Implementation of lateral boundary perturbations into mesoscale EPS

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In the previous report (Saito et al., 2007a), a BGM method for mesoscale ensemble prediction was presented where the JMA nonhydrostatic model (NHM) with a horizontal resolution of 10 km was employed. Targeting the 2004 Niigata heavy rain event, 12 hourly self breeding cycles were conducted from 12 UTC 09 July to 12 UTC 12 July 2004, using the moist total energy norm by Barkmeijer et al. (2001) to normalize the bred vectors. The variation of rainfall amount in the initial stage (FT=0-6), which was too large in the simple downscaling method of the JMA's operational global EPS (WEP), was reduced while in the later half of the forecast period (FT=12-18) the variety of precipitation amount reached 2 times in averaged values and 3 times in peak values. On the other hand, prior to the 2007 preliminary experiment in the WWRP Beijing Olympic 2008 Research and Development Project (B08RDP), we tested a similar self BGM method but no distinct gain was found in the tested BGM method compared with WEP in the growth of the ensemble spread for surface conditions. Two 12 hourly self breeding cycles were employed in the tested B08RDP BGM method using the perturbations of WEP in the day before as the initial seed.

In the MRI/JMA EPS, lateral boundary conditions were given by the forecast of the JMA's regional NWP (RSM) and perturbations in the lateral boundary were neglected. Without the lateral boundary perturbations, regional bred vectors may tend to become similar if some appropriate orthogonalization is not applied. In the ensemble Kalman filter (EnKF), the forecast error covariance may be underestimated near the lateral boundary, which yields underestimation of Kalman gain in the assimilation of observed data. In B08RDP, most participants use forecasts of global EPSs for lateral boundary conditions, however use of low resolution global EPS forecasts enlarges the resolution gap at lateral boundaries. Besides, the forecast values from the JMA one week global EPS are sent to MRI as the thinned pressure plane files; 1.25 degrees and 11 planes for the RSMC Tokyo responsible area (RSMC125 file).

In order to overcome above problems, we developed an incremental boundary perturbation method where the perturbations by the RSMC125 file are added to the model plane forecast values by the high resolution deterministic global forecast (TL959L60) of JMA. The RSMC125 file consists of 11 level pressure planes and surface plane data which cover RSMC Tokyo responsible area (90 E - 180E and 0N -71.25N) with 6 hourly forecast output. The initial and forecast ensemble perturbations on NHM model planes are computed by subtracting the interpolated values of the control run from the interpolated values of the ensemble members. Since the highest level of the RSMC125 file is 100 hPa, perturbation increments above 100 hPa level in the NHM model plain are computed by extrapolation and set to zero at the model top of NHM.

Result of a downscale ensemble experiment for 12 UTC 14 January 2008 is shown, where initial condition is the JMA mesoscale analysis (MA) and the lateral boundary condition of control run is the forecast of high resolution GSM (TL959L60). The initial and lateral perturbations are given by the RSMC125 file. Other specifications are almost same as the B08RDP experiment (15 km L40, 11 members) except the model domain (Japan area, 3000 km x 2700 km).

Figure 1 shows ensemble spread (root mean square errors from the ensemble mean) of horizontal wind (U) at z*=1.46 km level when the perturbations are not added to the lateral boundary conditions. The spread is relatively large along the convergence zone over the western central part of the Japan Sea, which indicates that the forecast results tend to diverse at positions of disturbances, however, the spread decreases in the lateral boundary relaxation areas (24 grids in each side) after the start-up (Fig. 1a), and the influence of lateral boundaries propagates inside of the model domain with the time. At FT=24 (Fig. 1b), spreads over disturbance free areas become very small, such as less than 0.5 m/. Figure 2 shows the ensemble spread when incremental perturbations are added to the lateral boundary conditions. In this case, even at FT=24, areas of large ensemble spread are seen throughout the entire model domain including the

East China Sea (Fig. 2b). Spread over the western central part of the Japan sea is larger and extends to more wide areas. Figure 3 shows time sequence of area averaged ensemble spreads over the central part of the model domain. Differences of spreads with and without lateral perturbations are distinct after FT=12 and become more than twice at FT=36.

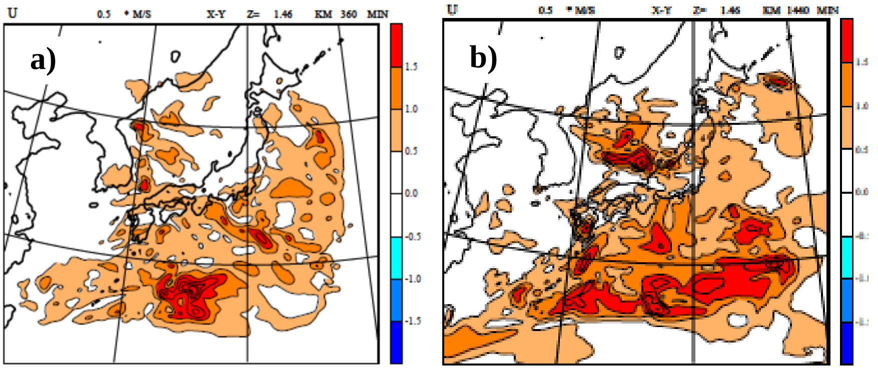

Fig. 1. Spread of horizontal wind with the 11 member mesoscale ensemble prediction. Perturbations are not added to the lateral boundary conditions. **a)** FT=6. **b)** FT=24.

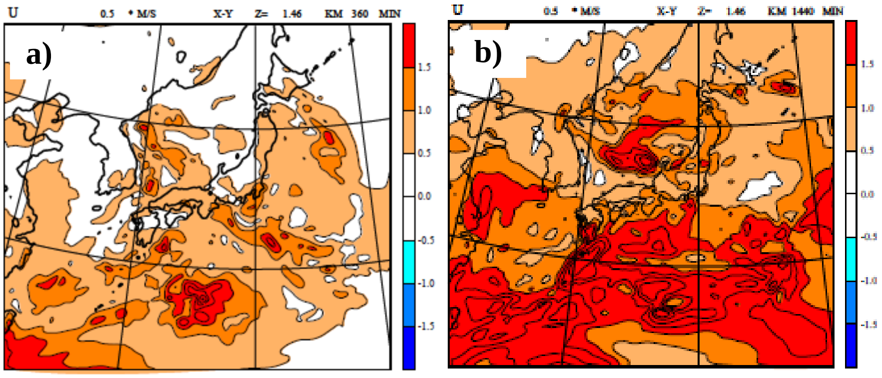

Fig. 2. Same as in Fig. 1, but incremental perturbations are added to the lateral boundary conditions.

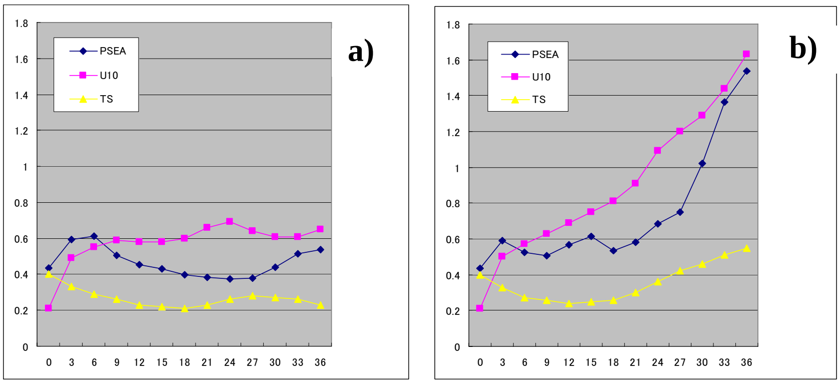

Fig. 3. Time sequence of area averaged ensemble spreads over the central part of the model domain (a rectangle of 1000 km square). **a)** Perturbations are not added to the lateral boundary conditions. **b)** incremental perturbations are added to the lateral boundary conditions. (Psea; Mean sea level pressure, U10; Horizontal wind at 10m, TS=Surface temperature). In these comparative experiments, no perturbations are used in soil temperatures.

References

Saito, K., 2007a: Development of a BGM method with the JMA nonhydrostatic mesoscale model. *CAS/JSC WGNE Research Activities in Atmospheric and Oceanic Modelling*. **37**, 5.27-5.28.

Saito, K., H. Seko, M. Kunii, T. Hara, M. Kyouda and M. Yamaguchi, 2007b: Preliminary Mesoscale Ensemble Prediction experiment for WWRP Beijing 2008 RDP. *CAS/JSC WGNE Research Activities in Atmospheric and Oceanic Modelling*. **37**, 5.25-5.26.