Mesoscale data assimilation for a local severe rainfall event with the NHM-LETKF system

Masaru Kunii

Forecast Research Department, Meteorological Research Institute, Japan, mkunii@mri-jma.go.jp

1. Introduction

This study aims to improve forecasts of local severe weather events through data assimilation and ensemble forecasting approaches. Here, the local ensemble transform Kalman filter (LETKF, Hunt et al. 2007) is implemented with the Japan Meteorological Agency's nonhydrostatic model (NHM, Saito et al. 2006; 2007).

The newly developed NHM-LETKF is applied to a heavy rainfall event that occurred in Japan in 2012, and the performance of the system is investigated by running data assimilation as well as ensemble forecast experiments.

2. The NHM-LETKF System

- LETKF with the JMA regional mesoscale model NHM
- Base on the WRF-LETKF (Miyoshi and Kunii 2012)
  - The latest version of LETKF core
  - Effectively utilize feedbacks from WRF-LETKF users
- Research use
  - Simple (NOT include QC processes)
  - Independent of computer environment
  - 1way nested data assimilation

3. Experimental Settings

The NHM-LETKF is applied to the heavy rain event that occurred over northern Kyushu in Japan in July 2012.

Ensemble size	50
Lateral boundary conditions	JMA Global Forecast (+ PTBs from JMA Global EPS)
Covariance inflation	Adaptive (Miyoshi 2011)
Covariance localization	200 km, 0.2 ln p
Analyzed variables	u, v, w, t, p, qv, qc, qr, qci, qs, qg
Observation data	MA CDA4 (U, V, T, RH, TPW)
Domain size	241 x 193 x 50 (Δx = 15km)

Table 1. Experimental settings in this study

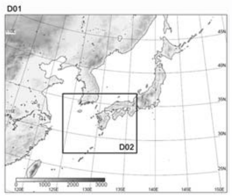


Fig. 1. Model domain

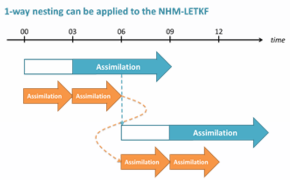
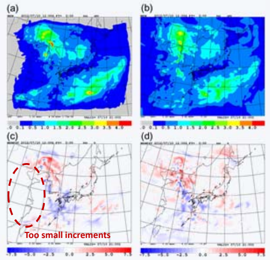


Fig. 2. Schematic diagram of the nested LETKF

4. Result

4.1 Effect of the lateral boundary perturbations (LBPs)



Perturbing lateral boundaries, even with other perturbation schemes, would positively impact the LETKF application with regional models.

Fig. 3. Ensemble spread and analysis increment of zonal wind at 500 hPa level in the outer LETKF. (a)(c) Without LBPs (b)(d)With LBPs.

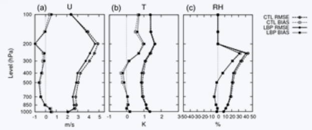
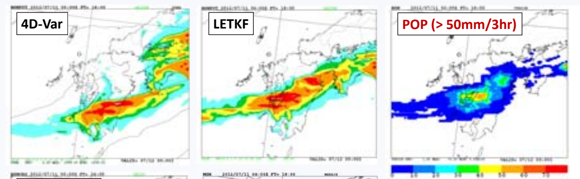
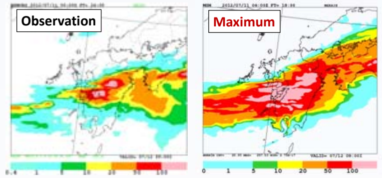


Fig. 4. 6-h forecast verifications relative to radiosonde observations averaged over 10 days.

4.2 Forecast results

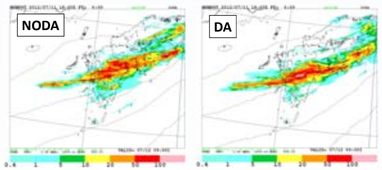




- Forecasts from LETKF analyses successfully captures the intense rainfall.
- The maximum probability reaches as high as 50 percent at the 18-h forecast.

Fig. 5. Simulated 3-h accumulated precipitation (mm) in 18-h NHM forecasts with a horizontal resolution of 5 km at 0000 UTC 12 July 2012.

4.3 One-way nested LETKF



NODA	Forecast from 15-km LETKF analysis
DA	Forecast from 5-km nested LETKF analysis

Nested LETKF shows positive impact on the quantitative precipitation forecast.

Fig. 6. Similar to Fig. 5, but in NHM with horizontal resolution of 1km, initialized with (a) the original LETKF, (b) the nested LETKF.

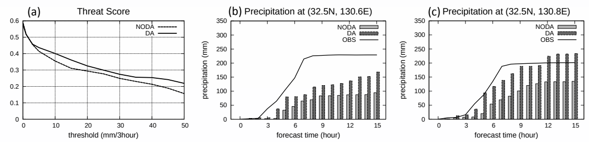


Fig. 7. (a) Threat scores for 3 h accumulated rainfall averaged between 3 and 15 hours in the NODA and DA experiments. Accumulated precipitation in the NODA and DA experiments at (b) 32.5 °N, 130.6 °E and (c) 32.5 °N, 130.8 °E, respectively. The initial time of the forecast is 1800 UTC July 11 2012.

5. Summary

- The NHM-LETKF was applied to severe rainfall that occurred in Japan in 2012. Compared with the operational result from JMA, the forecast initialized with the LETKF analysis clearly improved the results, successfully capturing torrential rainfalls.
- The ensemble forecast experiments provided probabilistic information for precipitation that visually corresponded well with the observed rainfall amount.
- Experiment results with the one-way nested data assimilation demonstrated that assimilation with a finer-resolution model was advantageous in quantitative precipitation forecasting of local severe weather conditions, but there would still be difficulties in predicting these severe events with adequate temporal and special accuracy in NWP models.

REFERENCES

Hunt, B. R., E. J. Kostelich, and I. Szunyogh, 2007: Efficient data assimilation for spatiotemporal chaos: A local ensemble trans- form Kalman filter. *Physica D*, **230**, 112–126.

Kunii, M., 2013: Mesoscale data assimilation for a local severe rainfall event with the NHM-LETKF system. *Weather and Forecasting* (under review).

Miyoshi, T. and M. Kunii, 2012: The Local Ensemble Transform Kalman Filter with the Weather Research and Forecasting Model: Experiments with Real Observations. *Pure and Appl. Geophys.*, **169**, 321-333. doi:10.1007/s00024-011-0373-4.

Saito, K., T. Fujita, Y. Yamada, J. Ishida, Y. Kumagai, K. Aranami, S. Ohmori, R. Nagasawa, S. Kumagai, C. Muroi, T. Kato, H. Eito and Y. Yamazaki, 2006: The operational JMA nonhydrostatic mesoscale model. *Mon. Wea. Rev*., **134**, 1266-1298.

Saito, K., J. Ishida, K. Aranami, T. Hara, T. Segawa, M. Narita and Y. Honda, 2007: Nonhydrostatic atmospheric models and operational development at JMA. *J. Meteor. Soc. Japan*, **85B**, 271-304.

ACKNOWLEDGEMENTS

This work was supported by JSPS KAKENHI Grant Number 21244074 and by MEXT Strategic Programs for Innovative Research (SPIRE). Part of the results is obtained by using the K computer at the RIKEN Advanced Institute for Computational Science (Proposal number hp120282).