Operational Use of GOES-17 Atmospheric Motion Vectors (AMVs) in JMA's Global NWP System

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1. Introduction

Atmospheric Motion Vectors (AMVs) derived from geostationary meteorological satellites provide valuable information on tropospheric wind in the tropics and at mid-latitudes, and are used in data assimilation for JMA's global NWP system (GSM). GOES-17 is the second of the third-generation GOES series of satellites equipped with Advanced Baseline Imagers (ABIs), and began operation as GOES West at 137.2°W in Feb. 2019. GOES-16 is the same type of satellite, and is operated as GOES East at 75.2°W. GOES-16 AMVs have been operationally assimilated in the GSM since 29 July 2020 (Nonaka and Koyamatsu 2021).

This report presents the results of comparison between GOES-16 AMV and GOES-17 AMV data and related impacts on observing system experiments (OSEs) with GSM.

2. Comparison of GOES-16 and 17 AMVs

GOES-16 and 17 AMVs are derived from ABI sequential imagery using the same algorithm (Daniels et al. 2019), and their qualities are considered essentially comparable. The GOES-17 ABI has issues with its cooling system, and some degradation is observed in its infrared channel imagery over a period of several hours before and after the vernal and autumnal equinoxes (GOES-17 ABI Performance, n.d.). To determine the effects of the cooling issues on the quality of GOES-17 AMVs, the difference between these AMVs and those of GOES-16 was evaluated by comparing values collocated within 0.05-degree grid boxes.

Figure 1 shows statistical differences between GOES-16 and 17 infrared-channel (3.9 and 11.2 μm) AMVs (GOES-17 minus GOES-16) for speed and height every hour from 11 November 2019 to 25 October 2020. Although speed differences are relatively small, GOES-17 AMVs exhibited low height biases against GOES-16 AMVs for several hours a day during the period of approximately four months before and after the vernal and autumnal equinoxes at around 11 – 16 UTC in Feb., Apr., Aug. and Oct. The periods and hours during which GOES-17 AMVs exhibited height biases against GOES-16 AMVs correspond to those during which degradation is expected in GOES-17 ABI imagery. These results prompted avoidance of GOES-17 AMV data usage in the GSM for unreliable hours (11 to 16 UTC throughout the year). This is referred to here as time screening.

3. Optimization of QI threshold values

GOES-16 and 17 AMV data include a quality indicator without forecast testing (QI) (Holmlund 1998) which is used for data selection at major NWP centers. QI threshold values for both sets of AMVs were determined to reduce the bias and the standard deviation of observation minus background (O-B) statistics for the period from 10 July to 11 September 2020 using GSM as the background. Figure 2 shows typical QI dependency of O-B statistics for u-component of upper-layer (< 400 hPa) GOES-16 and 17 AMVs in the tropics (20°S –20°N). The bias and standard deviation tend to decrease as QI values increase.

4. Assimilation experiments

OSEs were performed with application of time screening to GOES-17 AMVs and new QI threshold values to both GOES-16 and 17 AMVs to determine impacts of assimilating GOES-17 AMV data on GSM. The experiments were based on an environment equivalent to that of JMA's operational system for September 2020, and were verified over one month around August 2020.

Figure 3 shows the zonal mean of relative improvement in root mean square errors (RMSEs) of wind vectors for 24-hour forecasts from 12 UTC initials using ERA5 data as a reference. Figures 3 (a) and (b) show results of applying a low QI threshold (QI > 60), and (b) shows those of applying time screening in addition. Figure 3 (c) shows results of applying a constant high QI threshold (QI > 87). It can be seen that the high QI threshold and time screening are effective in improving short-term wind forecast fields, especially in the troposphere from the tropics to the Southern Hemisphere.

5. Summary

Positive impacts were observed on analysis and short-term forecast fields in the troposphere

using GOES-17 AMVs in the GSM with application of time screening and the new optimal QI thresholds for GOES-16 and 17 AMVs. GOES-17 AMVs have been used operationally with the GSM since 29 June 2021.

References

Daniels, J., et al., 2019: GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Derived Motion Winds, Version 3.1.

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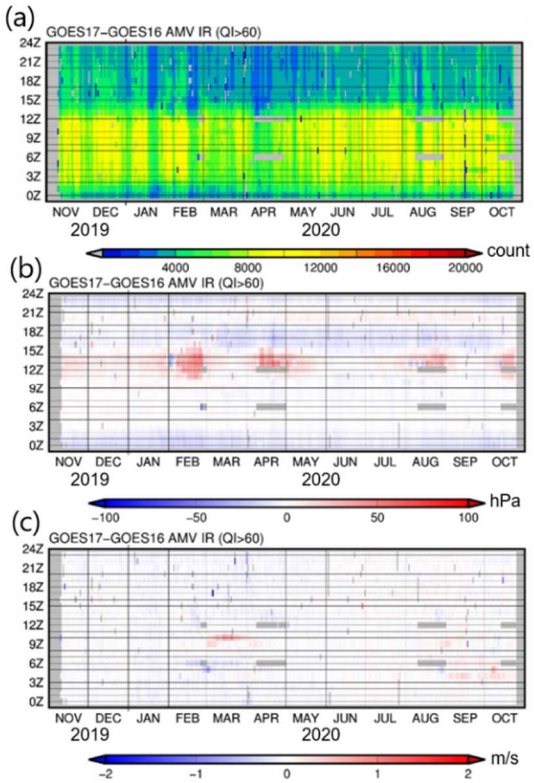

Figure 1. Time-series representation of statistical differences between GOES-16 and 17 infrared-channel AMVs every hour from 11 Nov. 2019 to 25 Oct. 2020. (a) Number of collocation vectors, (b) assignment height (pressure, hPa) difference (GOES-17 – GOES-16) and (c) speed difference (m/s) (GOES-17 – GOES-16). The horizontal and vertical axes represent the month and time (UTC), respectively.

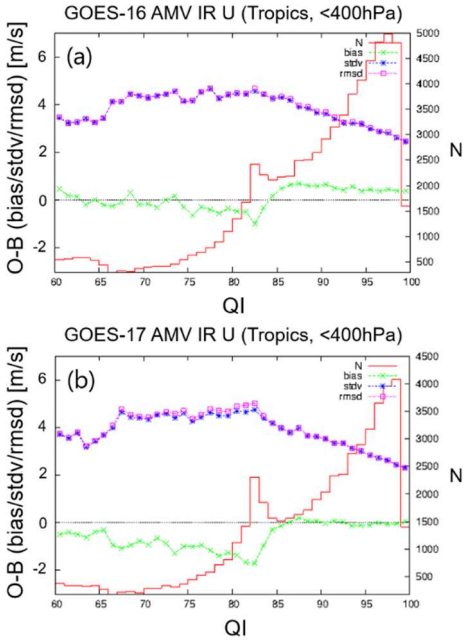

Figure 2. QI dependency of O-B bias, standard deviation and root mean square difference (RMSD) for upper-layer u-component wind in the tropics. (a) GOES-16 infrared–channel AMVs, and (b) GOES-17 infrared-channel AMVs. The red, green, blue and magenta lines indicate number of samples, bias, standard deviation and RMSD, respectively.

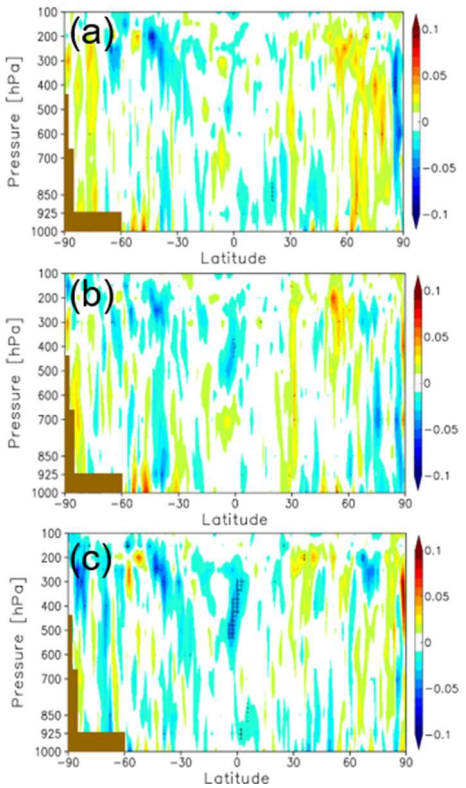

Figure 3. Zonal mean of relative improvement in root mean square error (RMSE) of wind vectors for 24-hour forecasts from 12 UTC initial against ERA5. The QI thresholds applied for GOES-16 and 17 AMVs are (a), (b) QI > 60 and (c) QI > 87. In (b) and (c), time screening is applied to GOES-17 AMVs. Negative values indicate reduced RMSEs from those of the reference experiment. Hatched areas represent statistically significant changes. The validation period is 1 – 31 August 2020.