Assimilation of Himawari-8 atmospheric motion vectors into JMA's operational global, mesoscale and local NWP systems

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1. Introduction

The Meteorological Satellite Center of the Japan Meteorological Agency (JMA) has produced operational Himawari-8 atmospheric motion vectors (AMVs) since July 7th 2015 (Bessho et al. 2016). These are based on three sequential satellite images taken at intervals of 10 minutes, as opposed to the 30 – 60 minute intervals of images used for MTSAT-2 AMVs.

Himawari-8 AMVs will be assimilated into JMA's operational global, mesoscale and local numerical weather prediction (NWP) systems (see the JMA website[1]) in place of MTSAT-2 AMVs in March 2016. A specific quality control (QC) system has been created to enable the use of Himawari-8 AMVs in operational global and mesoscale four-dimensional variational data assimilation systems (GSM-DA and MSM-DA) and in the operational local three-dimensional variational data assimilation system (LFM-DA). Observing system experiments (OSEs) for Himawari-8 AMVs were performed over periods of one and two months using the GSM-DA, MSM-DA and LFM-DA systems with this QC approach in the winter and summer of 2015.

2. Characteristics of Himawari-8 AMV data

The characteristics of Himawari-8 AMVs were evaluated statistically against the first guesses of the GSM-DA, MSM-DA and LFM-DA systems. Figure 1 shows a histogram of the normalized difference (O-B) between the relevant wind speeds and first guesses in the GSM-DA system for the Northern Hemisphere (NH) at levels above 400 hPa from February 5 to March 20 2015. These were compared with O-B for MTSAT-2 AMVs, which are already assimilated in the operational GSM-DA and MSM-DA systems. As shown in Fig. 1, the histograms of O-B for NH AMVs in the GSM-DA system exhibit Gaussian distribution. Those for other regions and those in the MSM-DA and LFM-DA systems have the same characteristics (not shown). The standard deviation (STD) of O-B is around 0.5 m/s less than that of the MTSAT-2 AMVs, suggesting improved data quality. Data coverage is also improved (Fig. 2).

3. QC for Himawari-8 AMV data and OSEs

To support the effective use of Himawari-8 AMVs, the AMV pre-processing system has been updated in three main ways.

First, the quality indicator (QI, Holmlund 1998) thresholds for low-quality AMV rejection were revised in consideration of Himawari-8 AMV characteristics. Second, climatological checking was revised to involve the use of more AMVs in the middle troposphere. Third, a 100-km super-observation technique (Yamashita 2014) was introduced into the global NWP system for Japan and the surrounding areas. Details of other QC measures are provided on the NWP SAF AMV monitoring page[2].

To determine the impact of Himawari-8 AMVs with the revised pre-processing system in comparison with that used for MTSAT-2 AMVs, OSEs were performed for the periods from January to February 2015 (winter 2015) and from July to September 2015 (summer 2015).The term TEST is used to refer to the experiments with assimilation of Himawari-8 AMVs and without that of MTSAT-2 AMVs, and CNTL is used to refer to those with assimilation of MTSAT-2 AMVs. The results of two tests were compared, and other observations were used in both experiments as in the actual operational systems.

4. OSE results

The OSEs performed with the global NWP system revealed reduced O-B wind speed differences between TEST and CNTL over the Himawari-8 observation area (especially around Japan; Fig. 3). Figure 4 shows the normalized RMSE difference around Japan between TEST and CNTL forecasts covering periods from one to eleven days for 850 hPa wind vectors in summer 2015. Significant improvements (up to 3 – 6% on average) are seen until two-day forecasts for summer 2015. Positive or neutral impacts are seen for other physical elements and heights/regions. Mean positional errors for ten typhoons in summer were also reduced with 24-hour to 48-hour and 90-hour to 120-hour forecast

[1] http://www.jma.go.jp/jma/en/Activities/nwp.html
[2] http://research.metoffice.gov.uk/research/interproj/nwpsaf/satwind_report/amvusage/jmamodel.html

lead times. The reduction was around 6% with 24-hour to 48-hour forecast lead times (Fig. 5). The OSEs conducted with JMA's mesoscale and local NWP systems also showed improvement in rain forecasting (Fig. 6). Positive impacts on most physical elements and heights in the Southern Hemisphere were also seen in four-day forecasts for winter 2015 (not shown).

Himawari-8 AMVs with the revised pre-processing system are scheduled for assimilation into JMA's operational NWP systems in March 2016.

References

Bessho, K., K. Date, M. Hayashi, A. Ikeda, T. Imai, H. Inoue, Y. Kumagai, T. Miyakawa, H. Murata, T. Ohno, A. Okuyama, R. Oyama, Y. Sasaki, Y. Shimazu, K. Shimoji, Y. Sumida, M. Suzuki, H. Taniguchi, H. Tsuchiyama, D. Uesawa, H. Yokota and R. Yoshida, 2016: An introduction to Himawari-8/9 – Japan's new-generation geostationary meteorological satellites. J. Meteor. Soc. Japan, 94

Holmlund, K., 1998: The utilization of statistical properties of satellite-derived atmospheric motion vectors to derive quality indicators. Wea. Forecasting, 13, 1093 – 1104

Yamashita, K., 2014: Observing system experiments of MTSAT-1R rapid scan AMVs using JMA's operational NWP system from 2011 to 2013. Proc. 12th Int. Winds Workshop, Copenhagen, Denmark, EUMETSAT

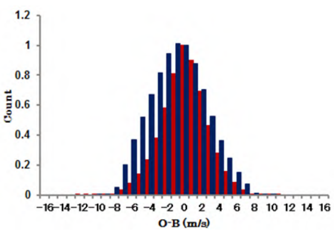

Figure 1. O-B normalized histograms of infrared AMVs at levels above 400 hPa in the Northern Hemisphere (poleward of 20°N) from February 5 to March 20 2015. The red and blue bars correspond to Himawari-8 and MTSAT-2 AMVs, respectively.

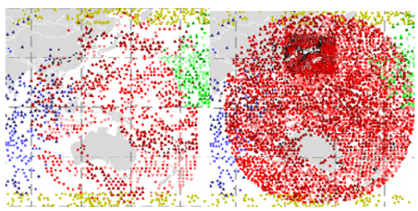

Figure 2. Assimilated AMV data coverage in the GSM-DA system for the 60°S – 60°N and 90°E – 170°W region at 00 UTC on July 20 2015. Left: MTSAT-2 AMVs (red plots); right: Himawari-8 AMVs (red plots).

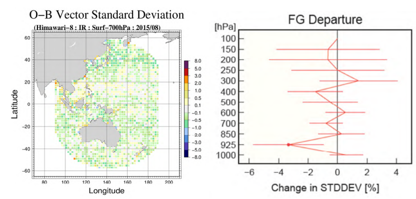

Figure 3. O-B wind speed differences between Himawari-8 and MTSAT-2 AMVs below 700 hPa for summer 2015 (left; negative values indicate better scores) and normalized O-B wind speed standard deviation differences between TEST and CNTL against wind profiler observations for summer 2015 (right; negative values indicate better scores, error bars represent a 95% confidence interval, and red dots indicate statistical significance).

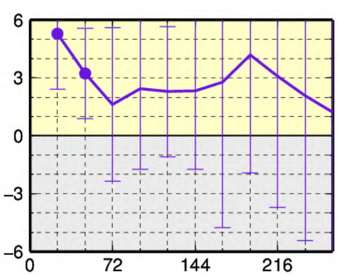

Figure 4. Normalized RMSE differences (y-axis) around Japan between TEST and CNTL covering periods from one to eleven days (x-axis) for 850 hPa wind vectors in summer 2015. Positive values indicate better scores. Error bars represent a 95% confidence interval, and dots indicate statistical significance.

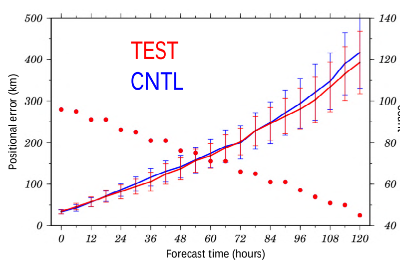

Figure 5. Average typhoon track forecast errors for summer 2015. The red line is for TEST values, the blue line is for CNTL values, and the red dots are sample data numbers. Error bars represent a 95% confidence interval.

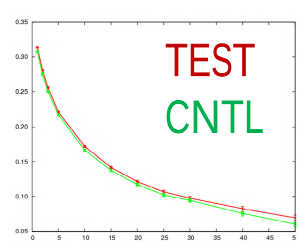

Figure 6. Equitable threat scores against radar-rainfall composite precipitation for each threshold of precipitation for summer 2015