Assimilation of SSMIS humidity sounding channels into JMA's global NWP system

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1. Introduction

Satellite microwave radiance observation provides information on atmospheric temperature and moisture for numerical weather prediction (NWP) models. In this context, the Japan Meteorological Agency (JMA) utilizes clear-sky radiance data from the MHS[1] onboard NOAA[2]-18, NOAA-19, MetOp[3]-A and MetOp-B satellite, SAPHIR[4] onboard Megha-Tropiques satellite, and GMI[5] onboard GPM[6]-core satellite in its global data assimilation system. In addition, JMA began utilizing humidity sounding channels from Special Sensor Microwave Imager/Sounder (SSMIS) onboard DMSP[7] F-17 and F-18 satellite in March 2017. Assimilated SSMIS humidity sounding channels (i.e., those located around the 183-GHz water vapor absorption line) are calibrated with the Unified Preprocessor Package (UPP) (Bell et al. 2008). Assimilating SSMIS UPP humidity sounding channels into the system helps to fill gaps among other humidity sounding data coverage areas. This report describes the SSMIS humidity sounding channel assimilation procedure and the resulting impacts on analysis and forecasts.

2. Methodology

It is crucial to detect and discriminate data affected by cloud and precipitation in clear-sky assimilation because the effects of cloud liquid water emission and freezing-particle scattering are not considered in radiative transfer calculation for data assimilation. Oceanic SSMIS UPP data are used because ocean surface emissivity estimation is relatively accurate, whereas estimation of land and sea ice surface emissivity is challenging due to inhomogeneity and seasonal dependence. The use of oceanic data allows analysis to determine the effects of liquid and frozen hydrometeor particles without consideration of complex surface contributions. Expertise gained from research and development on a cloud screening method for assimilation with 24 SSMIS observation channels is expected to support the future development of all-sky microwave radiance assimilation.

A new algorithm detects cloud-affected SSMIS data by classifying such information into three categories based on hydrometeor types (i.e., cloud liquid particles, snow crystals and ice crystals). The determination of each cloud type is based on retrieved cloud liquid water (CLW), the polarization-corrected brightness temperature (Spencer et al., 1986), which involves the use of low-frequency channels, and the scattering index (Ferraro et al., 2000), which involves the use of high-frequency channels. The approach of Weng et al. (1997) is applied for CLW retrieval.

In JMA's global data assimilation system, the variational bias correction (VarBC) scheme (Sato 2007, Ishibshi 2009) is applied for radiance bias correction. Microwave humidity sounding data are also thinned with a distance value of 180 km.

3. Impacts on the NWP system

The impacts of SSMIS UPP data assimilation in JMA's global NWP system were assessed in two observing system experiments (OSEs) covering the one-month periods of August 2015 and January 2016. The results showed improved model first-guess (FG) fits to existing MHS and SAPHIR observations, which are sensitive to atmospheric moisture, indicating consistent improvement in the quality of the model FG water vapor field (Figure 1). The impact of SSMIS UPP data on forecast skill was neutral in the January 2016 experiment (figure not shown). In the August 2015 experiment, positive impact on skill in forecasting the geopotential height field over the Southern Hemisphere was observed (Figure 2).

4. Summary

A cloud detection algorithm for the clear-sky assimilation of SSMIS humidity sounding channels was developed and implemented in JMA's global NWP system. The algorithm was effective for the screening of cloud-affected data. OSE results showed that the use of SSMIS UPP data improved the FG water vapor field and geopotential height forecast skill for the Southern Hemisphere in the January 2016 experiment. Based on these findings, assimilation of SSMIS humidity sounding data into JMA's global NWP system was begun in March 2017.

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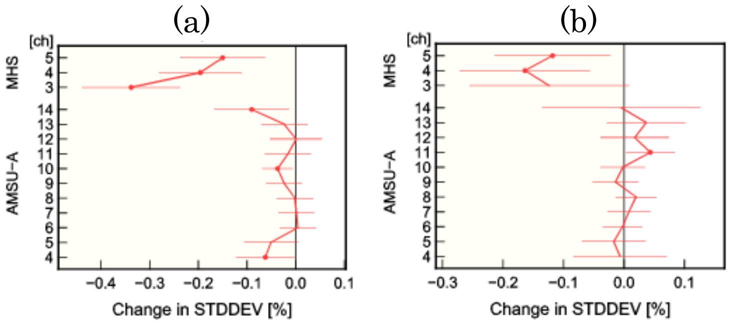

Figure 1. Normalized changes in the standard deviation of FG departures to MHS and AMSU-A for (a) the experiment of August 2015 and (b) that of January 2016. Negative values indicate FG field improvements.

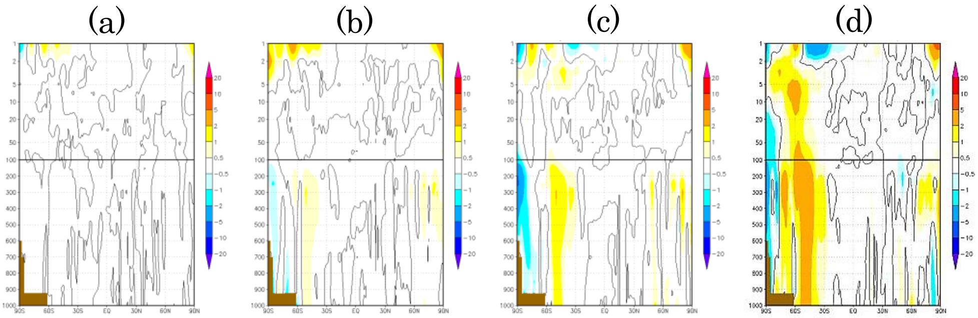

Figure 2. Latitude-Altitude cross section of changes in RMSE of geopotential height fields for (a) 24-hour forecast, (b) 48-hour forecast, (c) 72-hour forecast, (d) 96-hour forecast. Warm colors indicate improvement in the forecast skill.

[1] MHS: Microwave Humidity Sounder
[2] NOAA: National Oceanic and Atmospheric Administration
[3] MetOp: Meteorological Operations
[4] SAPHIR: Sounder for Probing Vertical Profiles of Humidity
[5] GMI: GPM Microwave Imager
[6] GPM: Global Precipitation Measurement
[7] DMSP: Defense Meteorological Satellite Program