RENEWAL OF OPERATIONAL AMV EXTRACTION SYSTEM IN JMA

Ryoji Kumabe

Japan Meteorological Agency / Meteorological Satellite Center
3-235, Nakakiyoto Kiyose-shi, Tokyo 204-0012, Japan

ABSTRACT

The Group of Meteorological Satellite (CGMS) has been recommending the standardization of Atmospheric Motion Vector (AMV), the principle products from geostationary meteorological satellites, in terms of retrieval method, quality information and the format of dissemination.

The Meteorological Satellite Center of Japan Meteorological Agency (JMA/MSC) has developed a high density AMV retrieve and dissemination system to suffice the recommendation. MSC started operation of the system at 12 UTC 22 May 2003. The most significant alternation of the process from the previous AMV system is abolition of "manual quality control". The EUMETSAT QI and the UW-CIMSS RFF are used as quality control schemes. Accuracy of the high density AMVs is about the same levels as that of previous MSC's AMV which human operators had quality checked. The ranges of Root Mean Square Error (RMSE) are 6 to 7 m/s for upper-level vectors, 3 to 4 m/s for low-level vectors and 6 to 8 m/s for water vapor vectors. AMVs are reported in both SATOB and BUFR messages and the numbers of AMVs are increased significantly if a user gets and uses BUFR report.

The HD-AMV system could be established by accepting new idea and techniques introduced and explained in IWW meetings by other AMV producers. Further development on some parts of AMV algorithm such as height assignment and pattern matching which should lead to the improvement of the accuracy is underway.

1. INTRODUCTION

MSC has been producing Atmospheric Motion Vectors (AMVs) for visible, thermal infrared channels (from 1978) and water vapour channel (from 1995) of GMS series satellites. The outline of the AMV extraction system in MSC was reported at the third IWW (Tokuno: 1996). The procedure involves target cloud selection, automatic tracking of the targets, wind vector calculation, height assignment, and automatic/human quality control. These procedure components are basically similar to those in the AMV extraction systems at other AMV operators. However the human process at quality control in JMA couldn't afford to produce so many vectors as many of other AMV producers.

In the sixth IWW, JMA reported the status of developing High Density AMV (HD-AMV) extraction system (Tokuno et al: 2002) and the impact of the rapid scan AMVs on NWP model (Nakamura et. al: 2002) produced by the experimental HD-AMV system. The HD-AMV system in MSC was built by using the EUMETSAT QI and the UW-CIMSS RFF quality control (QC) schemes instead JMA develop its original method. At the workshop JMA showed those imported QC schemes works properly and the output of the HD-AMV system is efficient in numerical prediction.

JMA put the HD-AMV system in operation on 22 May 2003 at the same timing of the start of GOES-9 satellite operation over the western pacific region. The system configuration is briefly reviewed with some updating of the processes, and the accuracy and other properties of the operational HD-AMVs are reported in this document. Because of the clumsiness of handling GOES-9 data, the accuracy of AMVs from GOES-9 is a little worse than ones from GMS satellites and it is difficult to evaluate the efficacy of the process upgrading with GOES-9 driven AMVs. Therefore, the evaluation is done with the AMVs from GMS-5 data.

2. OUTLINE OF HD-AMV SYSTEM

Fig. 1 shows the diagrams of present HD-AMV and former AMV extraction systems in MSC. The major difference between two systems is QC. In the former system, quality was controlled by internal automatic QC just after the vector derivation, by external automatic QC with NWP data, and human QC with a man-machine computer visualise system. Present QC for HD-AMV is much simplified. Derived AMVs just go through the EUMETAT QI and the UW-CIMSS RFF QC processes.

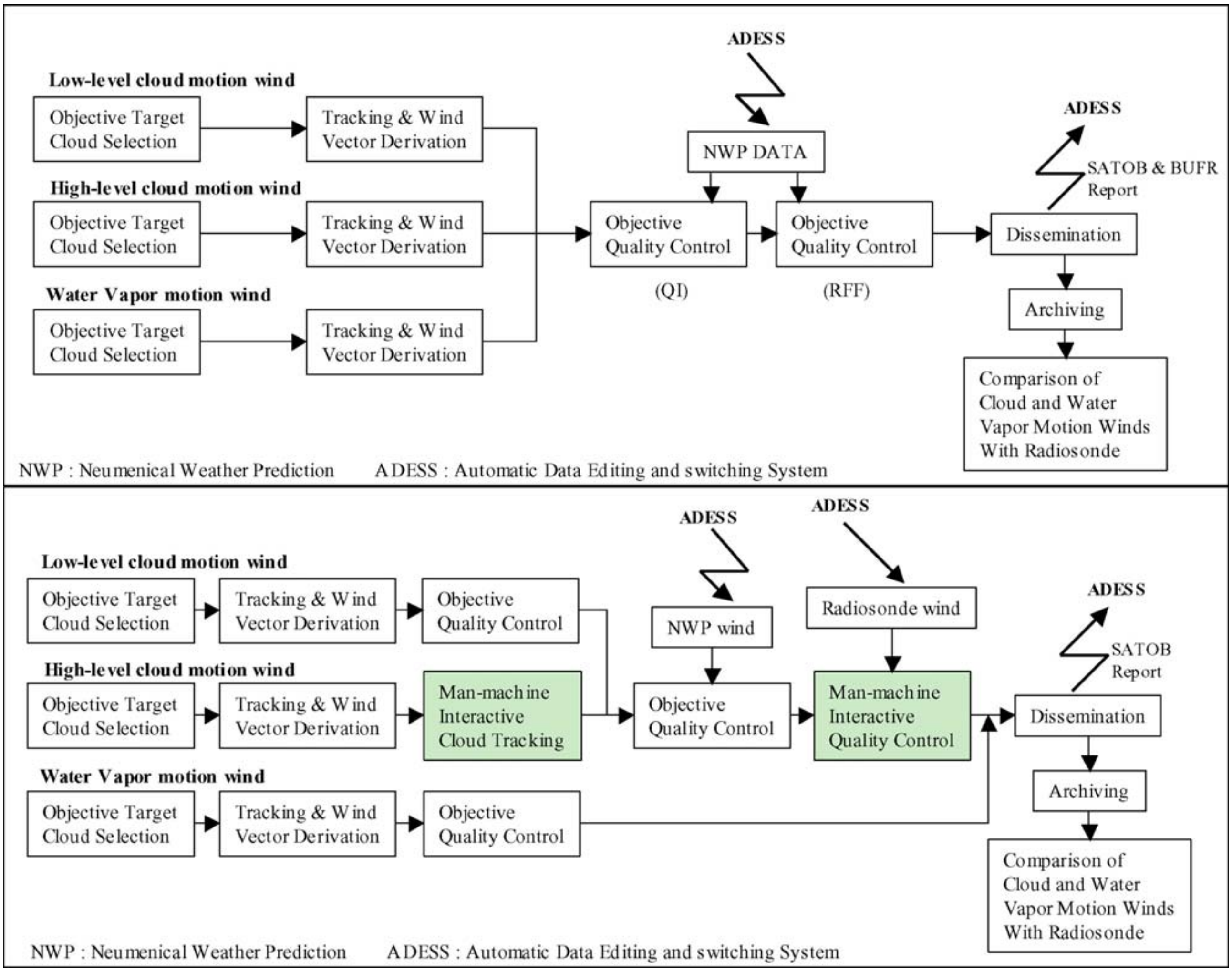

Figure 1. Diagrams of AMV system for HD-AMV (upper) and former AMV (bottom) systems.

Most of the computer programs of other parts are as same as former system, but they are configured that they can produce more wind vectors. The configurations are:

1) Grid distance for targets selection is set to 0.5 degree latitude/longitude distance form former 1 degree distance.
2) AMV extraction area is divided into 4 sub areas of NW, NE, SW, SE sectors and the calculations are done in parallel to reduce the processing time.

3) Water vapour (WV) AMVs are calculated not only for cloud area but also for clear sky. Height for a WV-AMV in clear sky is assigned based on a mean brightness temperature in the target area.
4) Height for a low-level AMV is assigned variably instead of fixed 850 hPa. The method is presented in Tokuno (1998).
5) AMVs are disseminated in BUFR format to GTS with QI and RFF information. SATOB reports are also sent. The AMVs in SATOB report are assorted from HD-AMVs to provide 1 degree interval AMVs with high QI value (QI of 0.85 and over) .

Height assignment for WV-AMV is processed in two steps. Heights of all WV-AMVs are assigned with the height assignment method for high-level IR-AMV. The WV-AMVs with a height higher than 400 hPa are supposed to be WV-AMVs in cloudy sky but ones with a height lower undergo a height assignment of clear sky WV-AMV, which is to assign a height inferred from an averaged brightness temperature of water vapor channel in a target region.

The new system was put into operation on 22 May 2004, when NOAA operated GOES-9 started the operational observation over the area of GMS-5 observation. Because the system is tailored to work with VISSR data taken by GMS series satellites, GVAR data from GOES-9 is coverted into VISSR format of GMS-5. In the conversion the spatial resolutions of 4km for IR channels and 1km for visible channel are filtered to be 5km and 1.25 km, and the bit digits are thinned to be 8 bits for IR channels and 6 bits for visible channel from original 10 bits. Further, JMA add Earth Edge Data Compilation (Kigawa: 1993) scheme to get a finer navigation for the satellite images before the conversion.

3. ACCURACY OF HD-AMV

Preliminary evaluation of the accuracy of HD-AMV was reported in Tokuno et. al (2002). The result was promising: the general relationship between QI values and quality indices such as RMSE, bias and vector numbers is similar to the result done at EUMETSAT (Holmlund: 1998), and the quality of the AMVs with high QI values more than a criteria of 0.85 is almost the same as that of the operational human QCed AMVs at that time.

However, it is difficult to show that present operational HD-AMV system produces AMVs with coherent quality, because JMA had to replace the system at the same timing with GOES-9 operation, and the quality of the image data is thought to be deteriorated by the process of the format conversion and the clumsiness of the navigation handling. The AMVs from GOES-9 were a little worse than those from GMS-5 from the comparison of the two kinds of AMVs process by the same system during the period of GOES-9 and GMS-5 parallel operation.

Firstly in this section the quality of AMVs disseminated in SATOB reports is shown. A comparison of both the quality and the number of AMVs between the year 2002 and 2003 is made for the period from June to December. AMVs are calculated at grid points arrayed at 0.5 degree latitude/longitude intervals and all the AMVs with QI > 0.3 are disseminated in BUFR messages, those thinned to be at 1 degree intervals and with QI > 0.85 are disseminated in SATOB messages. The results are shown in Fig. 2.

1) **Low level infrared vectors:** In 2002, bias is in the range from –0.9 m/s to +0.3 m/s, and RMSE is from 4.1 m/s to 5.3 m/s. In 2003, bias is in the range from –0.7 m/s to +0.1 m/s, and RMSE is from 3.1 m/s to 4.4 m/s.
2) **High level infrared vectors:** In 2002, bias is in the range from –3.4 m/s to –1.4 m/s, and RMSE is from 8.1 m/s to 9.2 m/s. In 2003, bias is in the range from –5.2 m/s to –2.3 m/s, and RMSE is from 8.4 m/s to 10.7 m/s.
3) **High level water vapour vectors:** In 2002, bias is in the range from –0.2 m/s to +0.9 m/s, and RMSE is from 8.4 m/s to 9.2 m/s. In 2003, bias is in the range from –1.8 m/s to –0.4 m/s, and RMSE is from 7.7 m/s to 8.9 m/s.

Quality is not very different between 2002 and 2003 for AMVs disseminated in SATOB messages, but it is slightly better in 2003 for low level infrared vectors and water vapour vectors, while it is slightly worse in 2003 for high level infrared vectors. Bias of water vapour vectors has become negative in 2003 from the positive in the previous year. High level water vapour vectors had been produced only in the cloudy area until April 2003. The change of the sign of water vapour vector bias might be related with that high density AMVs are produced in clear skies as well as in cloudy areas.

The number of AMVs disseminated in SATOB has decreased by about 20 % for water vapour and high level infrared vectors while the decrease in low level vectors are small as seen in Fig. 3. The number of AMVs in BUFR messages is 20 times for water vapour vectors and 15 times for visible and infrared vectors more than those in SATOB messages (Fig. 4).

JMA is producing AMVs in SATOB report with basically almost same quality but the number of the vectors is a little less. The AMVs in SATOB and a lot more vectors are contained In BUFR reports.

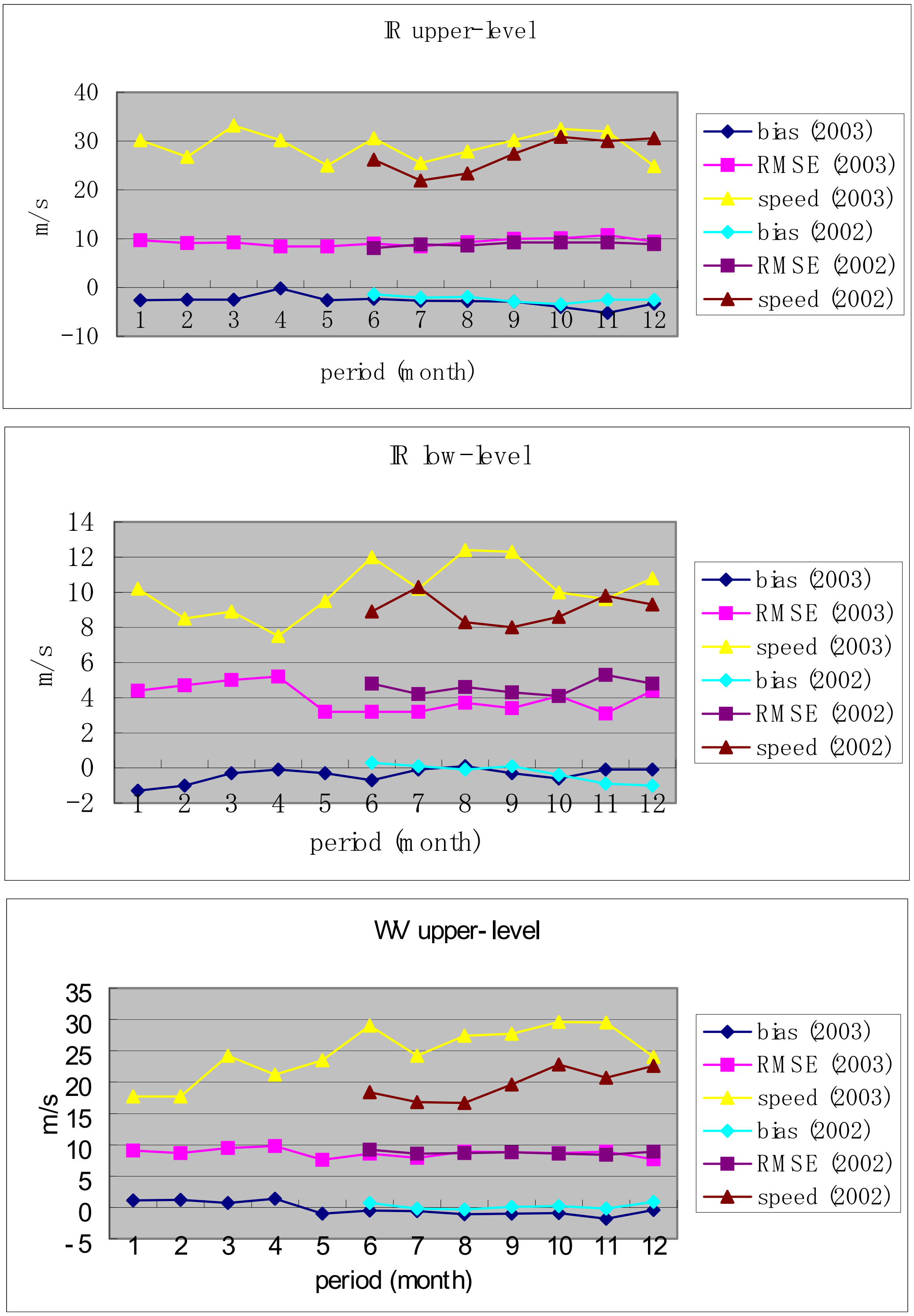

Figure 2. Monthly mean of differences between AMVs and radiosonde winds.

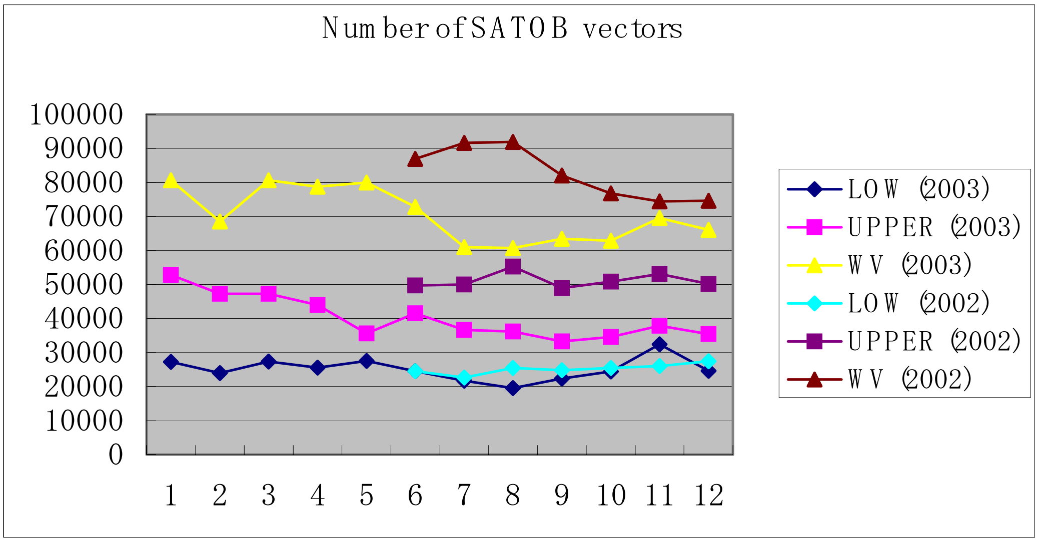

Figure 3. Monthly number of SATOB vectors.

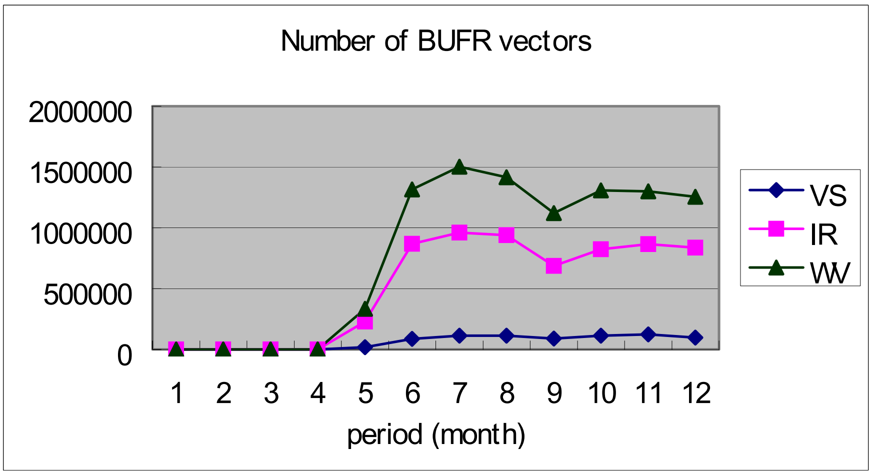

Figure 4. Monthly number of BUFR vectors.

Some other notion related to the accuracy of the AMVs are shown from here.

3.1 Accuracy of low-level AMVs

As shown in item 4 in Chapter 2, height assignment for low -level vector is modified. In the former system the height for a low-level vector is fixed to 850hP. In the new system a method to estimate a cloud base height is introduced developed by Tokuno inspired by Le Marshall et al. (1994). Tables 1 and 2 show some quality parameters vs. QI values driven by standard CGMS AMV verification method (Menzel: 1996) in January 2003. RMSVD and BIAS are improved at any QI grades with the new height assignment. At the present, the new height assignment scheme is configured to limit the up most height for low-level AMVs to 850 hPa. We plan to add additional measure to remove this inhibition and assign more probable heights.

QI	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MVD	16.24	8.79	7.85	6.64	5.96	5.11	4.77	4.48	3.78	2.85
RMSVD	20.53	10.63	9.29	8.1	7.44	6.23	5.91	5.81	4.83	3.38
BIAS	6.57	-4.42	-3.73	-2.71	-2.15	-1.75	-1.04	-0.34	-0.41	-0.63
SPD	13.77	3.54	3.98	4.14	4.5	5	6.72	8.21	8.99	10.16
NAMV	3543	3182	6120	12110	22091	32996	41080	50642	59122	52437

Table 1. Accuracy of Low-level AMVs with variable heights (m/s).

QI	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MVD	16.11	9.06	8.05	6.83	6.13	5.21	4.82	4.53	3.83	3.03
RMSVD	20.32	10.94	9.57	8.37	7.76	6.46	5.96	5.87	4.91	3.54
BIAS	6.48	-4.73	-3.97	-2.91	-2.34	-1.91	-1.14	-0.51	-0.51	-0.74
SPD	13.77	3.54	4	4.15	4.5	5	6.72	8.21	8.99	10.15
NAMV	3543	3182	6120	12110	22091	32996	41080	50642	59122	52437

Table 2. Accuracy of Low-level AMVs with fixed height of 850 hPa (m/s).

3.2 Accuracy of high-level AMVs

JMA's height assignment for high-level AMVs uses IR-WV method as most of other AMV producers. However, the efficacy of this technique is quite limited because of some reasons. This is now on verification stage but JMA is experimenting NSMC's height assignment for transparent cirrus clouds (Xu et al.: 1998).

Tables 3 and 4 are same as Tables 1 and 2 but for high-level AMVs of the experimental NSMC method (Table 3) and operational JMA method (Table 4).

QI	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MVD	29.04	23.06	18.06	15.17	12.87	10.95	9.42	9.02	8.56	5.84
RMSVD	36.08	30.59	24.21	20.94	18.07	15.48	12.97	12.3	11.59	7.31
BIAS	-24.62	-18.37	-13.75	-10.89	-8.66	-6.66	-4.84	-3.67	-2.16	-1.37
SPD	6.09	6.64	6.78	6.58	7.03	8.81	10.74	13.33	18.27	25.66
NAMV	6497	13125	22381	38808	59481	79748	91483	117242	148642	110257

Table 3. Accuracy of high-level AMVs with NSMC's height assignment (m/s).

QI	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
MVD	30.8	24.54	19.21	16.23	13.16	11.13	9.48	9.11	8.59	5.91
RMSVD	37.64	31.97	25.42	22.29	18.47	15.62	13.15	12.42	11.65	7.42
BIAS	-26.27	-19.82	-15.1	-12.05	-9.1	-6.91	-4.98	-3.8	-2.13	-1.39
SPD	5.88	6.54	6.58	6.23	6.73	8.4	10.35	13.09	17.96	25.55
NAMV	5141	10071	17716	34537	56772	79187	92281	118834	156268	116857

Table 4. Accuracy of high-level AMVs with JMA's operational height assignment (m/s).

RMSDV and BIAS are smaller with NSMC's method than with JMA's method at all QI levels but BIAS at 0.8 of QI. This result shows NMSC's height assign gives AMVs with higher accurate than JMA's height assign, though the numbers of vectors of NMSC's method with high QI values more than 0.6 are less than those of JMA's method.

4. PROBLEMS AND SOLUTIONS

JMA had to put HD-AMV system in operation before it experience enough parallel operation of former and new systems because of the tight schedule with the GOES-9 operation for GMS satellites. There are a few problems because of this hectic preparation for the operational HD-AMV system.

We notice some problems in BUFR encoding and all problems are solved by present. The updated BUFR encoding program will be adopted very soon.

There is a problem for the height assignment for WV-AMVs. Unrealistic heights for WV-AMV are sometimes assigned. As a solution of this WV-AMVs with very high (more than 90 hPa) and very low (lower than 500 hPa) height will be deleted as a makeshift solution and the problem of very high AMVs will be investigated thoughtfully. JMA started to calculate and disseminate WV-AMVs in clear sky as mention in Chapter 2 but it hasn't put information to distinguish cloudy and clear skies in BUFR report yet. The distinction flag should be added in the BUFR report.

The performance of the EUMETSAT-QI is well investigated with AMVs of JMA's system but the UW-CIMSS RFF hasn't yet. Also QI has developed since JMA imported and adopted in its AMV system but JMA hasn't followed. There are a coincidence in additional quality control measure though: reduction of QI for winds above tropopause and WV winds of low heights. The new test of QI for very low speed AMVs should be adopted as soon as possible because there are some numbers of AMVs with low speed that don't represent the actual atmospheric motion. We think we have to evaluate the QI performance with AMVs of very high speed that appears in winter in Far-East Jet streams.

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