Operational Use of Satellite Radiance in JMA Mesoscale Analysis

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In order to assimilate observed satellite radiance in JMA's operational Numerical Weather Prediction (NWP), a fast radiative transfer model, RTTOV [1], was integrated into the JMA operational mesoscale 4D-Var system [2] as a satellite radiance observation operator. Clear sky radiance data are assimilated in the initial implementation. The radiance assimilation scheme was tested with operationally available satellite radiance observations such as AMSR-E, TMI, SSMIS, AMSU-A/B, MHS and MTSAT data. In this test, temperature retrievals from ATOVS and Total Column Water Vapor (TCWV) retrievals from microwave imagers were removed. Similar quality control of radiance data in JMA's global analysis [3] was applied for this system. In radiative transfer calculation, atmospheric profiles were extrapolated using the lapse rate of the U.S. standard atmosphere from the mesoscale model's top height (22km). The horizontal data thinning distance was also set as 45km to fit the high-resolution mesoscale model (the model's horizontal resolution is 5km for the outer model and 15km for the inner model). Bias correction coefficients determined in the variational bias correction scheme of JMA's global analysis are used in this system.

The radiance assimilation brought considerable improvements, especially in tropospheric analysis of temperature/humidity and short-range forecasts. These improvements were confirmed through verification using radiosonde and surface observation in Japan [4]. Assimilations of radiance from various microwave imagers and humidity sounders produced TCWV analysis increments similar to those of the retrieved TCWV assimilation. As radiance assimilation enables the use of satellite data without the need for a retrieval process, DMSP F-16 and F-17 SSMIS radiances were newly incorporated into the system. These data brought a significant moisture analysis improvement and strengthened the TCWV contrast between moist and dry areas in typhoon events (Figure 1).

In addition to improvements in the analysis field, enhancements in track forecasting for low-pressure systems and intensity forecasting were also confirmed. Simulated MTSAT infrared images from analysis and forecasting in radiance assimilation showed features similar to those of real MTSAT infrared images. Forecasting for typhoon intensity and maximum wind speeds was also improved (not shown). Enhanced forecasting of heavy rainfall was confirmed in verification with rainfall analysis from ground-based radar and rain gauges in Japan (Figure 2).

Based on these findings, the radiance assimilation scheme was implemented in JMA's operational mesoscale NWP system on December 13, 2010.

References

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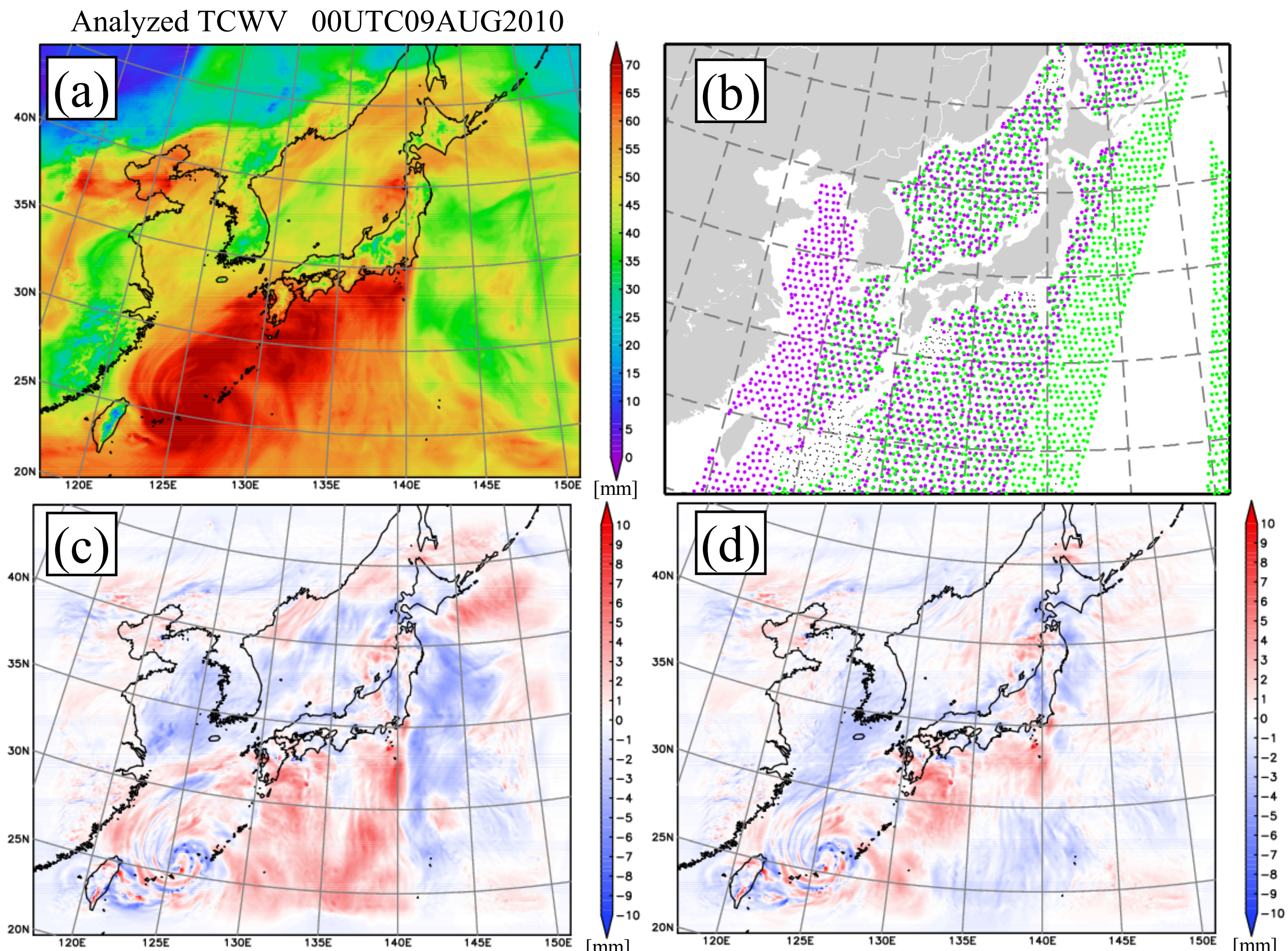

Figure 1 (a) Analyzed TCWV fields in radiance assimilation for a typhoon event on 9 August 2010, (b) Data coverage of newly added SSMIS radiance data – F-16 (green), F-17 (purple); (c) analysis increment for TCWV in radiance assimilation; (d) analysis increment for TCWV in retrieval assimilation

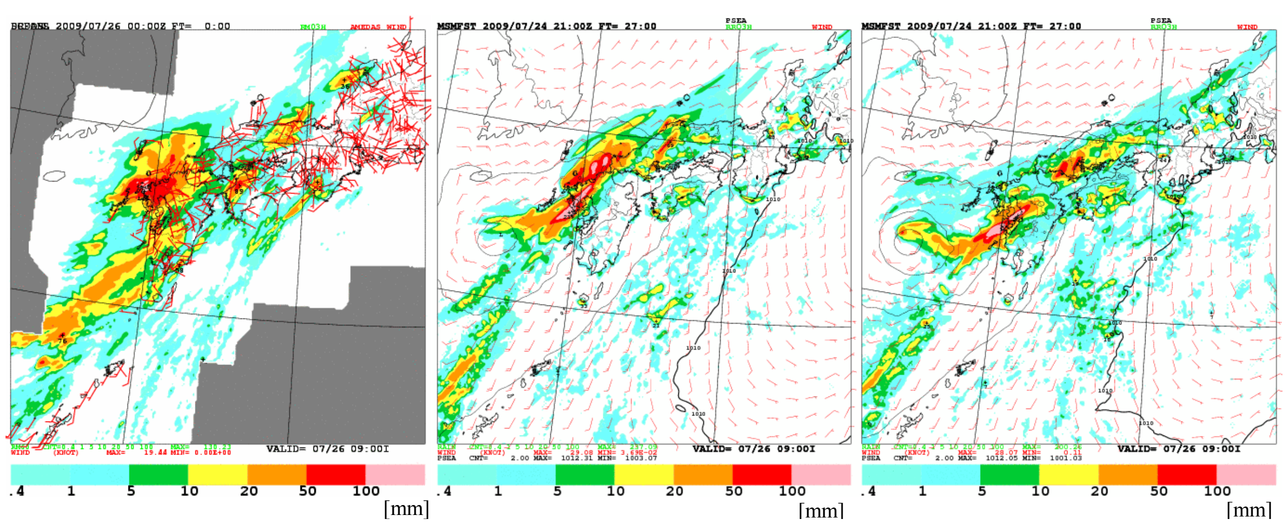

Figure 2 Three-hourly accumulated precipitation of 27-hour forecasts from 24 July 2009 with an initial time of 21 UTC. From the left, analyzed precipitation, forecasting of radiance assimilation and that of retrieval assimilation are shown.