Assimilation of IASI and AIRS radiances at JMA

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1. Introduction

Observations from the Infrared Atmospheric Sounding Interferometer (IASI) and the Atmospheric Infrared Sounder (AIRS) have been operationally assimilated into JMA's global Numerical Weather Prediction (NWP) model since 4 September 2014. Only radiances unaffected by cloud are assimilated. This report briefly outlines the usage of these data at JMA and impacts on NWP quality.

2. Data and channel selection

IASI is a Michelson interferometer with 8,461 channels covering the infrared spectral domain (3.5 – 15.5μm). The first IASI was launched on EUMETSAT's Metop-A satellite in October 2006 and its successor was launched on the Metop-B satellite in September 2012. AIRS is a grating spectrometer with 2,378 channels covering a domain similar to that of IASI. It was launched on NASA's Aqua satellite in May 2002. These high spectral resolution sounders are capable of providing information on atmospheric temperature and humidity with high vertical resolution.

JMA utilizes the IASI dataset consisting of 616 channels spatially thinned to one pixel from four for each scan position, and the AIRS dataset consisting of 324 channels spatially thinned to one from nine for each scan position. Long-wave temperature sounding channels (around 15 μm) were selected as assimilation targets to improve the accuracy of the temperature field in analysis. There are 69 selected channels for IASI and 76 for AIRS. For AIRS, 9 channels around 4.4 μm are added only in the nighttime.

3. Quality control

Quality control (QC) for IASI and AIRS involves quality-flag checking, gross checking and cloud checking. Treatment of cloud is essential in comparing infrared observation and forecast models in the troposphere. Cloud contaminated observations are excluded to avoid the complexity of having to consider the effects of cloud in data assimilation.

Cloud checking is applied for each field of view over the ocean. It involves cloud detection based on the difference between observed radiance and simulated radiance assuming clear sky in the window channel, and cirrus detection based on the difference between observed radiance in the 11 and 12 μm channels. When cirrus is detected, a cloud top height is assigned at the tropopause height. When cloud other than cirrus is detected, the cloud top height is estimated using the minimum residual method (Eyre and Menzel 1989). Channels sensitive to the atmosphere below the estimated cloud top are excluded because they could be affected by cloud, while others are flagged as clear. Figure 1 shows histograms of the first-guess (FG) departure of IASI lower-tropospheric channels for all and clear-flagged data. The normal distribution curve for clear-flagged data indicates that cloud checking appropriately screens out cloud-contaminated observations. All channels sensitive to the troposphere are excluded over land or sea ice.

4. Verification results

A pre-operational experiment was conducted to evaluate the impact of IASI and AIRS assimilation. The trial period covered a total of six months from July to September 2013 (JAS) and from December to February 2013/2014 (DJF). Observations from IASI onboard Metop-A/Metop-B, and AIRS were additionally assimilated into the JMA operational global model in April 2014. Figure 2 shows that the root mean square (RMS) of FG departure for AMSU-A and MHS is reduced by the introduction of IASI and AIRS. This indicates accuracy improvement for temperature fields in the analysis and the first guess. Errors also exhibit a statistically significant reduction in short-range forecasting (Figure 3).

References

Eyre, J. R. and W. P. Menzel, 1989: Retrieval of Cloud Parameters from Satellite Sounder Data: A Simulation Study. J. Appl. Meteor. Climat., 267 – 275.

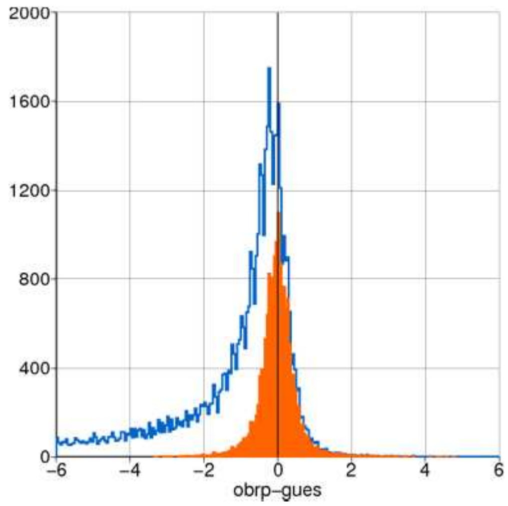

Figure 1. Histograms of FG departure [K] for MetopB/IASI lower-tropospheric channels. Blue: all data; Red: clear-flagged data in QC.

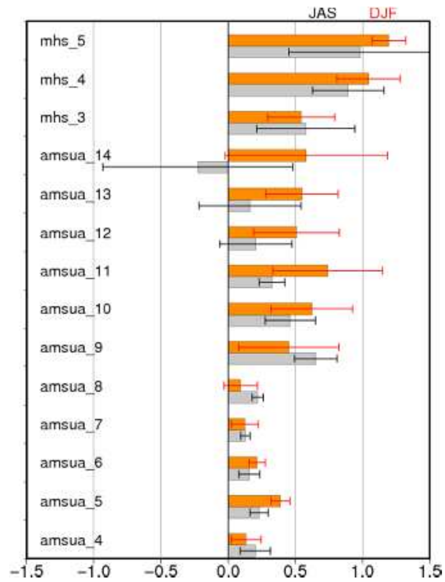

Figure 2. Normalized difference of RMS [%] in FG departure for AMSU-A channels 4 – 14 and MHS channels 3 – 5. Gray bars show the JAS period, and red bars show DJF. Positive values correspond to reduced RMS with IASI and AIRS assimilation. Error bars show a 95% confidence interval.

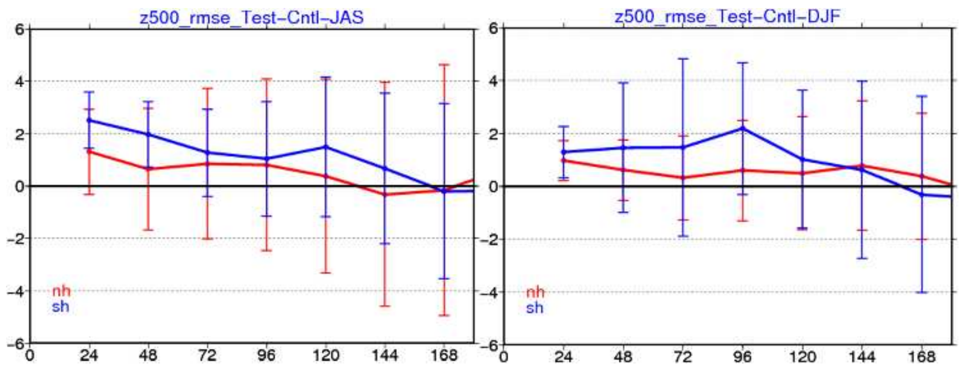

Figure 3. Normalized differences of RMS [%] in forecast errors for 500-hPa geopotential height verified against initial fields as a function of forecast range [hours]. Positive values correspond to reduced RMS with IASI and AIRS assimilation. Left: JAS period; Right: DJF period. Red lines show verification results for the northern hemisphere (20N – 90N), and blue lines show those for the southern hemisphere (90S – 20S). Error bars show a 95% confidence interval.