An upgrade of the JMA Operational Global NWP Model

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1. Introduction

The JMA operational global NWP model was upgraded to the new high resolution model on 21st Nov 2007. Introducing the new supercomputer SR11000-K1 with a peak performance of 21.5 Tflops has enabled us to improve the resolution of the model. The other major changes were in surface boundary conditions, global aerosol climatology, and the convection scheme. In this paper, we present these changes except the convection scheme (refer to "Improvement of the Cumulus Parameterization Scheme of the Operational Global NWP Model at JMA" in this volume or Nakagawa 2005), and a verification of the new model.

2. Model Resolution

Since the horizontal resolution was changed from TL319 (grid interval is about 60km) to TL959 (about 20km), and the number of horizontal grids increased from 640x320 to 1920x960, the new model can represent more detailed land/sea mask and topography. For example, the central part of Japan is expressed as a huge mountain by the old model (Figure 1, left), while the new model can resolve each major mountain (right). The better representation of topography and land/sea could improve forecasts of synoptic and sub-synoptic weather. For example, since these mountains work as a wall to prevent wind from blowing in typical winter weather conditions, new topography benefits the local weather forecasts.

The number of vertical layers increased from 40 to 60, and the pressure of the topmost level changed from 0.4hPa to 0.1hPa (Figure 2). Increased layers were given mainly to near ground surface and over the 30hPa level to improve representation of the surface boundary layer and the upper stratosphere. Furthermore, the raise of the topmost level helps to assimilate satellite observations more effectively.

3. Surface Boundary Conditions

The horizontal resolution of Sea surface temperature (SST) analysis as sea surface boundary condition was improved to 0.25 degree from 1.0 degree to bring out the detailed structure in the new high resolution forecast model. Not just the horizontal resolution was improved but the analysis method was totally revised to assimilate satellite observations with various temporal and spatial spectrums (Kurihara 2006).

In the old model, sea ice concentration (SIC) was given as boundary condition by a daily climatology interpolated from monthly statistics values. This old boundary condition was replaced with a new high resolution (0.25 degree grid) daily analysis (Cavarieli 1999). The difference between the new analysis and the old climatology is large in spring and in autumn. Figure 3 shows the difference of SIC in the Arctic Ocean between climatology (left) and analysis (right) for 21st Nov 2007. The analyzed sea ice covered more extensively over the Bering Strait and the Beaufort Sea compared to the climatology.

A snow depth and surface albedo over land are diagnosed at each time step in the land surface scheme. Since high resolution domestic observations of snow depth became available in its initial condition, the new model can predict more correctly the change in air temperature affected by snow cover.

4. Aerosol Climatology

The old model has two types of total aerosol optical depth. One is available over land, the other is over sea. Both of them were assumed to be independent of the season. The horizontal distribution of total aerosol optical depth in a new aerosol climatology is based on the actual distribution derived from the satellite data measured by MODIS and TOMS. The new model can represent regional features and seasonal changes in the distribution of aerosol. Figure 4 shows the total aerosol optical depth in May. New climatology can realistically show the dense aerosol over the deserts and the Asian dust (Aeolian dust) distributed in East Asia and the Northwest Pacific. By this upgrade, radiation flux came to be calculated more accurately in the new model.

5. Verification

Figure 5 shows the root mean square error (RMSE) of the operational forecast against the analysis for the 500hPa geopotential height in the northern hemisphere verified in Nov 2007. The new model was at an advantage of about 3-8% to the old model for every forecast time, particularly 1-2 days forecast. Improved skills were also found in other elements (temperature, wind speed, and sea level pressure), on other pressure levels, and in other regions.

Table 1 shows the improvement rate in RMSE of trial periods which lasted 61 days in Aug/Sep 2004, and 62 days in Dec 2005 and Jan 2006. These rates are averaged over the all forecast time (1 to 9 days). The rates are positive in the most parameters.

Reference

Cavarieli, D. J., C. L. Parkinson, P. Groersen, J. C. Comiso, and H. J. Zwally, 1999: Deriving long-term time series of sea ice cover from satellite passive microwave multisensor data sets. J. Geophy. Res., 104, 15, 803-15814.

Kurihara, Y., T. Sakurai and T. Kuragano, 2006: Global daily sea surface temperature analysis using data from satellite microwave radiometer, satellite infrared radiometer and in-situ observations. Weather Bulletin, JMA, 73, S1–S18. (in Japanese)

Nakagawa, M., 2005: Precipitation forecasts by a high resolution global model at JMA. BMRC Research Report No.111, 127-130.

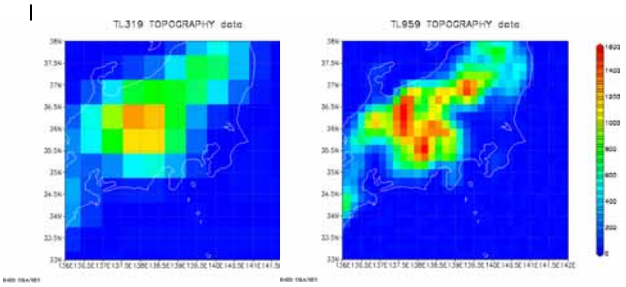

Figure 1: Model topography of the middle Japan (meters). Grid intervals are about 60km (left) and about 20km (right) in the old model and in the new model, respectively.

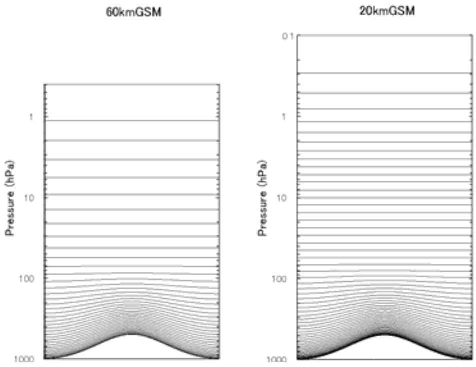

Figure 2: Profiles of vertical layers. The old model (left) and the new model (right) have 40 layers and 60 layers, respectively.

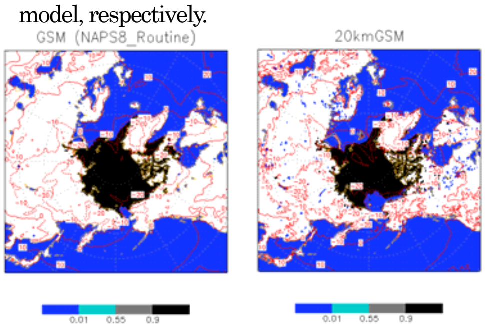

Figure 3: Distribution of sea ice concentration on 21st Nov 2007. The old model used daily climatology interpolated from original monthly values (left). The new model uses 0.25 degree daily analysis (right).

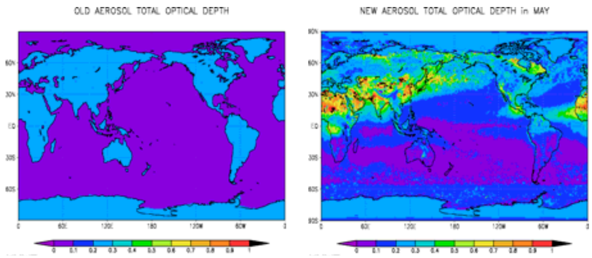

Figure 4: Distribution of total aerosol optical depth climatology in May. The old model assumes distribution which is distinguished only by land and by sea (left). The new model uses climatology derived from satellite data (right).

Table 1: Improvement rate in RMSE by the model upgrade [%]. Trial periods are 2 months in 2004 summer (top) and in 2005/6 winter (bottom). Positive values indicate an improvement of skills.

2004SM	Psea	T850	Z500	Wspd850	Wspd250
Global	+1.54	+0.41	+0.96	+0.29	+0.95
N.Hem.	-0.22	+1.52	-0.53	-0.93	+0.46
Tropics	+1.49	+1.05	-2.39	+1.32	+0.18
S.Hem.	+2.30	-0.43	+1.81	+0.51	+1.46

2006WN	Psea	T850	Z500	Wspd850	Wspd250
Global	+1.37	+1.87	+0.94	+0.10	+1.00
N.Hem.	+2.47	+2.96	+1.63	+0.33	+1.28
Tropics	+3.53	-0.77	+6.37	+1.05	+0.80
S.Hem.	-0.33	+1.06	-0.28	-0.84	+0.67

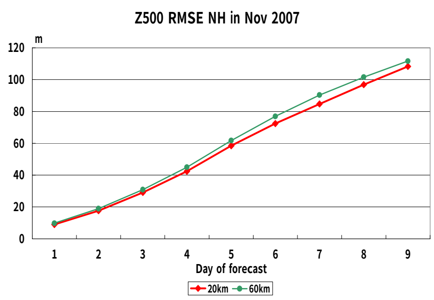

Figure 5: Root mean square error against analysis for the 500hPa geopotential height in the northern hemisphere verified in Nov 2007. Red and green lines show scores of the new model and the old model, respectively.