

Multi-scale Structure of A Meso-beta-scale Vortex that Caused Sudden Gusty Winds Over the Sea of Japan: A Case Study on 1 September 2015

*Eigo Tochimoto¹, Sho Yokota², Hiroshi Niino¹, Wataru Yanase¹

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Meteorological Research Institute, Japan Meteorological Agency

A sudden gusty wind accompanied by a meso-beta-scale vortex of about 30km diameter occurred in the Tsushima Strait at the southwest part of the Sea of Japan between 0300 and 0400 JST (Japan Standard Time) on 1 September 2015. It upset 6 fishery boats, causing 5 fatalities and 1 missing people. Some of the survived fishermen reported that they were hit by a waterspout. The meso-beta-scale vortex was located near the warm front about 300 km northeast of the center of a meso-alpha-scale cyclone. The structure and evolution of the meso-beta-scale vortex are examined using a numerical simulation.

A numerical simulation using JMA non-hydrostatic model (JMA-NHM) with horizontal resolution of 2km and 50 vertical levels successfully reproduced the meso-beta-scale vortex. The simulated vortex had a diameter of about 30-50 km, and was formed in the northeast quadrant of the meso-alpha-scale cyclone at around 0400 JST. The vortex developed between 0400 and 0430 JST and the associated wind exceeded 20 m s^{-1} near the surface. To examine the development process of the vortex, a vorticity budget analysis is performed. The vorticity and each term of a vorticity equation are averaged over 60 km around the vortex center. The vorticity developed through tilting and stretching terms at 1000-1500 km height in the early developing stage. Subsequently, the vortex was intensified near the surface thorough the stretching term.

An additional numerical simulation with horizontal resolution of 50 m and 100 vertical levels has been performed to clarify more detailed structure and evolution of the meso-beta vortex and to reproduce small-scale features that caused the damaging gusty wind. In the simulation, micro-scale vortices with horizontal scale less than 1km were simulated within the meso-beta-scale vortex. It is suggested that these vortices formed with shear instability. The maximum of vorticity and wind speed occasionally exceeds 50 m s^{-1} and 1 s^{-1} , respectively, during the simulation.

Keywords: Gusty wind, Vortex, Cyclone