A new inner model with a higher horizontal resolution (TL319) in JMA's Global 4D-Var data assimilation system

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Since February 2005, a four-dimensional variational (4D-Var) data assimilation system has been employed for atmospheric analysis to provide initial conditions for JMA's Global Spectral Model (GSM) (Kadowaki 2005; JMA 2007). In this system, analysis increments are calculated using an inner model with a horizontal resolution lower than that of the GSM due to the limitations of available computational resources. The resolution of the inner model was originally configured as T63L40, and was enhanced to T106L40 in March 2006 (Narui 2006), then to T159L60 in November 2007. A reduction in the 4D-Var system's calculation time was required in order to allow further enhancement of the inner model's resolution from T159L60, which was still insufficient for the GSM's TL959L60 resolution. In the inner model, a Eulerian advection scheme and standard Gaussian grids were used. A semi-Lagrangian advection scheme and adaptive (reduced) Gaussian grids (Miyamoto 2009), both of which have been used in the GSM since August 2008, were also introduced into the 4D-Var system (Kadowaki 2009). This introduction was able to successfully enhance the inner model's resolution to TL319L60 in October 2011 while requiring less additional computational power. At the same time, the background and observational error statistics used in the 4D-Var system were also recalculated.

Observation errors for the new 4D-Var system were estimated through a statistical study based on the work of Desroziers et al. (2005). The statistical period covered the two months of August and January 2010. Observation errors for conventional and satellite observations were calculated from the covariance of the differences between the observations and first guesses and those between the observations and analyses. The observation errors were also adjusted manually through forecast-analysis cycle experiments. The results are shown in Fig. 1. The estimated observation errors for temperature and brightness temperature are smaller than the previous ones, while those for wind components become larger above the stratosphere.

In order to evaluate the performance of the new system, forecast-analysis cycle experiments were performed for the two months of January and August 2010. Nine-day forecasts were made once a day based on 12 UTC initial conditions throughout the experimental period. Improvements on 500-hPa geopotential height forecasts were found in comparison with the previous system, mainly in the Northern Hemisphere (Fig. 2). Figure 3 shows the track forecast errors for seven typhoons observed from 01 August, 2010, to 09 September, 2010. The values for the new system are almost the same as those for the previous system, although in some cases the new system better represented the atmospheric structure around typhoons, as shown in Fig. 4.

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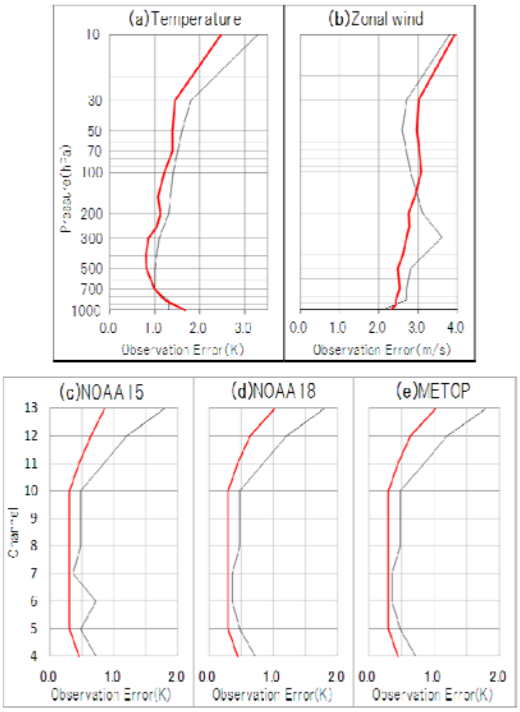

Fig. 1: Observation errors for conventional and satellite brightness temperatures. (a) Temperature, (b) Zonal wind, AMSU-A aboard (c) NOAA15, (d) NOAA18, and (e) METOP. The statistical period covers the two months of August and January 2010. The red and black lines show observation errors for the new and previous systems, respectively.

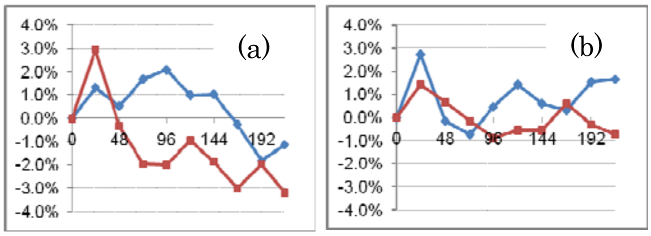

Fig. 2: Improvement rates (%) of the RMSE in 500hPa height for the new system against the previous system. The horizontal axis represents forecast hours. Positive values indicate improved scores. The blue and red lines represent the northern and southern hemispheres, respectively. (a) January 2010, and (b) August 2010.

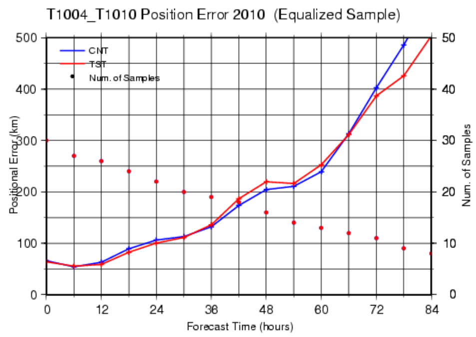

Fig. 3: Track forecast errors for seven typhoons observed from 01 August, 2010, to 09 September, 2010. The red and blue lines represent the new and previous systems, respectively.

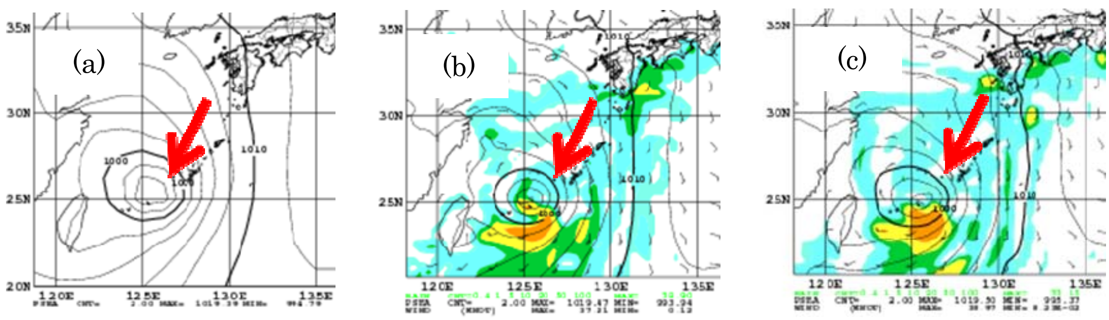

Fig. 4: Horizontal distributions of mean sea level pressure (contours) in hPa and precipitation (shading) in mm/3h. (a) Analysis and 12-hour forecast with (b) the previous system and (c) the new system.