Assimilation of Himawari-8 clear sky radiance data in JMA's NWP systems

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Introduction

Clear sky radiance (CSR) data from JMA's new-generation Himawari-8 geostationary meteorological satellite, which was launched on 7 October 2014, have been disseminated operationally to the NWP community since 7 July 2015. These data contain observational information on upper tropospheric water vapor in clear sky conditions, and are provided in temporally and spatially dense form for assimilation in operational NWP systems. Data from three water vapor absorption bands (6.2, 6.9 and 7.3 micrometers, referred to as bands 8, 9 and 10, respectively) are provided. The current horizontal resolution of Himawari-8 CSR data for assimilation is 32 km, and full-disk data are provided every hour.

Data assimilation systems and CSR data processing

JMA operates global DA (data assimilation) and mesoscale DA systems in which CSR data are used. CSR data from the previous MTSAT-2 satellite are assimilated in both. To evaluate Himawari-8 CSR data before their operational use, related first-guess (FG) departure statistics (observed radiance minus calculated radiance) were examined. Improved cloud detection in CSR data production at JMA's Meteorological Satellite Center increases the number of available CSR data, especially over land. Further cloud detection in the preprocessor of the DA systems is based on the clear-pixel ratio of Himawari-8 band 13 (10.4 micrometers). Overall, Himawari-8 CSR data quality is superior to that of MTSAT-2.

Assimilation experiments

Himawari-8 CSR data assimilation experiments were conducted using the global and mesoscale DA systems. In the former, Himawari-8 band 8, 9 and 10 CSR data were assimilated. However, only oceanic data from bands 9 and 10 were assimilated to avoid land surface signal contamination under dry atmospheric conditions. In the mesoscale DA system, band 8 CSR data were assimilated. The data thinning distance was set as 220 km for the global system and 45 km for the mesoscale system. Hourly CSR data were assimilated in both systems.

The assimilation of CSR data in JMA's global DA system reduced dry biases in analyzed water vapor fields in the troposphere and brought better FG fitting to other water vapor-sensitive observations (Figure 1). Assimilation in the mesoscale DA system enhanced water vapor contrast in the troposphere (Figure 2) and contributed to improved presentation of forecast precipitation distribution (Figure 3).

Summary

Himawari-8 CSR data provide much more information on atmospheric water vapor in the troposphere than the previous MTSAT-2 satellite for JMA's DA systems. The data are spatially dense, and observations from multiple water vapor bands are available with an improved cloud screening method. These enhancements contribute to improved water vapor analysis in the DA systems. The area of improvement corresponds to that covered by Himawari-8 observation range. Improvement of water vapor analysis is crucial for the accurate prediction of severe weather phenomena such as the development of tropical cyclones and heavy precipitation caused by stationary fronts in East Asia.

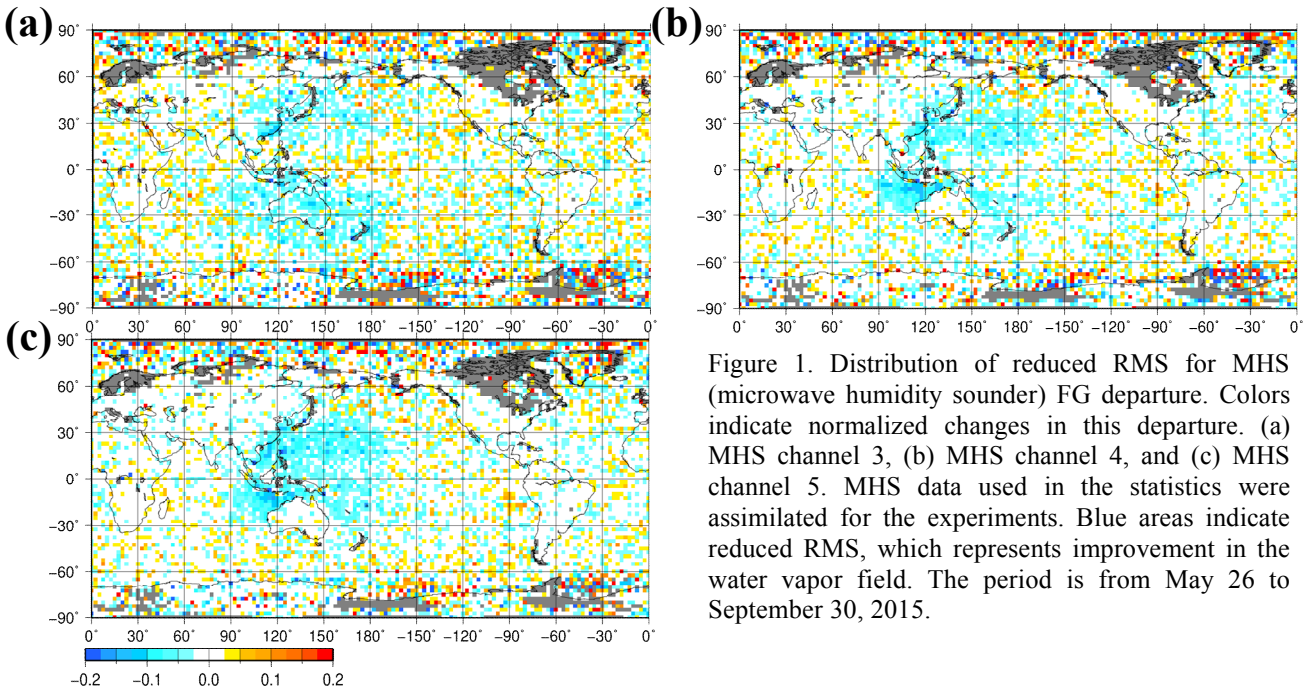

Figure 1. Distribution of reduced RMS for MHS (microwave humidity sounder) FG departure. Colors indicate normalized changes in this departure. (a) MHS channel 3, (b) MHS channel 4, and (c) MHS channel 5. MHS data used in the statistics were assimilated for the experiments. Blue areas indicate reduced RMS, which represents improvement in the water vapor field. The period is from May 26 to September 30, 2015.

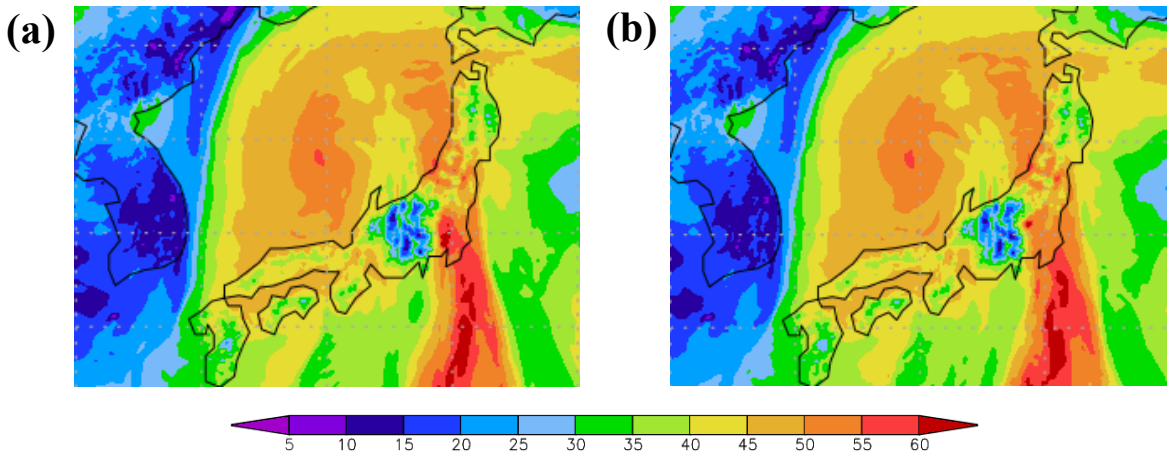

Figure 2. Comparison of analyzed total column water vapor between (a) Himawari-8 CSR usage and (b) MTSAT-2 CSR usage. The analysis time is 12 UTC on September 9, 2015, and the unit is mm.

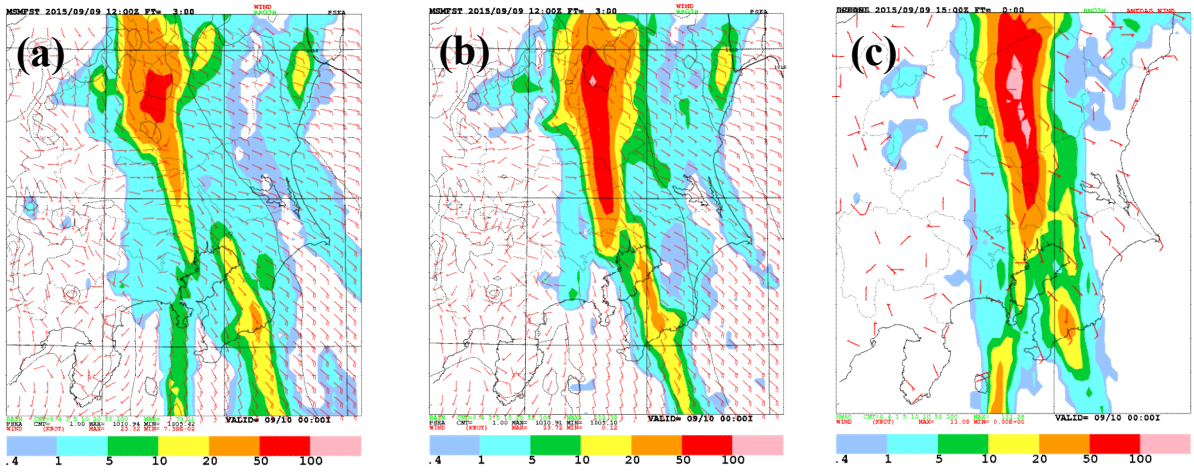

Figure 3. Comparison of three-hour cumulative rainfall forecasts for 15 UTC on September 9, 2015. The forecast period is three hours. Panel (a) shows the results without Himawari-8 CSR, panel (b) shows those with Himawari-8 CSR, and panel (c) shows rainfall distribution estimated from radar observations and rain gauges. The unit is mm/3 hrs.