CGMS-XXXIII JMA-WP-13
Prepared by JMA
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Discussed in WG II

Status of Atmospheric Motion Vectors

This paper reports on updated features of MSC's AMV product in association with transition of operational satellite from NOAA's GOES-9 to MTSAT-1R.

Status of Atmospheric Motion Vectors

With the commencement of formal operation of MTSAT-1R, JMA increased the number of observation. Hourly half-disk observations have been added to the conventional GMS-5's schedule which was only capable of hourly full-disk observations. While the interval of deriving Atmospheric Motion Vectors (AMVs) remains the same as that of GOES-9, the interval of successive observations used for deriving respective AMV was reduced from 30 to 15 minutes. Moreover, the updated observation schedule enables MSC to provide NWP Division of JMA with hourly AMVs in the northern hemisphere for the improvement of numerical weather forecasting. This paper briefly describes the updated features of AMVs along with replacement of the JMA operational satellite. In section 1, initial evaluation of 6-hourly MTSAT-1R AMV product is reported with the updated features. In section 2, introduction of hourly AMVs as a new MTSAT-1R product is described with the initial product evaluation.

1. Initial evaluation of 6-hourly MTSAT-1R AMVs

For the 6-hourly AMV products of both GOES-9 and MTSAT-1R, infrared 1 (IR1), water vapor (WV), and visible (VIS) channels are used. The corresponding wavelengths are 11μm, 6.7μm and 0.63μm, respectively. AMVs are calculated at grid points arrayed at 0.5 degree latitude/longitude intervals, and all the AMVs with Quality Indicator (QI) greater than 0.5 are disseminated in BUFR format, and ones with QI greater than 0.85, thinned to be at 1 degree intervals, are disseminated in SATOB format, to users worldwide via the Global Telecommunication System (GTS).

While GOES-9 or GMS-5 observations for derivation of AMVs were two full disk images of 30-minute interval, MTSAT-1R observes not only full-disk but also half-disk images for AMVs. Figure 1 shows a fraction of MTSAT-1R observation schedule at 06UTC. In addition to the conventional hourly full-disk observation indicated with red background, two half-disk images of the northern hemisphere prior to the full-disk observation are observed (indicated with blue lettering on pink background). For the southern hemisphere AMVs, two half-disk images indicated with pink background are obtained after the full-disk observation. The time intervals of these successive observations of the northern and southern hemispheres are both about 15 minutes. It is expected that these more frequently observed images possibly increase the number of AMVs without the algorithm update from GOES-9.

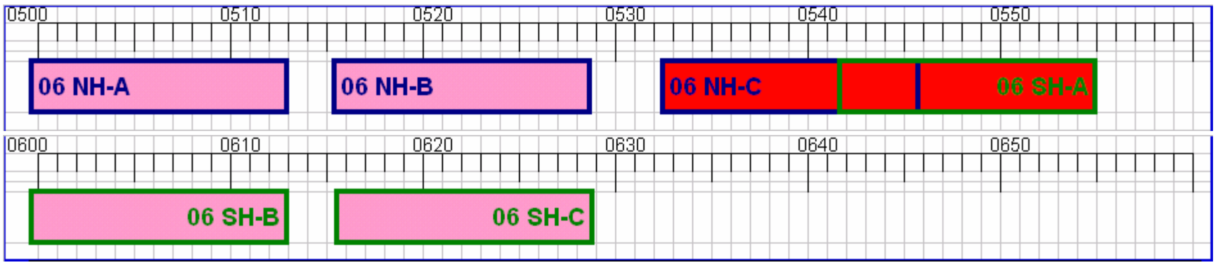


Figure 1 MTSAT-1R observation schedule for 06 UTC AMV calculation
06 NH-A, B, C: images used for the northern hemisphere AMV
06 SH-A, B, C: images used for the southern hemisphere AMV
(NH and SH stand for the northern hemisphere and the southern hemisphere, respectively. A, B and C are assigned for convenience.)

MTSAT-1R AMVs were evaluated for the initial operational period from 15 July to 28 August 2005. The mean numbers of the computed vectors per derivation from MTSAT-1R and GOES-9 were 33692.6 and 27071.3, respectively. The QI of the product is defined for each individual vector based on the properties of the vector itself and its consistency with other AMVs in the vicinity.

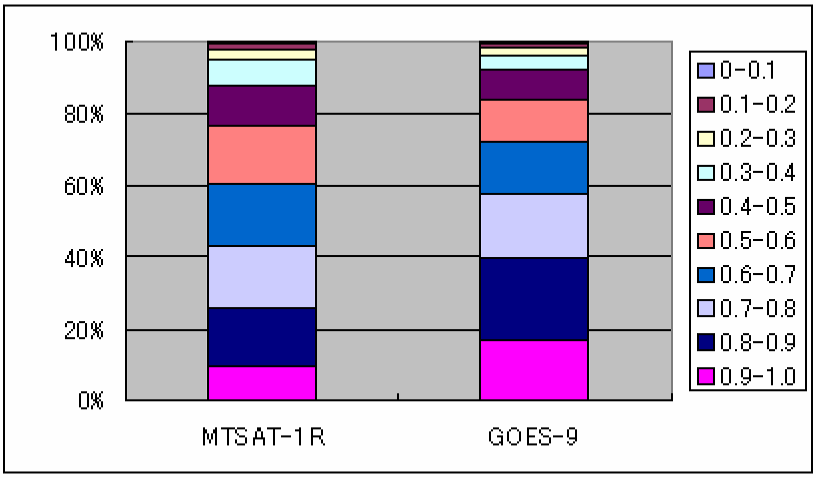


Figure 2 The distribution of derived AMV numbers grouped by QI magnitudes for MTSAT-1R (6-hourly) and GOES-9.

Figure 2 illustrates the distribution of AMVs grouped by their QI magnitudes. The percentage of MTSAT-1R AMVs with QIs greater than 0.9 is 9.4%, while that of GOES-9 AMVs is 16.9%, i.e. the rate of AMVs with significantly high QI derived from MTSAT-1R is smaller than that of GOES-9. This may have resulted from navigation problem and shortened time interval between successive observations for AMV.

Table 1 shows the mean of number of AMVs with QIs greater than 0.85 for the two satellites which are categorized by the channel and the region. The results show that the number of derived vectors on VIS images of MTSAT-1R is larger than that of GOES-9 in each region.

	GOES-9				MTSAT-1R (6-hourly)			
	ALL	NH	TROP	SH	ALL	NH	TROP	SH
IR1	2651.5	772.8	889.1	989.5	1733.5	456.1	591.4	686.0
VIS	890.2	173.2	211.3	505.8	1262.7	185.0	373.4	704.3
WV	2778.7	973.3	935.0	870.4	1995.1	687.5	643.4	664.1

Table 1 Mean derived vector number per derivation of AMVs with QIs greater than 0.85 for GOES-9 and MTSAT-1R (6-hourly) categorized by the channel and the region.

As a supplement to the above MTSAT-1R AMV product evaluation in the initial period, AMVs derived from MTSAT-1R and GOES-9 are compared to the winds observed by rawinsonde (RAOB) within the overlapped coverage. In this comparison, only the AMVs disseminated as SATOB messages are compared. Following the standard CGMS quality statistics, vector difference (VD) between the corresponding AMV and RAOB, and deviation of AMV speed against RAOB speed at the assigned AMV height (BIAS) are studied. The results are shown in the Figure 3 and 4. No discrimination by the observation channel is applied in this comparison. The BIASes are grouped into two half-disk observations: the northern and southern hemispheres.

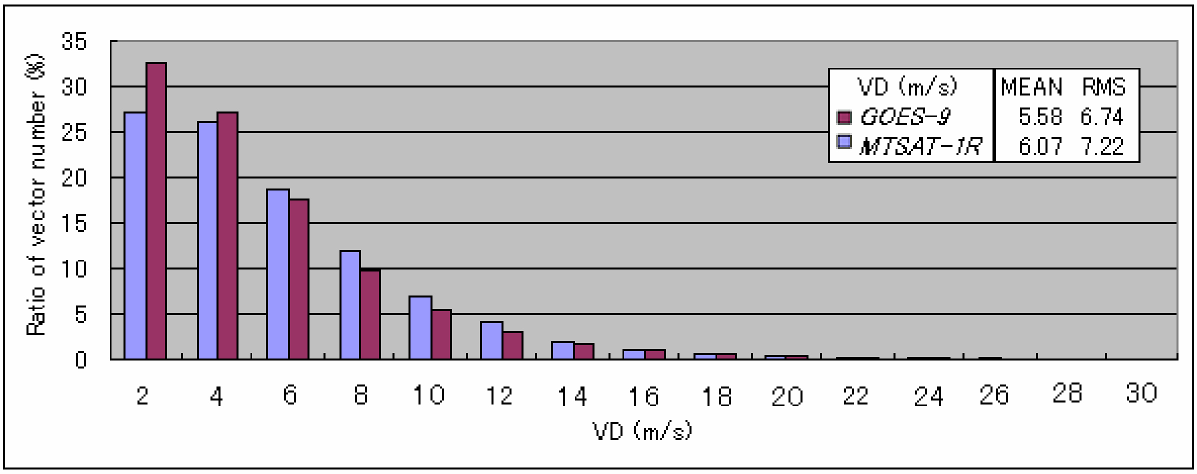
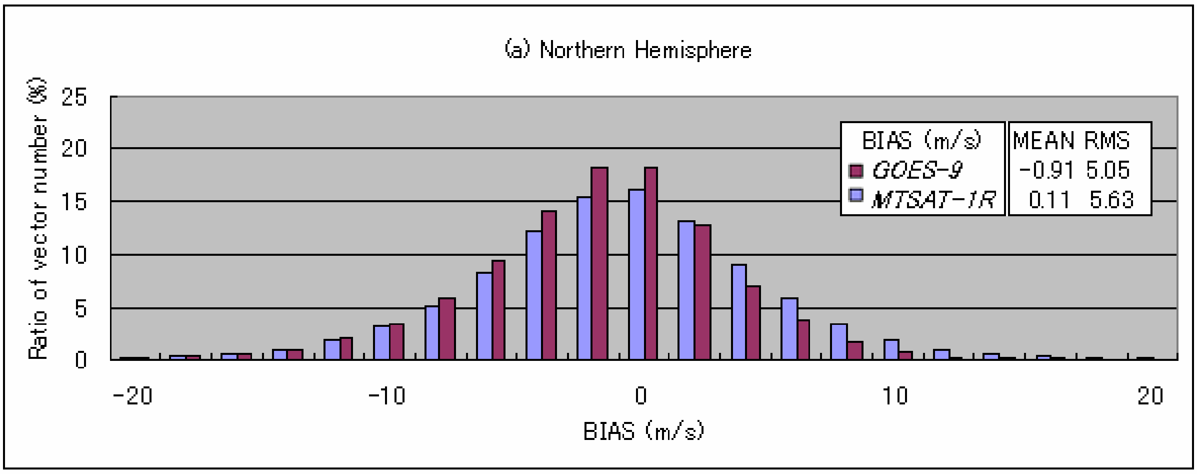


Figure 3 Comparisons of wind observations by rawinsonde and AMVs within the overlapping observed region. Frequency distribution of AMV's vector difference (VD) is plotted. MEAN denotes mean VD (MVD), and RMS denotes root-mean-square VD.

The percentage of derived MTSAT-1R AMVs with VDs less than 4 m/s is less than that of GOES-9, while those AMVs are major part of all observations. Mean vector differences (MVD) for GOES-9 and MTSAT-1R are 5.58m/s and 6.07m/s, respectively, implying that the quality of MTSAT-1R AMVs is slightly worse than that of GOES-9. The result of comparison with respect to the root-mean-square VD (RMSVD) is similar to that of MVD. Note that AMVs with QI greater than 0.85 are considered.



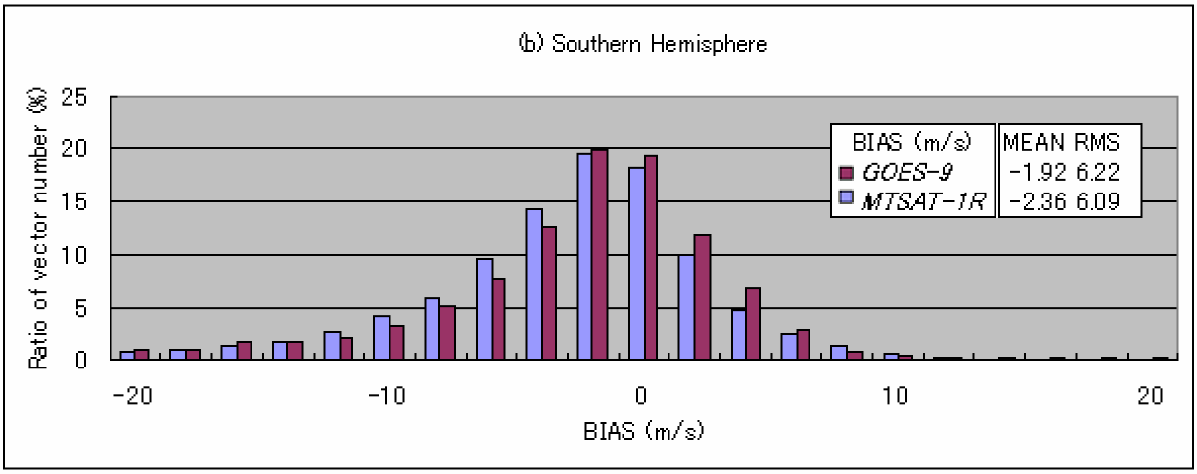


Figure 4 Comparisons of wind observations by rawinsonde and AMVs within the overlapping observed region. Frequency distribution of AMV deviation of AMV wind speed from the RAOB speed at the assigned AMV height (BIAS) is plotted. MEAN denotes mean BIAS and RMS denotes root-mean-square BIAS.

In the northern hemisphere, mean BIASes of GOES-9 and MTSAT-1R are -0.91 m/s and 0.11 m/s, respectively. It implies that the derived MTSAT-1R AMVs are generally greater than those of GOES-9. In the southern hemisphere, the mean BIASes are greater than those of the northern hemisphere. The mean BIASes for GOES-9 and MTSAT-1R in the southern hemisphere are -1.92 m/s and -2.36 m/s, respectively, i.e. GOES-9 AMVs tend to be greater than those of MTSAT-1R. Although further investigation is necessary to specify the causes of the difference between the two hemispheres, MTSAT-1R's navigation problem may have caused the contrastive results.

2. Hourly MTSAT-1R AMVs

An algorithm for hourly MTSAT-1R AMVs is the same as that for the 6-hourly MTSAT-1R AMV. The difference is that the former coverage is limited to the northern hemisphere, and that its time interval between used images is longer (30 or 60 minutes). Figure 5 shows a partial daily observation schedule including a sequence of successive images for derivation of the hourly product.

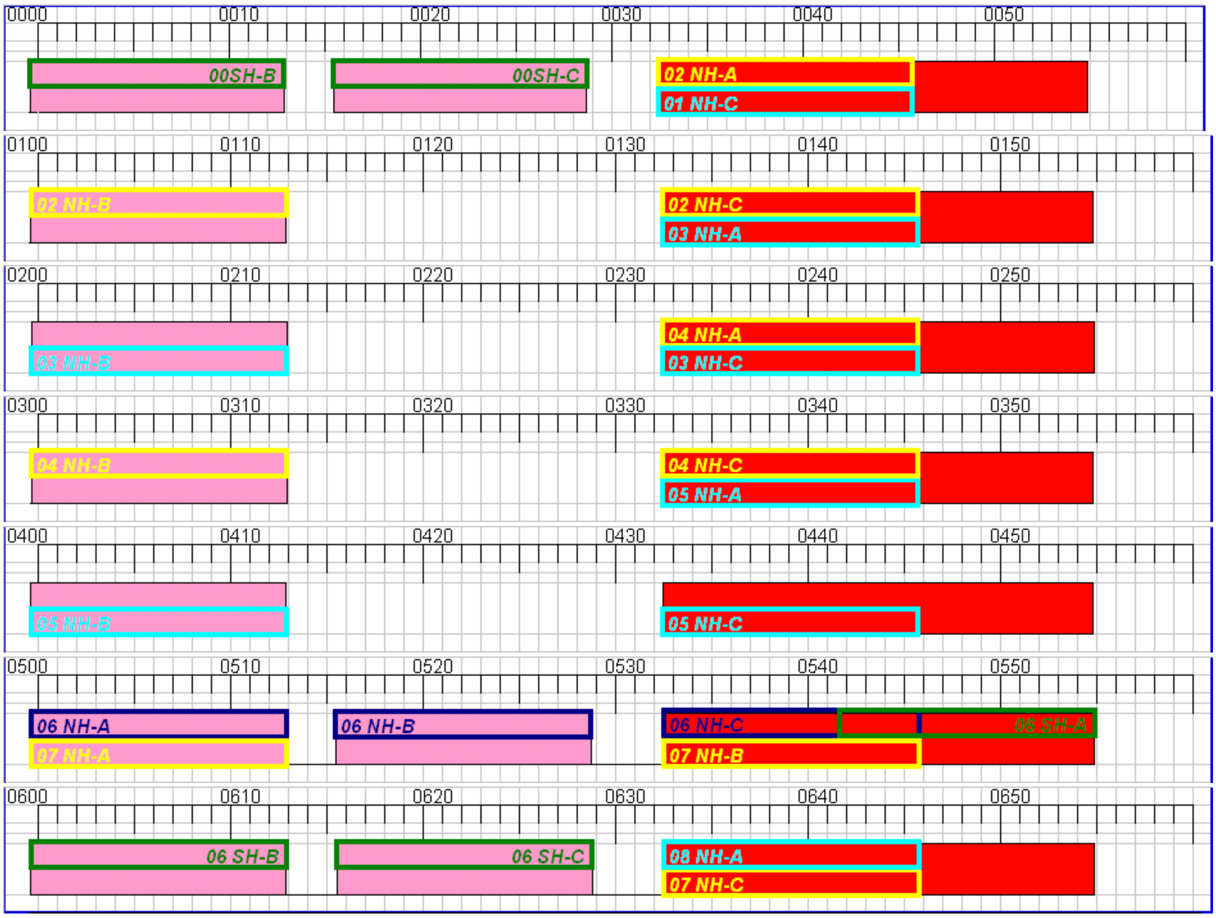


Figure 5 MTSAT-1R observation schedule from 00 to 07 UTC. Intervals of successive images for the hourly product are 30 minutes from 02 to 05 UTC, and 60 minutes for 01 and 07 UTC.

hh NH-A, B, C: images used for the northern hemisphere AMV at *hh* UTC
hh SH-A, B, C: images used for the southern hemisphere AMV at *hh* UTC
(NH and SH stand for the northern and southern hemisphere. A, B and C are assigned for convenience.)

The hourly AMV product was evaluated for the initial operational period from 15

July to 28 August in the same ways as the 6-hourly AMVs. Mean numbers of AMVs per derivation for 30- and 60-minute intervals were 16539.3 and 10393.4, respectively. These numbers are less than the mean number (19997.4) of 6-hourly AMVs using successive images of 15-minute interval. Figure 6 shows the distribution of AMVs grouped by their QI magnitudes for the 15-, 30-, and 60-minute time intervals, respectively. Percentage of the AMVs with QIs greater than 0.9 of the 15-, 30- and 60-minute time AMVs are 9.0%, 10.9% and 12.2%, respectively. AMVs using successive images of longer time interval contain more vectors with greater QI. This tendency is consistent with the result discussed in section 1. Table 2 shows the mean MTSAT-1R AMVs with QIs greater than 0.85 for each time interval. The results are shown by channels. There is no apparent relationship between the mean numbers and the time intervals of successive observations in the table.

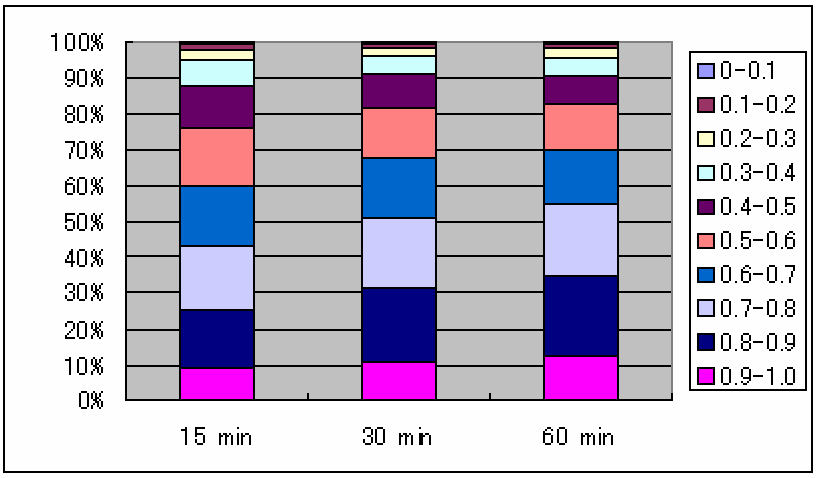


Figure 6 The distribution of derived MTSAT-1R AMVs grouped by their QI magnitudes for each time interval

	15 min	30 min	60 min
IR1	819.7	1202.4	838.2
VIS	315.7	112.5	116.4
WV	1198.1	1618.3	1119.0

Table 2 Mean derived vector number per calculation of AMVs with QI greater than 0.85 for MTSAT-1R for 15-, 30- and 60-minute interval

Moreover, for the initial evaluation, hourly AMVs are compared to the observation data of JMA's Wind Profiler (WP). Figure 7 shows the WP locations used for the comparison. Figure 8 shows the statistical results using the 6-hourly product study in section 1: VD and BIAS against WP data are plotted for the 15-, 30-, and 60-minute observation intervals. No discrimination by the observation channel is applied to this statistics.

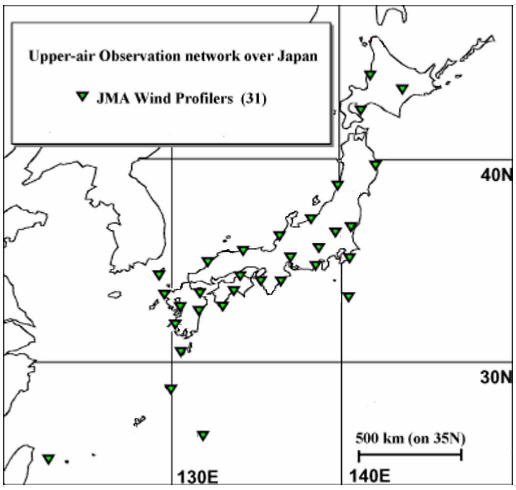
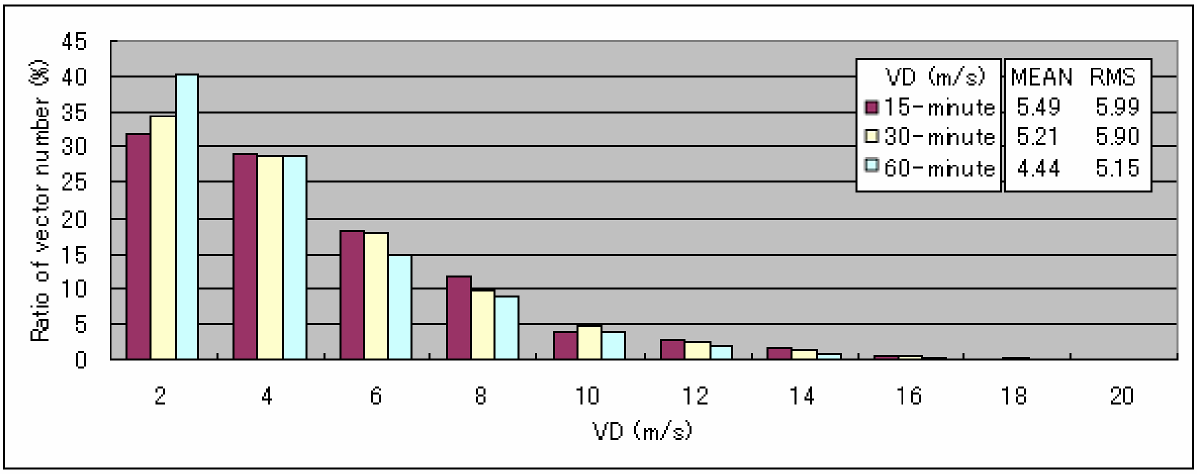


Figure 7　Locations of Wind Profilers used for the evaluation



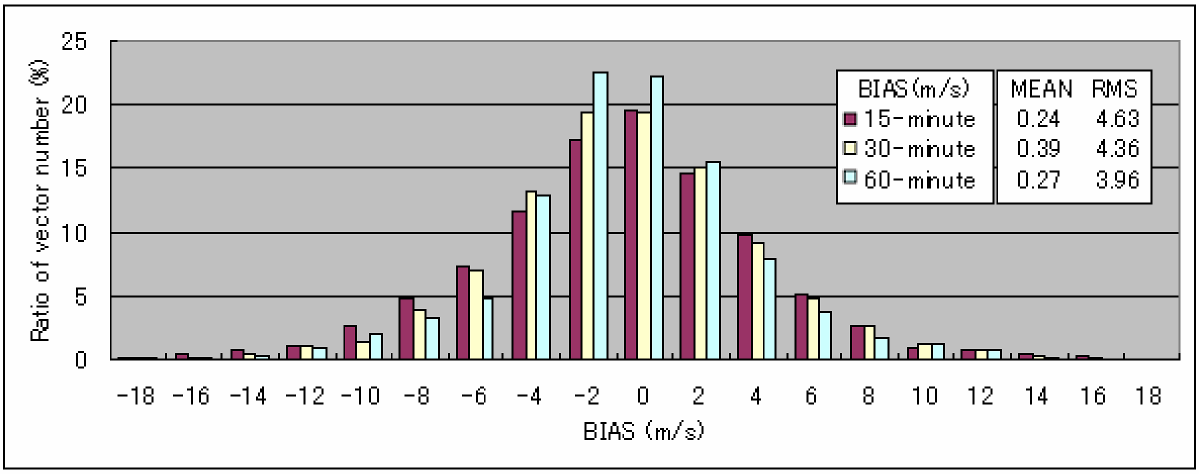


Figure 8　Comparisons of wind observations by WPs and AMVs in the vicinity of Japan. Vector difference (VD), deviation of AMV wind speed from the WP speed at AMV assigned height (BIAS) are plotted to show frequency distribution.　MEAN and RMS denotes mean and root-mean-square of each value.

In the results of VD distributions, the percentage of vector number in the smallest VD (2m/s) shows the largest proportions as expected, and the percentage of the 15-minute time interval is less than the others in the above VD. In the results of BIAS distributions, hourly (30- and 60-minute time interval) are more concentrated in the vicinity of respective mean value than that of 6-hourly (15-minute time interval), while significant difference is not recognized in those mean BIASes. Root-mean-squares of BIAS of the hourly (30- and 60-minute time interval) are also smaller than that of 6-hourly (15-minute time interval). The hourly AMVs (30- and 60-minute time interval AMVs) have more vectors with small VD and BIAS than the 6-hourly AMVs (15-minute time interval AMVs). These mean hourly AMVs have better quality than 6-hourly AMVs.

3. Summary

Evaluations of MTSAT-1R 6-hourly and hourly AMVs are performed for an initial operational period. The results show that:

1) The MTSAT-1R qualities of 6-hourly AMVs are slightly worse than those of GOES-9, but the derived number of AMVs is increased. The mean BIASes for MTSAT-1R and GOES-9 show contrastive characteristics between the northern and the southern hemispheres.
2) The hourly MTSAT-1R AMV product has better quality than the 6-hourly product, while the derived vector numbers per derivation are decreased.

JMA will continue evaluating MTSAT-1R AMVs during the on-going tune-up of MTSAT-1R and report to the CGMS members in due course.

In addition to the current AMVs using three channels of MTSAT-1R, it is planned to introduce an additional infrared channel with wavelength 3.7 μm (IR4) for the AMV product at nighttime in the future.