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Evaluation of a result of a coupled atmosphere-ocean model around a tropical cyclone center using aircraft observations

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Aircraft observations are enable us to understand the dynamical, thermodynamical, and microphysical structure of an inner region of TCs, such as their eye and eyewall. Numerical simulation is also a useful tool to clarify the structure of TCs, however, the reproducibility around the inner region of TCs could not be confirmed. This study shows an application of aircraft observations to evaluate the structure of a simulated TC using a coupled atmosphere-ocean non-hydrostatic model, Cloud Resolving Storm Simulator (CReSS) and Non-Hydrostatic Ocean model for Earth Simulator (NHOES), CReSS-NHOES.

The target typhoon is T1013 (Megi) developed over the tropical western Pacific Ocean in October 2010. During the Impact of Typhoons on the Ocean in the Pacific (ITOP), 200 dropsondes are dropped into and around T1013, including its eye and eyewall regions, from a height of about 2.5 km. Dropsondes can observe a vertical profile of pressure (height), temperature, humidity, wind direction, and wind speed. The profiles of these parameters are used to evaluate the simulation result using CReSS-NHOES. A simulation with horizontal grid resolution of 0.02 degree (approximately 2 km) is conducted for 7 days from 00 UTC on October 14, 2010, after one day of the formation of the T1013.

The simulation well reproduces its track and the tendency of the minimum central pressure. The reproduced minimum central pressure is 889 hPa and corresponds the observed one (885 hPa). To conduct the direct comparison between dropsonde observations and the simulation result, the target time of the simulation to compare with the observed one is determined to consider the value of minimum central pressure and its tendency. At the observed target time when conducted the dropsonde observations, the observed TC center is determined by the linear interpolation of the best track data provided by Japan Meteorological Agency. The simulated TC center at the target time is defined by the application to the Braun's method to the CReSS-NHOES output data. The location of the simulated profiles are determined by that of the dropsonde observations relative to the center of the TC at the simulated target time.

The eyewall region in this study is defined as the region that relative humidity of all layers is greater than 95% and maximum wind speed exceeds 25 m s^{-1} below a height of 2 km. The eye and outer region are defined by the inner and outer ones of the eyewall. The simulated potential temperature, mixing ratio of water vapor, and wind speed in the outer region are in the range of 1-sigma (standard deviation), thus, the simulated thermodynamic parameters are well reproduced statistically. After the rapid intensification of T1013, weak and maximum wind speed regions are reproduced in the eye and lower level of the eyewall, respectively. High potential temperature in the low-level of the eye is also reproduced. Thus, qualitative properties of the TC are well reproduced in the simulation. However, the simulated potential temperature is 3 K greater than that in the observation. And the simulated wind speed is 25 m s^{-1} lesser than that in the observation. The quantitative differences are expected to be caused by the difference of the structure of the eye. The problem on the structure of the eye appears in comparison with the application of the aircraft observations for the first time.

Keywords: aircraft observation, tropical cyclone, cloud-resolving model, coupled atmosphere-ocean model, model evaluation