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Mesoscale Data Assimilation of Tropical Cyclones with GPS Atmospheric Information

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A four-dimensional variational (4D-Var) mesoscale data assimilation (DA) system in low latitudes was developed and impacts of GPS derived atmospheric information on tropical cyclone prediction was investigated through two case studies.

Prediction of tropical cyclones (TC) including typhoons is one of the most important issues in meteorology. Although accuracies of the operational numerical weather prediction (NWP) in world forecast centers have been considerably improved in recent years, there are still many difficulties in the TC prediction. Resolution and physical processes of NWP model together with mesoscale DA is a key factor for the issue. However, the most mesoscale regional DA systems operated routinely are designed for mid-latitudes.

In this study, to prepare high-resolution (10 - 20 km horizontal grid spacing) initial fields for the simulation of tropical cyclones, the mesoscale 4D-Var DA system (meso 4D-Var) for the JMA hydrostatic meso-scale model (MSM) is modified in order to optimize to use in low latitudes where TCs generate and develop. In addition, the impact of GPS derived atmospheric information such as refractivity profile or precipitable water vapor (PWV) on TC prediction is also investigated thorough the following two case studies.

1. DA of GPS radio occultation (RO) data for typhoon USAGI in 2007

The assimilation period of the experimental meso 4D-Var is 24-hour and typhoon bogus data is not assimilated. Numerical predictions are attempted using JMA non-hydrostatic model (NHM) with 10km horizontal resolution. When the global analysis is used for the initial field, the typhoon is not formed in the forecast. By contrast, when the global analysis is replaced by the meso 4D-Var analysis in the experiment, the generation of the typhoon is successfully predicted. With GPS RO refractivity assimilated, the simulated typhoon intensity is closer to the best-track data.

2. DA of GPS PWV for TC NARGIS in 2008

NHM predictions using initial fields produced by DA experiments that used only ordinary observational data (without GPS PWV) exhibited a large variation of predicted maximum TC intensity (958 to 983 hPa) according to DA period (12, 24, 36, and 48 h). In these experiments, a longer assimilation period did not necessarily result in better prediction. The DA of GPS PWV yielded a smaller variation of predicted maximum TC intensity (964 to 974 hPa), and a longer assimilation period tended to bring deeper depression of TC central pressure. Overall, TC intensities determined by DA experiments with GPS data were closer to the best track produced by the Regional Specialized Meteorological Centre (RSMC) New Delhi than the DA experiments without GPS data.

In those two experiments, it was confirmed through the close inspection that implementation of GPS data contributed to create a more favorable environment for the generation and development of the TCs.

Keywords: Numerical Prediction, Data Assimilation, GPS Meteorology, Remotesensing, Cyclone Nargis