Verification of mesoscale forecasts by the newly implemented JMANHM

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1. Introduction

The Japan Meteorological Agency (JMA) started operating a numerical prediction system for disaster prevention in March 2001 using a hydrostatic model (MSM) with a horizontal resolution of 10 km. A nonhydrostatic model (NHM) has been developed based on the MRI/NPD unified nonhydrostatic model (Saito et al., 2001) in collaboration with the Meteorological Research Institute, and put into operation on 1 September 2004 in place of MSM.

2. Specifications of the operational NHM

The forecast domain of NHM covers the Japan Islands and surrounding areas with grid points of 361 x 289 at a horizontal resolution of 10 km, and the model is integrated up to 18 hours four times a day. The initial fields are prepared by the JMA mesoscale 4D-Var analysis based on MSM. Since the 4D-VAR analysis does not produce the initial fields of the water substances except water vapor, guessed values for these variables are taken from the outputs of the preceding forecast (Ishida and Saito, 2005). The lateral boundary conditions are given by the forecast from the JMA regional model with a grid spacing of 20 km. The model topography of NHM is made from GTOPO30 developed by the U.S. Geological Survey.

The governing basic equations of NHM are fully compressible equations with conformal map factors. Terms responsible for sound waves and gravity waves are treated implicitly in the vertical direction and explicitly in the horizontal (HE-VI, time splitting scheme), where long and short time steps are 40 and 80/7 seconds, respectively. The fourth order scheme is chosen for horizontal advection considering accuracy and computational efficiency (Fujita, 2003). To enhance the computational stability the lower (second order) components of the advection terms are adjusted at each short time step only in the later half of the leap-frog time integration (Saito, 2003) and the modified centered difference advection scheme (Kato, 1998) is used.

A three-ice bulk microphysics scheme was implemented, and some trivial processes are omitted for computational efficiency (Yamada, 2003). The Kain-Fritsch cumulus convection scheme (Kain and Fritsch, 1993) is employed with some parameters changed to suit operational run with 10 km mesh (Ohmori and Yamada, 2004). The non-local effect is considered in the planetary boundary layer scheme (Kumagai, 2004).

The details of the above mentioned scheme and other features are described in Saito et al.(2005).

3. Verification results

In this section, the performance of NHM is shown in comparison with MSM for the period of April to August 2004. The rainfall prediction is verified against rader-rain gauge composite data. Figure 1 shows the time sequences of bias and threat scores for three hour precipitation by NHM and MSM. The verifications are carried out for every 20 km square mesh and for grids over land and over sea nearby the coast. The threat scores of NHM are mostly equal to those of MSM for threshold value 1mm/3hr, and moderately better for 10mm/3hr, while the bias scores of NHM are almost same as those of MSM for both of the threshold values.

Figure 2 shows root mean square error of the 18-hour predicted fields by NHM and MSM against radiosonde observations. Verifications are done for the zonal wind field (left top), for the meridional wind field (right top), for the temperature field (left bottom), and for the relative humidity field (right bottom). The performance of NHM is comparable with that of MSM except that NHM performs better than MSM in the upper troposphere and the lower stratosphere, especially for the relative humidity field.

4. Concluding Remarks

The development of the model is continued for further improvement of the model dynamics and physics. The mesoscale numerical prediction system will be enhanced in terms of the horizontal resolution and frequency of operation after the replacement of the computer system in March 2006.

Acknowledgement

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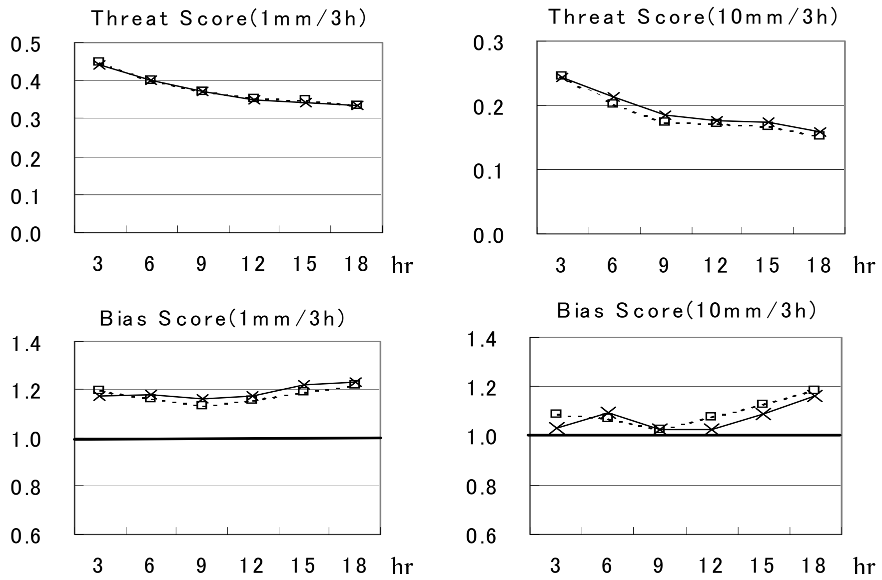

Fig. 1 Time sequences of threat and bias scores for three hour precipitation.
The solid line indicates NHM and the dashed line indicates MSM.

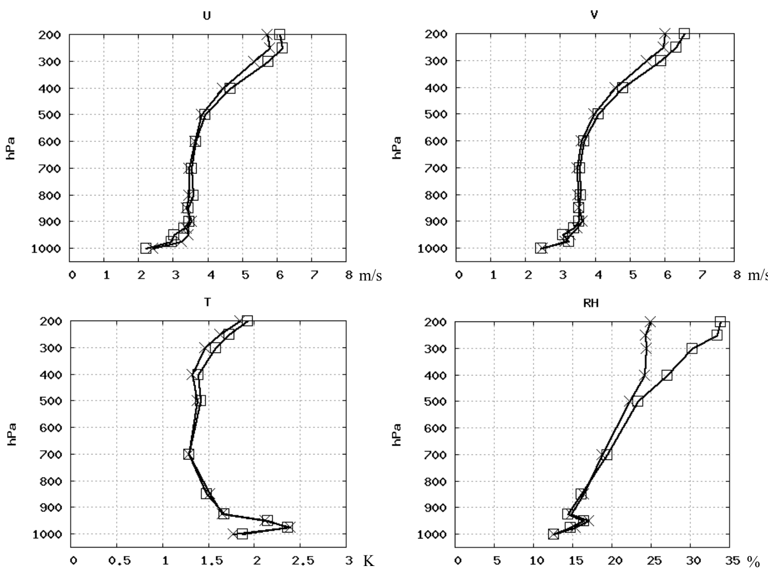

Fig. 2 RMSE of 18 hr forecasts from NHM (×) and MSM (□) against radiosonde. Verifications are carried out for the zonal wind field (left top), for the meridional wind field (right top), for the temperature field (left bottom), and for the relative humidity field (right bottom).