Upgrade of the Operational Mesoscale 4D-Var System at the Japan Meteorological Agency

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1. Introduction

For disaster prevention and aviation forecasting, the Japan Meteorological Agency (JMA) operates a mesoscale numerical weather prediction system known as the Mesoscale Model (MSM). The current operational mesoscale analysis setup consists of a four-dimensional variational data assimilation system based on a hydrostatic spectral model (Meso 4D-Var)(Ishikawa and Koizumi, 2002). In Honda and Sawada (2008), we announced the replacement of the Meso 4D-Var with a new JMA-NHM-based four-dimensional variational data assimilation system called JNoVA. However, this upgrade was postponed because of the deterioration of the forecast score of weak rain in summer. After various modifications and many experiments, we have succeeded in improving the JNoVA and plan to replace Meso 4D-Var with it in April 2009.

2. Improvements in the new mesoscale analysis system (JNoVA)

Detailed specifications of JNoVA are described in Honda et al. (2005). In this section, the modifications made since Honda and Sawada (2008) are briefly explained. First, the outer model has been upgraded to the latest operational forecast version, and its vertical resolution has been raised from 40 to 50 layers. Second, the moist process of the inner model has been changed; the moist convective adjustment scheme has been replaced with the Kain-Fritsch convective scheme. Although this scheme is only considered in the forward step, it contributes to the improvement of forecast trajectories. Third, a fix has been introduced for a serious bug in the handling of precipitation observation that caused a deterioration in the forecast score for weak rain in summer. Several other modifications have also been made, including the adjustment of the background error covariance matrix.

3. Performance of JNoVA

To compare the performance of JNoVA with that of Meso 4D-Var, twin experiments were conducted under almost the same conditions as the operational system in summer (2006/7/16 – 8/31) and in winter (2007/12/23 – 2008/1/23). The experimental period was changed from Honda and Sawada (2008).

The quantitative precipitation forecast (QPF) of JNoVA is better than that of Meso 4D-Var for all thresholds according to the equitable threat score (ETS) of three-hourly accumulated precipitation forecasts (Fig. 1). Even for weak rain, which is our concern here, the improvement is significant. Upper-air verification reveals that the analysis of JNoVA is better than that of Meso 4D-Var, although the impact on the forecast is quite limited (not shown). From surface verification, it is found that the root mean square errors (RMSEs) of the surface temperature in summer and the surface wind in winter are reduced, and that the scores of other surface variables are neutral (Fig. 2).

Typhoon Wukong (T0610) is picked up as a case in which JNoVA improves the forecast compared to Meso 4D-Var. Figure 3 shows a 24-hour forecast of three-hourly accumulated precipitation from the initial time of 15 UTC on 17 Aug. 2006. The improved typhoon track forecast leads to an enhancement of the precipitation pattern.

4. Summary

In general, JNoVA outperforms Meso 4D-Var, especially in the area of the quantitative precipitation forecasts. Accordingly, we plan to introduce the operation of JNoVA in April 2009 as a replacement for Meso 4D-Var. This upgrade will raise the horizontal resolution of analysis from 10 km to 5 km, while that of the inner model will also be changed from 20 km to 15 km.

References

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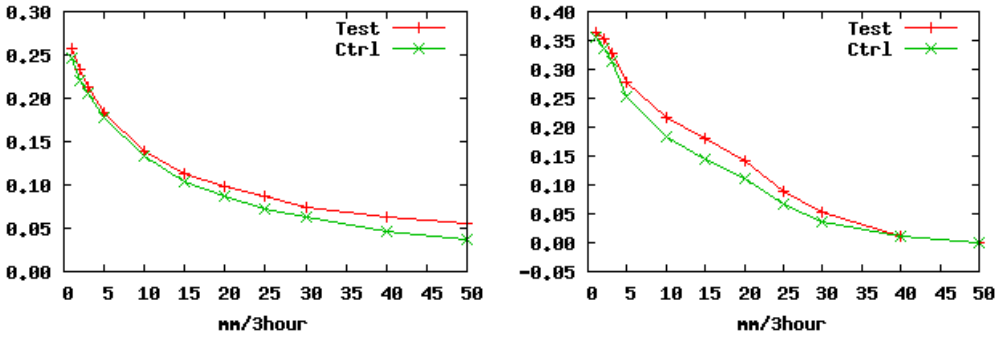

Fig. 1: Equitable threat scores of three-hourly accumulated precipitation forecasts in summer (right) and winter (left). The red and green lines show the results of JNoVA (Test) and Meso 4D-Var (CTRL), respectively. The horizontal axis is the threshold value of the rainfall amount.

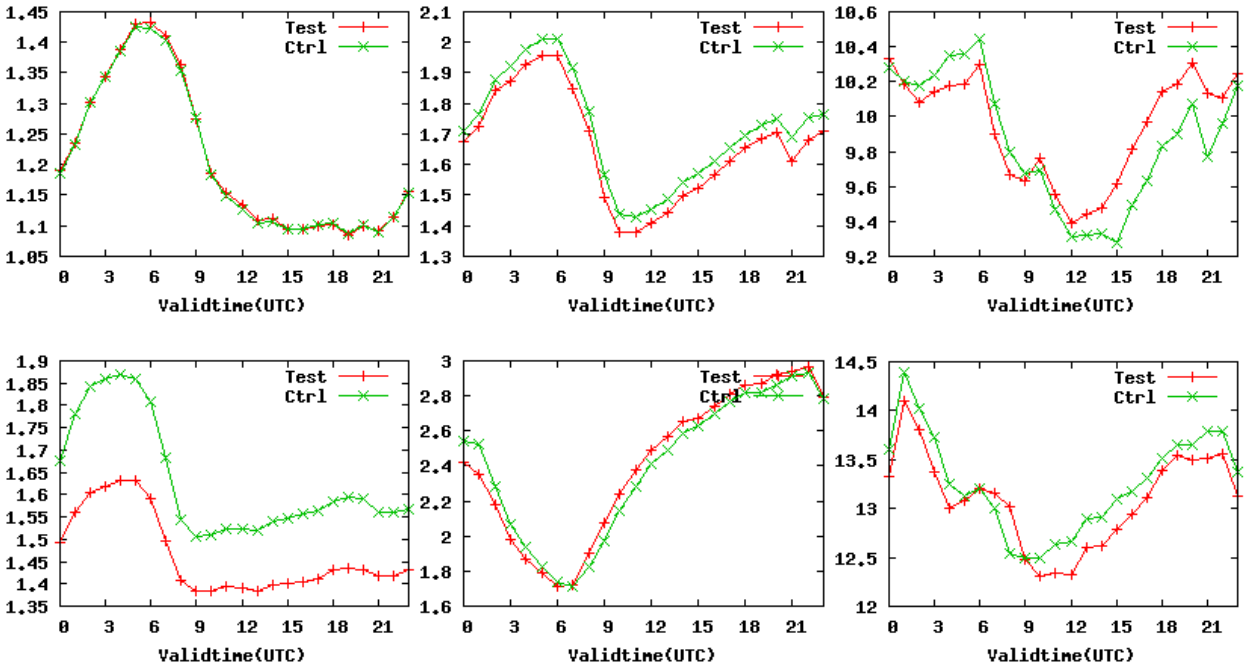

Fig. 2: Root mean square errors of wind velocity, temperature and relative humidity at the surface are shown from left to right, respectively. The upper panels are the results for summer, and the lower ones are those for winter. The line colors are the same as those in Fig. 1. The horizontal axis is the valid time, which is the real time of the forecast.

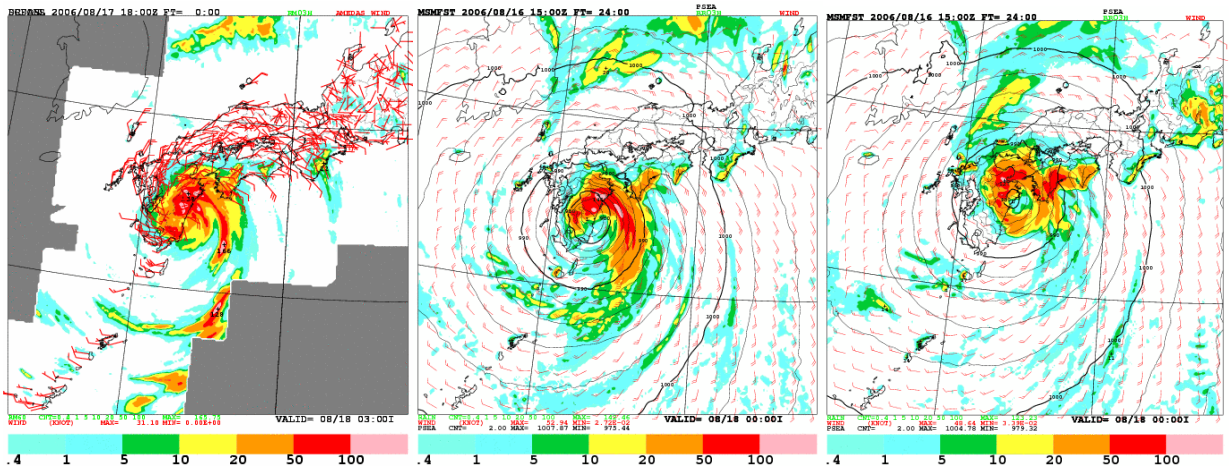

Fig. 3: Three-hourly accumulated precipitation of 24-hour forecasts from 17 Aug. 2006 at an initial time of 15 UTC. From the left, analyzed precipitation, the forecast of JNoVA and that of Meso 4D-Var are shown.