CURRENT STATUS OF OPERATIONAL WIND DERIVATION AT EUMETSAT

Kenneth Holmlund, **Arthur de Smet, Jörgen Gustafsson and Régis Borde**

EUMETSAT, Am Kavalleriesand 31, D-64295 Darmstadt, Germany

ABSTRACT

The generation of Atmospheric Motion Vectors (AMVs) from geostationary satellite data at EUMETSAT has this year moved into a new era by the start of routine operations of Meteosat-8 (Meteosat Second Generation 1). The new instrumentation on Meteosat-8 provides several opportunities to improve the quality of the wind fields generated with data from geostationary satellites, including more spectral bands, improved sampling distance of the image pixels and increased image frequency, as compared to the first generation satellites. EUMETSAT is currently operating and generating products from four geostationary satellite and additionally to the full field of view coverage provided over the African and Indian Ocean regions, Meteosat-6 provides a rapid scan service with 10 min imagery over Europe. This paper will present the current status of the AMVs derived by all spacecrafts, comparing the performance of the AMVs derived with first and second generation satellite data, including a brief look into the future and the foreseen evolution of the operationally derived wind fields.

1. INTRODUCTION

One of the key products derived from geostationary satellite imagery data are the Atmospheric Motion Vectors (AMVs). At EUMETSAT the AMVs are currently produced operationally with data from the Meteosat first and second generation satellite series. Three first generation satellites are now operated; Meteosat-7 located at 0° longitude, Meteosat-5 at 63° East and Meteosat-6 at 10° East and one second generation satellite, Meteosat-8 at 3.3° West. The wind fields derived with Meteosat-7 and Meteosat-5 are based on the nominal image interval of 30 min., providing full coverage over the full field of view. Meteosat-8 also provides a full field of view coverage. However due to the improved capabilities of the imager, the image frequency is 15 min. Additionally to the improved frequency Meteosat-8 provides several new spectral bands and a higher sampling distance further improving the observation capabilities. Meteosat-6 is currently providing wind fields based on 10 min. rapid scan imagery over the European and Northern Atlantic region (De Smet, 2002).

2. A SHORT REVIEW OF THE EUMETSAT ATMOSPHERIC MOTION VECTOR RETRIEVAL SCHEMES

The main components of the AMV extraction scheme consist of 1) Target extraction; 2) Image enhancement; 3) Tracking; 4) Height Assignment; 5) Quality control. The new capabilities of Meteosat-8 manifests itself in two major areas namely in the target extraction and the height assignment. The target extraction for the first generation satellites is based on segments with a fixed location where one wind is extracted per segment. For Meteosat-8 the targets are extracted at any suitable location. The main criteria for valid targets are cloud type, contrast and variability within the target area. The new scheme will therefore preferably extract targets along cloud edges providing a more stable tracking. Figure 1 gives an example of an AMV field derived over northern Africa and southern Europe.

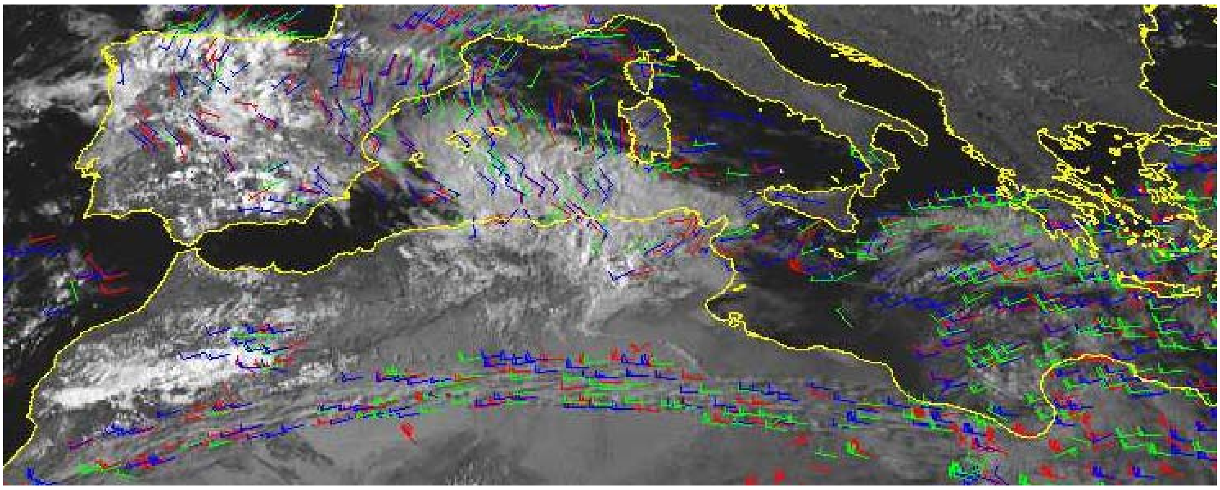

Figure 1. A high level jet-stream area depicted by Atmospheric Motion derived from cloudy targets with the IR channel (red), water vapour channel (blue) and visible channel (green).

The height assignment of AMVs is currently the most challenging task in the AMV extraction schemes. Broken clouds, multi-layered cloud targets, low level targets (requiring cloud base height assignment) and height assignment of clear sky targets, do all require their special attention. The biggest problems however are generally encountered with semi-transparent clouds.

With Meteosat-8 it is for the first time possible to operationally derive the correct height for semi-transparent clouds using two operationally established methodologies simultaneously; the semi-transparency correction utilizing the WV and IR channel (e.g. Schmetz 1993) and the CO2-ratioing method (Eyre and Menzel, 1989, Nieman et. al. 1997). Nieman et. al. (1993) showed that for high level clouds the mean pressure difference of the estimated cloud height is of the order of 20 hPa and the RMS difference is ca 80 hPa between the two methods. The implementation of these methods contains the following new features:

- channel dependant noise is included in the calculations
- refined selection of pixels or groups of pixels depending on the characteristics of the pixels and the neighboring pixels
- various possibilities to extract background/surface information (real observations, history of previous observations, forecast, climatology)

Figure 2 presents a sample of comparisons between different methods, semi-transparency. In general all methods provide similar results, except for the pure EBBT method which has a strong high bias as expected.

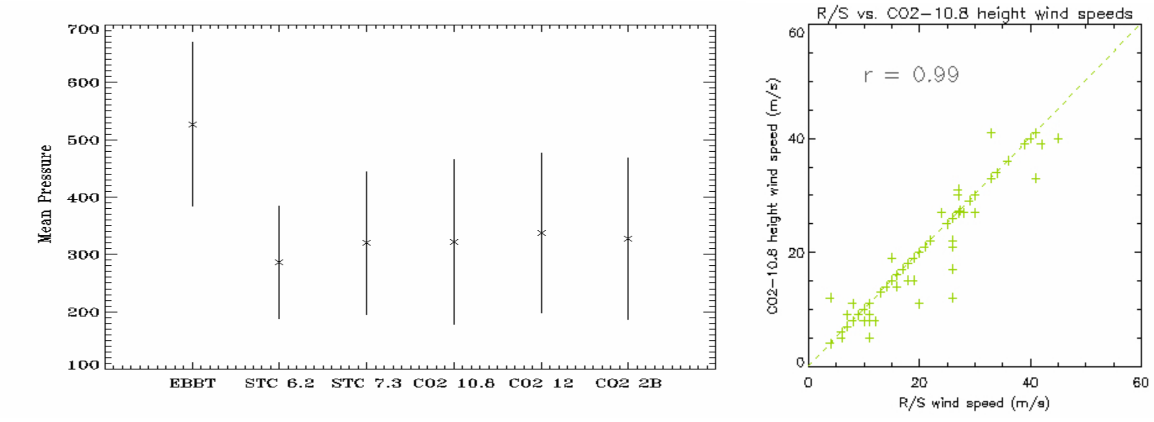

Figure 2. Comparison of various height assignment methods (left) and collocated wind speeds derived with Meteosat-8 and radiosonde observations (right).

The derivation of the final height for the derived winds was initially based on an average of all methods and all intermediate results. A further refinement has now taken place, where the final height will be based on the individual height assignments only. Furthermore, in-house testing has shown that currently the success rate is for the CO2-ratioing approach higher than for the traditional semi-transparency correction scheme. Hence the height assignment of high level clouds is currently based on the CO2-method unless the observed uncorrected radiance of the target provides a higher height (lower pressure) when the uncorrected EBBT related height is used.

For further details on the Meteosat-8 AMV generation scheme see Buhler and Holmlund (1993) and Holmlund (2002).

3. THE AMV PRODUCTS

3.1 The first generation Meteosat AMV products

Product type	**Product Information**	**Quality Threshold**	**Distribution type**
CMW (Cloud Motion Winds)	Only winds above 995 hPa, only best wind in segment. WV winds only above 400 hPa Minimum speed 2.5 m/s	0.8	SATOB
ELW (Expanded Low-resolution Winds)	All three channels (VIS, IR and WV) at 160 km resolution at sub-satellite point (SSP)	0.3	BUFR
HRV (High Resolution Visible)	VIS winds at 80 km resolution at SSP	0.3	BUFR
WVW (Clear Sky Water Vapor Winds)	Only Clear Sky Targets	0.3	BUFR
HWW (High-resolution Water Vapor Winds)	Only Cloudy Targets	0.3	BUFR

Table 1. The Meteosat AMV product suite.

Table 1 presents the operational product suite derived with all three operational satellites. The extraction frequency is 90 min. for Meteosat-7 and Meteosat-5 and 30 min with the rapid scan data (10 min image interval) from Meteosat-6. It should be noted that the HWW product is not produced with the rapid scan data from Meteosat-6. Table 1 also gives a short summary of the characteristics of the various products and the minimum quality for each vector as defined by the AMV Automatic Quality Control (Holmlund, 1998). As of July 2002 the product extraction times are centralized around the synoptic observation times. Further details on the EUMETSAT AMV products can be found at the EUMETSAT WEB-pages (www.eumetsat.de).

3.2 The Meteosat-8 AMV products

Table 2 presents the current baseline channels for AMV extraction. The table also incorporates an extended set of channels that may provide significant and improved data. Currently only the introduction of the HRVIS AMVs are foreseen in the near future, with a pre-operational implementation and final testing in early 2006. All products are distributed in BUFR format only. Due to the higher image frequency the Meteosat-8 AMV products are generated on an hourly basis. It should further be noticed that with Meteosat-8 it is possible to scan throughout the solar eclipses. This, combined with better baffles for straylight enables a continuous product generation also during the eclipse period.

Baseline channels:		
Band	Central wavelength	Prime targets
IR	10.8 µm	Clouds
IR	6.2 µm	HLC/Moisture
IR	7.3 µm	HLC/MLC/Moisture
VIS	0.8 µm	LLC over land
Extended channels*Future enhancement):		
IR	9.7 µm	Clouds/ozone
IR	3.9 (8.7) µm	LLC at night
HRVIS	0.8 µm	LLC over sea
VIS	0.6 µm	LLC over sea

Table 2. The AMV channels and target type. HLC, MLC and LLC refer to high, medium and low-level clouds, respectively.

4. QUALITY AND RELIABILITY OF THE AMVs

The new capability of Meteosat-8 provides already now five times more winds than the first generation satellites. Monitoring of the data has shown that the quality of the Meteosat-8 winds are comparable to that of Meteosat-7 and that with appropriate filtering or data selection the quality is even higher. This is illustrated in Figure 3 where the quality of the derived vectors from the two systems is defined by the normalised RMS (NRMS) difference to collocated radiosonde wind measurements for different quality categories as determined by the Automatic Quality Control. The normalisation is performed by the mean wind speed of the collocated observations. The figure also presents the number of winds for the different quality classes. It can be seen that for a specific quality class the NRMS is higher for Meteosat-8, but if a higher quality class is selected the NRMS is equal or better and that at the same time the number of vectors is still higher. The selection of different quality classes for different satellites is a typical behaviour for the Automatic Quality Control (AQC) scheme used.

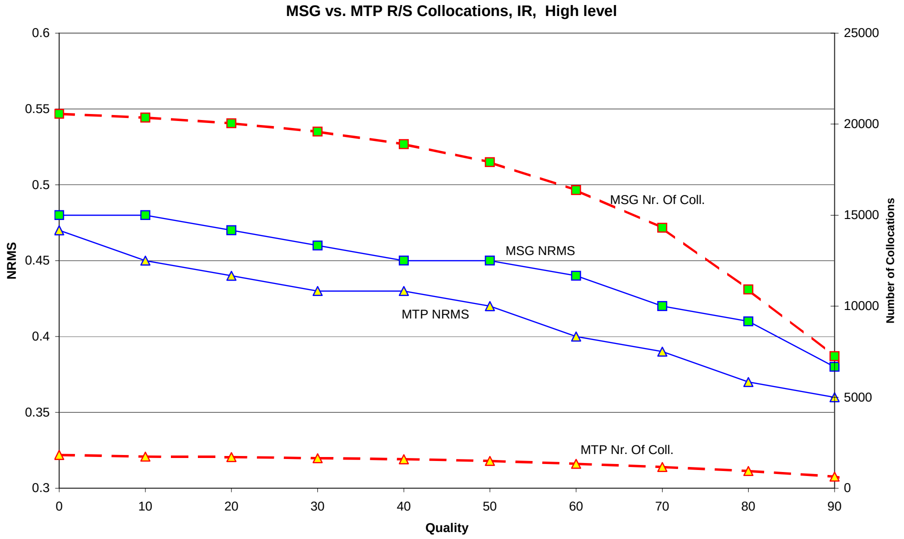

Figure 3. Meteosat-8 (MSG) and Meteosat-7 (MTP) IR high level AMV quality as determined by the Normalised RMS (NRMS) difference (solid line) derived against collocated radiondes. Additionally the number of winds (Dashed line) for all categories is shown. (Squares = Meteosat-8, Triangles = Meteosat-7).

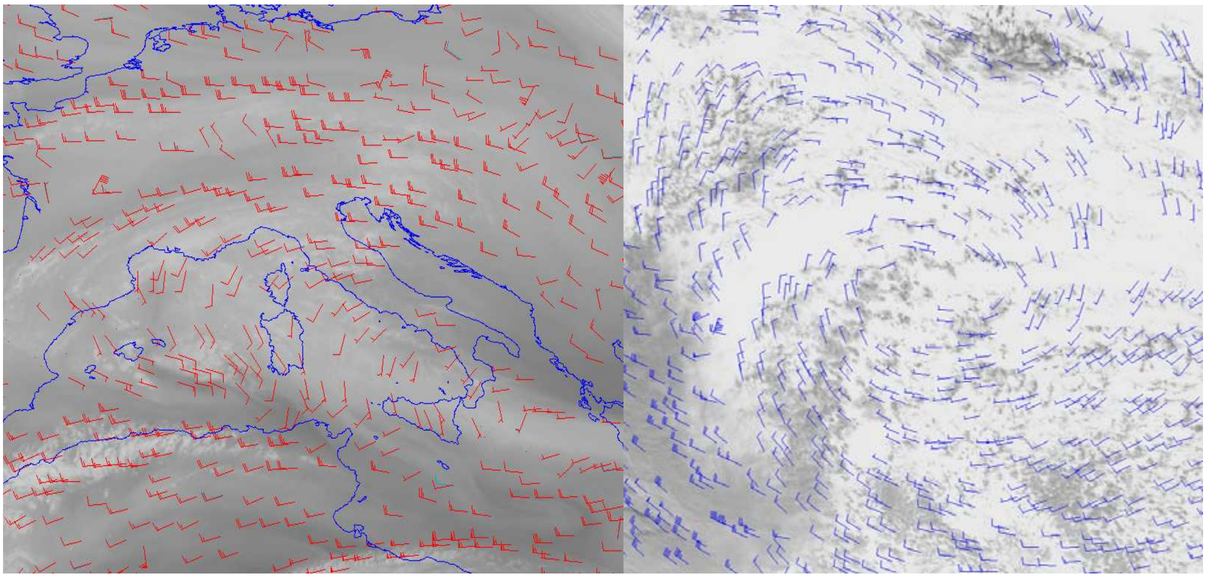

Figure 4. High level Atmospheric Motion Vectors (AMV) derived from cloudy targets with the WV channel over central Europe (left) and low level AMVs derived with the VIS channel over the South Atlantic (right).

The high density of the Meteosat-8 AMV fields is illustrated in Figure 4 with two examples; one over Italy and the other over the South Atlantic. Both cases show areas of high curvature and high spatial variation. In The increased positive impact of Meteosat-8 AMV data over the existing Meteosat-7 data in regional NWP has been demonstrated by Bonavita (2004).

The actual quality of the derived AMV products are monitored both internally by comparisons against collocated radiosondes and by external users like the Numerical Weather Prediction Satellite Application Facility (NWP SAF, see www.eumetsat.de). The comparisons against the collocated radiosondes are in general a good indication of the overall quality of the derived vectors. However, it should always be noted that the two sets of wind data represent different spatial and time scales that to some extent attribute to the observed differences (see e.g. Holmlund, 1998). Table 3 presents the collocation statistics for Meteosat-7 and Meteosat-8 using the CGMS (Co-ordination Group for Meteorological Satellites) criteria. It can be noted that in most cases Meteosat-8 collocations are more numerous and of higher quality. The collocation period is 1.9.2004 – 30.11.2004. On 1.12.2004 further improvements in the AMV extraction scheme for Meteosat-8 were introduced and hence further improved results are expected.

	IR AMV Met-7 / Met-8			**WV cloud tracked AMV Met-7 / Met-8**		**VIS AMV Met-7 / Met-8**
	High level	**Medium level**	**Low level**	**High level 6.2/6.3 µm**	**High level 7.3 µm**	**Low level**
R/S speed	23.81/25.17	16.17/16.16	10.16/10.19	24.28/25.43	–/25.34	9.27/9.77
MVD	6.19/6.45	5.04/5.71	3.68/3.63	6.55/6.22	–/6.48	3.25/3.66
NRMS	0.32/0.31	0.38/0.45	0.43/0.43	0.33/0.30	–/0.31	0.43/0.43
Bias	–2.61/–2.47	–1.93/–0.83	–0.81/–0.67	–2.53/–1.14	–/–2.03	–1.02/–1.03
No. coll.	1662/12448	455/2231	573/1941	3748/20680	–/19018	451/2131

Table 3. CGMS statistics for Meteosat-7 and Meteosat-8 for September-November 2004 showing the speed of the collocated radiosonde (R/S speed in m/s), Mean Vector Difference (MVD in m/s), Normalised Root Mean Square difference (NRMS), bias (R/S – AMV in m/s) and number of collocations (No. coll.).

A further aspect of the reliability of a system is the availability of the derived products. For primary mission (currently covered both by Meteosat-7 and Meteosat-8 the target figure is 98.5%, i.e. 98.5% of the monthly scheduled products should be derived and distributed in near real time. For the Indian Ocean Data Coverage the target figure is 98.0%. Figure 5 presents the weekly availability figures for Meteosat-7 and Meteosat-8. In general, the target figure is met even on a weekly basis, which is a harder requirement. However, some larger outages (e.g. week 41 for Meteosat-8, when the satellite went into standby for 3.4 days) for a limited number of cases do impact also the monthly figures. In general, Meteosat-8 is at least as reliable as the Meteosat-7 product extraction facility.

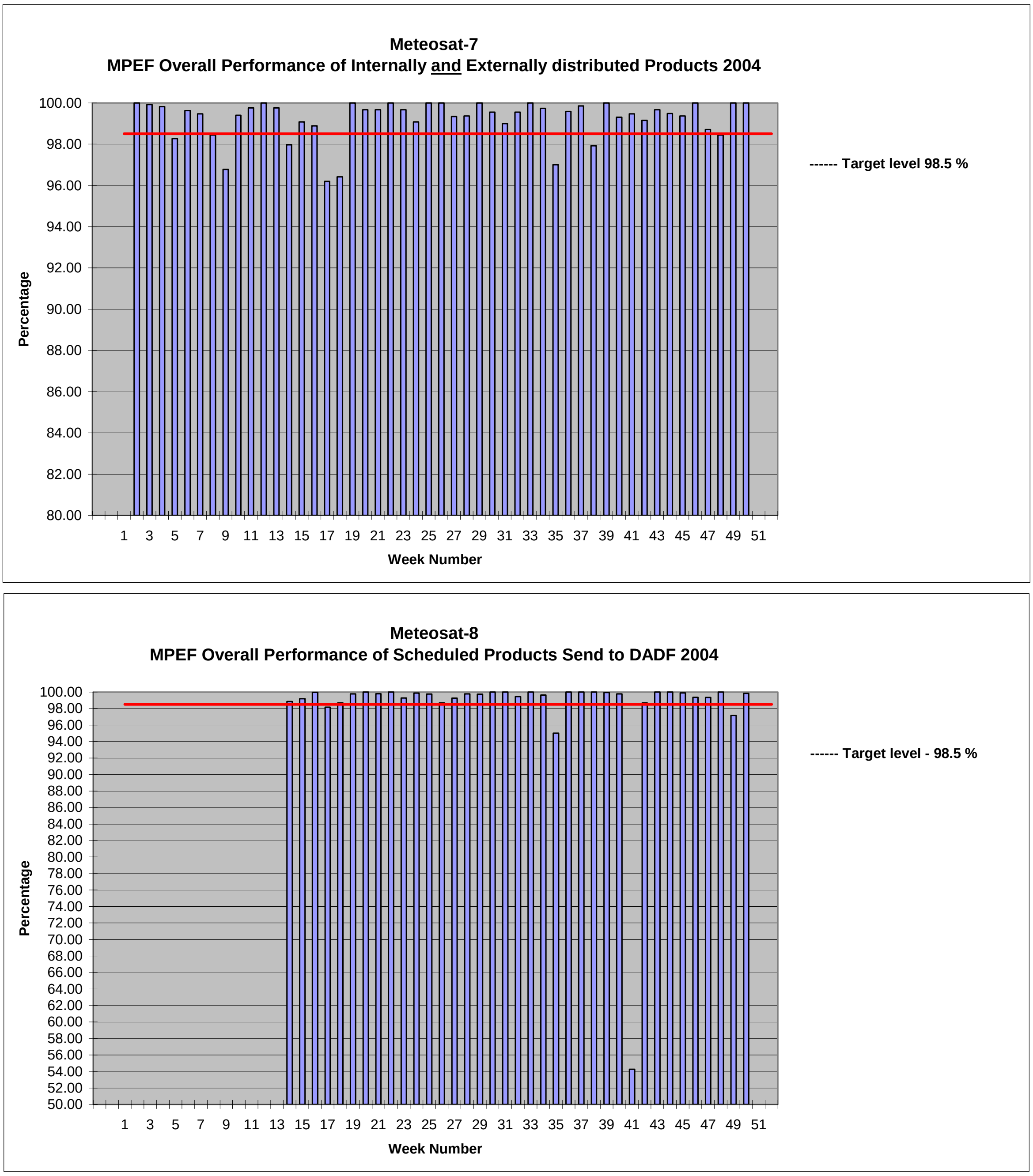

Figure 5. Weekly performance figures for Meteosat-7 (above) and Meteosat-8 (below) for 2004.

5. CONCLUSIONS

Meteosat-8 entered routine operations in January 2004. One of the main products are the Atmospheric Motion Vectors where the capabilities of the new instrument provides several areas of potential improvements. Some of the Meteosat-8 products are already now used operationally at various Numerical Weather Prediction Centers (e.g. the Clear Sky Radiance product at ECMWF). The Meteosat-8 AMV product on the other hand has not yet replaced the Meteosat-7 AMVs in global NWP. However, the results derived during 2004 show the great potential of the product and continuous improvements made throughout the year have further improved the quality of the derived AMVs. A further set of improvements have been introduced in December 2004. Based on the monitoring at EUMETSAT, comparisons with collocated radiosondes and evaluations by external users, the Meteosat-8 AMV products have now reached a quality at least as good as of Meteosat-7 and with a significant increase in the derived number of vectors. Further improvements to the Meteosat-8 AMV generation scheme will be introduced as a normal evolution of the products.

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