Operational use of Meteosat-11 Atmospheric Motion Vectors (AMVs) and Clear-Sky Radiance (CSR) Data in JMA's Global NWP System

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1. Introduction

The Japan Meteorological Agency (JMA) utilizes atmospheric motion vectors (AMVs) and clear-sky radiance (CSR) data derived from Meteosats (the operational geostationary satellites of the European Organization for the Exploitation of Meteorological Satellites: EUMETSAT) to produce analysis fields in the global data assimilation (DA) system. On March 6th 2018, EUMETSAT operational satellite observing over longitude 0 deg. was switched from Meteosat-10 to Meteosat-11. Against such a background, JMA examined the data quality of AMV and CSR data from both satellites and the impacts of related data assimilation on the accuracy of numerical weather prediction (NWP).

2. Assimilation experiments

Meteosat-10 AMV data from three channels of visible (VIS, 0.635 um), infrared (IR, 10.8 um) and water vapor (WV, 6.25 um) channels and CSR from the WV channel are used in JMA's global DA system. To compare the impacts of Meteosat-11 and Meteosat-10 data assimilation on the accuracy of NWP, experiments were conducted with 1) no AMVs and CSR from Meteosat-10 and -11 (BASE), 2) Meteosat-10 AMVs and CSR (CNTL), and 3) Meteosat-11 AMVs and CSR (TEST). The common quality control methods used with CNTL were applied for the TEST experiment. The experiment period was from February 7th to 26th 2018 (20 days).

3. Data quality and data assimilation impacts on the NWP system

- **Meteosat-11 AMVs**

Figure 1 shows histograms of the first-guess (FG) departure for the zonal wind component of AMVs. The standard deviation (STD) of the zonal (U) and meridional (V) wind components in the upper level (100 – 400 hPa) from Meteosat-11 were approximately 0.1 – 0.5 m/s for all latitude areas. These values were larger than those of Meteosat-10. Figure 2 shows histograms of FG departure (U and V components) for VIS channel lower winds. Higher STDs were observed for Meteosat-11 AMVs. However, as Meteosat-10 AMVs were operationally used in the NWP system and quality indication (QI) with forecasts resulted in favorable judgement for Meteosat-10 winds, leading to superior statistics in terms of FG departure comparison, the qualities of the two wind values were actually comparable.

An advantage of Meteosat-11 AMVs was observed in the data counts. Those for IR/WV AMVs of Meteosat-11 were larger than those for Meteosat-10, particularly for WV AMVs (Fig. 3). The improved tracking success rate of the cloud/water vapor pattern in satellite imagery contributes to this increase. As there was no marked difference in the histograms of FG departure statistics among other Meteosat-11 AMVs and those of Meteosat-10, the data count increase was considered to stem from the higher image quality of Meteosat-11 over that of Meteosat-10.

Figure 4 shows changes in the STD of FG departure for other wind observations (radiosonde and aircraft). These changes exhibit no particular deterioration, and indeed minor improvement is observed. Thus, no particular issues were found with the use of Meteosat-11 AMVs for data assimilation.

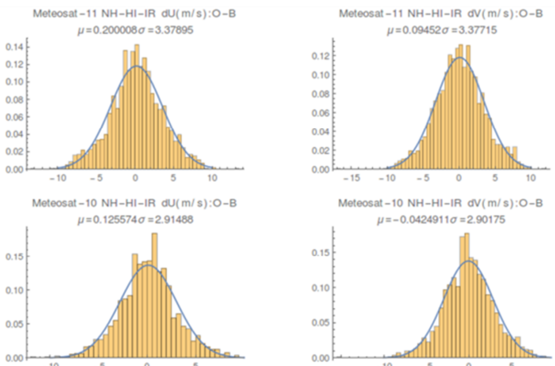

Figure 1. First-guess departure histograms of U (left) and V components (right) for IR upper-level (100 – 400 hPa) AMVs from Meteosat-11 (top) and -10 (bottom). Solid lines show normal distribution.

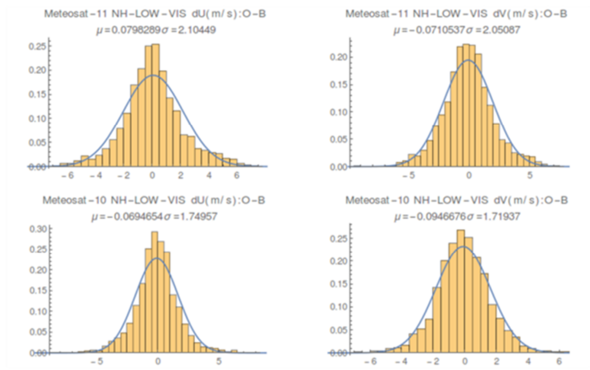

Figure 2. As per Figure 1, but for lower-level (700 – 1,000 hPa) AMVs

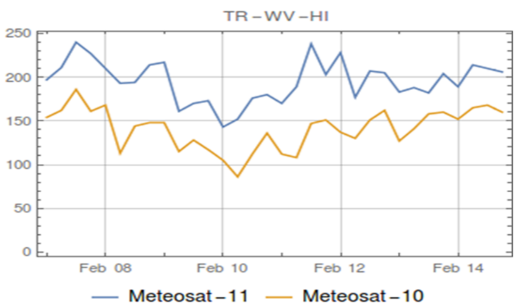

Figure 3. Time sequence plots for data counts of Meteosat-10 (yellow) and -11 (blue) active WV AMVs over the tropics

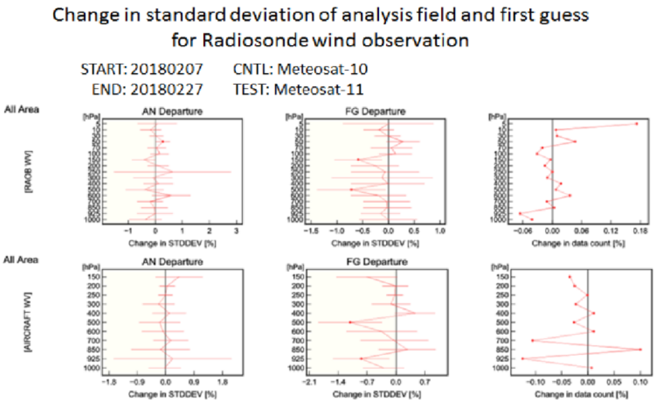

Figure 4. Changes in standard deviation of analysis fields and first guesses for wind observation (radiosonde and aircraft)

● Meteosat-11 CSR

The mean bias of the FG departure for Meteosat-11 CSR was approximately 0.16 K, and that of Meteosat-10 was -0.24 K. After variational bias correction (Ishibashi 2009), the difference in these biases was less than 0.01 K. The STD of FG departures and the data counts were very similar.

Figure 5 shows differences in the FG departure's STD for microwave humidity sounder data between CNTL and BASE (left) and those between TEST and BASE (right). Certain decreases (plotted in blue) of STD indicating improved WV fields were observed over the Meteosat observation area in both cases, indicating similar positive impacts on WV field analysis for Meteosat-10 and -11. Consistent improvement in both sets of data was also observed with other microwave instruments (e.g., ATMS, SAPHIR and microwave imagers) as shown in Figure 6.

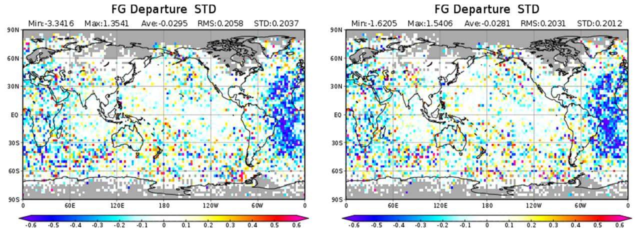

Figure 5. Differences in the first-guess departure standard deviation (STD) of microwave humidity sounding (MHS) data between CNTL and BASE (left) and between TEST and BASE (right). Blue indicates decreases (i.e., improvement) in the STD of CNTL or TEST over BASE.

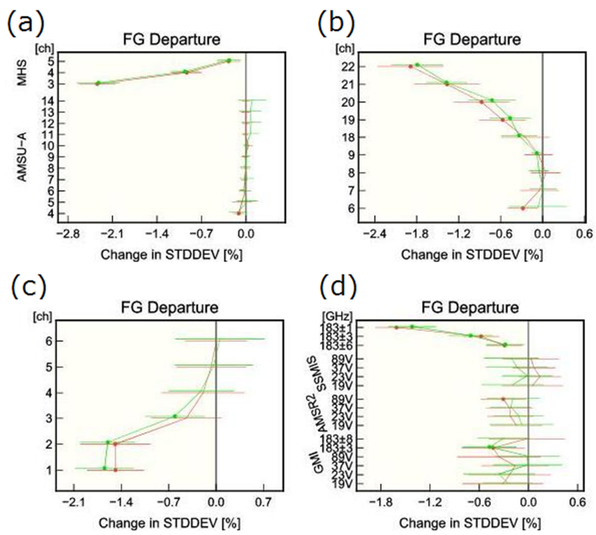

Figure 6. Normalized changes in the standard deviation of first-guess departures for (a) microwave sounding data, (b) ATMS, (c) SAPHIR and (d) microwave imager data with assimilation of Meteosat-10 (green) and Meteosat-11 (red) CSRs

4. Summary

The data qualities of AMVs and CSR from Meteosat-11 were equivalent to those of Meteosat-10, and their data assimilation impacts in NWP were similar. Based on these findings, Meteosat-11 AMV and CSR data were incorporated into JMA's operational global NWP system on March 6th 2018.

References

Ishibashi, T., 2009: Implementation of a new background error covariance matrix in the variational bias correction scheme for the JMA Global 4D-Var System. *CAS/JSC WGNE Research Activities in Atmospheric and Oceanic Modeling, Rep.*, **39**, 1 – 15.