CGMS-35, JMA-WP-06
Prepared by JMA
Agenda Item: II/5
Discussed in WG II

JMA'S ATMOSPHERIC MOTION VECTOR PRODUCTS

In response to CGMS Action 34.22 and Recommendation 34.15

This working paper reports on the status of Atmospheric Motion Vector (AMV) products generated by JMA.

JMA generates three types of AMV associated with three MTSAT-1R channels, IR, WV and VIS. JMA generates and delivers AMVs for full disk via GTS every six hours at 00, 06, 12 and 18 UTC. In addition, JMA also generates AMVs over the Northern Hemisphere for use in its NWP system.

To mitigate a slow wind speed bias, a new height assignment scheme was introduced at 06 UTC on 30 May 2007.

In response to Recommendation 34.15, JMA generated AMVs from METEOSAT-8 images using its own algorithm and sent them to the CGMS study coordination team.

For further AMV improvement, JMA is currently examining another height assignment scheme, and also plans to generate AMVs from MTSAT-1R 3.8 μm images.

JMA'S ATMOSPHERIC MOTION VECTOR PRODUCTS

1 INTRODUCTION

The Meteorological Satellite Center (MSC) of the Japan Meteorological Agency (JMA) has been producing Atmospheric Motion Vectors (AMVs) since 1978. As reported in working paper JMA-WP-10 of CGMS-34, JMA has been using MTSAT-1R images for the calculation of AMVs since 15 July 2005 following the utilization of GMS-5 and GOES-9 images.

The three types of AMV produced by JMA are associated with the following three MTSAT-1R image channels: Infrared window (IR: 11 μm), Water Vapor (WV: 6.7 μm) and Visible (VIS: 0.63 μm) (referred to below as *IR AMV*, *WV AMV* and *VIS AMV* respectively).

JMA generates AMVs for full disk every six hours at 00, 06, 12 and 18 UTC from three successive images with an interval of 15 minutes, and distributes them via the Global Telecommunication System (GTS) in Binary Universal Form for data Representation (BUFR) format (i.e. six-hourly AMVs). In addition, JMA generates AMVs over the Northern Hemisphere every hour between the six-hourly AMVs from images with an interval of 30 or 60 minutes (i.e. hourly AMVs). These hourly AMVs are currently used in JMA's Numerical Weather Prediction (NWP) system. Table 1 shows an outline of the MTSAT-1R AMVs.

Table 1: MTSAT-1R Atmospheric Motion Vector products generated by JMA

Wind Product	Time (UTC)	Image sector	Level of Height	Image interval (minutes)	Distribution
Infrared (11μm)	00, 06, 12, 18	Full Disk	Upper, middle, lower	15	BUFR via GTS (SATOB[*1])
	02-05, 08-11, 14-17, 20-23	Northern Hemisphere	Upper, middle, lower	30	Internal use only
	01,07,13,19	Northern Hemisphere	Upper, middle, lower	60	Internal use only
Water Vapor (6.7μm)	00, 06, 12, 18	Full Disk	Upper, middle	15	BUFR via GTS (SATOB[*1])
	02-05, 08-11, 14-17, 20-23	Northern Hemisphere	Upper, middle	30	Internal use only
	01, 07, 13, 19	Northern Hemisphere	Upper, middle	60	Internal use only
Visible (daytime)	00, 06	Full Disk	Lower	15	BUFR via GTS (SATOB[*1])
	02-05, 08, 09 21-23	Northern Hemisphere	Lower	30	Internal use only
	01, 07	Northern Hemisphere	Lower	60	Internal use only

*1 JMA stopped disseminating SATOB to users via GTS at 06 UTC on 30 May 2007 other than to except some specific users.

2 STATUS OF MTSAT-1R AMVs

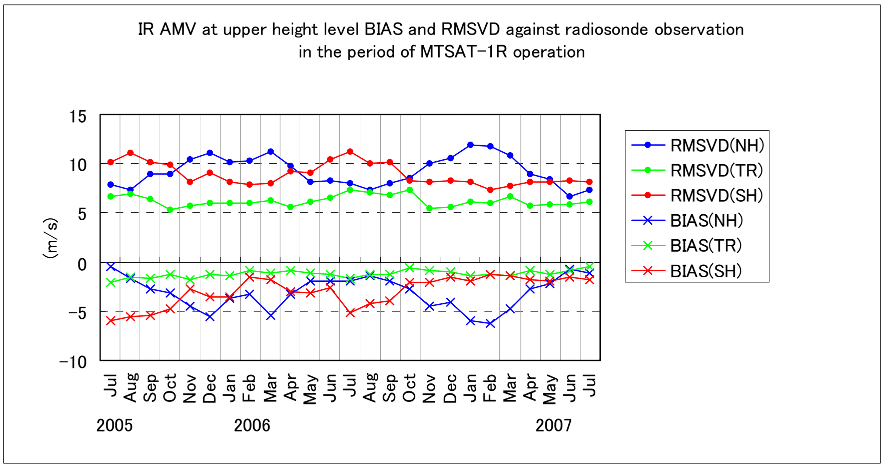
Six-hourly AMVs

This section describes the quality of the six-hourly IR and WV AMVs over the past two years based on the standard CGMS AMV statistics, focusing on the time variation.

Figure 1 (a) shows a time series of monthly statistics (Root Mean Square Vector Difference (RMSVD) and wind speed bias (BIAS)) for upper and middle troposphere IR AMVs with reference to radiosonde observations. For comparison, AMVs with Quality Indicators (QIs) above 0.85 are used. The results show that RMSVDs and BIASes are large in winter for both the Northern and Southern Hemispheres up to 11 to 12 m/s and -4 to -6 m/s respectively. Compared to 2005 and 2006, RMSVDs and BIASes decreased considerably over the winter (Southern) hemisphere in June and July 2007 after the new height assignment scheme was introduced on 30 May 2007. An outline of this new height assignment scheme is given in Section 3.

Figure 1 (b) shows a time series of monthly statistics for upper and middle troposphere WV AMVs. RMSVDs are also around 10 m/s in the winter hemisphere. Slow BIASes in winter are smaller than those of the IR AMVs, while small fast BIASes are seen in the summer hemisphere.

(a)



(b)

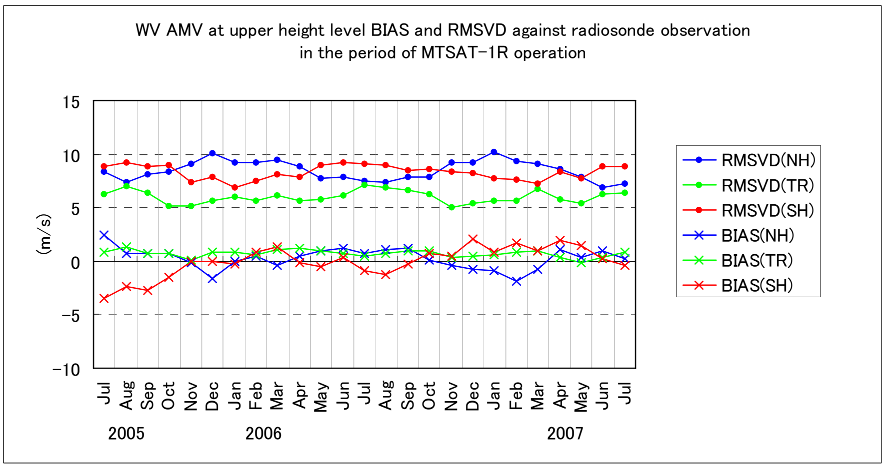


Figure 1: Long-term time series of RMSVDs and BIASes for (a) IR AMVs and (b) WV AMVs at upper height level over the Northern Hemisphere (blue), the Southern Hemisphere (red) and the Tropics (green). NH, TR and SH stand for Northern Hemisphere (20°N-50°N), Tropics (20°S-20°N) and Southern Hemisphere (50°S-20°S) respectively.

Hourly AMVs

This section describes the quality of the hourly AMVs based on the standard CGMS AMV statistics, including those at 00, 06, 12 and 18 UTC, from the viewpoint of dependency on the difference in intervals between the images used to derive the AMVs.

To evaluate the quality of the hourly AMVs, they are compared with observational data from JMA's wind profilers, whose locations are shown in Figure 2. Thirty-one wind profilers are installed throughout Japan.

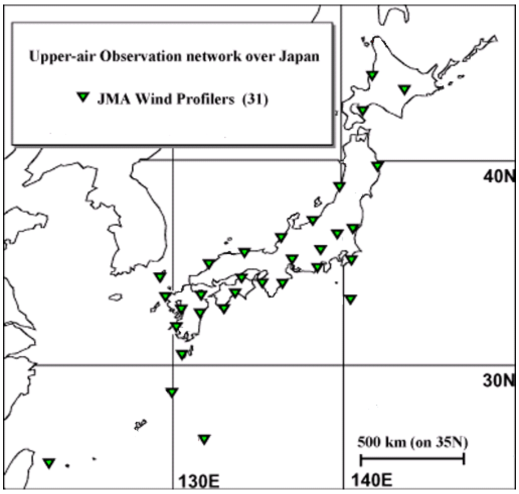


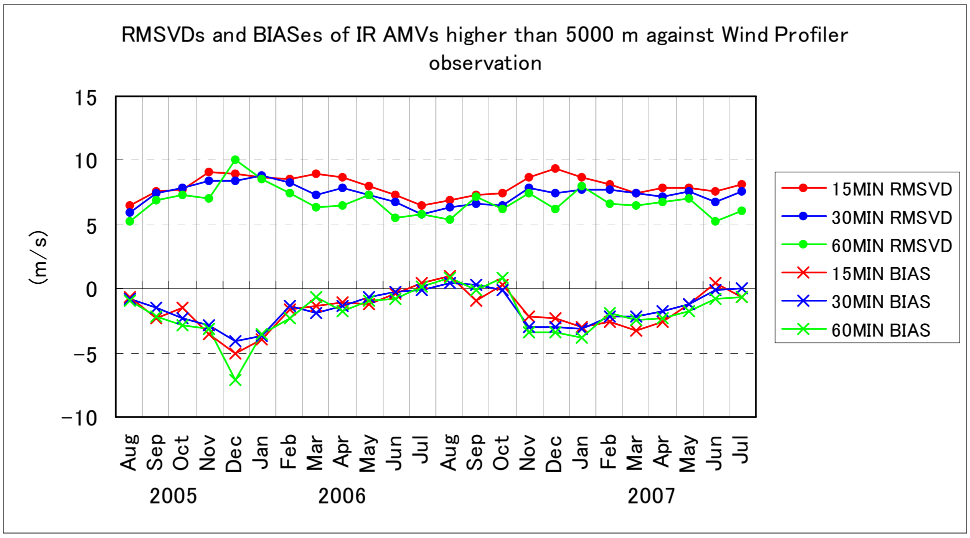
Figure 2 JMA wind profiler network

Figure 3 shows a time series of monthly statistics (RMSVDs and BIASes) from the hourly IR AMVs (QI > 0.85) in the upper and middle troposphere (higher than 5,000 m) with reference to wind profiler observations. The red lines represent statistics from the six-hourly AMVs using images with intervals of 15 minutes (referred to below as *15-min AMVs*), the blue lines represent those from the hourly AMVs using images with intervals of 30 minutes (*30-min AMVs*), and the green lines represent those of the hourly AMVs using images with intervals of 60 minutes (*60-min AMVs*).

The RMSVDs of the 15-min AMVs are the largest, while those of the 60-min AMVs are the smallest. However, the differences between the 15-, 30- and 60-min AMVs are very small. The number of 15-min AMVs is larger than those of the 60-min and 30-min AMVs.

Slow BIASes, which are recognized in the winter hemisphere, are expected to decrease in the coming winter due to the introduction of the new height assignment scheme in May 2007.

(a)



(b)

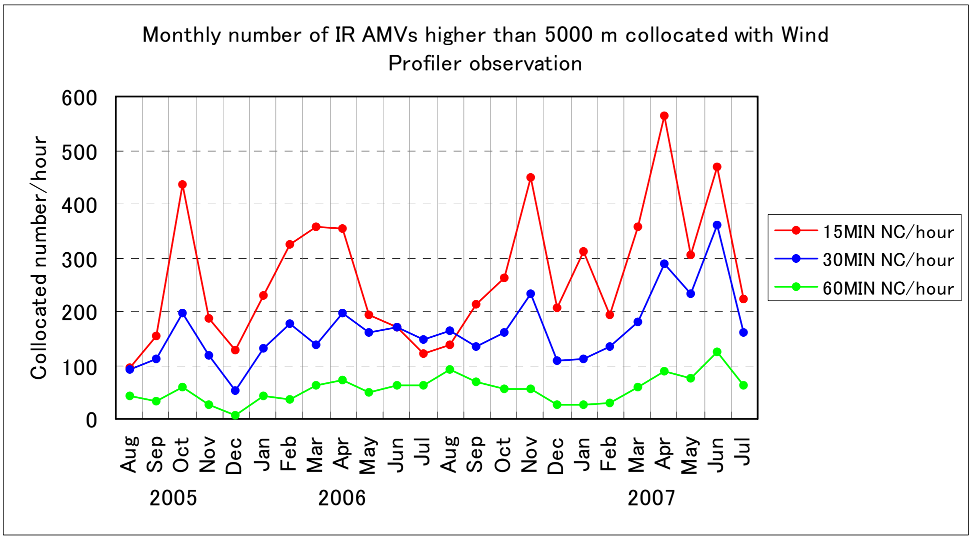


Figure 3: Time series of monthly statistics from IR AMVs over the upper and middle troposphere (higher than 5,000 m) with reference to wind profiler observations. Figure (a) shows RMSVDs and BIASes, while (b) shows the average numbers figures for collocated AMVs per hour. AMVs with QIs above 0.85 are used for these statistics.

3 OUTLINE OF THE NEW AMV DERIVATION SCHEME

The new AMV derivation scheme has been in operation since 06 UTC on 30 May 2007. The purpose of the implementation is to resolve the slow BIASes of the IR AMVs, particularly in the winter hemisphere (as mentioned in Section 2). This problem is mainly due to the inappropriate height assignment of semi-transparent cloud. In the new scheme, the height assignment method has been revised as described below.

1) Improvement of height correction procedure for semi-transparent cloud:

The H2O-IRW intercept method has been utilized by the MSC of JMA to calculate the height of semi-transparent cloud within the image segment of 32 pixels by 32 lines used for tracking process. In the calculation process, the height is estimated by referring to the profile of WV and IR radiances from opaque clouds, which are simulated using a Radiative Transfer Model (RTM) and forecast profiles of temperature and humidity. In the previous AMV derivation scheme, the profile of simulated radiances from opaque clouds was used without modification in the H2O-IRW method. With the new AMV derivation scheme, the value is corrected using the observed radiances, and is then used as a profile for reference in the H2O-IRW method. The correction value for each cloud height level is decided on the basis of the difference between the Clear Sky Radiance (CSR) product (which is theoretically equivalent to the surface radiance of opaque cloud) and the surface radiance, which is estimated using a two-dimensional histogram of the observed IR and WV radiances.

2) Use of the most frequent cloud height level:

Respective AMV is newly allocated to the most frequent cloud height level instead of the highest cloud height level within the image segment.

Table 3 shows the accuracy of the IR AMVs (QI > 0.85) generated under the new and previous schemes. The statistics are computed with reference to radiosonde data. The statistical period spans nearly one month, running from 00 UTC on 1 May to 18 UTC on 29 May 2007. The RMSVDs and BIASes of the new AMVs are apparently smaller than those of the previous AMVs. The number of new AMVs is approximately equal to or larger than those of the previous AMVs. There is a large increase in the middle troposphere (700 hPa to 400 hPa) in particular.

Table 3: Statistical comparison of IR AMVs against sonde observations between the new and previous schemes: (a) at upper height level (100 - 400 hPa) and (b) at middle height level (400 - 700 hPa). NH, TR and SH stand for Northern Hemisphere (20°N-50°N), Tropics (20°S-20°N) and Southern Hemisphere (50°S-20°S) respectively.

400 hPa <= height

AMV (QI>0.85) Statistics against sonde wind	NH (50N – 20N)		TR (20N – 20S)		SH (20S – 50S)	
	New	Previous	New	Previous	New	Previous
RMSVD (m/s)	7.39	8.50	5.11	5.96	7.29	8.40
BIAS (m/s)	−1.47	−2.22	−0.78	−1.20	−0.80	−2.11
Number	52377	53123	36913	29325	39672	39632

700 hPa < height < 400 hPa

AMV (QI>0.85) Statistics against sonde wind	NH (50N – 20N)		TR (20N – 20S)		SH (20S – 50S)	
	New	Previous	New	Previous	New	Previous
RMSVD (m/s)	6.36	7.50	3.84	4.56	6.41	7.43
BIAS (m/s)	−1.02	−1.20	−0.50	−1.74	−0.76	−1.68
Number	5854	3093	1669	840	8836	5962

Table 4 shows the accuracy of the WV AMVs over cloud regions (QI > 0.85) generated under the new and previous schemes. There is no significant difference in either the RMSVDs or BIASes between the two schemes. However, the number of WV AMVs under the new scheme is approximately twice as high as that under the previous scheme. This increase indicates the improved accuracy of the WV AMVs.

Figure 4 (a) shows the height dependencies of the BIASes and the number of IR AMVs under the previous scheme (QI > 0.85), while Figure 4 (b) shows the same values under the new scheme. The BIASes are computed with reference to NWP wind fields. The BIASes of the new AMVs at levels of 100-400 hPa are much smaller than those of the previous AMVs. Although fast BIASes have increased in the new AMVs at levels of 500-700 hPa, the number of AMVs at these levels is small.

Table 4: Statistical comparison of WV AMVs at upper height level (100 - 400 hPa) over cloudy regions against sonde observations between the new and previous schemes. NH, TR and SH stand for Northern Hemisphere (20°N-50°N), Tropics (20°S-20°N) and Southern Hemisphere (50°S-20°S) respectively.

400 hPa <= height

AMV (QI>0.85) Statistics against sonde wind	NH (50N – 20N)		TR (20N – 20S)		SH (20S – 50S)	
	New	Previous	New	Previous	New	Previous
RMSVD (m/s)	7.40	7.95	5.44	5.53	7.17	7.79
BIAS (m/s)	0.21	0.36	0.27	−0.06	1.17	1.25
Number	91495	56982	53801	18708	52777	27196

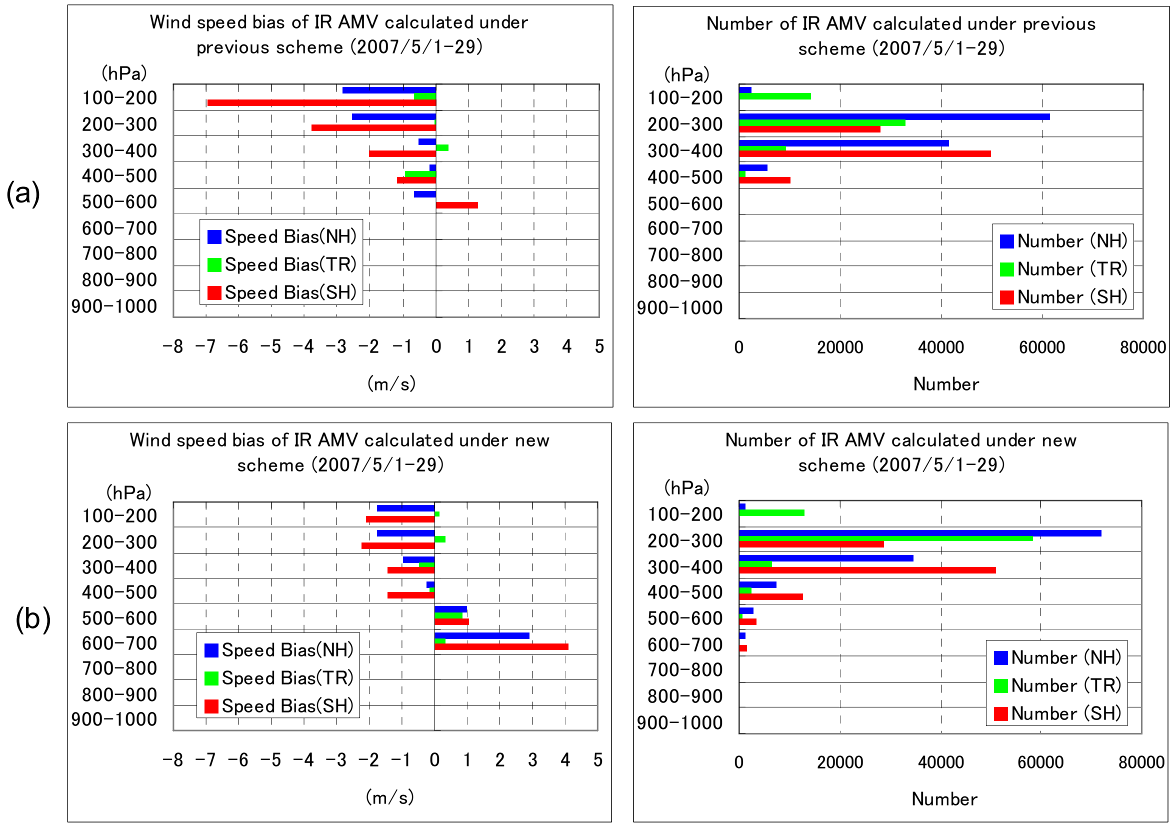


Figure 4: BIAS and number of AMVs with QIs above 0.85 calculated under (a) the previous scheme and (b) the new scheme against NWP at each height level. NH, TR and SH stand for Northern Hemisphere (20°N-50°N), Tropics (20°S-20°N) and Southern Hemisphere (50°S-20°S) respectively. The statistical period is from 00 UTC on 1 May 2007 through 18 UTC on 29 May 2007.

4 RESPONSE TO RECOMMENDATION 34.15

In response to Recommendation 34.15 on the comparison of operational algorithms for the height assignment of AMVs, JMA calculated AMVs from METEOSAT-8 0.8 μm, 10.8 μm and 6.7 μm images at 12:00, 12:15 and 12:30 UTC on 18 August 2006 using its own AMV algorithm. Table 5 shows the results of comparison between AMVs with QIs above 0.85 and JMA’s NWP wind fields. The BIASes and RMSVDs are comparable to those of MTSAT-1R AMVs. The AMV data were sent to the CGMS study coordination team for use in a study to compare the assigned height with cloud LIDAR observations.

Table 5: Statistics from AMVs calculated using METEOSAT-8 images against JMA NWP winds at 12 UTC on 18 August 2006. NH, TR and SH stand for Northern Hemisphere (20°N-50°N), Tropics (20°S-20°N) and Southern Hemisphere (50°S-20°S) respectively.

(a) IR AMVs at upper height level (above 400 hPa)

	NH (20N - 50N)	TR (20S - 20N)	SH (50S - 20S)
SPEED(m/s)	25.30	11.19	46.08
BIAS(m/s)	-2.36	-0.69	-2.50
RMSVD(m/s)	7.69	4.34	7.34
NUMBER	186	254	1180

(c) IR AMVs at lower height level (below 700 hPa)

	NH (20N - 50N)	TR (20S - 20N)	SH (50S - 20S)
SPEED(m/s)	8.07	8.45	13.63
BIAS(m/s)	-0.06	0.81	-0.40
RMSVD(m/s)	2.28	3.20	2.91
NUMBER	272	1185	1395

(b) WV AMVs at upper height level (above 400 hPa)

	NH (20N - 50N)	TR (20S - 20N)	SH (50S - 20S)
SPEED(m/s)	22.70	14.25	44.51
BIAS(m/s)	-1.64	0.39	-0.09
RMSVD(m/s)	6.24	5.05	7.46
NUMBER	638	874	2230

(d) VIS AMVs (below 700 hPa)

	NH (20N - 50N)	TR (20S - 20N)	SH (50S - 20S)
SPEED(m/s)	8.09	8.41	13.53
BIAS(m/s)	-0.04	0.87	-0.58
RMSVD(m/s)	2.30	3.24	2.95
NUMBER	515	1472	1516

5 FUTURE PLANS

JMA has two plans for further improvement of AMV quality. One is a new height assignment technique that is currently under examination. In this technique, only the heights of cloud pixels tracked in the retrieval of wind vectors are used for AMV height assignment. Also being examined is the computation of AMVs using images from the MTSAT-1R IR4 channel (3.8μm). Using IR4 images, low troposphere wind data are expected to increase at nighttime. Table 6 shows the statistics from IR4 AMVs (QI > 0.85) on a trial basis and the operational IR AMVs (QI > 0.85) in the low troposphere with reference to NWP wind fields. In the comparison, only AMVs at nighttime (at 12 and 18 UTC) are used. The number of IR4 AMVs increased by 10% compared to that of IR AMVs, while both RMSVDs and BIASes remained nearly the same. The results have been satisfactory so far, and JMA plans to start producing IR4 AMVs for its internal use in the near future.

Table 6: Monthly statistical comparison between IR4 and IR AMVs at lower height level (850 - 925 hPa) against NWP winds. The statistical period is April 2007. The statistics are taken for AMVs at 12 and 18 UTC. NH, TR and SH stand for Northern Hemisphere (20°N-50°N), Tropics (20°S-20°N) and Southern Hemisphere (50°S-20°S) respectively.

AMV(QI>0.85) statistics against NWP winds	NH (50N-20N)		TR(20N-20S)		SH(20S-50S)	
	IR4 AMV	IR AMV	IR4 AMV	IR AMV	IR4 AMV	IR AMV
RMSVD (m/s)	3.02	3.09	2.44	2.44	2.81	2.81
Wind speed BIAS (m/s)	0.01	0.00	-0.10	-0.22	0.15	0.16
Number	16347	15280	36119	31942	20846	19934