Ensemble Forecast Experiment of Cyclone Nargis

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On 2 May 2008, cyclone Nargis made landfall in southwestern part of Myanmar and caused the worst natural disaster in the country which claimed more than one hundred thousand people by storm surge. This cyclone formed in the Bay of Bengal on 27 April and moved eastward while developing rapidly. Numerical simulations of Nargis and the associated storm surge have been performed by Kuroda et al (2009). Storm surge about 3.5 m was simulated in their study despite a positional lag of the cyclone center of about 150 km. It is well known that magnitude of storm surge highly depends on the track and intensity of the tropical cyclone and the numerical weather prediction has inevitable forecast errors due to uncertainties of initial/boundary conditions and model dynamics/physics. Considering the destructive disasters caused by storm surge, the warning and measures should be issued and taken respectively preparing for the worst case scenarios. The ensemble forecast may present realistic spread of tropical cyclone tracks while current most ensemble prediction systems (EPS) for typhoon forecast are based on global models and their horizontal resolutions are not enough to simulate local storm surge. In this study, we conducted a mesoscale ensemble forecast of cyclone Nargis using a mesoscale model with a horizontal resolution of 10 km, and examined spread of simulated tide levels.

A mesoscale EPS is developed to consider forecast errors in the storm surge forecast of cyclone Nargis. NHM with a horizontal resolution of 10 km is employed as the forecast model, which covers the Bay of Bengal and its surrounding areas by 341x 341 grid points. Hybrid-vertical coordinates with 40 stretched levels are used whose lowest level is located at 20 m AGL. These specifications are identical to the forecast experiment of Kuroda et al. (2009), and their simulation is adopted as the control run. Thus, JMA’s high-resolution operational analysis at 12 UTC 30 April 2008 and the 6 hourly GSM forecast are used as the initial and boundary conditions of the control run. Initial and boundary perturbations are given by JMA’s operational one-week EPS. Although the JMA’s one-week EPS is conducted with a T213 (60km) L60 GSM, only 12 hourly low resolution (1.25 degrees) pressure plane (10 levels) forecast GPVs are available at MRI (and even at JMA) as the archived data. Incremental perturbations are extracted by subtracting the control run forecast from the first 10 positive ensemble members of JMA’s one-week EPS, and are interpolated with time and space to the 6 hourly 10 km L40 initial and lateral boundary conditions for NHM. Since the highest level of the pressure plane forecast GPV is located at 200 hPa level and is lower than the model top of NHM (22 km), perturbations at highest 8 levels of NHM are extrapolated from the incremental perturbation at 32nd level assuming the perturbation becomes zero at the model top. Adding 10 negative members, 20 mesoscale ensemble perturbations are prepared in all, and the saturation adjustment is applied to all initial and lateral boundary conditions.

Figure 1a compares predicted tracks of Nargis by the control run and member p01 and m01 with the best track. Track of member m01 is predicted in south of the control run and closer to best track while member p01 is predicted too northerly. Control run and both p01 and m01 are all predicted in east of best track, which means these runs predicted the landfall time too early. Main reason of this discrepancy is attributable to the positional lag in initial condition of control run at FT=0. Figure 1b shows predicted tracks until FT=42 by all ensemble members. The center positions of Nargis are distributed in an elliptic area with 200-300 km distant from the control run. This spread of predicted positions is roughly comparable to the statistical errors of JMA’s typhoon track forecast in northwestern Pacific at FT=48. The major axis of the ellipse is oriented along the direction of cyclone’s movement, suggesting that Nargis’s forecast was a case where timing of landfall was relatively difficult. Predicted positions of the cyclone center in member p02, m05, m09 and p10 were better than the control run, while the intensities were weaker than the control run. The predicted center pressures were between 972 and 985 hPa. Here, we show forecasts by member m01 and p02 in Fig. 2.

Storm surge simulation is performed using surface wind forecasts by the mesoscale EPS. The Princeton Ocean Model (POM) is used with same specifications as in Kuroda et al.

Figure 3 shows time sequence of wind speeds, wind directions and tide levels predicted by all ensemble members at Irrawaddy (16.10N, 95.07E) and Yangon (16.57N, 96.27E) point. Wind speeds in some members have sharp minima in 2 May, corresponding to passage of the cyclone’s ‘eye’. At Irrawaddy point, tow members predict high tide levels near 4 m, while the timings are different from the control run. At Yangon point, where only moderate surge of 1.5 m was simulated in the control run, the maximum tide level reaches about 2.5 m. From the plume figures shown in Fig.3, we can compute the maximum, minimum and center magnitudes of tide levels with 25 % and 75 % probability values (Fig. 4). This result suggests that relying only on a single deterministic forecast is often dangerous. Quantitative information on forecast errors and reliability based on the ensemble prediction are very important for effective risk management, and will become indispensable in the future disaster mitigation system.

Acknowledgment

We thank Nadao Kohno of JMA for their helps to run POM.

References

Kuroda, T., K. Saito, M. Kunii and N. Kohno, 2009: Numerical Experiments of Myanmar Cyclone Nargis. *CAS/JSC WGNE Research Activities in Atmospheric and Oceanic Modelling.* **39**. (this volume)

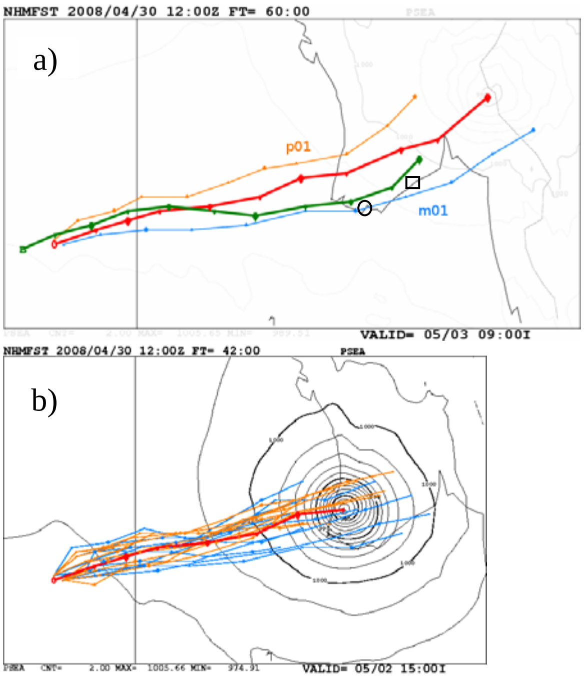

Fig. 1. a) Predicted tracks of Nargis until FT=60 (valid time 00 UTC 3 May 2008) by the control run (thick line) and the member p01 and m01. Corresponding best track is also indicated. Circle and square shows location of Irrawaddy and Yangon point, respectively. b) Predicted tracks until FT=42 (valid time 06 UTC 2 May 2008) by the control run (thick line) and the ensemble prediction.

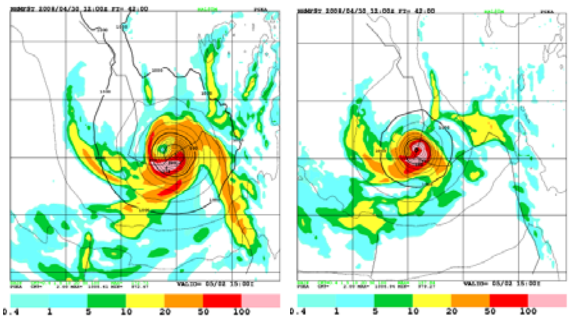

Fig. 2. Mean sea level pressure and 3 hour accumulated precipitation at FT=42 predicted by member m01 (left) and p02 (right).

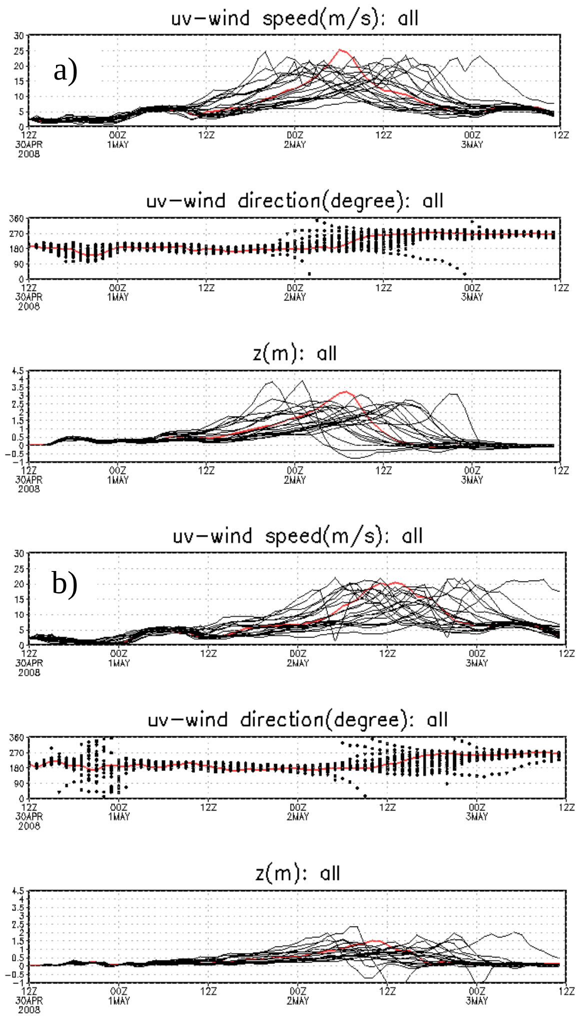

Fig. 3. a) Time sequence of wind speeds (upper), wind directions (middle) and tide levels (bottom) by all ensemble members at Irrawaddy point. b) Same as in a) but at Yangon point.

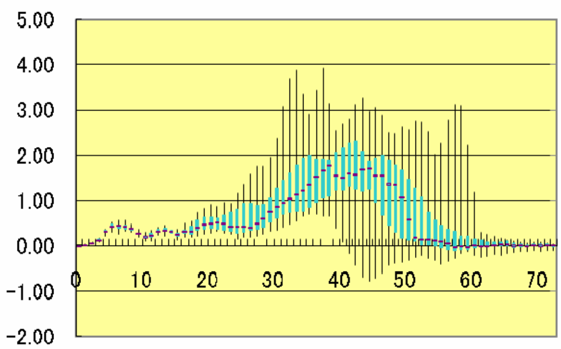

Fig. 4. Time sequence of the maximum, minimum and center magnitudes of tide levels at Irrawaddy point. Widths between 25 % and 75 % probability values are depicted with solid rectangles.