Assimilation of GPM microwave imager data in JMA's NWP systems

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Introduction

Accurate forecasts of severe precipitation are essential for mitigating the effects of natural disasters. In this context, space-based microwave imager observations of atmospheric water vapor, cloud and precipitation provide crucial information for real-time environmental monitoring and weather forecasting. The Japan Meteorological Agency (JMA) operates two numerical weather prediction (NWP) models (one global and one regional (mesoscale)) for such forecasting. Both are initialized using four dimensional variational data assimilation systems in which microwave imager observations play important roles in producing accurate initial fields of moisture. In 2015, clear-sky microwave imager radiances from GCOM-W/AMSR2, DMSP-F16, F17 and F18/SSMIS were assimilated into the global and mesoscale NWP systems, and precipitation data retrieved from these radiances were assimilated into the mesoscale NWP system. A new GPM microwave imager (GMI) was launched by NASA and JAXA in February 2014, and related real-time data have been available since March 2014. GMI is the successor to the previous TRMM microwave imager, and continuity of data usage in operational NWP systems must be ensured. Assimilation of data from the new microwave imager is expected to contribute to accurate humidity analysis and precipitation forecasting. The two new GMI water vapor sounding channels at 183+3 and 183+7 GHz are expected to bring further improvement to water vapor analysis in the middle and upper troposphere.

Methodology

Clear-sky radiance data from GMI's 19, 23, 37 and 89 GHz vertical polarized channels and the new 183+3, 183+7 GHz channels are assimilated in the global and mesoscale NWP system. Former low-frequency channels are assimilated as with other microwave imagers [1]. Removal of cloud-affected radiance for 183 GHz channels is based on the GMI window channel's (166 GHz) first-guess departure (observed radiance minus simulated radiance). GMI retrieved precipitation data for assimilation into the mesoscale NWP system are retrieved from the set low-frequency channels using a statistical method [2]. The data coverage of the GMI radiance data and retrieved precipitation data used in JMA's NWP systems is shown in Figure 1.

Assimilation experiments

Assimilation experiments involving GMI radiance data with the global NWP system were conducted for the periods of January 2014 and July 2015, and corresponding experiments were performed with the mesoscale NWP system. The results indicated similar impacts in analysis of water vapor fields between the two systems, which both exhibited better agreement with existing observations. As shown in Figure 2, normalized changes in the standard deviation of the first-guess departure indicate consistent improvement in the water vapor field. Better lower-tropospheric temperature fields were also confirmed from AMSU-A channels 4 and 5. Improvements in MHS channels 3, 4, and 5 were brought by the new 183 GHz GMI channels, as evidenced by the fact that the observation frequency is common to the 183 GHz water vapor absorption band. In the experiments with the mesoscale NWP system, precipitation forecast improvement was confirmed (e.g., Figure 3). Improved water vapor field in the initial condition is considered to have brought realistic precipitation forecasts in the mesoscale NWP system.

Summary

Assimilation of GMI radiance data under clear-sky conditions and retrieved precipitation assimilation showed consistent improvement in water vapor analysis and helped to ameliorate precipitation forecasts in JMA's NWP systems. The addition of the 183 GHz GMI observation channels brought clear benefits in mid- and upper-tropospheric water vapor analysis. Based on these findings, GMI radiance data are scheduled for assimilation into JMA's operational NWP system in March 2016.

References

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[2] Takeuchi, Y. and T. Kurino 1997: Document of algorithm to derive rain rate and precipitation with SSM/I and AMSR: Algorithm description of PIs for SSM/I and ADEOS-II/AMSR. Second AMSR Workshop 61.1-61.9, NASDA, Tokyo, Japan

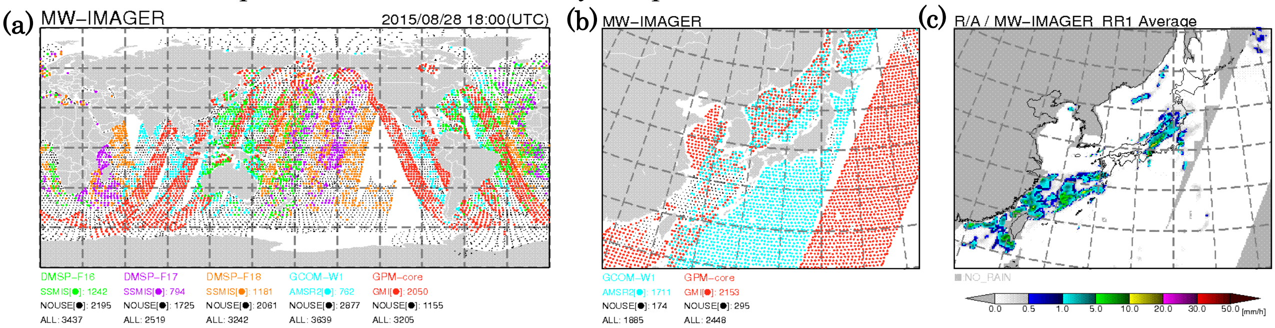

Figure 1. Microwave imager data used in JMA's NWP systems at 18 UTC on August 28 2015. Red dots denote GMI radiance data. (a) Data coverage in the global NWP system. (b) Data coverage in the mesoscale NWP system. (c) Data coverage of precipitation retrieved from microwave imager and ground-based radar in the mesoscale NWP system.

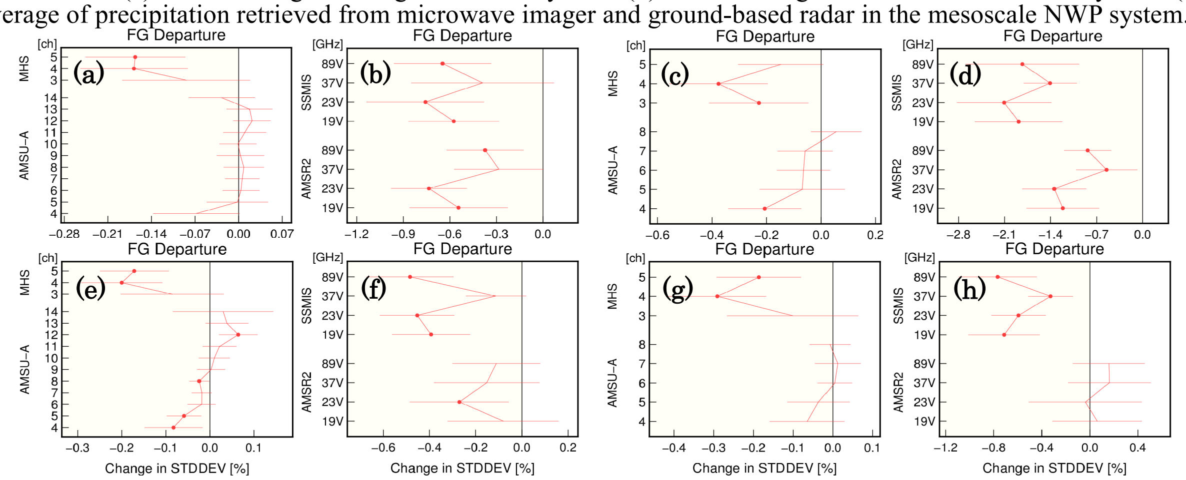

Figure 2. Normalized changes in the standard deviation of first-guess departures from (a) microwave sounding data (b) microwave imager data with assimilation of GMI radiance data in the global NWP system for boreal summer. (c) and (d): as per (a) and (b), but for the mesoscale NWP system. (e), (f), (g) and (h): as per (a) and (b), but for boreal winter. Negative values indicate first-guess field improvement.

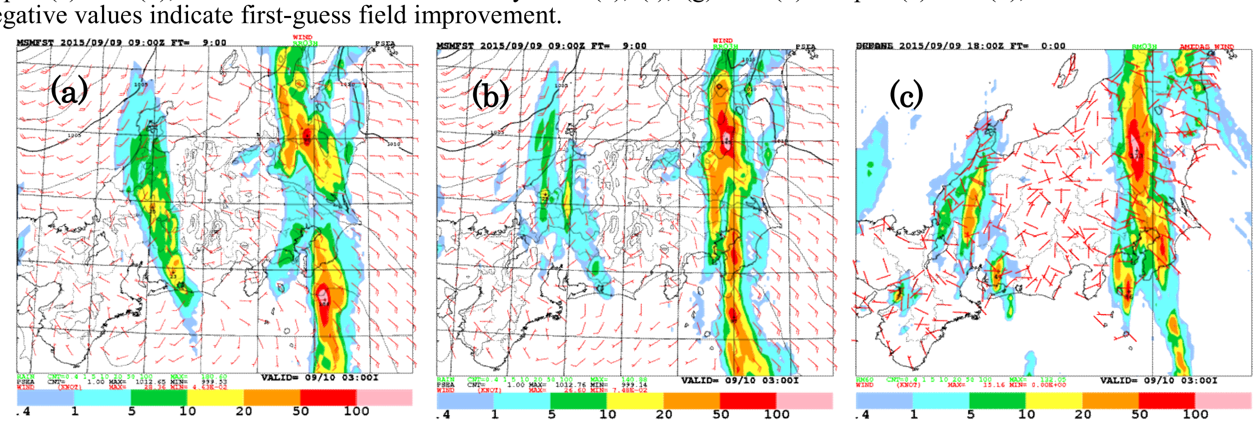

Figure 3. Comparison of three-hour cumulative rainfall forecasts for 00 UTC on September 9 2015. The forecast period is nine hours. (a): CNTL run (without GMI); (b) TEST run (with GMI); (c) rainfall distribution estimated from radar observation and rain gauge data (unit: mm/3 hr).