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CURRENT STATUS OF ATMOSPHERIC MOTION VECTORS AT JMA

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Abstract

Since July 7th 2015, the Meteorological Satellite Center (MSC) of the Japan Meteorological Agency (JMA) has operationally distributed Himawari-8 Atmospheric Motion Vector (AMV) data via the Global Telecommunication System (GTS) (Shimoji 2017). To support this provision, the Agency's Himawari-9 satellite was launched in November 2016, and on March 10th 2017 was put into standby operation as backup for the Himawari-8 unit. Himawari-9 carries the Advanced Himawari Imager (AHI), which is capable of 16-band observation in the visible to infrared range with specifications similar to those of the Himawari-8 AHI. Both satellites are stationed at almost the same longitude (140.7°E) and cover the same observation area. The unit will perform backup duties in the event of any Himawari-8 malfunction, thereby enabling JMA/MSC to continue its provision of quality-checked AMV data without lacking for a long term.

Himawari-9 was operated in four periods of trial observation before April 2018 to verify appropriate functioning of its equipment and systems, and Himawari-9 AMVs were derived and evaluated using the provisional data collected. This paper reports on the statistical characteristics and current status of Himawari-8/9 AMVs.

HIMAWARI-8/9 MISSION SCHEDULE AND CONFIGURATION

Himawari-8 has operated stably since July 7th 2015, and Himawari-9 (launched on November 2016) commenced in-orbit standby on March 10th 2017. The two satellites have now completely taken over the missions of JMA's previous MTSAT-1R/2 satellites. Himawari-9 will continue its in-orbit standby role until 2022 before taking over and performing Himawari-8's duties until 2029 (Bessho *et al*. 2016). The observation areas and frequencies of the Advanced Himawari Imagers (AHIs) on board Himawari-8/9 are summarized in Figure 1. These imagers can produce full-disk scans every 10 minutes as well as images of the Japan region and specific target areas every 2.5 minutes. Table 1 shows Himawari-8 AHI central wavelengths, and Figure 2 shows the spectral response functions (SRFs) of the Himawari-8/9 AHIs, which have 16 observation bands ranging from visible to infrared with approximately equivalent specifications and observation functions. Both satellites remain in close proximity (at around 140.7°E) and cover the same observation area. Accordingly, in the event of any Himawari-8 issues relating to anomalies or scheduled maintenance, Himawari-9 will be able to continue observation and provide almost identical imagery.

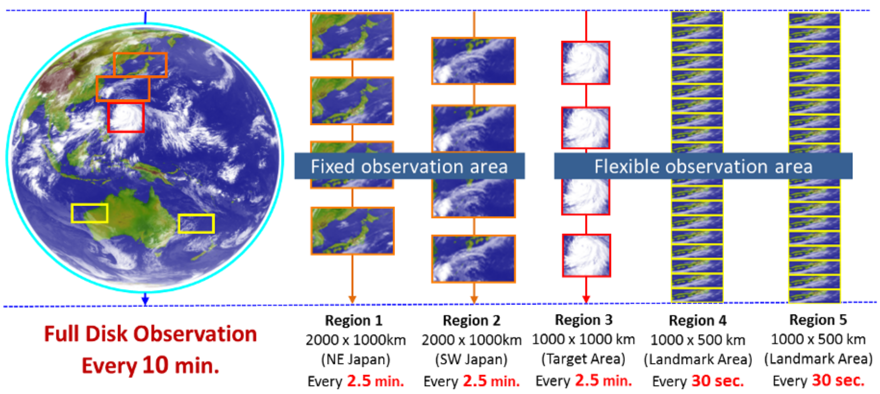


Figure 1: **Himawari-8/9 AHI observation areas and frequencies**

Table 1: **Central wavelengths of the Himawari-8 AHI's 16 observation bands**

	B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B11	B12	B13	B14	B15	B16
Central Wave length [µm]	0.47	0.51	0.64	0.86	1.6	2.3	3.9	6.2	6.9	7.3	8.6	9.6	10.4	11.2	12.4	13.3
Spatial Resolution [km]	1	1	0.5	1	2	2	2	2	2	2	2	2	2	2	2	2

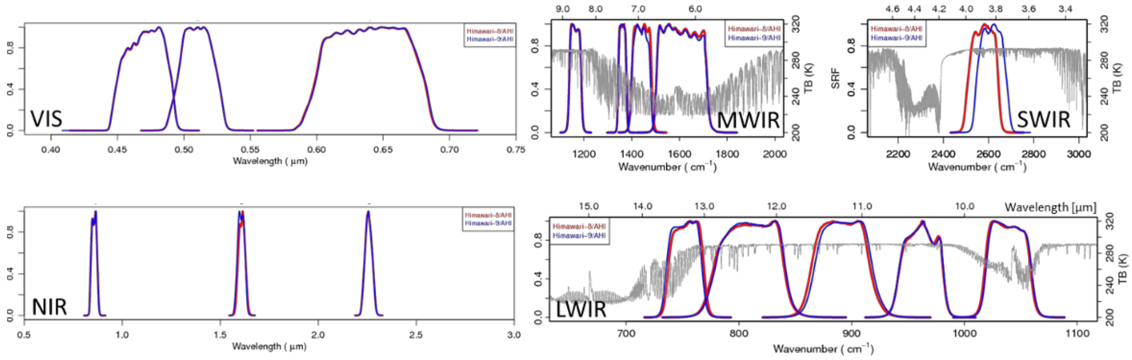
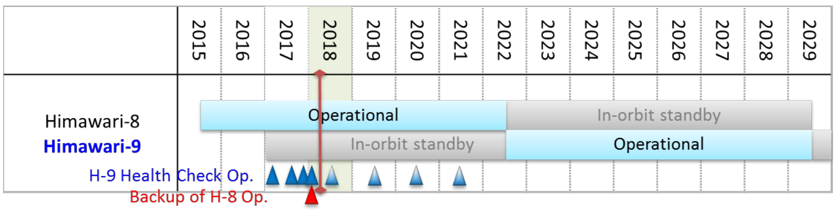


Figure 2: **AHI-8/9 SRFs (red: AHI-8; blue: AHI-9)**

HIMAWARI-9 HEALTH CHECK OPERATIONS AND BACKUP OPERATION

Health check operations (HCs) are executed once or twice a year to verify the status of Himawari-9. Figure 3 shows the HC schedule from 2015 onward. Four HCs had been performed by April 2018 (Figure 3), and Himawari-9 AMVs were derived from the provisional observation imagery produced. Himawari-8 observation operation was suspended for maintenance on February 13th and 14th 2018 during the fourth HC (HC-4), and Himawari-9 AMVs were provided instead for this time as a backup. The next section covers evaluation of Himawari-9 AMVs, which were derived over a period of around two weeks including the backup operation period.



Health check operation (HC)	Operation term
HC-1	29 May – 12 Jun, 2017
HC-2	29 Aug – 13 Sep, 2017
HC-3	28 Nov – 12 Dec, 2017
HC-4 and Backup Operation	31 Jan – 15 Feb, 2018 (13 Feb – 14 Feb, 2018)

Figure 3: **Himawari-9 HC schedule**

QUALITY OF HIMAWARI-9 AMVS

Figure 4 shows upper-layer O-B statistics (< 400 hPa) for Himawari-8/9 AMVs (IR 10.4 µm) over the Northern Hemisphere (NH; > 20°N) and the Southern Hemisphere (SH; < 20 °S) during HC-4, including Himawari-9's backup operation period (Feb. 2nd to 14th 2018). Shown are the number of samples, mean wind speed, root mean square vector difference (RMSVD) and wind speed bias. The AMVs from both satellites exhibited similar results with the same range of variations except for one period (Feb 9th to 11th, when the quality of Himawari-9 AMVs was degraded due to a navigation anomaly whose causes are currently being determined).

Figure 5 shows O-B statistics for Himawari-8/9 IR (10.4 µm) AMVs for HC-4, indicating the bias, RMSVD and mean wind speed against the first guess (from the top). Similar statistical characteristics are observed for both satellites.

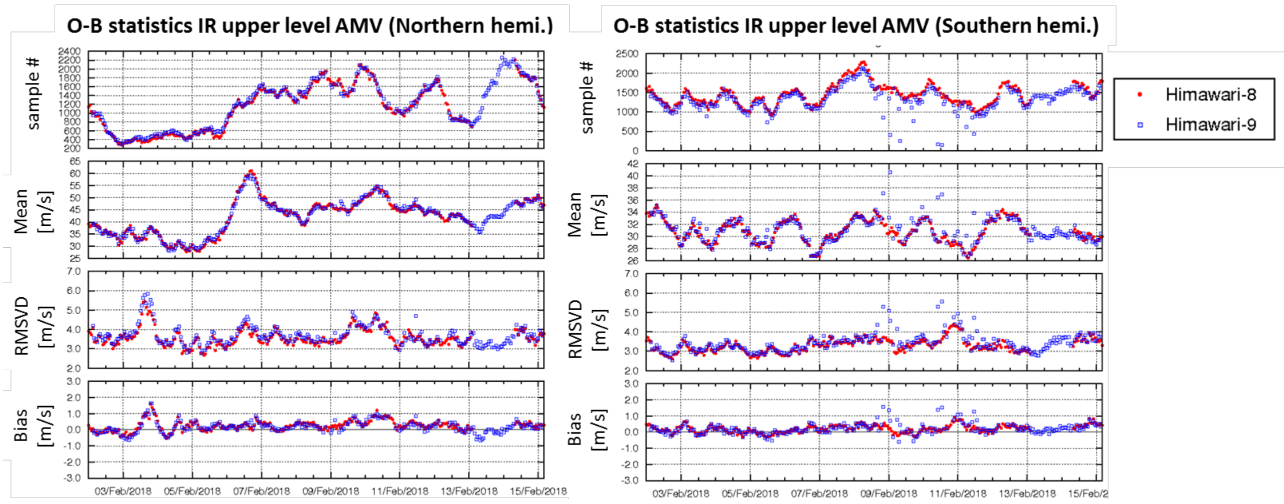


Figure 4: **Time-series representations of O-B statistics for Himawari-8/9 AMVs (IR 10.4 μm, upper wind) from Feb. 2nd to 14th 2018 (from the top: number of samples, mean wind speed, RMSVD, bias). The panel on the left presents upper-level AMVs over the Northern Hemisphere (> 20 °N), and that on the right panel shows the same for the Southern Hemisphere (< 20°S). Red: Himawari-8; blue: Himawari-9.**

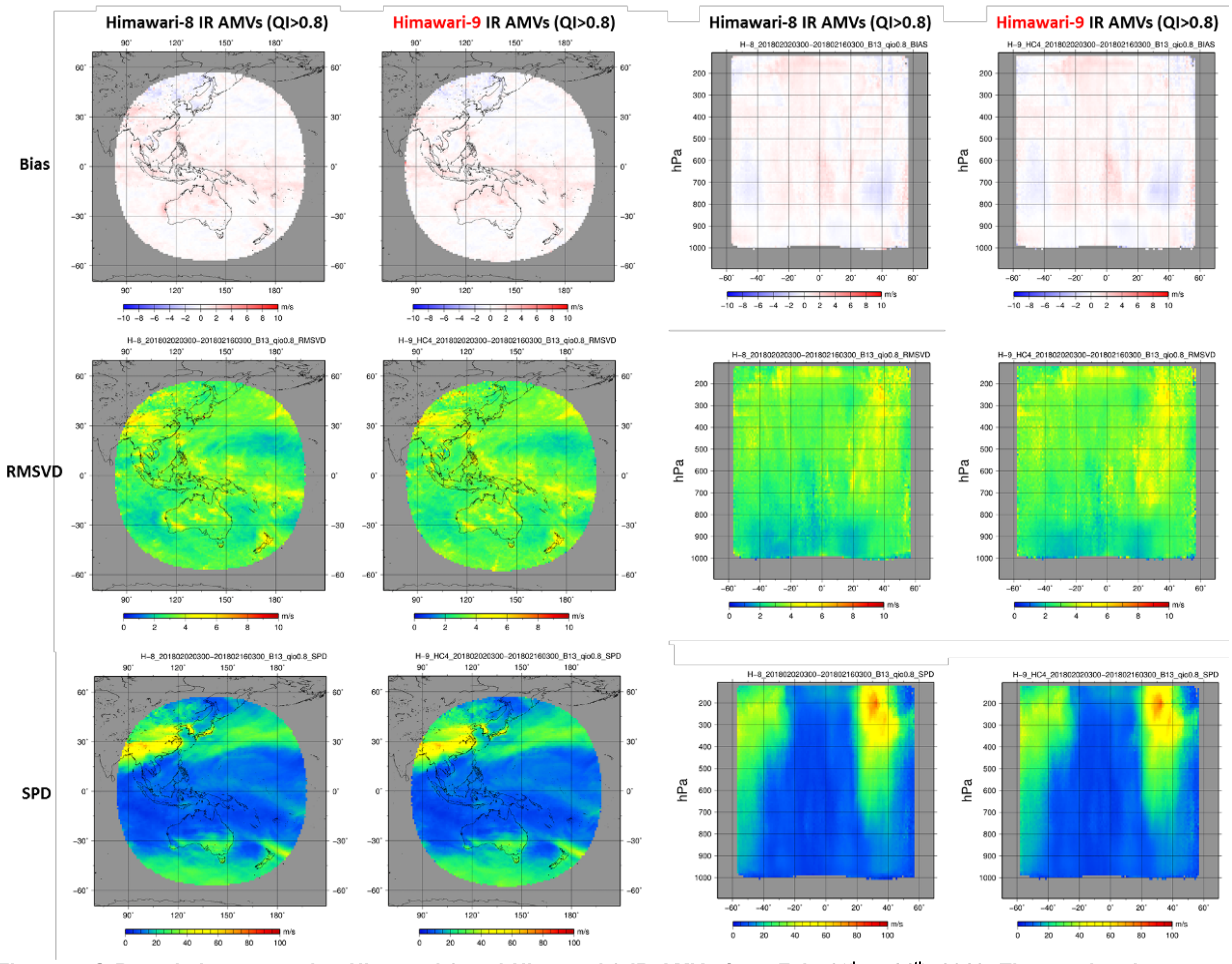


Figure 5: **O-B statistics comparing Himawari-8 and Himawari-9 IR AMVs from Feb. 2nd to 14th, 2018. The graphs show speed bias (top), RMSVD (middle) and mean wind speed (SPD) (bottom). The six graphs on the right show zonal plots of O-B statistics from south to north.**

CURRENT STATUS OF HIMAWARI-8/9 AMVS

Figure 6 shows the current status of Himawari-8/9 AMVs produced by JMA/MSC. Himawari-8/9 full-disk AMVs, provided via GTS for assimilation of global numerical weather prediction (NWP) models, are calculated every hour at a 34-km (@SSP) horizontal resolution. Since July 2015, high-resolution AMVs have been calculated for Japan and the surrounding area from full-disk imagery for JMA's operational global and mesoscale NWP system.

Since 2017, high-resolution Himawari-8/9 AMVs derived from full-disk and regional rapid-scan (RS) imagery have been calculated using a specialized algorithm, and are used for typhoon monitoring and meso-scale NWP assimilation experiments. Positive weather forecasting impacts have been reported from experiments involving the use of RS-AMVs for a mesoscale regional NWP model (e.g., Kunii *et al*. 2016).

Figure 7 shows a snapshot of sea surface winds as estimated from Himawari-8 low-level RS-AMVs for targeted observation around Typhoon Talim. Sea surface wind data from RS-AMVs and high-resolution full-disk AMVs are provided to the RSMC Tokyo - Typhoon Center for operational wind monitoring (Nonaka *et al*. 2016). The ability to track rapidly changing clouds such as those often seen around tropical cyclones has been improved by the use of RS imagery. Himawari-8/9 full-disk imagery scanning can be performed more quickly than with MTSAT-1R/2, making the resulting RS-AMVs and high-resolution full-disk AMVs suitable for monitoring of wind distribution around tropical cyclones.

Himawari-8/9 RS-/high-resolution AMVs are currently available only within JMA, but will be provided internationally in the future.

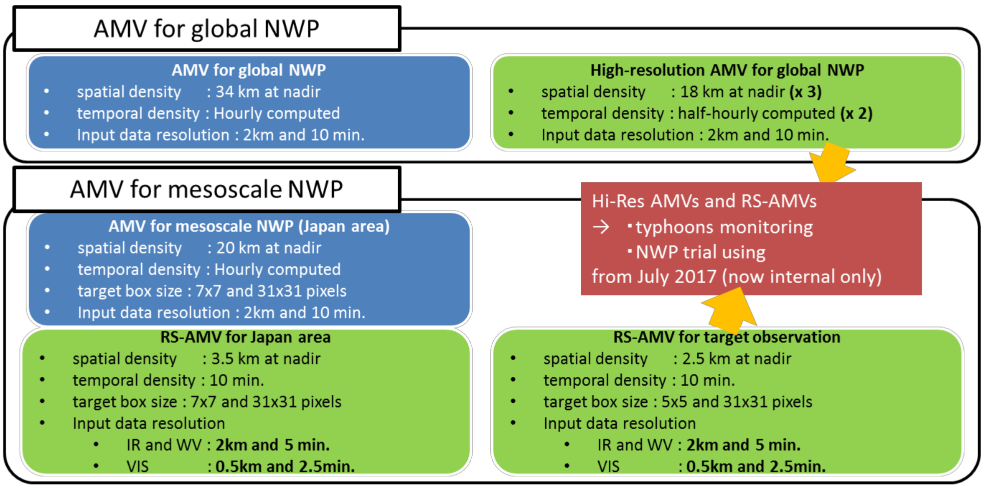


Figure 6: **Current status of Himawari-8/9 AMVs (blue: conventional algorithm; green: new algorithm for high-density operation)**

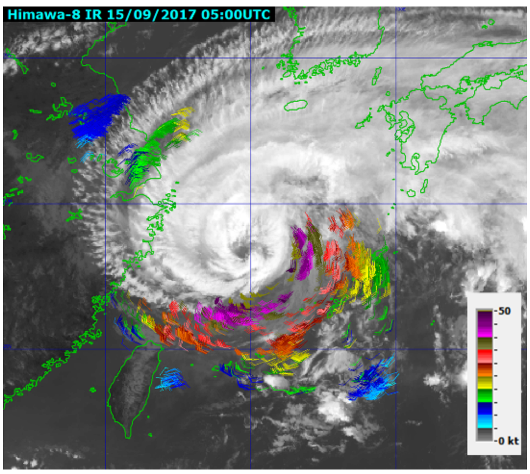


Figure 7: **Sea surface winds estimated from Himawari-8 low-level RS-AMVs (VIS, target obs.) around typhoon Talim (2017) (Overlaid on full-disk IR imagery)**

SUMMARY

Himawari-9 was launched in November 2016, and backup operation to Himawari-8 was started in May 2017. The Himawari-9 AHI has the same observational functions and coverage as the Himawari-8/AHI. Himawari-9 will provide AMVs with quality largely equivalent to those of Himawari-8 in the event of anomalies or scheduled maintenance involving Himawari-8. The satellite executed four periods of observation before April 2018 to verify its status, and AMVs were calculated from the provisional observation data collected. Himawari-9 AMVs derived from approximately two weeks of observation imagery demonstrated almost the same statistical characteristics as those of Himawari-8.

Himawari-8/9 AMVs are produced with high resolution using a new specialized derivation algorithm from full-disk and regional imagery, and the resulting RS-AMVs are used for typhoon monitoring and experiments on mesoscale NWP model assimilation. The new RS-/high resolution AMVs are currently available to internal and offline users only, but will be provided internationally in the future.

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