NHM-LETKF modifications in application for tropical cyclones

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Introduction

LETKF is a state-of-the-art method in data assimilation. Many studies showed that LETKF may produce a better initial condition for tropical cyclone (TC) forecast in comparison with other methods. In this study, we investigate the work of LETKF in regions where observations are relatively sparse and examine the available modifications of LETKF in this case.

NHM-LETKF

The NHM-LETKF system originally developed at JMA was adopted in this study with some modifications. This LETKF program supports adaptive inflation, adaptive vertical and horizontal localization, and outer loop as options. To apply this system for TC, we introduced 3 additional options: SST perturbations, the Running in Place (RIP) algorithm (Yang et al., 2012), and assimilation of TC advisories.

Experiment and results

The system was tested with the cyclone Nargis which formed in the Bay of Bengal in April 2008. We applied NHM-LETKF with the resolution of 20km over a domain of 201x161 grid points and 40 vertical levels. The boundary perturbations were interpolated from JMA's 1-week ensemble prediction system. The resulting analysis was used as the initial condition for 60-hour NHM deterministic forecast at 10 km resolution.

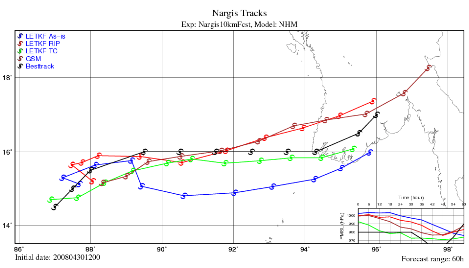

Fig. 1: Impact of different strategies on Nargis forecasts.

With 50 members and the assimilation cycle of 3 hour, we found that the largest impact came from the assimilation of TC advisories. When applying RIP alone or running NHM-LETKF as-is, the system usually produced weak TC analyses, resulting in forecasts with large errors both in track and intensity. This is illustrated in Fig. 1.

Impact of RIP

When combining with assimilation of TC advisories, RIP gives a better forecast (Fig. 2).

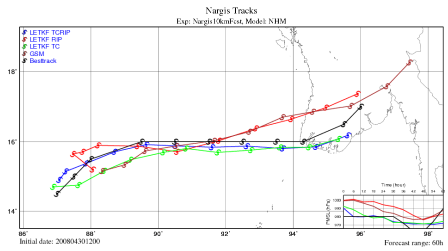

Fig. 2: Impact of RIP on Nargis forecasts.

Impact of SST perturbations

SST perturbations were implemented by using SST analyses from 7 centers: FNMOC, JMA, JPL, NCDC, NCEP, REMSS, and UKMO. Each member will chose SST randomly at each cycle. Fig. 3 shows clearly the important role of SST perturbations.

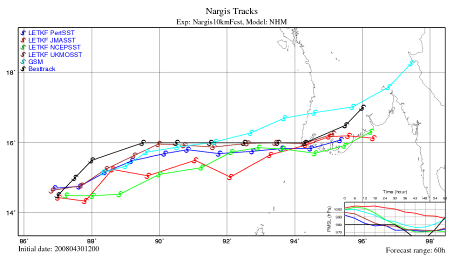

Fig. 3: Sensitivity test of SST on Nargis forecasts.

Storm surge simulation

The best forecast was obtained with the combination of all options. We use this result to run POM model for predicting storm surge associated with Nargis (Fig. 4).

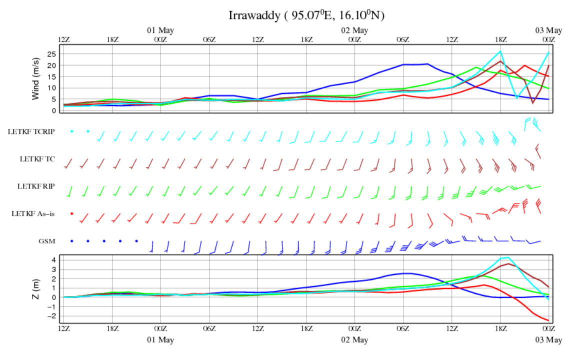

Fig. 4: Wind and water level forecasts at Irrawaddy..

Reference

Yang, S. C., E. Kalnay and B. Hunt, 2012: Handling nonlinearity in an Ensemble Kalman Filter: Experiments with the three-variable Lorenz model. *Mon. Wea. Rev.*, in press. doi: 10.1175/MWR-D-11-00313.1.