The impacts of an Improved Quality Control and Ocean Emissivity Model for Microwave Radiance Assimilation in the JMA Global 4D-Var Data Assimilation System

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Introduction

JMA has been assimilating clear radiance data from Microwave Imagers (AMSR-E, SSM/I and TMI) in the operational global 4D-Var data assimilation system since 2006. The assimilation of these measurements provides moisture information in data-sparse areas over ocean regions and produces better typhoon forecasts and rainfall distribution [1]. The brightness temperature and its Jacobians are calculated by using a fast radiative transfer model (RTTOV-7) for the radiance data assimilation. In RTTOV-7, FASTEM-2 is used as the microwave ocean emissivity model. For the assimilation of microwave surface- sensitive channels over the ocean, the performance of the microwave ocean emissivity model within the radiative transfer model is a key element of the radiance data assimilation system. Here, the impact of improved quality control and a new microwave ocean emissivity model (FASTEM-3) in RTTOV-8 [3] were studied.

Improved quality control for microwave radiance data

Assimilation of clear radiance data is assumed in the current system. Accordingly, quality control for cloud contamination removal and bias correction of radiance data are crucial elements in the pre-process part of the assimilation. Observed brightness temperature data are categorized (clear, cloudy, rain, etc.), and only clear radiance data are selected for the assimilation. The current JMA bias correction scheme [2] corrects O-B (Observed brightness temperature minus calculated brightness temperature from the background) biases, including instrument biases, radiative transfer model biases and forecast model biases. The bias correction scheme adopts a linear regression using a number of predictors, and the regression coefficients are optimized in the 4D-Var and used in subsequent analysis. Current predictors for microwave imager data in the JMA operational system are surface wind speed, total precipitable water, incident angle, sea surface temperature (SST) and squared SST.

In this study, another quality control was added to remove cloud contamination. Retrieved cloud liquid water (CLW) values were used to estimate cloud contamination. The CLW criterion for the data rejection was set at $100g/m^2$. The remaining biases (thin cloud and/or minimal cloud in the sensor field of view) were adjusted through variational bias correction using CLW as one of the predictors.

Experiments

Experiments for the impact study were performed using the JMA low-resolution global data assimilation system (TL319L60) and a global forecast model. The experimental period was July 20 – September 30, 2007, and the forecasts were produced from each 12 UTC initial for the test run and control run. For verification, 52 forecast cases (from 1 August to 21 September 2007) were used. In both the control run and the test run, the same JMA operational data set was used, including conventional data (surface observations, radiosonde observations and aircraft data), atmospheric motion vectors from 5 geostationary satellites and polar-orbiting satellites (Aqua and Terra), and microwave radiance data (AMSU-A, AMSU-B, MHS, SSM/I, TMI and AMSR-E). The differences between the test run and the control run were the radiative transfer model

(RTTOV-7 for the control run, RTTOV-8 for the test run), which includes a microwave ocean emissivity model change (from FASTEM-2 to FASTEM-3), and quality control and bias correction for microwave imager data.

Results

Impacts were found in the form of 850 hPa temperature forecast improvement in the tropics (Figure 1) and RMSE reductions in 500 hPa geopotential height forecasts (Figure 2). As the use of microwave imager data was limited in oceanic regions, large forecast improvements were found in the Southern Hemisphere. These experimental results indicate that the removal of cloud-contaminated data through improved quality control and the use of CLW as one of the predictors in variational bias correction were essential parts of the microwave clear radiance assimilation. The pre-process modifications and update of the radiative transfer model (including FASTEM-3 in the data assimilation) also produce improved moisture analysis, which leads to better temperature and geopotential height forecasts in the lower troposphere.

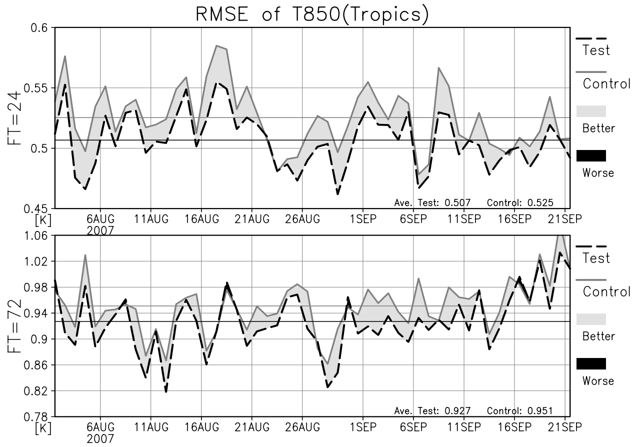

Figure 1. Time sequence of the RMSE for temperature forecasts in the tropics against the initial for one-day (upper panel) and three-day (lower panel) forecasts. The grey lines are for the control run, and the dark dashed lines are for the test run.

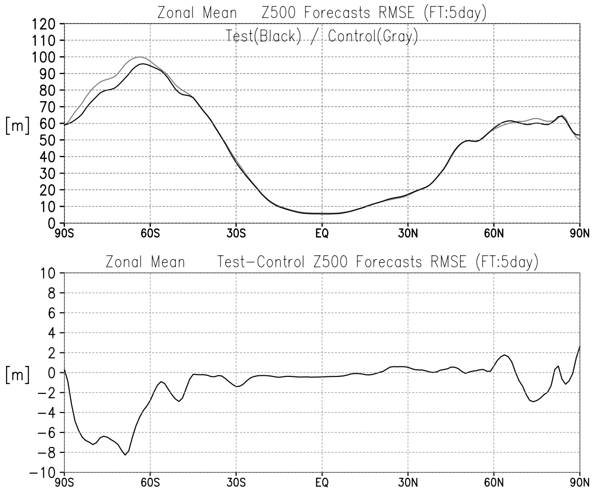

Figure 2. Zonal mean of the RMSE for five-day geopotential height forecasts (upper panel) against the initial. The black line is for the test run, and the gray line is for the control run. The lower panel shows the difference between the test run and the control run.

References

[1] Sato, Y., “Introduction of spaceborne microwave imager radiance data into the JMA global data assimilation system”, *Research Activities in Atmospheric and Oceanic Modelling (WGNE Blue Book)*, Report No. 37, WMO/TD-No. 1397, Section 01, pp. 17 – 18, April 2007.

[2] Sato, Y., “Introduction of variational bias correction technique into the JMA global data assimilation system”, *Research Activities in Atmospheric and Oceanic Modelling (WGNE Blue Book)*, Report No. 37, WMO/TD-No. 1397, Section 01, pp. 19 – 20, April 2007.

[3] Saunders, R. W., 2006: *RTTOV-8 Science and Validation Report.* EUMETSAT, pp. 46