Assimilation experiments involving surface-sensitive microwave radiances in JMA's global data assimilation system

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The Japan Meteorological Agency (JMA) operates a global model for short- to medium-range weather forecasting, and a four-dimensional variational method is employed to produce the initial conditions for such forecasts. Since 2003, satellite-observed radiance data have been assimilated using a fast radiative transfer model (RTTOV) [1] in the global data assimilation system. Although data from observations over oceans are intensively used, current use over land is limited to channels that are not sensitive to surface conditions. Recent studies ([2], [3]) have suggested the possibility of using information from surface-sensitive microwave radiances if improved land surface emissivity and land surface temperature estimates are used together in radiative transfer calculation. The goal of this research was to improve global forecast skill using lower tropospheric microwave channels over land in data assimilation.

In JMA's current radiative transfer calculation for the satellite data assimilation, land surface emissivity is set to a fixed value and the atmospheric temperature at the lowest model level from the short-range global forecast is used as a substitute for land surface temperature. In order to assimilate surface-sensitive microwave radiances from various microwave radiometers, climatological land surface emissivity values supplied with RTTOV-10 codes were employed in assimilation experiments, and hourly land surface temperature data from JMA's global land surface model were also used. Although observation errors of AMSU-A channel 6 over land were inflated in the current system due to inappropriate land surface emissivity usage, the utilization of climatological land surface emissivity values makes it possible to reduce the inflation factor. The hourly land surface temperature was used as a predictor in the variational bias correction of radiance data. With these improvements, the lower tropospheric channels of MHS (channel 3, 4 and 5) over land were newly incorporated into the assimilation experiments. A one-month experiment for August 2010 was run using the low-resolution version (TL319L60) of JMA's global data assimilation system in its July 2011 operational version. The control experiment was performed with the same configuration as the operational one. In the test experiment, the modifications were applied for the control run.

Impacts of MHS assimilation over land were seen in desert areas with an increase in total column water vapor (TCWV) (Figure 1(a)). The increased values were consistent with data from ground-based GPS integrated water vapor observation (Figure 1 (b) and (c)) and TCWV values retrieved from MERIS [4] on ENVISAT (Figure 2) in the desert area. A reduction of O – B departure during the assimilation experiment period was also found for AMSU-A channel 6, and improvement of short-range forecast errors for the temperature at 850 hPa was seen globally (not shown here).

Assimilation of MHS radiance data over land with the emissivity atlas and hourly surface temperature brought a forecast improvement in JMA's global data assimilation system. Plans are now being made to extend the use of climatological surface emissivity values for other microwave radiance data (such as SSMIS, AMSR-E and AMSR2 on GCOM-W1). Further, in order to obtain more realistic information from measurements, dynamical estimation of land surface emissivity value and/or land surface temperatures in the data assimilation system are planned.

References

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[3] Karbou, F., E. Gerard and F. Rabier, 2010: Global 4DVAR assimilation and forecast experiments using AMSU observations over land. Part I: Impacts of various land surface emissivity parameterizations. *Wea. Forecasting*, **25**, 5 – 19.

[4] ESA, 2006: MERIS Product Handbook. European Space Agency Issue **2.1**, 24th October 2006.

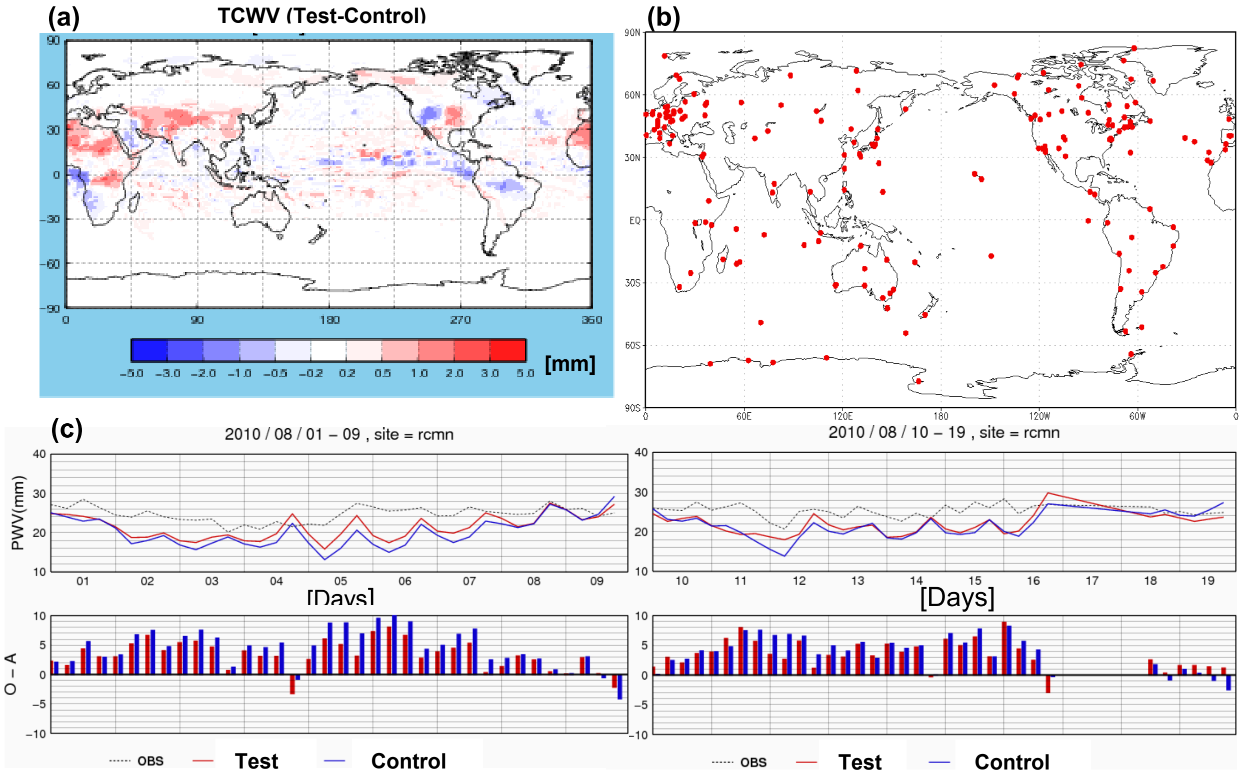

Figure 1 (a) Map showing monthly mean differences between TCWV analysis from the test and control experiments for August 2010. (b) Map showing available global GPS observation locations for August 2010. The GPS location selected for verification is indicated with a black arrow. (c) Six-hourly TCWV based on GPS (black dotted line) and TCWV analysis from the test run (red line) and the control run (blue line). The vertical bars in the lower panels indicate the difference between GPS TCWV and TCWV analysis values.

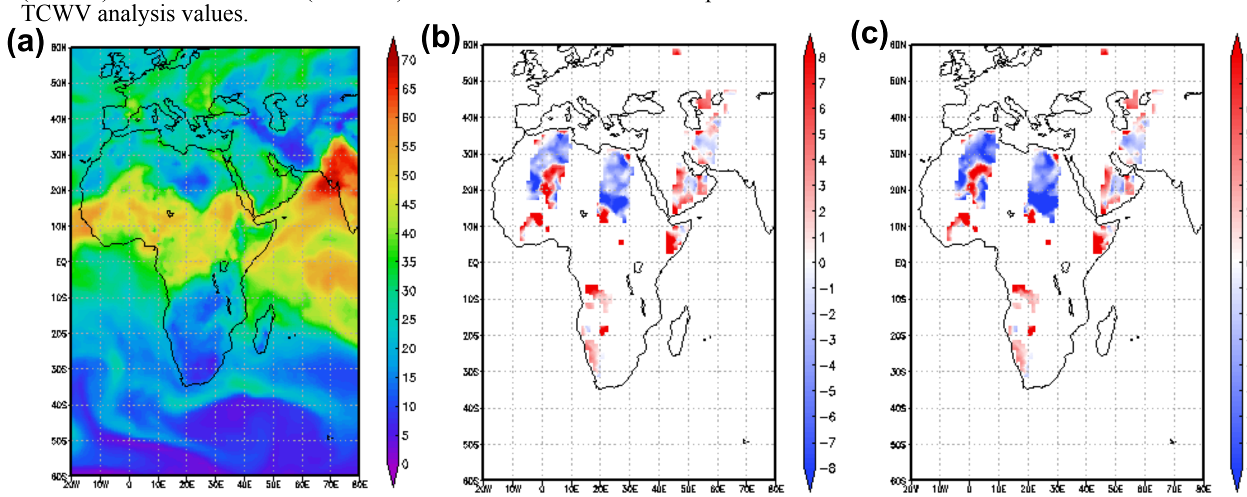

Figure 2 (a) The TCWV field analyzed in the test experiment at 12 UTC on August 1, 2010. (b) Differences of TCWV as analyzed in the test experiment and those from the MERIS TCWV product. (c) As per (b), but for the control experiment. The units are mm.