Operational use of hyper spectral infrared sounder radiance data in JMA's meso-scale NWP system

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1. Introduction

Operational assimilation of hyper spectral infrared sounder (HSS) radiance data from the Cross-track Infrared Sounder (CrIS) and Infrared Atmospheric Sounding Interferometer (IASI) in JMA's meso-scale Numerical Weather Prediction (NWP) system began on 28 March 2023. This report briefly outlines related channel selection and effects of HSS radiance data assimilation in the meso-scale NWP system.

2. Channel selection and quality control

Observation error settings and quality control processes such as cloud detection for HSS radiance data assimilation were implemented in the same manner as those for the global NWP system (Okagaki 2015, Kamekawa and Kazumori 2017). Not all the channels used in the global system are used in the meso-scale system because the meso-scale model top is lower than that of the global system. The height of meso-scale model top is approximately 5 hPa, and the atmospheric profiles above it are extrapolated for radiative transfer calculation using U.S. Standard Atmosphere lapse rates. However, the extrapolated profile is not sufficiently accurate, especially for higher-peaking channels. Differences in calculated brightness temperatures between the global and meso-scale systems were examined to determine the accuracy of radiative transfer calculation in the meso-scale system. Figure 1, which shows histograms of first guess (FG) departures in each system and the weighting functions of corresponding channels, indicates that biases of FG departure were farther from zero for higher-peaking channels, and that standard deviations were larger than those in the global system. For lower-peaking channels, the standard deviations and biases of FG departure are close to those in the global system. Such channels were considered to be less sensitive to layers above the model top of the meso-scale system and were selected for assimilation.

Preliminary experiments were conducted to evaluate the effects of the selected channels. The control experiment (CNTL) had the same configuration as JMA's operational meso-scale NWP system as of March 2022. In the TEST (a) experiment, CrIS assimilated channels were selected subjectively with reference to weighting function (green and red lines in Fig. 2 (c)), and TEST (b) was similar but with assimilated channels (red lines in Fig. 2 (c)) selected based on the FG departure statistics described above. Figures 2 (a) and (b) show that the standard deviation of FG departures against CNTL were larger for clear-sky radiance (CSR) data and microwave sounder data, indicating lower FG accuracy. FGs for TEST (b) were closer to observation values than those of CNTL. These results highlight the importance of removing channels that are even slightly sensitive to atmosphere above the model top.

3. Effects of humidity channel assimilation

In addition to usage of the temperature channels described in Section 2, we selected humidity channels via sensitivity analysis based on a Jacobian matrix, and extracted 9 channels considering inter-channel error correlations. These channels were confirmed to be less sensitive to extrapolated profiles above the model top. The effects of their assimilation were evaluated in data assimilation experiments with JMA's meso-scale NWP system. The experimental periods were 26 June 2020 to 31 July 2020 and 18 Dec. 2019 to 31 Jan. 2020. The CNTL experiment had the same configuration as JMA's operational meso-scale NWP system as of March 2022. In TEST (i), CrIS and IASI temperature channels were additionally assimilated to CNTL. In TEST (ii), the selected humidity channels were also assimilated in addition to those of TEST (i).

Figure 3 shows changes in the standard deviation of FG departures against CNTL. FGs in TEST (i) were closer to observation values than those of CNTL for sensors sensitive to humidity and temperature in the troposphere such as microwave imagers and sounders, indicating improved FG accuracy. TEST (ii) exhibited further improvement in FG departure, especially in humidity-sensitive observation such as MHS, GMI and SSMIS. These results indicate that HSS humidity channel assimilation has a positive impact on humidity fields in FGs.

4. Summary

JMA has begun to assimilate HSS radiance data in its meso-scale NWP system. It was found that channel selection in consideration of model top height is important for effective assimilation of HSS radiance. Water vapor channel assimilation also has positive effects on the humidity fields in FGs.

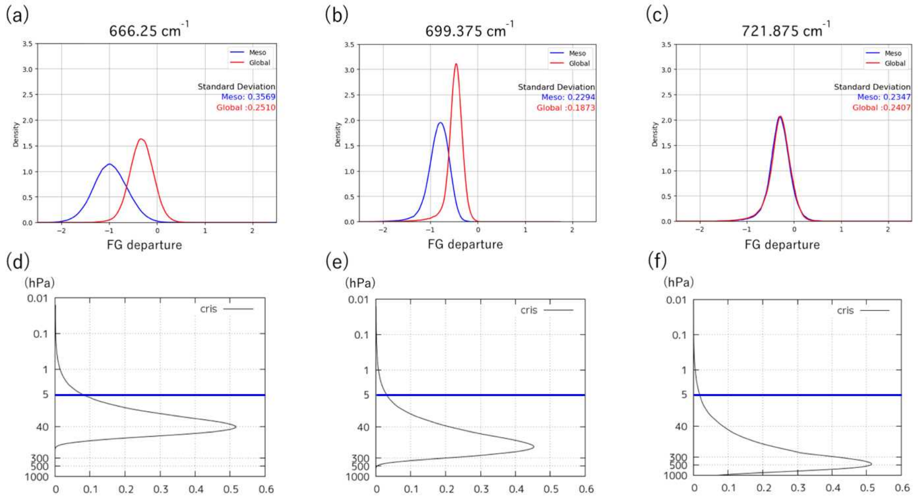

Figure 1: Histograms of CrIS FG departures [K] in the global system (red lines) and the meso-scale system (blue lines). (a) Channel 27 (666.25 cm^{-1}), (b) channel 80 (699.375cm^{-1}) and (c) channel 116 (721.875 cm^{-1}). (d), (e), (f): weighting functions [unitless] for each channel corresponding to (a), (b) and (c) respectively.

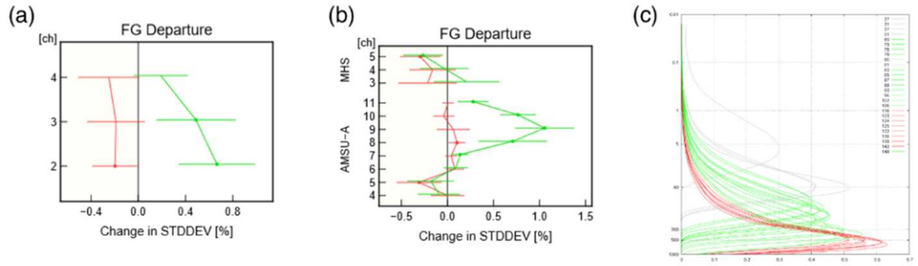

Figure 2: Normalized changes in standard deviation for FG departures in (a) CSR radiances from Himawari-8 and (b) MHS and AMSU-A radiances. Error bars show confidence levels of 95%. Green lines: TEST (a); red lines: TEST (b). (c) Weighting functions of assimilated channels in TEST (a) and TEST (b).

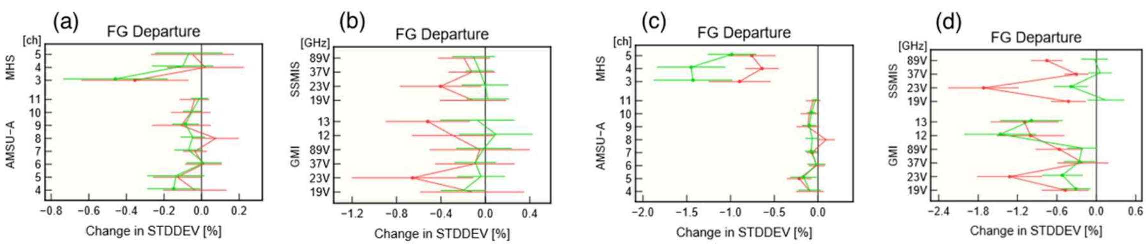

Figure 3: Normalized changes in standard deviation for FG departures of (a) MHS and AMSU-A radiances and (b) GMI and SSMIS radiances in TEST (i). (c) and (d) are as per (a) and (b), but for TEST (ii). The monthly validation periods are July (red dots) and January (green dots) 2020.

References

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