhoon Herb.

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