Development of JMA Local Analysis

Junya Fukuda, Tadashi Fujita, Yasutaka Ikuta,
Yoshihiro Ishikawa and Koichi Yoshimoto
Numerical Prediction Division, Japan Meteorological Agency
1-3-4 Otemachi, Chiyoda-ku, Tokyo 100-8122, Japan
E-mail: jfukuda@met.kishou.go.jp, t-fujita@met.kishou.go.jp

1. Introduction

The Japan Meteorological Agency (JMA) is developing the Local NWP system – a high-resolution numerical weather prediction system aimed at supporting aviation and disaster-prevention information services. It consists of a forecast model called the Local Forecast Model (LFM) with a horizontal grid spacing of 2 km and an objective analysis called Local Analysis (LA) that prepares the initial condition for the LFM. The LA and LFM domains are shown in Fig. 1. JMA has been conducting trial operation of the Local NWP system since November 2010, and will start actual operation in 2012 after the introduction of a new supercomputer.

2. Design of the Local Analysis system

LA was constructed using JNoVA-3Dvar – a three-dimensional variational data assimilation system based on JMA's non-hydrostatic model (JMA-NHM; Saito et al. 2006). JNoVA-3DVar is a degenerate version of JNoVA-4DVar (Honda et al. 2005). In order to frequently update analysis reflecting information from new observation data within a short time while minimizing the usage of computer resources, a rapid update cycle method is employed in which JNoVA-3DVar and one-hour forecasts of the JMA-NHM are executed in turn (Fig. 2). In addition to the observations listed in Ishimizu and Ujiie (2010), data on total column water vapor from the ground-based GPS (Ishikawa 2010) have been used since August 2010. At the same time, the number of Doppler radar sites used in the assimilation has been increased from 10 to 18, thereby improving the coverage of radial velocity observation. Quality control for surface station data has been introduced to take into account the representativeness error estimated based on statistics of difference and the correlation between observation and model forecasts since September 2010.

3. Recent developments

i) Vertical coordinate system of control variables

In the current system, 3DVar control variables are defined in z*-coordinate system. With this vertical coordinate system, the influence of topography on the analysis increment remains strong up to high altitudes (Fig. 3 (a)). In order to remedy this problem, we tried a new vertical coordinate system based on one by Ishida (2007) designed to follow terrain near the surface and rapidly shift to z-coordinate system higher up. Figure 3 (b) shows that the new coordinate system reasonably limits the influence of topography on the analysis increment in the lower troposphere.

ii) Surface observation operator

Observations from surface stations are assimilated in LA. The observation operator of JNoVA-3DVar diagnoses surface temperature based on similarity theory, and refers to potential temperatures at ground level and at the lowest atmospheric model level. Implementation of an update is under way to extend the 3DVar control variable to include potential temperature at ground level in addition to the variables on the atmospheric model levels. This update is found to mitigate excessive temperature increment in the lower troposphere. Using the analyzed potential temperature at the ground level to start the following forecast in the rapid update cycle helps to keep the lower boundary condition of the atmosphere consistent with analysis of the lower troposphere. The example shown in Fig. 4 indicates that assimilating surface temperature observations along with total column water vapor observations from the ground-based GPS assists the LFM in forecasting precipitation related to heated land in the afternoon.

4. Summary

Various efforts are being made to improve LA toward the planned operational use of the system in 2012. A new vertical coordinate system is being tested to control the effects of terrain on analysis increments, and the surface observation operator is being revised to secure more reasonable analysis in the lower troposphere. Further developments to improve LA are also under way, including assimilation of relative humidity data retrieved from radar reflectivity observation (Ikuta and Honda 2011).

References

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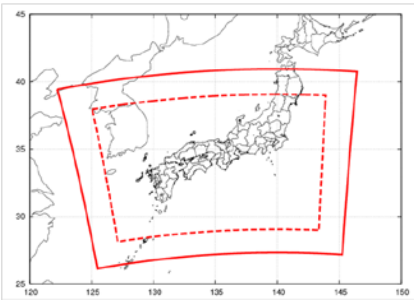

Fig. 1 LFM domain (dashed line) and LA domain (solid line)

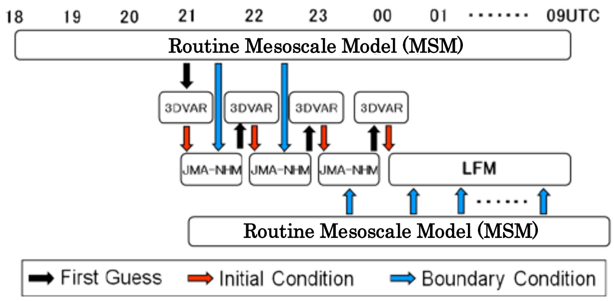

Fig. 2: Design of the LA rapid update cycle

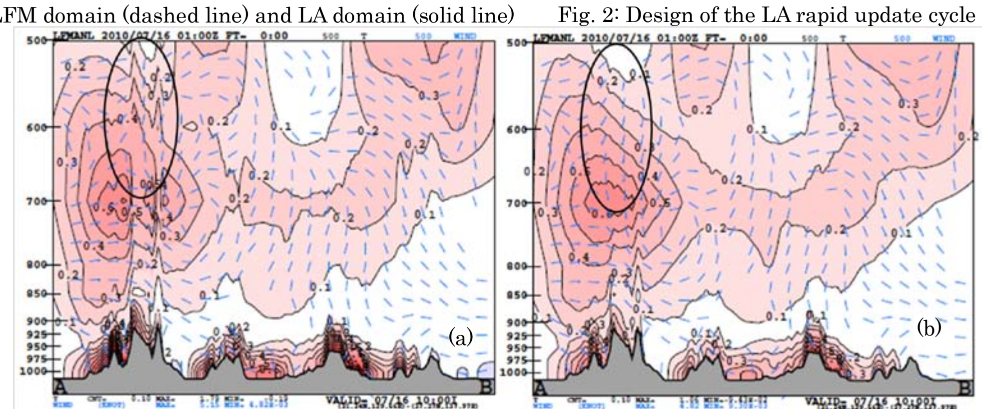

Fig. 3: Vertical cross section of temperature analysis increment: (a) z*-coordinate system; (b) new coordinate system

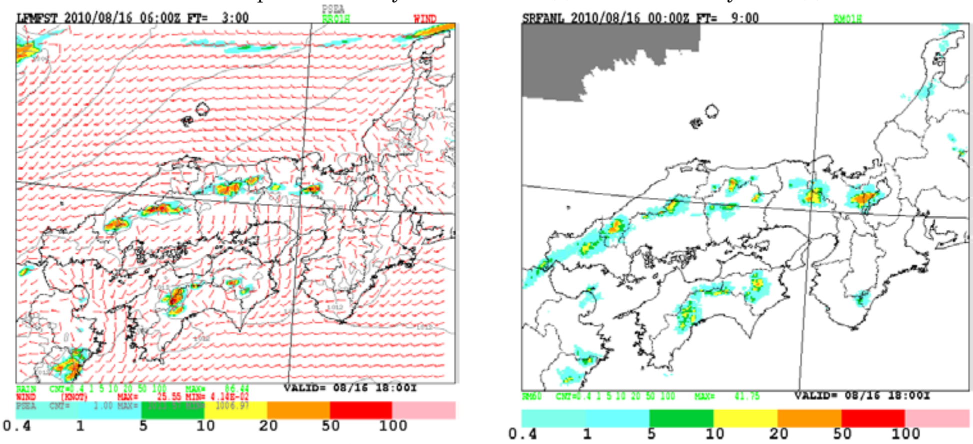

Fig. 4 1-h accumulated precipitation: (a) 3-h forecast from LFM; (b) observation