RECENT ADVANCES TO EXPERIMENTAL GMS ATMOSPHERIC MOTION VECTOR PROCESSING SYSTEM AT MSC/JMA

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ABSTRACT

High density Atmospheric Motion Vectors (AMVs) are in the process of development now in the Meteorological Satellite Center (MSC) of the Japan Meteorological Agency (JMA) using the software for AMV that was transferred into a UNIX workstation from the mainframe computer. The revaluation of the present AMV software and amelioration work is undertaken.

MSC/JMA plans to adopt the automatic quality controls schemes to produce high-density AMV that was recommended in the fifth International Wind Workshop. The EUMETSAT QI scheme has been already installed in the AMV software and has been evaluated with GMS-5 AMVs. The results of the ongoing evaluation show that QI performs well as a quality control scheme in the most cases except the case of middle level water vapor motion winds.

For the amelioration, the agendas that have been undertaken are of height assignment. The improved height assignment of water vapor winds is under evaluation. The preliminary result shows that the improvement of height of water vapor motion winds lower than 400 hPa takes effect on increasing the number of winds in high levels.

MSC produced AMVs for the impact experiment on NWP with rapid scan AMVs with 15-minute interval images by the experimental system. We present an interesting feature that the AMV in 15-minute intervals show in comparison with those in 30- minute intervals.

1. Introduction

MSC has operationally produced Atmospheric Motion Vectors (AMVs) using GMS series' image data since 1982. MSC has been carried out the improvement of AMV schemes such as automatic target selection and height assignment schemes (e.g. Tokuno 1996). However we have several limitations for development of AMV software in the mainframe computer. To overcome a part of the problems we had transferred the AMV software from the mainframe to a workstation. In addition, we included the EUMETSAT QI scheme in the experimental AMV system and has tested and evaluated with the software tuned to produce highly dense winds since May 2001.

This report firstly shows the present status of new processing system and characteristics of QI performance. Then, we show some interesting features of the AMV from a rapid scan observation. Finally we show a future plan for putting the experimental system in operation.

2. AMV Processing System

Fig. 1 shows the comparison of the present system and the experimental system for extracting AMV in MSC. The latter has the following changes from the former.

- QI scheme is added in replace of removing man-machine interactive processing.

- The results of conventional “Objective Quality Controls” are not referred.
- A grid size in the target selection process is reduced to 0.5 degrees in latitude and longitude from 1 degree.

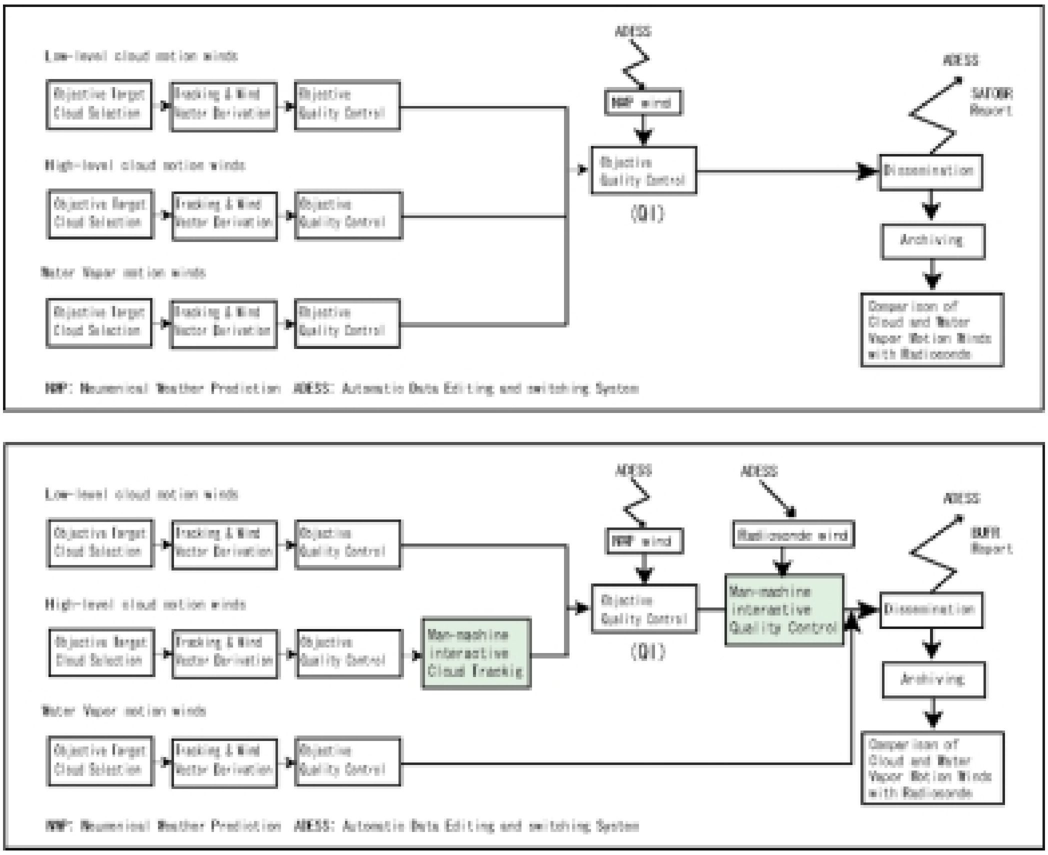


Figure 1: Diagrams of AMV system for operational winds (upper) and experimental ones (lower). Experimental winds are not disseminated yet.

The experimental system is operated in a workstation: Fujitsu Prime Power 400 that loads 4 SPAC 64GP (600MHz) CUPs since May 2001. Input data for the processing are transferred from the mainframe by ftp while the output wind vectors are stored in the workstation. In the operation stage, an administrative system will be installed to monitor the data transfer and task operation in the workstation.

3. Characteristics of QI in MSC’s AMV System

MSC has produced high-density winds by the experimental system near routine basis for nearly a year. IVH filter of QI had not been installed for the first few months. It was included in the QI scheme in October 2001. We show the general characteristics and some problems occurred during the period.

3.1 General Characteristics

To evaluate the QI values as a quality control scheme, we compared AMVs and collocated radiosonde measurements by the CGMS regular treatment. Figs. 2 to 4 present the relation between QI value and some accuracy indicators for low-level winds, middle level winds and high level winds respectively in December 2001. Except the case of middle level water vapor motion winds (WVMWs), every accuracy indicator approaches to zero as QI increases to unity. The feature is similar to the result of EUMETSAT (Holmlund, 1996). Thus QI performs well as a quality control scheme in the most cases.

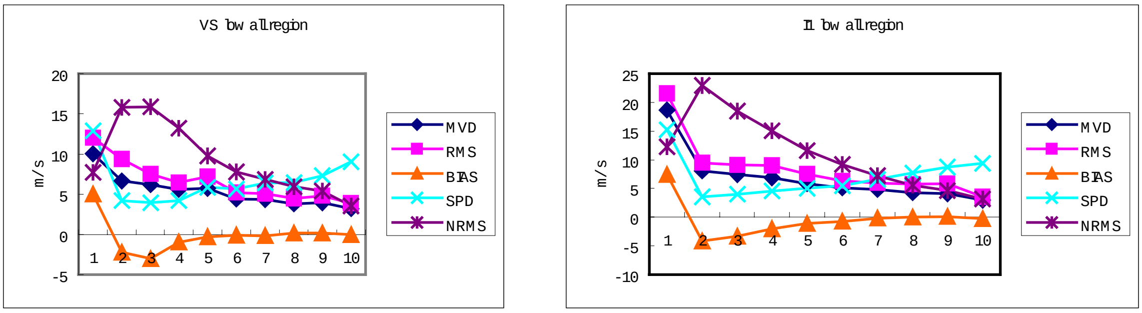


Figure 2: Relation between QI values and some accuracy indicators for VIS (left) and IR (right) winds in the low level. MVD: mean vector difference, RMS: root mean square vector difference, BIAS: average speed difference, SPD: mean wind speed, NRMS: normalized RMSVD (RMSVD/SPD). NRMS value is 1 /10 of the unit in the graph. QI is classified into ten classes every 0.1. The abscissa shows the number of classes. Class number 1 means the region of 0<= QI < 0.1.

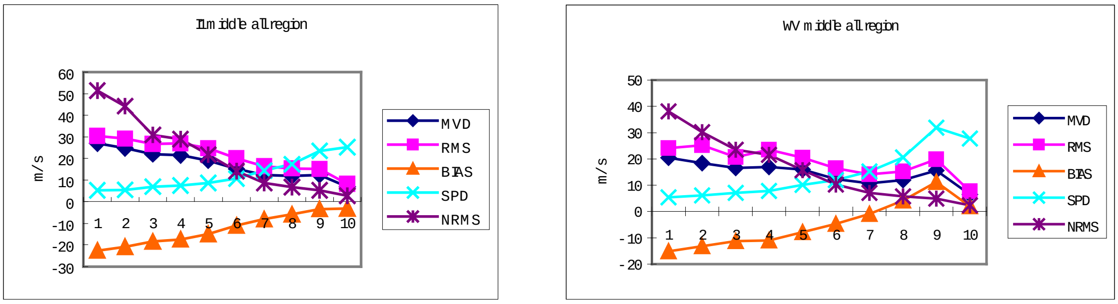


Figure 3: Same as Fig. 2 but for IR winds (left) and WV winds (right) in the middle level.

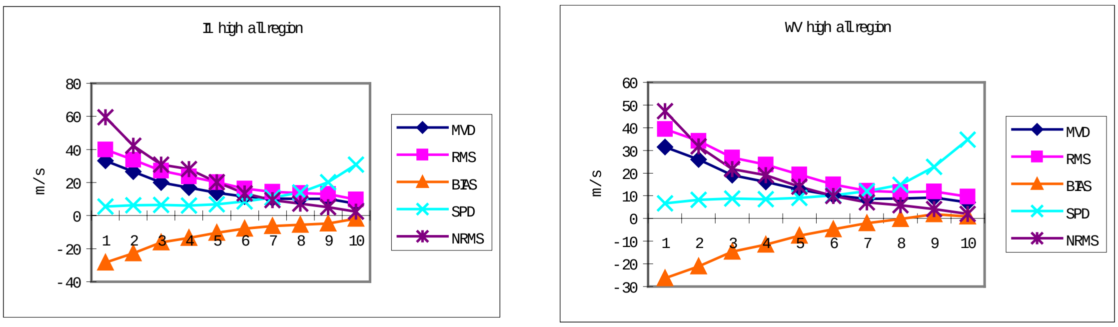


Figure 4: Same as Fig. 3 but for in the high level.

3.2 Problems with Water Vapor Winds

The current height assignment of WVMWs is carried out without distinguishing between cloudy and clear sky segments in MSC. All heights are assigned by the brightness temperature of thermal infrared channel. Therefore, the height of a WVMW in the clear or low-level cloud segments is very lower than the height of the target in water vapor imagery. To use WVMWs effectively in operational, WVMWs lower than 500 hPa are deleted.

Fig. 5 shows the relation between QI values and accuracy indicators for WVMWs with low-level height due to poor height assignment.

The tendency of deterioration of accuracy as QI increases is noted in the QI region from 0.6 to 0.9. This means that the accuracy isn't improved as QI increases. On the other hand, unexpected good accuracy is noted at QI more than 0.9. This means that QI cannot delete 1 to 2 % of WVMWs that matches environmental winds coincidentally.

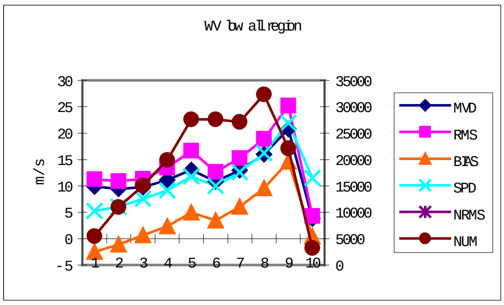


Figure 5: Same as Fig. 2 but for low-level WVMWs. Number of winds is added.

A primitive test has been done to decrease the problem of WVMW height assignment. If the height of a WVMW is lower than 400 hPa, we adopt the mean brightness temperature (WVMTBB) of a segment as the brightness level of WVMW height in the clear sky segment. WVMTBB is transformed to the WVMW height using the vertical profile forecasted by the NWP.

Fig. 6 shows the case of the modified WVMW height assignment.

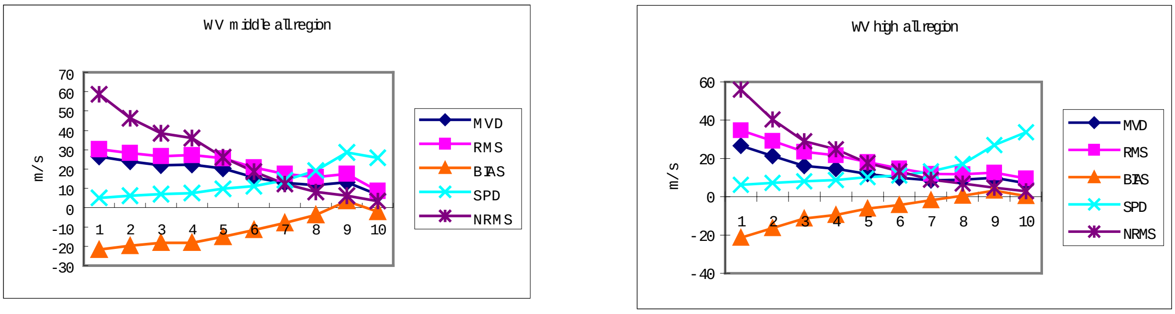


Figure 6: Same as Fig. 2 but for middle level (left) and high level (right) WVMWs in case of the modified WVMW height assignment.

In WVMWs with middle level height, BIAS was extremely improved, but RMS is worse than the previous level. On the other hand, accuracy of WVMW with high-level height is also a little worse than that in the previous level. The most significant improvement is occurred in the number of WVMWs. The number of WVMWs with QI > 0.8 is twice as many as before the process in high levels, followed by half in middle levels and none in low levels.

However, the following problem is occurred due to the application of the modified WVMW height assignment. The method has some adverse effect on the spatial test of QI in IR winds with a high level height due to the use of both WVMWs in cloudy segments and clear sky segments. As a result, the accuracy of IR winds with high-level height is reduced. Therefore it is suggested that we should use WVMWs in cloudy segments as before for the spatial test until the height assignment of WVMW is remarkably improved.

3.3 Problems with Low Level Infrared Winds

QI works well in most of experimental period, however it had not worked well in a few months including March 2002, which is the worst case. In the Fig. 7 for low-level IR winds in March 2002, the RMS doesn't decrease as QI increases, while BIAS is positive in the region. The tendency is similar to that of WVMWs with low-level height as shown in Fig. 5. It is inferred that the height assignment for low-level IR winds has a problem.

Next we investigated the performance of each element of QI tests for low-level IR winds in March 2002. The forecast consistency and spatial consistency test work well, but the direction, speed and vector consistency test don't work well as shown in Fig. 8. It is noted that the positive bias is appeared in the region with QI value from 0.9 to 1.0. The fact suggests that the estimated low-level IR winds are faster than real wind speed. This seems to be cause by the low-level IR wind height assignment in which the height is estimated from the cloud base height (CBH) as the same technique as that of Schmitz et al. (1996) although the CBH is reassigned to a fixed height of 850 hPa if the CBH is higher than that of 850 hPa (Tokuno, 1998). It is the possibility that many of the bad winds with high QI is grouped into low-level IR winds with the height of 850 hPa, and if the heights were assigned properly, they would be accurate winds as they are consistent from many aspects.

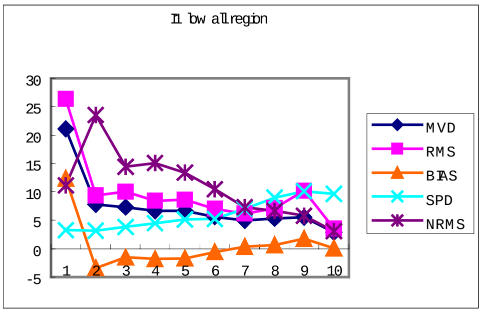
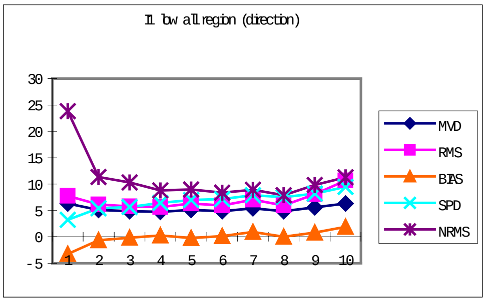
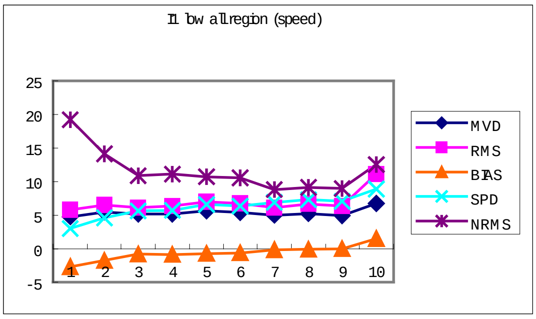


Figure 7: Same as Fig. 2 but for low-level IR winds in March 2002.





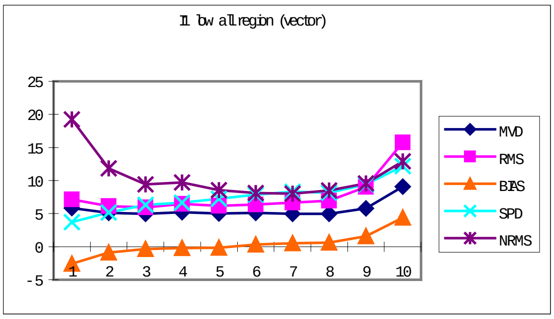


Figure 8: Same as Fig. 2 but for each element of OI tests for low-level IR winds in March 2002.

4. Interesting Feature in the Rapid Scan Experiment

4.1 Outline of the Experiment

JMA performed an impact experiment on NWP with rapid scan winds produced once in a day (04 UTC) when a typhoon presents. The impact of the rapid scan winds is examined by comparing the prediction with rapid scan winds to the control prediction without ones. The result o the NWP impact is reported in the other paper in the 6th International Wind Workshop (Nakamura et al., 2002).

VIS, IR and WV winds are calculated in 0-50N and 90E-170W and its target is selected every box with 0.5 degrees by 0.5 degrees latitude and longitude. In the tracking procedure, two types of the target size, i.e., 32 x 32 and 16 x 16 pixels, are chosen in WV, IR and VIS winds (hereafter WV_{32} or WV_{16}, IR_{32} or IR_{16}, VIS_{32} or VIS_{16}). AMV with QI are calculated by 3 successive 15-minute interval images.

4.2 Characteristics of the Rapid Scan Winds

Figs. 9 and 10 show the CGMS wind validation statistics of IR_{32} winds and IR_{16} winds against QI respectively. IR_{16} winds show positive BIAS in the region of QI larger than 0.7 and smaller than and equal to 0.9. The number of IR_{32} winds with QI more than 0.8 is larger than that of IR_{16} winds by 20%.

Figs. 11 and 12 show the statistics for WV_{16} and VIS_{16}. BIAS, RMSVD and NRMS show the similar features as one in operational winds, which show smaller values as QI increases, whereas the rate of the number of IR_{16} and WV_{16} with high QI values is quite less than ones in operational 30 minutes. However, QI is basically a good indicator to express the accuracy of rapid scan winds although the distribution is different from operational winds.

To examine the difference in the distribution of the vectors between rapid scan winds and operational winds, the number of vectors against each element of QI in the northern mid latitude are shown in Figs. 13 and 14. The numbers of vectors with QI value less than 0.1 in rapid scan winds are larger than that in operational ones, especially for forecast consistency test and vector consistency test among the QI elements.

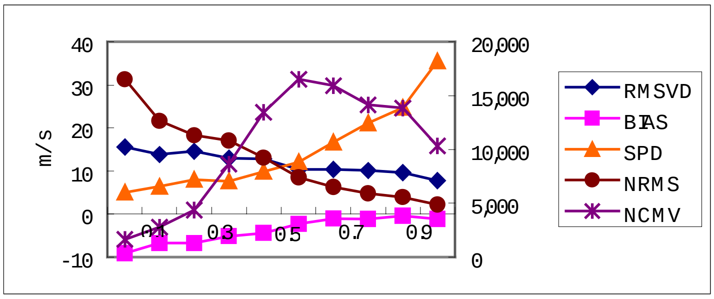


Figure 9: Same as Fig.3 but for IR winds with high level in 32x32 pixel target size in rapid scan.

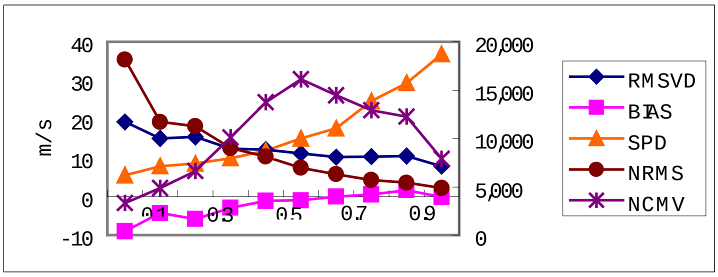


Figure 10: Same as Fig. 9 but for in 16x16 pixel target

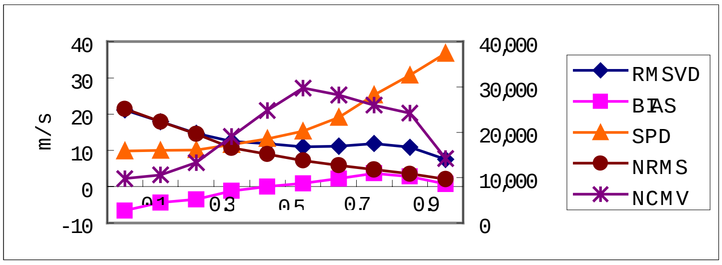


Figure 11: Same as Fig.10 but for WV_{16}.

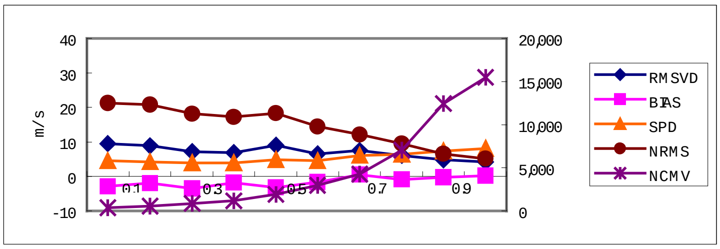


Figure 12: Same as Fig.11 but for VIS_{16}.

The reason of poor value of QI is inferred as follows. The displacement of a target might be influenced by smaller scale fluctuation or tracking error might be emphasized by short interval due to navigation error. In VIS winds, the index of vector consistency test is almost same as one in operational winds. MSC uses full resolution visible image for VIS winds and target size is smaller than other infrared channels. It is suggest that we need high-resolution image to get good wind vectors with rapid scan.

Although rapid scan winds shows good accuracy in general, accuracy and QI performance aren't good in the tropical area as shown in Fig. 15. RMSVD (NRMS) is not only bad but it also shows worse values value to the higher QI for the same QI region. Some measures have to be done to improve the quality in the tropical area.

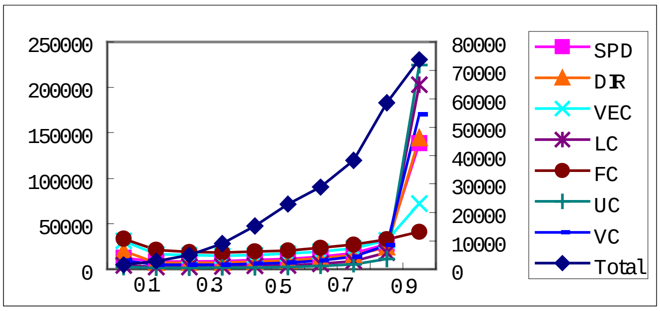


Figure 13: Number of operational IR winds with high-level height against QI elements in June in the northern hemisphere. SPD: Speed consistency test, DIR: Direction consistency test, VEC: Vector consistency test, FC: Forecast consistency test, LC: Spatial consistency test, UC: U-component test, VC: V-component test. A curve for Total is exaggerated and its scale is displayed in the right.

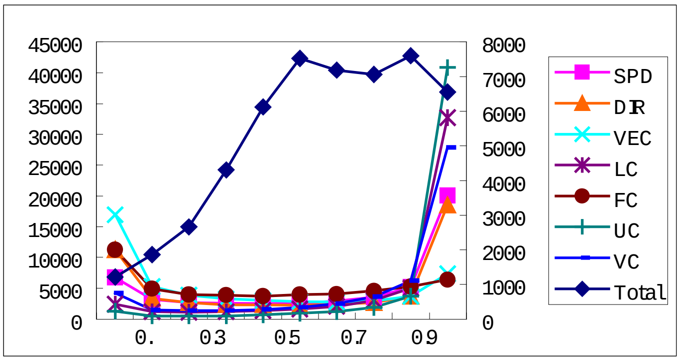


Figure 14: Same as Fig. 13 but for IR_{16} in rapid scan mode.

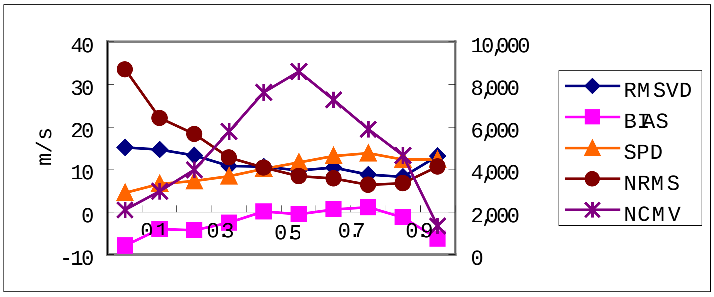


Figure 15: Same as Fig. 9 but for IR_{16} in tropical regions.

5. Near Future Plan

Outline of the future plan in MSC is shown in Fig. 16. MSC has been running the experimental AMV programs near real time basis. Wind vectors are basically in good shape. It is expected that we can produce about 10 times more wind vectors with compatible accuracy with present operational winds by choosing vectors with high QI values. The wind vectors are disseminated in BUFR format to put quality indicators, and SATOB winds are still disseminated in parallel if there are requests from users. MSC plans to start to provide the high-density winds from the system in the summer 2003.
MSC will establish an operational system by extending present experimental system by the time. MSC also tries the following experiments to upgrade AMVs in the system.

- More optimized water vapor height assignment.
- Upgraded height assignment for low-level wind vectors.
- Confirmation of QI performance and tuning if needed.

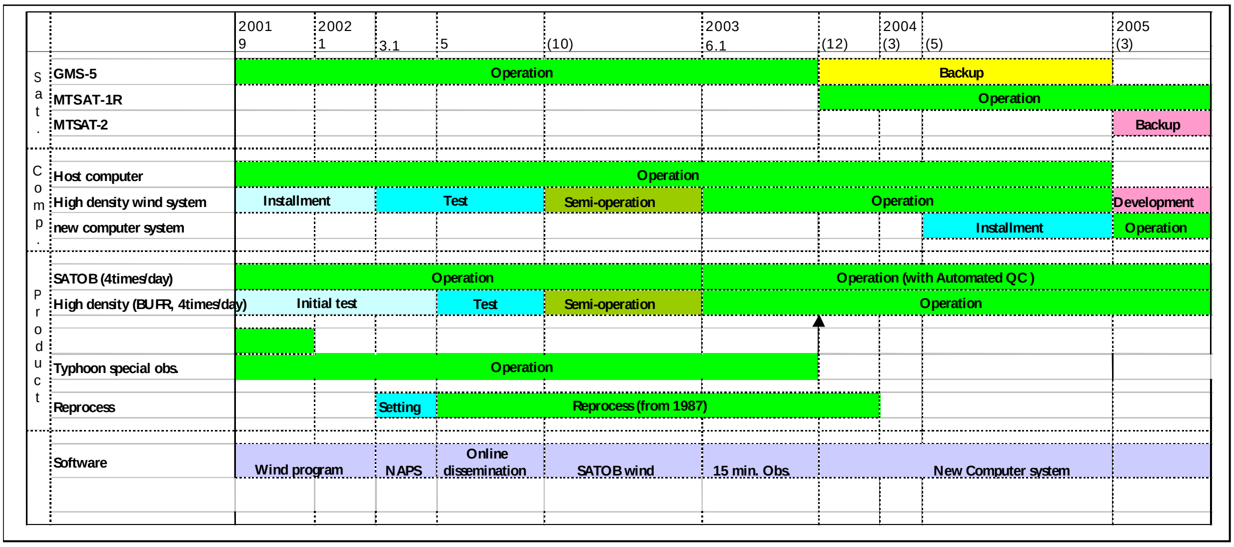


Figure 16 Outline of the future plan in MSC.

6. Conclusion

Forgoing analysis leads to the following conclusions. QI performs well as a quality control scheme in the most cases except middle level WVMW. The improvement of height of WVMW lower than 400 hPa takes effects on increasing the number of winds in high levels. The number of AMW with high QI values in 30-minute intervals is stably larger than that in 15-minute intervals.

ACKNOWLEDGEMENTS

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REFERENCES

Holmlund, K. 1996: Normalised quality indicators for EUMETSAT cloud motion winds. *Proc. 3rd International WindsWorkshop, EUMETSAT*, 155-164.

Nakamura, Y. et al. 2002: Impact experiment on NWP with rapid scan AMV. *Proc. 6th International WindsWorkshop, EUMETSAT (This publication)*

Schmetz, J., K. Holmlund, and A. Ottenbacher, 1996: Low-level winds from high-resolution visible imagery. *Proc. 3rd International WindsWorkshop, EUMETSAT*, 71-79.

Tokuno, M. 1996: Operational system for extracting cloud motion and water vapor motion winds from GMS-5 image data. *Proc. 3rd International WindsWorkshop, EUMETSAT*, 21-30.

Tokuno, M. 1998: Improvements in the method to extract operational cloud motion winds and water vapor motion winds of the GMS-5 system. *Proc. 4th International WindsWorkshop, EUMETSAT*, 61-68.