Meso-scale structure in the eye of Typhoon Trami(2018)

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Typhoons are a disturbance with an overall scale of 1000 km while meso-scale systems that form within them are a phenomenon with a scale of only a few 10 km. Meso-scale structures within typhoons are accompanied by strong winds and heavy rains, and are considered to be the most important part for disaster prevention. When Typhoon Trami (2018) passed between Okinawa main Island and Kume Island on September 29-30, weather radars on Okinawa Island observed the inner core region of the typhoon. The purpose of this study is to reveal characteristics and structure of the meso-scale systems that occurred in the eye of Typhoon Trami. In this study, we used Meteorological Satellite Himawari-8, JMA RSMC Best Track data, surface observation, NICT Okinawa Bistatic Polarimetric RAdar (COBRA), and Phased Array Weather Radar (PAWR).

The time-series of surface wind at four observation sites in Kume Island, Naha, Onna, and Nago showed the common characteristics of a passing typhoon: weaker winds in the eye and stronger winds within the eyewall cloud. On the other hand, a strong wind was observed with sharp drop of the equivalent potential temperature during the passage of the eye and the inner edge of the eyewall. The decrease of equivalent potential temperature lasted for about 40 minutes and was accompanied by an increase of wind speed. The mixing ratio also decreased during the period. This indicates that a dry air passed over the observation sites and that it was accompanied by the strong wind.

The radar observation of COBRA and PAWR showed that the size of Trami eye was larger than 100 km in radius, which was a very large and polygonal eye. The CAPPI display of COBRA radar reflectivity at an altitude of 1.0 km showed a meso-vortex in the typhoon eye. The equivalent potential temperature had started to decrease after the meso-vortex passed over the Onna observation site. However, there was no close relationship between the meso-vortex and strong wind because the meso-vortex was located more than 50 km away at the time the strong wind was observed at Onna.

To investigate the vertical motion in the inner core region, we developed a CVAD method and used it to analyze the wind field. The CVAD method calculates the vertical distribution of horizontal velocity above the radar from Doppler velocity data obtained by PAWR. This analysis shows that the downdraft was pronounced during the period when the equivalent potential temperature was decreasing. The results for a radius of 20 km showed strong horizontal wind and updraft. This suggests that Onna was located near the updraft of the secondary circulation, and that there were strong tangential winds of the primary circulation with a strong wind field within the eyewall near Onna. This indicates that the strong downward motion transported the upper-level dry air to the surface. This also suggests that the strong winds were caused by momentum transport of low equivalent temperature air from the upper-level of the inversion layer to the surface around the polygonal eyewall of the typhoon.

In this study, we identified the meso-scale structure causing strong winds that occur at the surface in the eye of Typhoon Trami. This strong wind was observed when the inner edge of the polygonal eyewall approached. We infer that the strong wind was caused by the compensating downdraft of the strong updraft of the typhoon secondary circulation. The low equivalent potential temperature air was transported by the downdraft from the above of the inversion layer to the surface.

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