Impact Study of the RTTOV-9 Fast Radiative Transfer Model in the JMA Global 4D-Var Data Assimilation System

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The Japan Meteorological Agency (JMA) operates a global four-dimensional variational data assimilation system for global forecasts. In this operational setup, a fast radiative transfer model (RTTOV) is utilized for satellite radiance data assimilation. Currently, RTTOV-8.7 [1] is employed in the system. However, RTTOV-9 was released by NWP SAF in March 2008 for the NWP community. Accordingly, the impact of introducing RTTOV-9 into the JMA system was investigated. RTTOV-9 includes various scientific and coding updates [2]; one important change in the model for the JMA system is the updating of the vertical interpolation method for atmospheric profiles from a user-defined level to RTTOV pre-defined levels [3]. This enables better mapping of computed temperature and moisture Jacobians on JMA global forecast model layers. Additionally, improper variation of the Zeeman effect with the strength of the earth's magnetic field for the AMSU-A upper-stratosphere channels was removed. A reduction in stratospheric temperature analysis error is expected as a result of this removal.

In order to examine the impact of the radiative transfer model updates, two assimilation experiments were performed using the JMA low-resolution global data assimilation system (TL319L60). Although the horizontal resolution is lower than that of the operational system (TL959L60), the number of the vertical layers (60) is the same in both. The observational data set used in the experiments was exactly the same as the operational one, which includes conventional data (radiosonde observations, SYNOP, BUOY and aircraft data), ocean surface wind data from QuikSCAT, atmospheric motion vectors and clear sky radiances from five geostationary satellites (MTSAT-1R, GOES-11 and 12, and Meteosat-7 and 9), MODIS polar wind data from Aqua and Terra, microwave radiance data (AMSU-A/B, MHS) from polar-orbiting satellites (NOAA-15/16/17/18, Aqua and Metop) and microwave imager radiance data from SSMI, TMI and AMSR-E. The experiments were performed for the two periods of January 2008 and September 2008. Forecasts were produced from each 12 UTC initial field during these periods. The test run used RTTOV-9.3 as the radiative transfer model, while the control run used RTTOV-8.7.

Analysis impacts related to RTTOV-9 were found in stratospheric temperature analysis. As shown in Figure 1, these impacts were large especially at high latitudes and in tropical areas. For the impact on forecasts, significant improvements of stratospheric temperature predictions were found in the winter season (S.H. in September 2008 and N.H. in January 2008), as shown in Figure 2. These improvements were also confirmed against GPS retrieval temperature data from GRACE satellites (Figure 3). Based on these findings, RTTOV-9 will be implemented in the JMA operational system after studying the impacts with high resolution model.

References

[1] Saunders, R. W., 2006: *RTTOV-8 Science and Validation Report.* EUMETSAT, pp. 46
[2] Saunders, R. W., 2008: *RTTOV-9 Science and Validation Report.* EUMETSAT, pp. 74
[3] Rochon, Y. J., L. Garand, D. S. Turner and S. Polavarapu, 2007: Jacobian mapping between vertical coordinate systems in data assimilation, *Q. J. Roy. Meteorol. Soc*. **133** *1547 – 1558*.

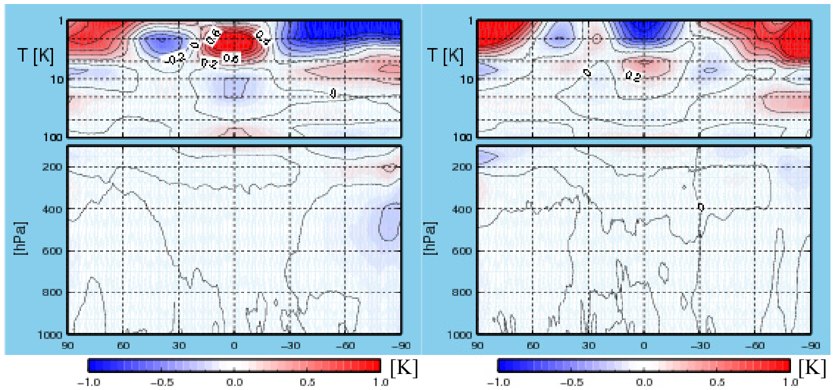

Figure 1. Monthly mean differences in zonal mean temperature between the test and control runs (Test – Control). The figure on the left is for the monthly mean of January 2008, and the one on the right is for that of September 2008.

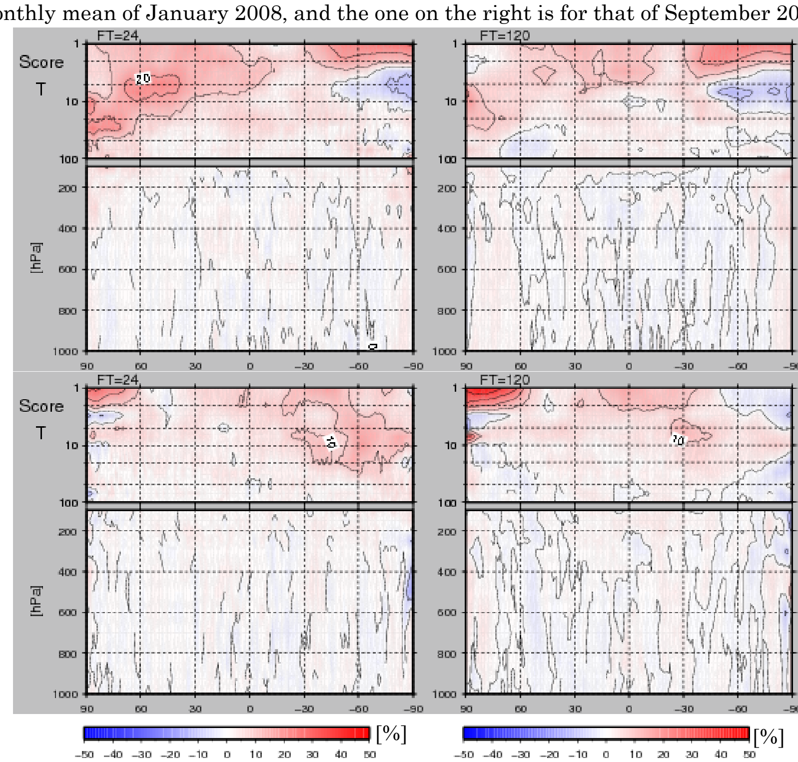

Figure 2. Zonal mean of improvement ratio for temperature forecast against the initial field. The upper two panels are for January 2008, and the lower ones are for September 2008. Those on the left are for 24-hour forecast and those on the right are for 120-hour forecast.

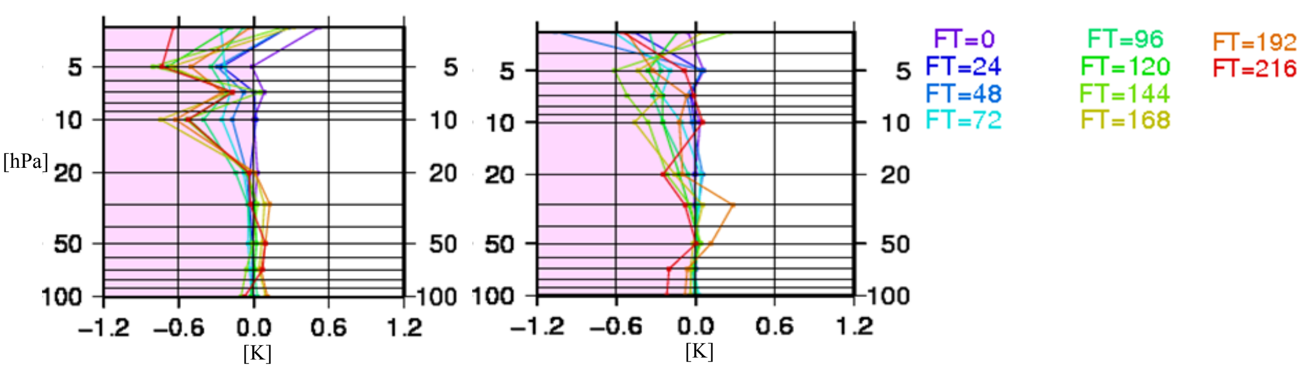

Figure 3. Difference in the standard deviation of temperature forecast profiles against GPS (GRACE) retrieval temperature profiles between the test and control runs (Test – Control). The panel on the left is for the Northern Hemisphere in January 2008, and that of the right is for the Southern Hemisphere in September 2008.