Mesoscale LETKF Data Assimilation on Cyclone Nargis

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Nargis was a severe tropical cyclonic formed on 27 April 2008 in the Bay of Bengal, and made landfall on 2 May in southwestern part of Myanmar. Nargis caused a destructive storm surge over the Irrawaddy Delta, claiming more than one hundred thousand lives. If an appropriate warning was issued about 2 days before the landfall, the number of casualties might have been reduced.

JMA global analysis (horizontal resolution is about 20 km) and forecast data of GSM (horizontal resolution is about 50 km and valid time is every 6 hours) expressed Nargis' track to some degree, but the expression on the development was inadequate both in early and mature stages. Thus, it was difficult to foresee a severe storm from these data.

Recently, a downscale NWP using JMA nonhydrostatic model (NHM) and the JMA data was conducted in order to perform a forecast experiment of Nargis (Kuroda et al. 2010). They carried out a regional forecast with NHM, using the JMA global analysis as the initial condition and the GSM global forecast as the boundary condition. They also used the JMA global land surface analysis and JMA global SST analysis. NHM was executed with a horizontal resolution of 10 km for a square region of 3400 km around the Bay of Bengal. The initial time was set to 12 UTC 30 April, 2008. JMA analysis expressed Nargis as a weak depression of 999 hPa at that time, although the intensity was less than 985 hPa in the best track. After 42 hour (06 UTC on 2 May), NHM intensified the weak depression to a cyclone of 974 hPa, and predicted the landfall of the cyclone in southern Myanmar. The development predicted by NHM was much better than the GSM forecast (994 hPa; Fig. 1), but the intensity was still weaker than that of best track. A reason for the inadequate deepening in the NHM forecast may be a weak expression of the initial condition obtained from the JMA global analysis. It is necessary to correct the analysis in order to obtain a better initial field, using data assimilation.

A local ensemble transform Kalman filter (LETKF) is a new assimilation method based on the ensemble forecast. Miyoshi and Aranami (2006) applied this method to NHM (NHM-LETKF), and performed a preliminary data assimilation experiment.

We apply NHM-LETKF to the Nargis' case with data assimilation cycles depicted in Fig. 2. To obtain the analysis at 12 UTC on 30 April, the first cycle begins at 12 UTC on 28 April. The initial seed consists of 20 (or 40) JMA global analyses before 12 UTC 30 April. Then, a 6-hourly ensemble forecast with a 40km resolution is conducted using the seed as the initial values. The forecast result and observation data are assimilated with LETKF and resultant analysis ensemble are used as the initial values for the next 6-houly forecast. After iterating these steps, an analysis ensemble at 12 UTC on 30 April is obtained. The ensemble mean is used as an initial value for the extended forecast with a 10km resolution.

Selection of observation data is important since it affects the accuracy of the analysis. Observation data used in the JMA analysis are stored in a dataset called CDA4, and each of them has a quality control (QC) flag. Among the observation, sea surface winds observed by QuikSCAT are important since the data express a circulation of the cyclone (Fig. 3a). Since QC is based on global forecast model, some data have been rejected in the global analysis (Fig. 3b). QC for mesoscale system may be able to utilize such rejected data. .

Using the above design, we conducted preliminary experiments. Two kinds of observation dataset are compared; one the same as used in the JMA operational global analysis (GAQC), and another that included both GAQC data and sea surface winds rejected in QC (ALLSCAT). Extended forecasts for these cases did not show the sufficient intensification at both in initial and landfall stages, but the tracks expressed an encouraging result showing favorably suppressed northward deviation at landfall seen in the downscale experiment by Kuroda et al (2010) (Fig. 4). We will continue to perform more experiments and to investigate the influence of several components (e.g., QC criteria, initial seed, lateral boundary perturbations) on the analysis for the purpose of improving the forecast.

References

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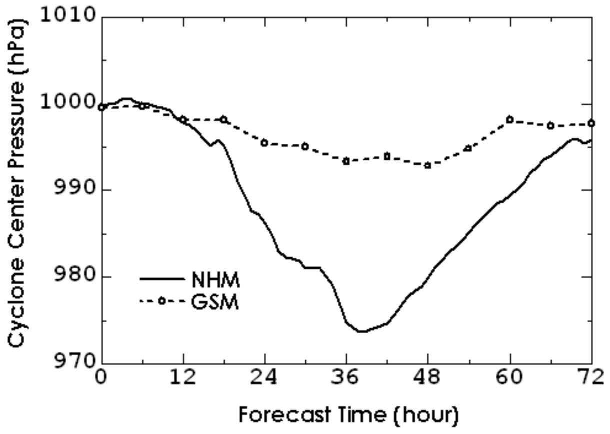

Fig. 1. Time evolution of sea level center pressure of Nargis by NHM and GSM forecasts. The initial time is 12 UTC 30 April 2008.

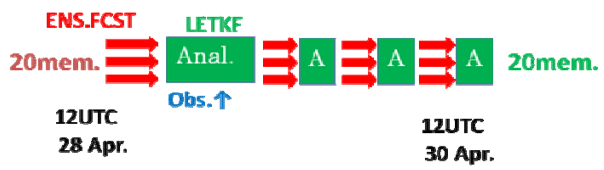

Fig. 2. Data Assimilation Cycles.

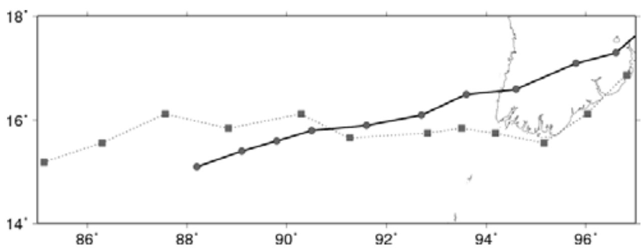

Fig. 4. Forecasted cyclone tracks around the Myanmar Delta. Thick solid line indicates the downscale experiment, and thin dotted line represents a extended forecast using LETKF result for the case of ALLSCATT with the ensemble size of 20..

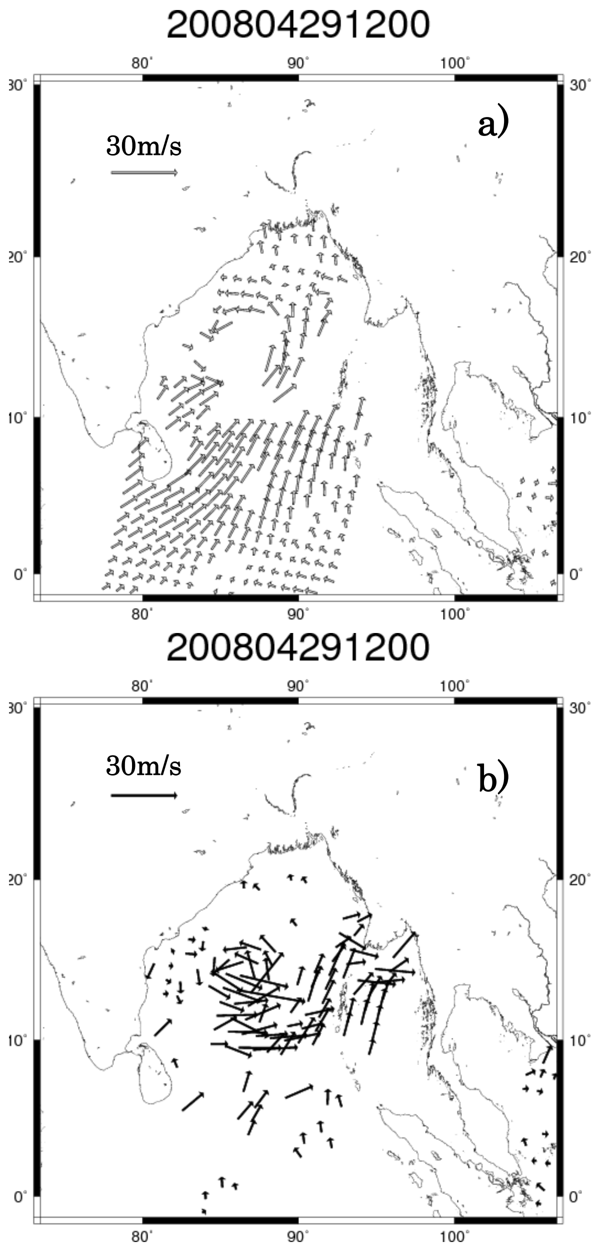

Fig. 3. Surface wind distribution at around 12 UTC on 29 April in the Bay of Bengal. a).Winds used in JMA global analysis. b) Winds rejected in QC.