Assimilation of Megha-Tropiques/SAPHIR radiance data in JMA's global NWP system

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Introduction

Space-based microwave radiance observation data are an essential part of accurate water vapor analysis for numerical weather prediction (NWP). Such data provide information on atmospheric water vapor in clear sky conditions, and their assimilation can be expected to improve initial fields for NWP. In this context, a joint mission of the Indian Space Research Organization (ISRO) and the Centre National d'Etudes Spatiales (CNES) launched the Megha-Tropiques satellite into a low-inclination orbit to observe tropical regions. The satellite carries a microwave humidity sounder (SAPHIR) with six 183 GHz water vapor absorption channels. Since the limitation of the satellite's orbit in tropical regions allows for frequent observation of these areas, the resulting data reflect rapidly changing water vapor profiles associated with tropical meteorological phenomena. As a result, assimilation of these data is expected to improve water vapor analysis and tropical cyclone prediction. The data have been available in real time to the NWP community since 2014, and related assimilation experiments have been conducted in JMA's global NWP system.

Methodology

Satellite radiance assimilation in JMA's global NWP system currently uses clear-sky radiance data. Accordingly, a cloud screening method for SAPHIR radiance data needed to be developed to enable the selection of clear-sky data for assimilation. As no window channel is available for SAPHIR, the relationship between the observed and simulated radiances of the channels adjacent to the one for assimilation were examined, and the empirical cloud detection thresholds of the difference between estimated clear-sky radiance and observed radiance were determined. This empirical cloud detection method is effective in screening out cloud-affected SAPHIR radiances in preprocess of the assimilation. SAPHIR land data are also removed to avoid surface signal contamination under dry atmospheric conditions. RTTOV version 10 was used as the radiative transfer model for assimilation.

Assimilation Experiments

Assimilation experiments for clear-sky SAPHIR radiance data were conducted with JMA's global NWP system for July, August, September and December of 2014, and for January and February of 2015. Assimilation brought significant improvements in analyzed water vapor fields and first-guess (FG) departure fits to other humidity and temperature observations. These changes (i.e., reduction of the FG departure's standard deviation) were statistically significant, and all results indicated consistent improvement of water vapor fields in analysis and FG (Figure 1). The improvements were dominant for the tropics. Assimilation of SAPHIR radiance data also significantly improved tropical cyclone track prediction in the JMA system for the experiment period (Figure 2).

Summary

Assimilation of SAPHIR radiance data in JMA's global NWP system improved water vapor analysis and FG fields. From FG fits to radiosonde observations and other humidity-sensitive satellite radiance data in the tropics, both water vapor profiles and column water vapor amounts were considered to be improved in analysis and FG. Small improvements of AMSU-A channel 4 to 6 indicate the amelioration of lower-tropospheric temperatures in the tropics. These improvements represent a promising contribution to better tropical cyclone analysis and prediction. Based on these findings, assimilation of SAPHIR radiance data into JMA's global NWP system was begun in June 2015.

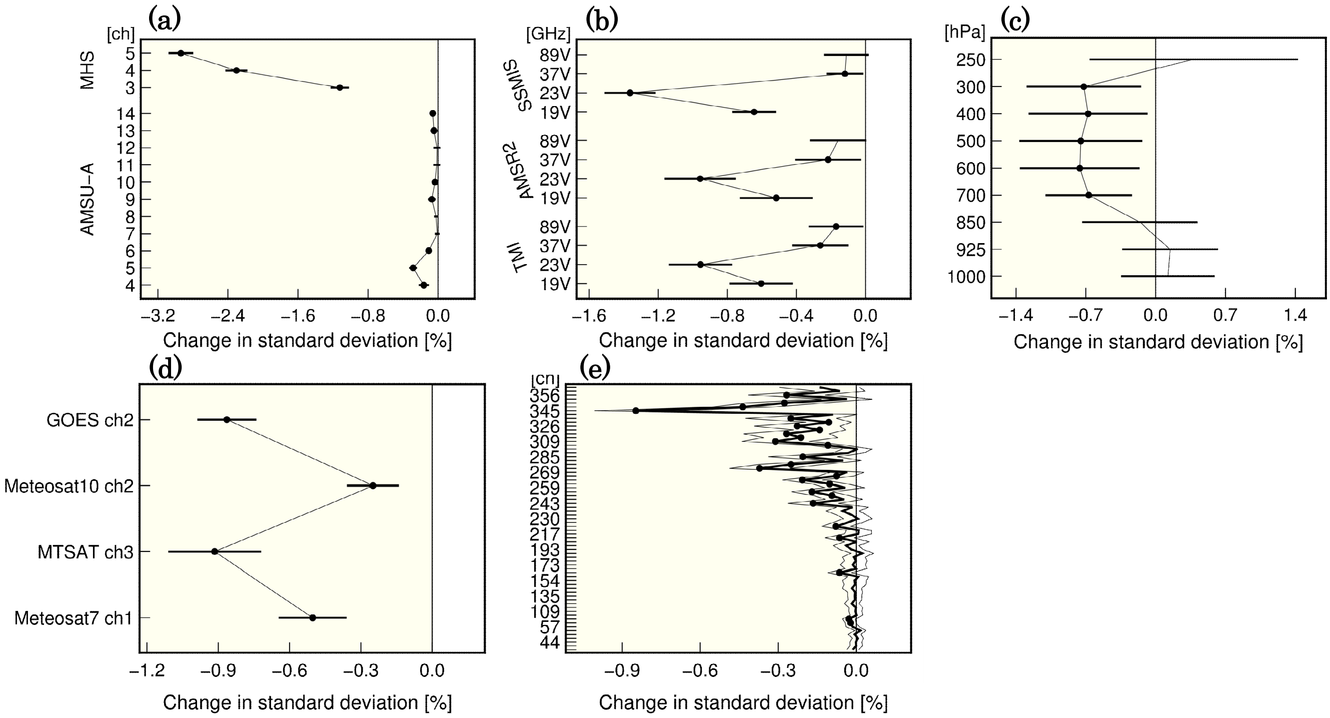

Figure 1. Normalized difference of standard deviation [%] in FG departure for (a) AMSU-A and MHS, (b) microwave imagers, (c) radiosonde relative humidity observation, (c) clear sky radiance (CSR) from geostationary satellites, and (e) IASI channels in the tropics. Negative values correspond to reduced standard deviation with SAPHIR radiance assimilation. Black dots indicate statistical significance, and error bars show a 95% confidence interval.

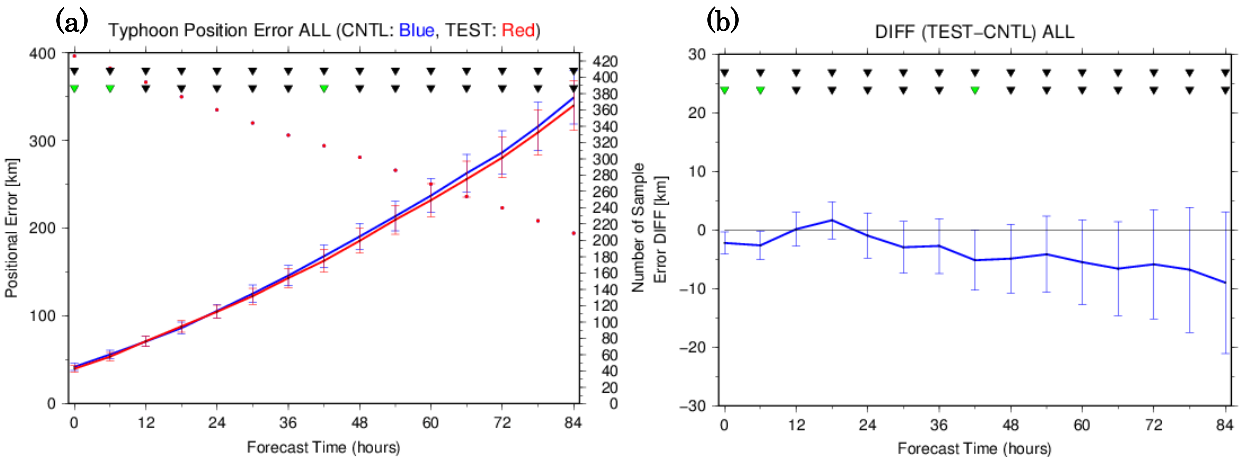

Figure 2. (a) Average typhoon track forecast errors for July, August, September and December 2014, and for January and February 2015. The red and blue lines represent the positional errors of TEST (with SAPHIR) and CNTL (without SAPHIR), respectively. Red dots indicate the number of cases included in the statistics. The error bars represent a 95% confidence interval. Best track data as truth are taken from RSMC Tokyo – Typhoon center analysis. The horizontal axis indicates the forecast time. (b) Typhoon position error difference between TEST and CNTL. The green triangles at the top in both panels indicate statistical significance in the difference. Negative values indicate error reduction.