Meso-scale Data Assimilation Experiments in Low Latitudes with GPS RO data

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Introduction

It is important to prepare accurate initial fields for the forecast of typhoons with numerical models. The resolution of the models is critical for predicting typhoon intensity. However, we are usually forced to use the coarse-meshed initial fields produced by global model analysis in low latitudes, where tropical cyclones originate and develop. In this study, to prepare high-resolution (20 km horizontal grid spacing) initial fields for the simulation of tropical cyclones, the meso-scale 4-dimensional variational data assimilation (meso-4D-Var) system of the Japan Meteorological Agency (JMA) is modified so as to permit its use in low latitudes. In addition, the impact of GPS radio occultation (GPS RO) data on typhoon forecast is also investigated.

Assimilation of RO data

Assimilation of RO path data

- Tangent point data provided by GFZ et al. are estimated using the assumption of spherical uniform distribution of data. The assumption is not always satisfied. (One example is shown in right panel.)
- Then, path data reproduced from tangent data were used for the assimilation.

Consideration of vertical correlation of the observational error

- Because of high vertical resolution of path data, the vertical correlation of observation error should be examined.
- Off-diagonal elements of the observation error covariance matrix were used in the assimilation.

Experiment System

Data Assimilation Experiment

System: Meso-4D-Var for JMA
- Initial fields: DA system (higher resolution, 20 km horizontal grid spacing)
- GPS RO data assimilation

Different Analysis Field

- DA: Using JMA global analysis (NAMAX) as initial condition
- MA: Using analysis field by Meso-4D-Var as initial condition
- Same as MA, but GPS RO data are assimilated additionally

Numerical Forecast Experiment

System: JMA Meso-hydrostatic model
- Initial time: 00 UTC 27 July 2007
- Forecast period: 96 hours
- Model area: 1000 km radius around the vortices
- Moist Microphysics: 3 ice bulk method, Sedimentation of cloud ice
- Turbulence: Modified Mellor-Yamada Level 3

Conclusion

- We applied the JMA’s regional meso-scale data assimilation (DA) system, which was originally designed for mid-latitudes, to the simulation of Typhoon USAGI with the new domain including the tropics after some modification;
- Expanding the model domain to include low-latitudes to perform TC simulations during the generating or developing stage.
- Considering that the relationship of the balanced (geostrophic) wind was not necessarily appropriate in the low latitudes, a weight coefficient for the regression coefficient matrix on the unbalanced wind was newly determined as a function of latitude based on statistics.
- A value of the coefficient for the penalty term which controls the gravity waves was changed to a larger value.
- To examine the impact of GPS RO data on Typhoon USAGI and to explore the usefulness of the data as well as the assimilation system, we conducted data assimilation experiments for the simulation of the generation and development of the typhoon.
- 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. The results show that the modified meso 4D-Var system works well in low latitudes and GPS radio occultation data is beneficial for typhoon forecasts.
- It is expected that in future such the DA system will contribute to the mitigation of meteorological disasters in the low latitude region.

Results

The difference of analysis fields

The difference of analysis fields between MA, RO and MA

Forecast Results

Figure. Forecast results of each experiment. SI and RSH.

Moisture Convergence

The moisture fields at mid-low level of MA is stronger than those of MA, RO. Assimilation of GPS RO seems to contribute to preparing the more outside environment for the TC generation.

References