JMA'S ATMOSPHERIC MOTION VECTORS

In response to CGMS Recommendations 37.18, 37.22 and 37.24

This working paper reports on the recent status of JMA's AMVs from MTSAT-1R and MTSAT-2, including responses to Recommendations 37.18, 37.22 and 37.24

JMA plans to increase the frequency of AMV dissemination via the GTS from the end of 2010. Under this plan, AMV data computed on an hourly basis, which have so far been used only internally, will be disseminated via the GTS every hour in BUFR format. This report outlines the dissemination plan.

JMA switched MTSAT-1R's observing function over to MTSAT-2 at 00 UTC on 1 July, 2010. In accordance with the switchover, JMA/MSC has disseminated MTSAT-2 AMVs since 03 UTC on 11 August, 2010. The quality difference between MTSAT-1R AMVs and MTSAT-2 AMVs as well as time series representations of AMV statistics based on the CGMS standard are also reported here.

In response to CGMS Recommendation 37.18, JMA plans to engage in international inter-comparison for improvement of the AMV algorithm. For 37.22, the Agency needs detailed information on stand-alone AMV derivation software for easy installation to its own AMV derivation software for follow-on satellites. For 37.24, JMA computed and evaluated Rapid Scan AMVs from MTSAT-2 for the THORPEX T-PARC campaign of 2008. The new algorithm has the potential to increase the spatial resolution of AMVs by applying a trade-off between this resolution and the excessive time resolution of rapid scan images.

JMA is currently developing an improved height-assignment method for low-level AMVs and executing impact testing for assimilation of Meteosat-7 AMVs derived using JMA's AMV algorithm.

1 INTRODUCTION

The Meteorological Satellite Center (MSC) of the Japan Meteorological Agency (JMA) produces Atmospheric Motion Vectors (AMVs) using images from MTSAT-2. This working paper reports on JMA's AMVs: the status of AMV production and dissemination is covered in Section 2, AMV quality is detailed in

Section 3, responses to Recommendations 37.18/37.22 and Action 37.24 are dealt with in Section 4, and JMA's recent activities in regard to AMVs are outlined in Section 5.

2 STATUS OF DATA PRODUCTION AND DISSEMINATION

Table 1 outlines the dissemination of MTSAT-2 AMVs. JMA generates four types of AMV from MTSAT-2 Infrared (IR: 10.8 micrometers), Water Vapor (WV: 6.8 micrometers), Visible (VIS: 0.63 micrometers) and Short-wave Infrared (IR4: 3.8 micrometers) images (referred to below as IR AMVs, WV AMVs, VIS AMVs and IR4 AMVs, respectively).

JMA disseminates MTSAT-2 AMVs every three hours at 00, 03, 06, 09, 12, 15, 18 and 21 UTC via the Global Telecommunication System (GTS) in Binary Universal Form for data Representation (BUFR) format.
MTSAT-2 AMVs disseminated via the GTS at 00, 06, 12 and 18 UTC are computed from three successive images with intervals of 15 minutes, and those disseminated at 03, 09, 15 and 21 UTC are computed from images with intervals of 30 minutes.

JMA plans to start disseminating IR, WV and VIS AMVs, which are currently computed exclusively for JMA's internal use (the yellow datasets in Table 1), via the GTS in BUFR format by the end of 2010. After this change, the yellow AMV datasets in Table 1 will be available.

Table 1: MTSAT Atmospheric Motion Vector products generated by JMA

AMV type	Level of height *	Time (UTC)	Image sector	Image interval (minutes)	Distribution
Infrared: IR (10.8 micrometers)	High, middle, low	00, 06, 12, 18	Full disk	15	BUFR via GTS
	High, middle, low	03, 09, 15, 21	Northern Hemisphere	30	BUFR via GTS
	High, middle, low	02, 04, 05, 08, 10, 11, 14, 16, 17, 20, 22, 23	Northern Hemisphere	30	BUFR via GTS
	High, middle, low	01, 07, 13, 19	Northern Hemisphere	60	BUFR via GTS
	High, middle, low	01, 02, 03, 04, 05, 07, 08, 09, 10, 11, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23	Southern Hemisphere	60	BUFR via GTS
Wator Vapor: WV (6.8 micrometers)	High, middle	00, 06, 12, 18	Full disk	15	BUFR via GTS
	High, middle	03, 09, 15, 21	Northern Hemisphere	30	BUFR via GTS
	High, middle	02, 04, 05, 08, 10, 11, 14, 16, 17, 20, 22, 23	Northern Hemisphere	30	BUFR via GTS
	High, middle	01, 07, 13, 19	Northern Hemisphere	60	BUFR via GTS
	High, middle	01, 02, 03, 04, 05, 07, 08, 09, 10, 11, 13, 14, 15, 16, 17, 19, 20, 21, 22, 23	Southern Hemisphere	60	BUFR via GTS
Vissible: VIS (0.63 micrometers)	Low	00, 06	Full disk	15	BUFR via GTS
	Low	03, 09, 21	Northern Hemisphere	30	BUFR via GTS
	Low	02, 04, 05, 08, 22, 23	Northern Hemisphere	30	BUFR via GTS
	Low	01, 07	Northern Hemisphere	60	BUFR via GTS
	Low	01, 02, 03, 04, 05, 07, 08, 21, 22, 23	Southern Hemisphere	60	BUFR via GTS
Short-wave Infrared: IR4 (3.8 micrometers)	Low	12,18	Full disk	15	Internal use only
	Low	08-11, 14-17, 20-23	Northern Hemisphere	30	Internal use only
	Low	07, 13, 19	Northern Hemisphere	60	Internal use only
	Low	09, 10, 11, 13, 14, 15, 16, 17, 19, 20	Southern Hemisphere	60	Internal use only

3 STATUS OF AMV QUALITY

This section describes the quality of MTSAT AMVs and recent changes to them.

3.1 SWITCHOVER FROM MTSAT-1R TO MTSAT-2

JMA switched the observing function of MTSAT-1R to MTSAT-2 at 00 UTC on 1 July, 2010. In accordance with the switchover, the Agency has disseminated MTSAT-2 AMVs since 03 UTC on 11 August, 2010.

Figure 1 shows probability distributions of differences in AMV parameters (speed and height) between IR high-level AMVs derived from MTSAT-1R and those from MTSAT-2. The speed difference between MTSAT-1R and MTSAT-2 AMVs is negligible, and the probability distribution of height differences shown in Figure 1 suggests a negative height bias of about 6 hPa in MTSAT-2 compared with MTSAT-1R.

Figure 2 is the same as Figure 1, but for WV high-level AMVs. The property of speed difference probability distribution is almost the same as that for IR AMVs, and there is a negative height bias of about 4 hPa in MTSAT-2 compared MTSAT-1R. On the other hand, the height difference probability distribution has slightly skewed symmetry. The asymmetric nature of these WV AMVs is probably caused by a difference in the response functions of MTSAT-1R and MTSAT-2.

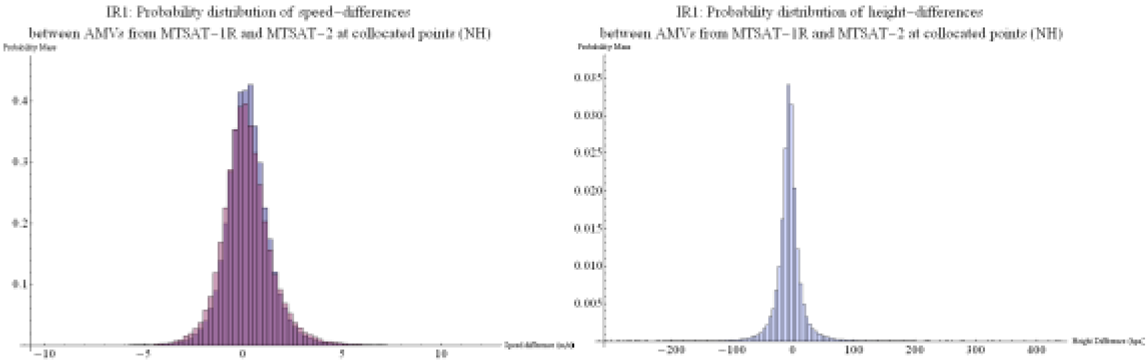


Figure 1: Probability distributions for speed and height differences between IR AMVs from MTSAT-2 and MTSAT-1R. The blue histogram in the figure on the left shows the IR AMV speed of the u-component, and the red shows that of the v-component. The histogram in the figure on the right shows the height of IR AMVs from MTSAT-2 and MTSAT-1R. These figures suggest that the accuracy of MTSAT-2 is equivalent to that of MTSAT-1R.

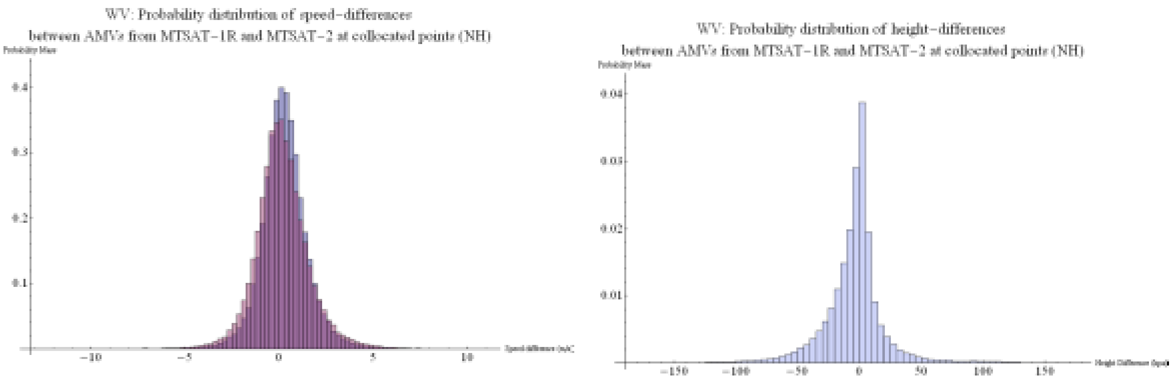


Figure 2: Probability distributions for speed and height differences between WV AMVs from MTSAT-2 and MTSAT-1R. The blue histogram in the figure on the left shows the WV AMV speed of the u-component, and the red shows that of the v-component. The histogram in the figure on the right shows the height of WV AMVs from MTSAT-2 and MTSAT-1R.

3.2 MONTHLY QUALITY OF AMVs

- IR high-level (> 400 hPa) and low-level AMVs

This section reports on the monthly quality of six-hourly IR and WV AMVs from July 2005 to July 2010 based on standard CGMS AMV statistics. To evaluate the quality of the AMVs, they are compared with sonde observations.

Figures 3 and 4 show time series graphs of monthly statistics (Root Mean Square Vector Difference (RMSVD), wind speed bias (BIAS) and number of high-quality AMVs) for high-level (above 400 hPa) IR AMVs. In the statistics, AMVs with a Quality Indicator (QI) value above 0.85 are used. In accordance with the sonde observation time, AMVs at 00 and 12 UTC are used. Figure 3 shows that BIAS and RMSVD have been significantly and stably reduced by the latest upgrade for the new height assignment scheme applied from May 2009. Figure 4 shows that the number of collocated high-level IR AMVs has also been improved by the tracking module upgrade applied from 15 September 2009.

Figures 5 and 6 also show time series representations of statistics for low-level IR AMVs.
Although BIAS and RMSVD show little change, the tracking module upgrade created a significant increase in the number of collocated AMVs with good quality (QI > 0.85) for all areas, especially over tropical regions and in the Southern Hemisphere.

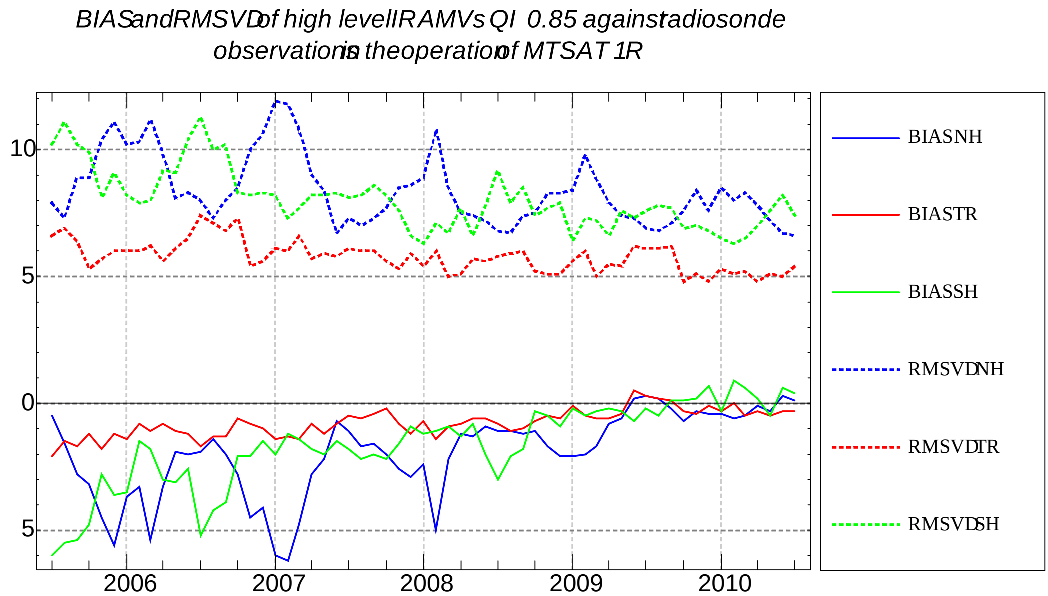


Figure 3: Time series representations of BIAS and RMSVD for MTSAT IR high-level AMVs. AMV accuracy has improved since the latest upgrades applied in 2009.

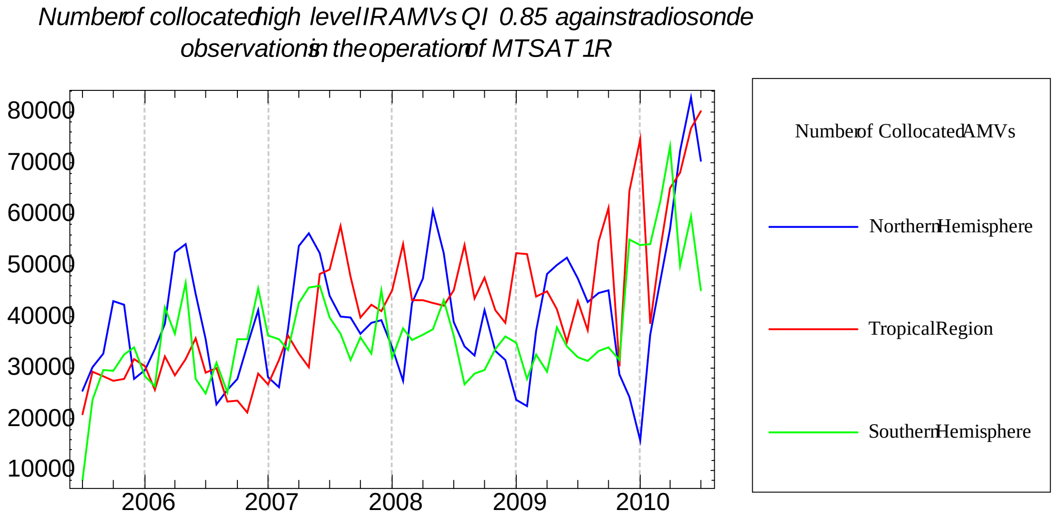


Figure 4: Time series representations of the number of high-quality (QI > 0.85) MTSAT IR high-level AMVs. The number of AMVs has also increased since the latest upgrades applied in 2009.

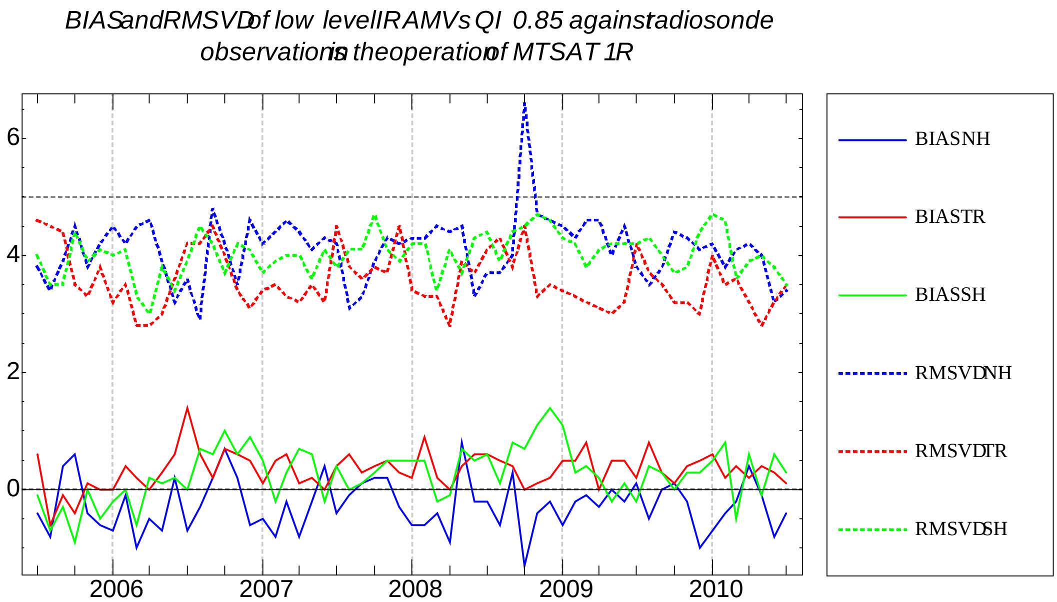


Figure 5: Time series representations of BIAS and RMSVD for MTSAT IR low-level AMVs. There are no significant changes in these variables.

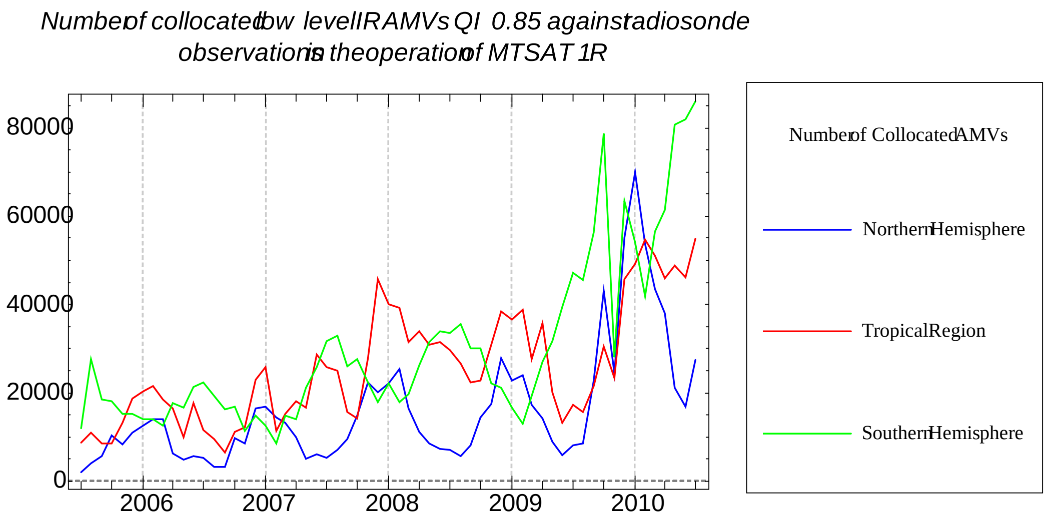


Figure 6: Time series representations of the number of high-quality (QI > 0.85) MTSAT IR low-level AMVs. Since the tracking procedure upgrades of September 2009, the number of high-quality AMVs has increased, especially over tropical regions and in the Southern Hemisphere.

- WV high-level (> 400 hPa) AMVs

Figures 7 and 8 are similar to those above, but for high-level WV AMVs. In regard to AMV quality change, the magnitude of the fast BIAS for WV high-level AMVs is slightly larger than that seen before the upgrades of 2009. However, the upgrades clearly reduced periodical BIAS fluctuations, especially those seen in winter over the Northern Hemisphere.

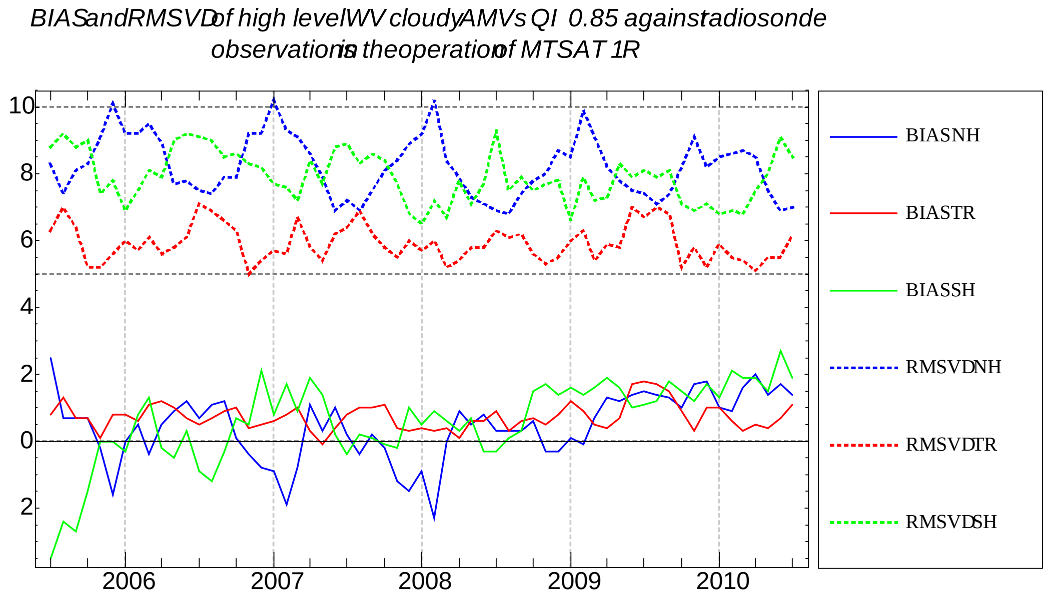


Figure 7: Time series representations of BIAS and RMSVD for MTSAT WV high-level AMVs. A positive bias is seen after the upgrades, but more importantly, periodical BIAS fluctuations are suppressed – especially in winter over the Northern Hemisphere.

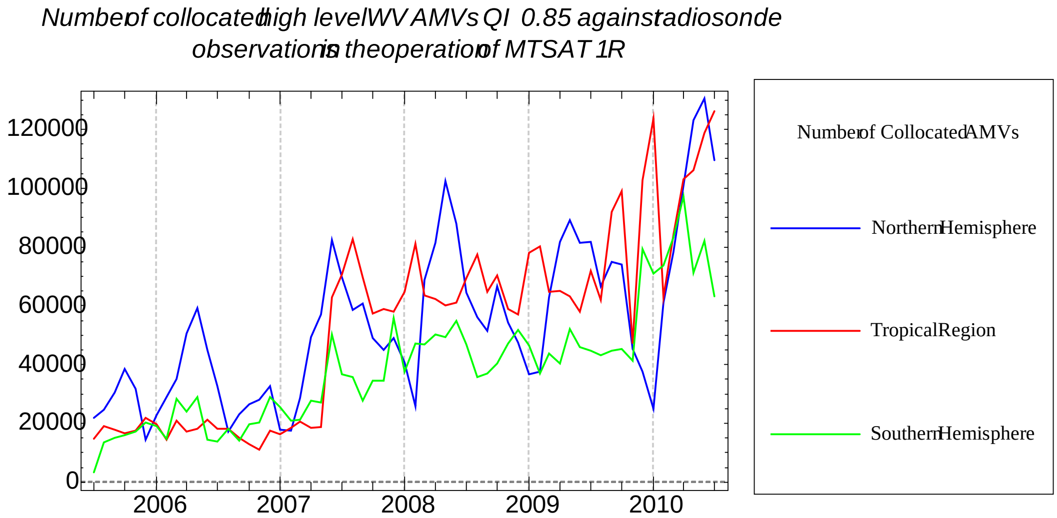


Figure 8: Time series representations of the number of high-quality (QI > 0.85) MTSAT WV high-level AMVs. The tendency of changes resulting from the upgrades is almost the same as that for IR high-level AMVs.

4 RESPONSES TO CGMS RECOMMENDATIONS

This section describes JMA's responses to CGMS recommendations.

4.1 RESPONSE TO RECOMMENDATION 37.18

JMA plans to engage in international AMV algorithm inter-comparison at regular intervals to improve algorithm quality. In order to introduce outstanding algorithms developed by other organizations, the Agency wishes to share detailed analysis of the results of inter-comparisons, not only in the form of comparisons against the NWP model but also as inter-comparisons against collocated AMVs generated by other organizations.

4.2 RESPONSE TO RECOMMENDATION 37.22

JMA is currently developing AMV derivation software for its follow-on satellite, which will be multi-channel compliant. The Agency's AMV derivation software for the follow-on satellite should be designed in a way that allows easy installation of the stand-alone software mentioned in Recommendation 37.22.

For this purpose, JMA hopes that detailed information on the stand-alone software will be released.

4.3 RESPONSE TO RECOMMENDATION 37.24

JMA took rapid scan images at intervals of 15, 7 and 4 minutes using MTSAT-2 for T-PARC (the THORPEX (The Observing system Research and Predictability EXperiment) Pacific Asian Regional Campaign) study executed from July to October of 2008.

The Agency computes Rapid Scan AMVs using an operational AMV algorithm that utilizes three successive images for AMVs and a new algorithm that, rather than being limited to three successive images, can also use general multiple successive images for AMVs. The new algorithm has the potential to increase the spatial resolution of AMVs by applying a trade-off between this resolution and the excessive time resolution of rapid scan images. At the Tenth International Winds Workshop, JMA reported that the new algorithm is especially effective for AMVs computed with very small target box sizes such as those with fewer than 10 x 10 pixels.

JMA will continue to develop AMVs as a strategy to trade the excessive time resolution of the rapid-scan function in geostationary meteorological satellites for the spatial resolution of AMVs and related products.

5 ACTIVITIES FOR AMV DEVELOPMENT

This section describes recent JMA activities for AMV development.

5.1 AMV COMPUTATION USING RAPID SCAN IMAGES

JMA is probatively conducting rapid scan observations using MTSAT-1R to capture images at intervals of five minutes around Japan from the end of MTSAT-1R’s operational meteorological mission. rapid scan observation by MTSAT-1R is scheduled to become operational from summer 2011. The Agency is constructing an environment to enable the computation of rapid scan AMVs toward numerical weather prediction for domestic use.

5.2 IMPROVEMENT OF HEIGHT ASSIGNMENT FOR LOW-LEVEL AMVs

JMA is developing a new height assignment scheme for low-level AMVs. The upper limit of its current height assignment method is set as 850 hPa. The new approach removes this arbitrary upper limit to improve the accuracy of low-level AMVs.

5.3 AMVs FROM METEOSAT-7

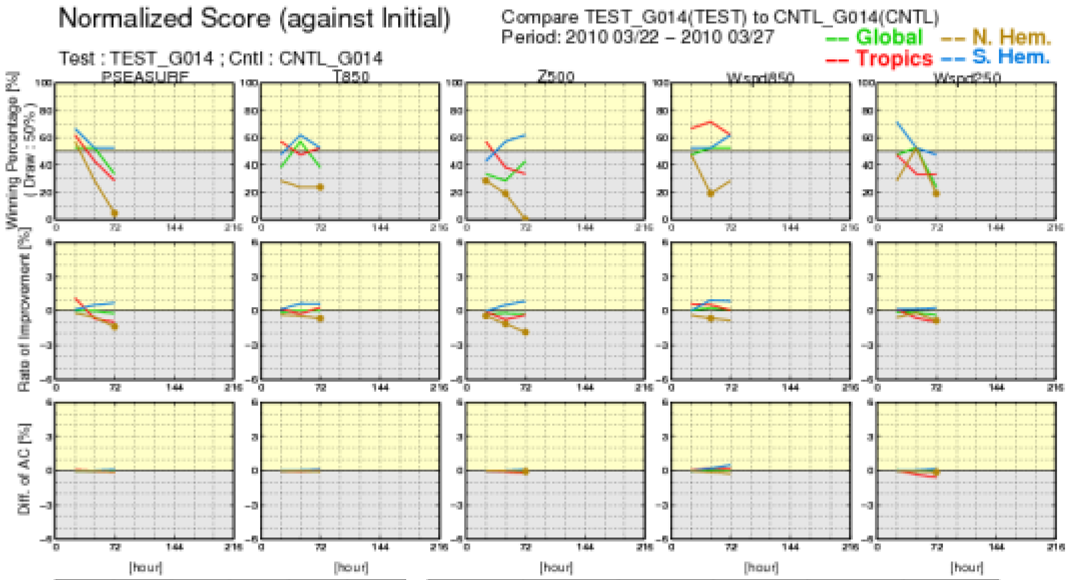
The object of this experiment was to ascertain the impact of using AMVs computed using the unique algorithm from the Indian Ocean to the West Pacific region on JMA's global Numerical Weather Prediction (NWP).

Courtesy of EUMETSAT, JMA operationally receives Meteosat-7 images taken over the Indian Ocean every 30 minutes via GTS. Using these images, JMA examined AMV generation with the JMA AMV algorithm and assimilation of the data into its NWP system. Then, the resulting forecast skills were compared with those obtained by assimilating Meteosat-7 AMVs operationally generated and delivered by EUMETSAT. Since the experiment was limited to the period from 22 to 27 March, 2010, the results are preliminary.

Figure 9 shows the difference in forecast skills between operation with JMA's Meteosat-7 AMVs (TEST) and those of EUMETSAT (CNTL). The plots and numbers in the yellow areas indicate that the forecast skills of TEST are better than those of CNTL. In general, the results show that TEST is superior to CNTL over the Southern Hemisphere (20°S – 90°S), while CNTL is better over the Northern Hemisphere (20°N – 90°N) and the Tropics (20°S – 20°N). Over the globe as a whole, the difference is neutral.

Figure 10 shows the levels of skill for forecasted positions of Cyclone Inami over the Indian Ocean as a function of the number of forecast hours. The blue points are lower than the red ones, indicating that TEST is superior to CNTL.

As mentioned above, the results of the experiment are preliminary. JMA is currently conducting further experiments, and will report the results in due course.



2-days	PseaSurf	T850	Z500	Wspd850	Wspd250
Global	−0.00	−0.07	−0.23	0.14	−0.12
N. Hem.	−0.39	−0.39	−0.79	−0.53	−0.37
Tropics	0.21	−0.07	−0.43	0.57	−0.25
S. Hem.	0.31	0.38	0.23	0.47	0.14

5-days	PseaSurf	T850	Z500	Wspd850	Wspd250
Global	−0.08	−0.04	−0.25	0.11	−0.21
N. Hem.	−0.72	−0.48	−1.16	−0.64	−0.53
Tropics	−0.18	0.05	−0.40	0.39	−0.49
S. Hem.	0.43	0.46	0.43	0.59	0.18

9–days	PseaSurf	T850	Z500	Wspd850	Wspd250
Global	−0.08	−0.04	−0.25	0.11	−0.21
N. Hem.	−0.72	−0.48	−1.16	−0.64	−0.53
Tropics	−0.18	0.05	−0.40	0.39	−0.49
S. Hem.	0.43	0.46	0.43	0.59	0.18

Rate of Improvement (Average) [%]

Fig. 9: JMA global NWP forecast skill differences with Meteosat-7 data between JMA's computation algorithm (TEST) and that of EUMETSAT (CNTL). The plots and numbers in the yellow areas indicate that the skills of TEST are better than those of CNTL. The experimental period was from 22 to 27 March, 2010.

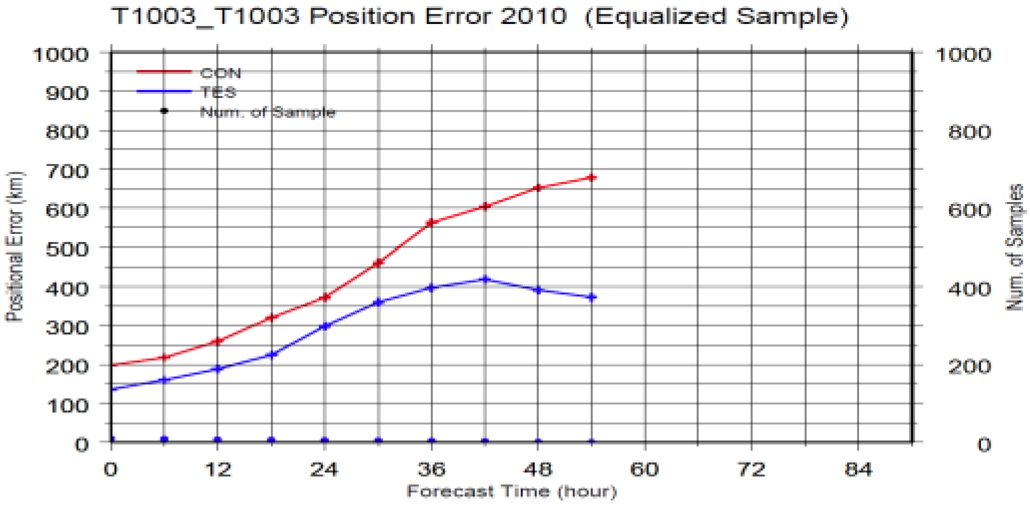


Fig. 10: As per Fig. 9, but showing errors of forecasted positions with respect to Cyclone Inami over the Indian Ocean as a function of the number of forecast hours. The blue and red points represent the errors of TEST and CNTL forecasts, respectively.

5.4 AMVs FROM PAST SATELLITE IMAGES FOR JRA-55

JMA reprocessed AMVs from GMS series, GOES-9 and MTSAT-1R images using the newest AMV algorithms. In addition, several target box sizes (16, 24 and 32 pixels) are applied to the reprocessing. The dataset will be provided for JMA's future long-term reanalysis (JRA-55) and Sustained Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM).

6 10TH INTERNATIONAL WINDS WORKSHOP

JMA hosted the Tenth International Winds Workshop (IWW10) in Tokyo, Japan from 22 to 26 February, 2010. A total of 46 experts and researchers, including JMA members, participated in the sessions. In the workshop's open forum and discussion session, two parallel working groups were formed with participants discussing AMV data assimilation and AMV derivation, respectively. The next meeting will be held in Auckland, New Zealand.