A mesoscale ensemble prediction system using singular vector methods

Kosuke Ono* Yuki Honda* and Masaru Kunii**
*Numerical Prediction Division, Japan Meteorological Agency, Tokyo, Japan
**Department of Atmospheric and Oceanic Science, University of Maryland, College Park, USA
E-mail: kou.ono@met.kishou.go.jp

We have been developing a mesoscale ensemble prediction system (MEPS) using singular vector (SV) methods for the provision of probabilistic information and multi-scenarios in operational mesoscale forecasting (MSM) since 2007. In order to improve the related probability scores, we developed a method of generating initial perturbations (IPs) by blending two mesoscale SVs (MSVs) (Ono et al. 2010). However, the IP amplitude is too large in regions where two MSVs turn in the same direction because this method involves simple addition of the two MSVs. It is also necessary to add a global SV (GSV) to the two MSVs to account for the uncertainty of synoptic scale phenomena. Accordingly, we have developed a new IP method in which multi-scale IPs are generated by blending three SVs using the variance minimum method (Yamaguchi et al. 2009), which rotates all SVs so that IPs have a broader structure. We conducted a daily mesoscale ensemble forecasting experiment using this IP method in the latter half of 2010 to ascertain its level of performance.

Table 1 lists the details of the SV calculations and the subsequent ensemble forecasts for the daily experiment. MSVs are calculated using the tangent linear and its adjoint model (TL/AD) based on JMA's nonhydrostatic model (JMA-NHM) (Honda et al.2005). GSVs are calculated using the TL/AD of the JMA's global spectral model. The lateral boundary is perturbed using the outputs of JMA's operational weekly ensemble prediction. In ensemble forecasting, the ensemble size is 11 (including control forecasting), and the horizontal resolution of JMA-NHM is set to 20 km to reduce computational costs.

A case of the heavy rain caused by Baiu front at 00 UTC on 03 July 2010 (T+6) is shown in Figure 1. Some ensemble members forecast heavy rain near the front that the control forecast does not forecast. However, at the southern side of the front, no member forecasts the heavy rain. The daily experiment suggests that this system forecasts heavy rain associated with disturbances such as fronts and low pressure systems well.

Figure 2 shows the rank histograms for wind speed against sonde observations around Japan (verification period: 03 July - 13 September 2010; total: 59 cases). It can be seen that the ensemble spread at the surface is too small over the forecast period. One of the main reasons for this is that the MSV amplitude is small near the surface. On the other hand, the ensemble spreads at 850 hPa and 500 hPa are more appropriate. Corresponding to these characteristics, the improvement rate of the ensemble mean forecast against the control forecast at upper levels is better than that near the surface (Figure 3). These characteristics are also confirmed for other elements.

Figure 4 shows reliability diagrams for three-hour accumulated precipitation. It can be seen that at higher levels of precipitation probability, this system tends to overforecast precipitation, i.e., most ensemble members forecast the same precipitation.

In order to improve the performance of this system (especially the ensemble spread near the surface and the precipitation score), we plan to develop a physics perturbation method and reinforce the horizontal resolution and ensemble size for ensemble forecasting on the next super computer system at the JMA.

Table 1 Ensemble spread of three-hour accumulated precipitation [mm/3h].

SV calculation				Ensemble forecast	
Type	MSV40	MSV80	GSV	Model	JMA-NHM
dx	40 km	80 km	180 km	dx	20 km
Optimization time	6 h	15 h	24 h	Ensemble size	11
Norm	Moist total energy	Moist total energy	Dry total energy	Forecast time	36 h
Number	10	5	5	Initial time	18 UTC

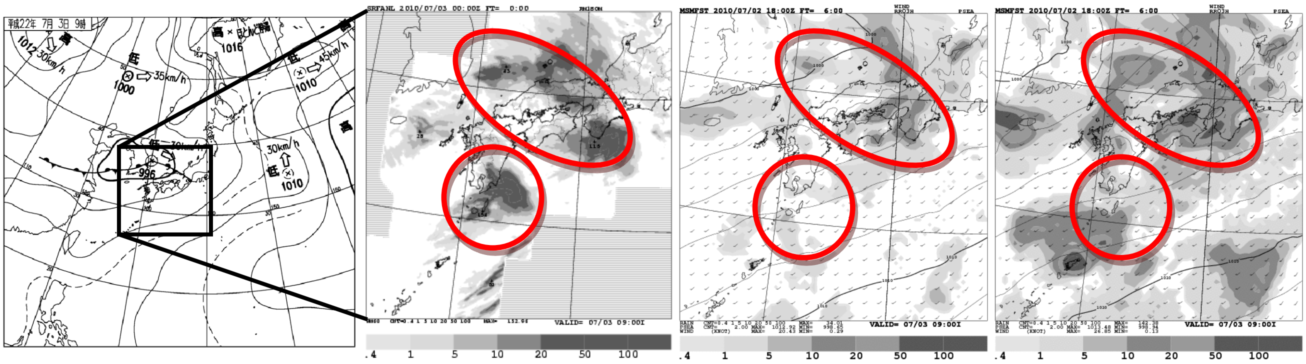

Fig1. Weather chart and three-hour accumulated precipitation at 00UTC on 03 July, 2010 (observation, control forecast and maximum precipitation in all ensemble members, T+6).

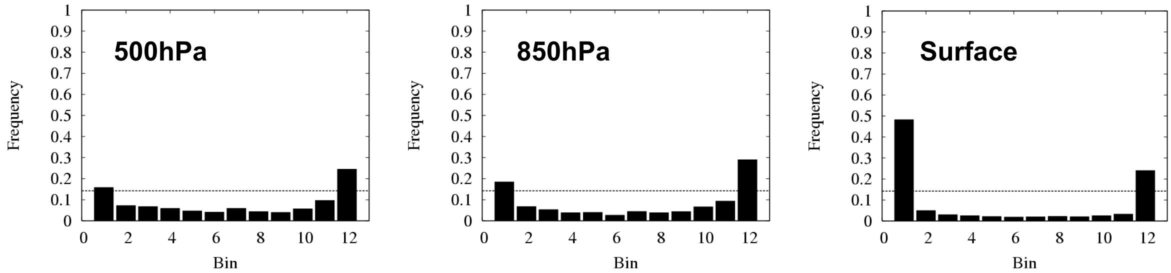

Fig2. Rank histograms of wind speed (500 hPa, 850hPa and surface, T+30).

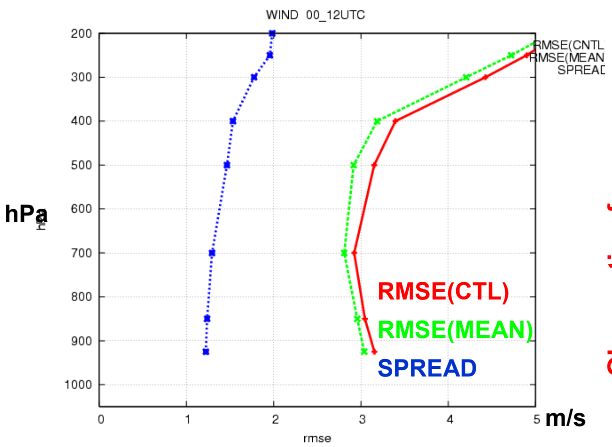

Fig3. Root mean square error and ensemble spread of wind speed (T+30)..

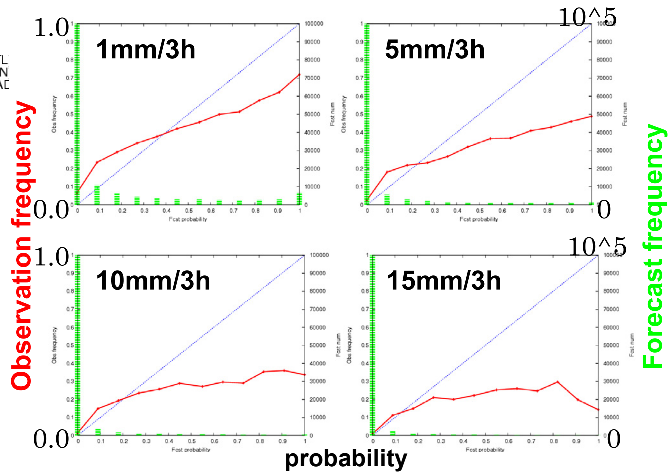

Fig4. Reliability diagrams of three-hour accumulated precipitation (T+12).

References

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