Applying a local ensemble transform Kalman filter to the JMA nonhydrostatic model

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In the 2006 issue of the WGNE Blue Book, Miyoshi and Yamane (2006) reported their successful implementation of the local ensemble transform Kalman filter (LETKF, Hunt 2005) with the AFES model (AGCM for the Earth Simulator). They made further comprehensive investigations; the results are now in press in Monthly Weather Review (Miyoshi and Yamane 2007). In the meantime, based on the investigations on the Earth Simulator, LETKF has been developed with the JMA's nonhydrostatic mesoscale model (NHM). Miyoshi and Aranami (2006, hereafter "MA06") published results of perfect model twin experiments with the NHM-LETKF. In this short report, we briefly overview our preliminary results with real observations.

After the successful investigations by MA06, real observations used in JMA's operational mesoscale analysis are assimilated with the NHM-LETKF. The model domain is chosen to be the same as the JMA operational mesoscale system (about 3600km x 2900km). The resolution is reduced to be 20-km grid spacing with 181x145x50 grid points, instead of the operational 5-km grid spacing which requires 16 times more grid points. The model parameters and physical processes of the 20-km NHM are chosen to be essentially the same as the operational settings. Differences are found in the orography, land-surface, finite-differencing time, and buffer area near the boundaries, all of which are minimum required changes by the resolution difference. The ensemble size is chosen to be 20. The data assimilation cycle begins on June 25, 2004.

Figure 1 shows 6-hour forecast fields (i.e., first guess) of the NHM-LETKF and JMA operational mesoscale NWP systems. The operational mesoscale NWP system as of June and July 2004 was not NHM but a hydrostatic spectral model with 10-km grid spacing, thus it is not straightforward to compare them precisely. Although NHM-LETKF indicates a little higher pressure, the position of the low pressure system and the precipitation pattern show good agreements.

Figure 2 shows analysis ensemble spreads after the first analysis step and a few week cycle processes. Since a large number of observations are available over Japan, the area with small spreads indicates the shape of Japan after the first analysis step. Due to the fixed boundary conditions for all ensemble members, spreads are artificially small near the boundaries, especially about 20 grids (400 km) which corresponds to the damping area. Still, we see large spreads beyond 7 m/s in the region; the errors are actually growing and not damped by the fixed boundaries. The ensemble spreads vary dynamically to show flow-dependent behaviors. The stable LETKF performance would explain that the error growth inside the region is not significantly affected by the fixed boundary conditions.

Although it is difficult to compare the analysis accuracy, the NHM-LETKF appears to generate reasonable analysis. Miyoshi et al. (2007) developed a new version of the LETKF that does not use local patches, which requires less computational time and generates better analysis without discontinuities at the edges of local patches. Future plans include applying the new version without local patches, as well as further investigations of the verifications and ensemble forecast experiments.

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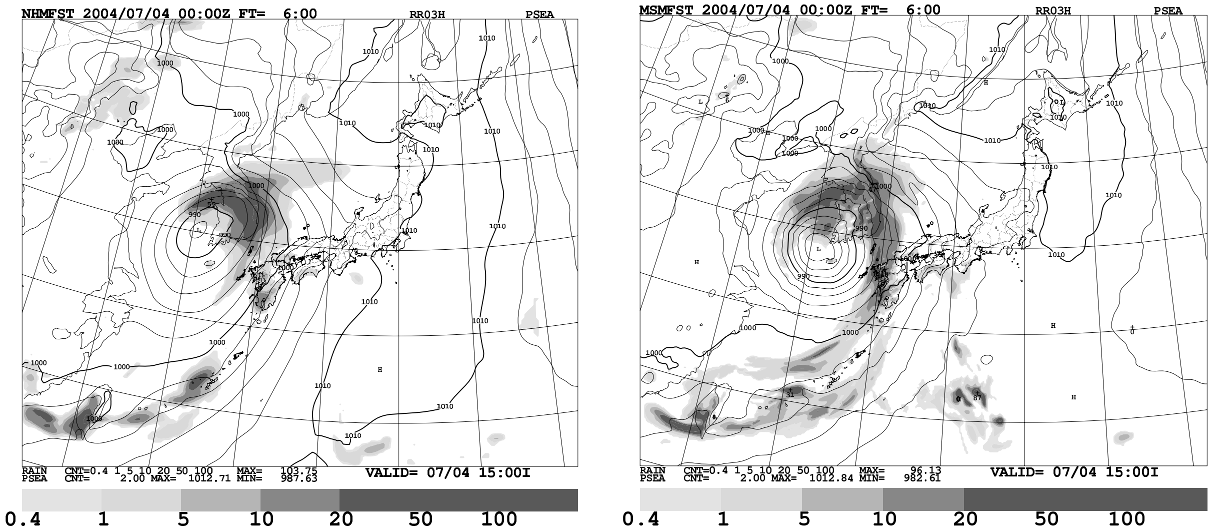

Figure 1. 3-hour accumulated precipitation (mm, shades) and sea-level pressure (contour) of NHM-LETKF 6-hour forecast ensemble mean (left) and JMA operational mesoscale 6-hour forecast (right) valid on 06Z July 4, 2004.

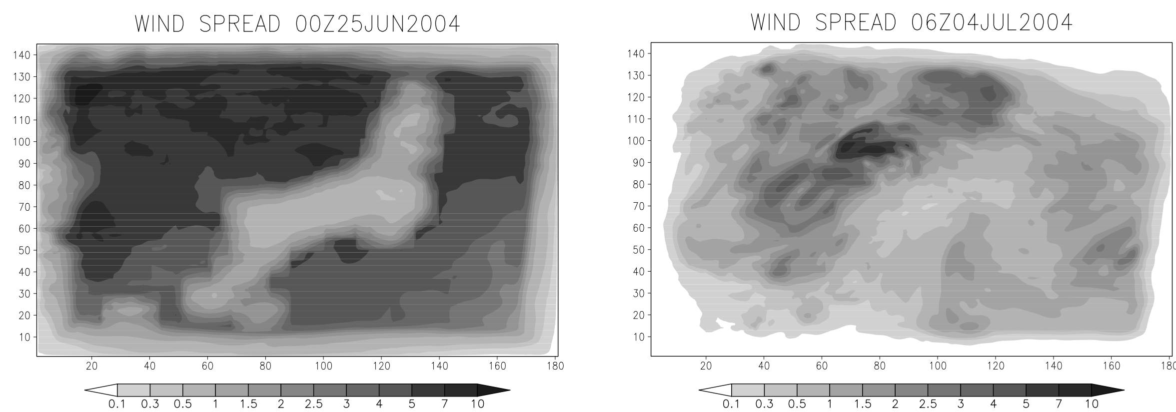

Figure 2. Horizontal pattern of the analysis ensemble spreads of wind speed (m/s) at the 21st vertical level (about 4000 meters high), after first analysis step (00Z June 25, 2004, left) and a few week cycle processes (06Z July 4, 2004, right). Horizontal and vertical axes indicate grid numbers.

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