Applying a local ensemble transform Kalman filter to the JMA global 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 global model (GSM) at a TL159/L40 resolution, which is the same version as the one used in the operational ensemble prediction system (EPS). In this short report, we briefly overview our preliminary results with the GSM-LETKF.

First, 20-member LETKF has been performed to ensure that the system works appropriately (Miyoshi and Sato 2007, hereafter "MS07"). MS07 investigated impacts by assimilating satellite radiances. Fig. 1 shows the results by MS07, where we see clear advantages of the satellite radiance assimilation. Here, the parameter values are fixed with the 21x21x13 local patch (about 1000-km radius), 5-grid (about 500-km) horizontal and 3-grid vertical Gaussian localization, and 10 % spread inflation.

Then, the ensemble size has been increased to be 50 with the same parameter values. Figs. 2 and 3 show the results, where we see significant improvements by the larger ensemble size. Still, LETKF shows

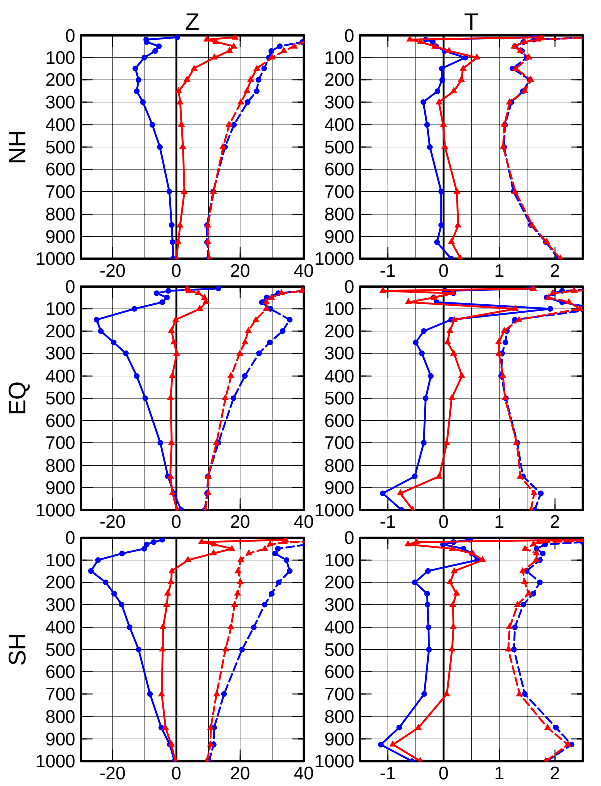

Figure 1. Analysis errors of height (m, left) and temperature (K, right) verified against radiosonde observations in each area for the cases with (red) and without (blue) satellite radiances, temporally averaged over 31 days in August 2004 (adapted from Fig. 5 of MS07). Solid and dashed lines indicate the bias and RMS errors, respectively.

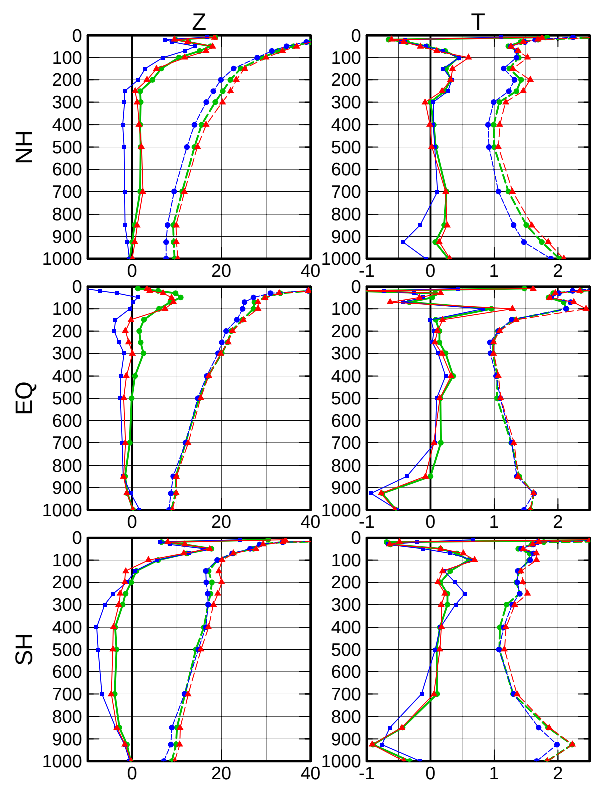

Figure 2. Similarly to Fig. 1, but for the cases of the LETKF with 20 members (red), LETKF with 50 members (green), and the operational 4D-Var (blue).

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generally larger errors than the operational 4D-Var (Kadowaki 2005).

After the above investigations, Miyoshi et al. (2007) developed a new version of the LETKF that does not use local patches. Without local patches, there is no need to specify the local patch size, thus the number of the localization tuning parameters are reduced. Moreover, it solves the discontinuity problem caused by the local patch near the Poles where the physical distances between successive grid points are short. The new algorithm has been applied to the GSM-LETKF. Furthermore, we apply vertical localization linear with the log-p coordinate, which is physically more meaningful. So far, the vertical localization was applied linearly with the model coordinate; in the lower troposphere where the model has a denser resolution, the vertical localization has been too narrow.

With the above upgrades, we obtained further improvements. Fig. 4 shows forecast verification scores. The blue curve shows results by the LETKF without local patches, but with the same parameters (500-km horizontal and 3-grid vertical localization with 10 % spread inflation). Red curve shows the latest results with tuned parameters (500-km horizontal and 0.5-hPa vertical localization with 30 % spread inflation), which appears to be much closer to the operational 4D-Var. We are expecting further improvements by refining the parameters and increasing the ensemble size up to 100.

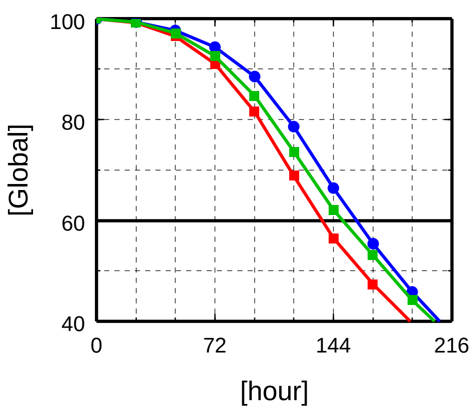

Figure 3. 9-day forecast anomaly correlations (%) of 500 hPa height averaged over 31 days in August, 2004, for the cases of the LETKF with 20 members (red), LETKF with 50 members (green), and operational 4D-Var (blue).

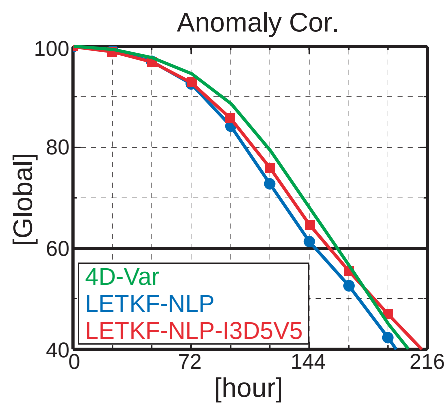

Figure 4. Similarly to Fig. 3, but for the LETKF without local patches and a different sample period (August 1-15, 2004). Blue and red lines indicate 50-member LETKF without local patches with the original and tuned parameters, respectively. Green line indicates the operational 4D-Var.

Acknowledgements

We thank Prof. Eugenia Kalnay, Drs. Shozo Yamane, Takeshi Enomoto, and Jeff Whitaker for fruitful discussions.

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