Preliminary assessment and assimilation of Himawari-8 Rapid Scan Atmospheric Motion Vector data for typhoons

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1. Introduction

The Meteorological Satellite Center of the Japan Meteorological Agency (JMA/MSC) has produced operational Himawari-8 Atmospheric Motion Vectors (AMVs) since July 7th 2015 (Bessho et al. 2016). The data are created using three sequential satellite images with temporal intervals of 10 minutes on an hourly basis. To support the provision of wind data relating to meso-scale phenomena and typhoons, JMA/MSC started operational generation of rapid-scan AMVs (RS-AMVs) based on Himawari-8 rapid-scan imagery in July 2017 for JMA's internal assessment. These RS-AMVs are produced every 2.5 minutes for a domain covering Japan and an additional small domain covering a typhoon presents over the western North Pacific (Fig. 1 (a)). RS-AMVs for typhoons are expected to clarify the fine structure of typhoon wind fields better than operational AMVs (Fig. 1). Accordingly, the assimilation of RS-AMV data is expected to improve typhoon analysis and forecasting skill.

2. Quality of RS-AMVs for five typhoons

RS-AMVs retrieved by JMA/MSC for five typhoons (Soudelor, Goni and Dujuan in 2015, and Nepartak and Megi in 2016) were used for data quality assessment. The data were validated against dropsonde (DOTSTAR; Wu et al. 2005) and sonde observations, and against first-guess (FG) wind data from JMA's global model. Validation was performed for each of the five cases.

The results showed that RS-AMV wind speeds exhibited a negative bias against sonde observations, especially over mid- and lower-levels, and occasionally against the FG (Table 1). This may be attributable to the significant difference in the vertical levels of wind speed shear between sonde and RS-AMV data (Fig. 2). Root mean square vector differences (RMSVDs) of RS-AMVs were larger than those of operational AMVs (RMSVD: 5 – 6 m/s) against sonde observations. Comparison of the five cases indicates that wind data for Typhoon Nepartak were more accurate than in the other cases (Table 1 and Fig. 2).

3. Typhoon RS-AMV observing system experiments (OSEs) with JMA's global NWP system

OSEs were performed for Typhoon Nepartak (for which data quality was the best of the five typhoons examined; see Section 2) with JMA's global NWP system for the period from July 1 to July 20 2016. Here, the term CNTL refers to an experiment involving assimilation of Himawari-8 AMVs processed using 1) the 100-km super-observation technique (100kmSPOB; Yamashita 2014) for the area over Japan and surrounding areas, and 2) 200-km thinning over other regions. TEST refers to an experiment involving assimilation of Himawari-8 RS-AMVs for typhoons processed with 100kmSPOB, in addition to the AMVs assimilated in CNTL. The Himawari-8 typhoon RS-AMVs were processed using 100kmSPOB to promote effective use of data from the area around the typhoon center. A larger body of AMV data was assimilated for the area around the typhoon center in TEST than in CNTL (Fig. 3). The typhoon track forecasts observed the experiments were verified against typhoon best track (BST) data provided by the Regional Specialized Meteorological Center (RSMC) Tokyo – Typhoon Center. Quality control for the wind data in both experiments was as per that of the operational NWP system. The OSE results showed neutral impacts on typhoon track forecasts. The typhoon intensity forecasts in TEST were weaker than in CNTL (Fig. 4). However, as shown in Fig. 5, forecast errors were reduced along the typhoon track areas at 500-hPa geopotential height.

More case studies are needed to clarify impacts from assimilation of RS-AMVs for typhoons.

4. Conclusions

The quality of Himawari-8 RS-AMVs for typhoons in five cases was evaluated using DOTSTAR dropsonde observation data and FG wind data from JMA's global model. The results indicated that RS-AMV wind speeds exhibited a negative bias against both data types. Meanwhile, assimilation experiments involving RS-AMV data demonstrated partially improved typhoon structures in JMA's global NWP system. Further investigation is needed to elucidate the mechanism behind differences in typhoon structure forecasts with RS-AMV data assimilation.

Acknowledgments
JMA is grateful to DOTSTAR project staff for their provision of the data used in this study.

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.

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.

Wu, C.-C., P.-H. Lin, S. D. Aberson, T.-C. Yeh, W.-P. Huang, J.-S. Hong, G.-C. Lu, K.-C. Hsu, I.-I, Lin, K.-H. Chou, P.-L. Lin and C.-H. Liu, 2005: Dropwindsonde observations for typhoon surveillance near the Taiwan Region (DOTSTAR): an overview. Bull. Amer. Meteor. Soc., 86, 787 – 790.

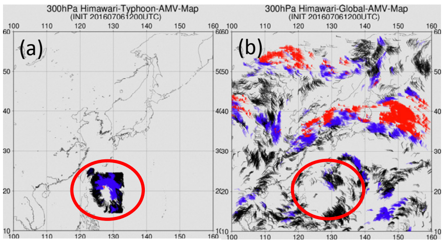

Figure 1: Himawari-8 AMV data coverage (a: RS-AMVs for a typhoon (approx. 4-km res.); b: operational AMVs (approx. 50-km res.) at 12 UTC on July 6 2016 for analysis of Typhoon Nepartak (AMVs: red: >= 50 kt; blue: >= 30 kt; black: < 30 kt)

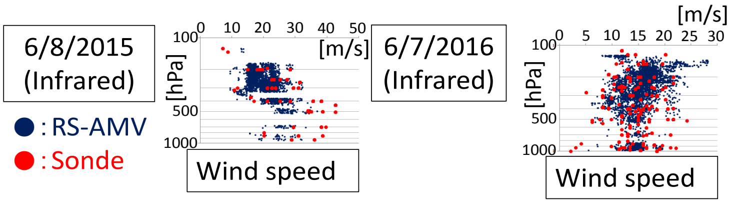

Figure 2: Wind speed vertical distributions of RS-AMVs for typhoons and wind sonde observation at 1104 UTC for August 6 2015 (Soudelor) and July 6 2016 (Nepartak)

Table 1. Results of typhoon RS-AMV validation against sonde winds and wind forecasts in five case studies. Bxx: Himawari-8 band number; ME: mean error of wind speed [m/s]; RMSVD: root mean square wind vector difference [m/s]; HL: 10 – 400 [hPa], ML: 400 – 700 [hPa], LL: 700 – 1,000 [hPa].

YYYYMMDDHH (Typhoon name)		2015080612 (Soudelor)		2015082000 (Goni)		2015092700 (Dujuan)		2016070612 (Nepartak)		2016092600 (Megi)	
Vs. Forecast		ME	RMSVD	ME	RMSVD	ME	RMSVD	ME	RMSVD	ME	RMSVD
B13 AMV (Infrared)	HL	0.33	6.69	0.04	6.16	-0.01	6.00	0.29	3.80	-0.46	5.74
	ML	-2.42	6.83	0.12	6.51	-1.13	4.44	0.27	2.99	-0.23	3.47
	LL	-1.10	4.83	0.00	3.49	0.38	4.02	-1.14	3.65	-0.18	3.21
Vs. Sonde		ME	RMSVD	ME	RMSVD	ME	RMSVD	ME	RMSVD	ME	RMSVD
ALL AMV (B03-B16)	HL	-5.03	11.28	-6.77	10.98	-1.49	6.89	0.63	5.53	-1.82	7.68
	ML	-4.17	10.14	-8.65	16.12	-2.55	7.11	-0.50	6.03	-4.46	7.86
	LL	-2.37	7.45	2.72	9.05	-1.36	6.70	0.58	5.01	0.14	6.58

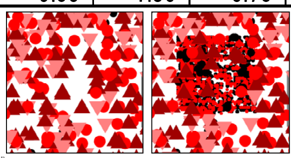

Figure 3: AMV data coverage after QC around Typhoon Nepartak in CNTL (left) and TEST (right) for 06 UTC on July 4 2016

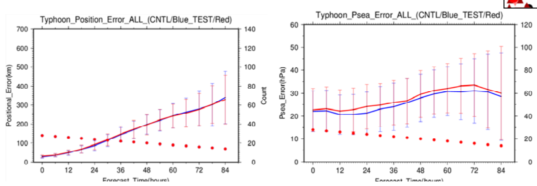

Figure 4: Average track forecast errors for Typhoon Nepartak (left) and intensity forecast errors (sea level pressure; right). The red line shows TEST values, the blue line shows CNTL values, and red dots show sample data numbers. Error bars represent a 95% confidence interval.

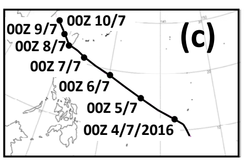
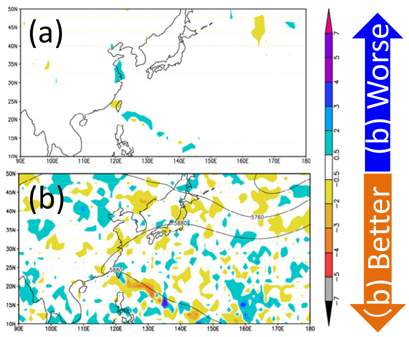

Figure 5: Mean error differences (a) and normalized root mean square error differences (b) between TEST and CNTL for 12-hour forecast lead times at 500-hPa geopotential height. (c) Typhoon Nepartak BST track.