STATUS REPORT ON THE OPERATIONAL DERIVATION OF ATMOSPHERIC MOTION VECTORS AT EUMETSAT

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ABSTRACT

The operational near-real time wind generation is at EUMETSAT based on two generations of geostationary satellites, namely Meteosat-6 and -7 of the first generation, and Meteosat -8 and 9 of the second generation satellites. The Meteosat Second Generation (MSG) satellites are located over the Gulf of Guinea, providing the primary service for Europe and Africa, with Meteosat-9 being the prime satellite and Meteosa-8 the hot standby. In the near future Meteosat-8 will be used for rapid scanning over Europe, providing images over most of Europe every five minutes, and corresponding wind fields every 20 minute. The first generation satellites are located over the Indian Ocean, with Meteosat-7 providing the primary service and Meteosat-6 being the hot standby.

This paper will give an overview of the current Atmospheric Motion Vector (AMV) products derived operationally from geostationary satellite data at EUMETSAT and the changes since the previous International Winds Workshop will be described. In addition to planned changes in the AMV derivation algorithms, the current planning for the geostationary satellite system will be given.

In addition to the AMVs from the geostationary satellites EUMETSAT supports global wind generation by deriving the calibrated sigma-0's from the ASCAT instrument on-board Metop-A and the subsequent wind observations with the Ocean and Sea Ice Satellite Application Facility. However, this paper focuses on the geostationary AMVs and does not cover the ASCAT winds. For further details about the ASCAT data and wind products, please consult the EUMETSAT web-site at www.eumetsat.int.

Finally, it should also be noted that in the future EUMETSAT will be deriving polar winds from AVHRR data. Further details on this subject are provided in Dew (2008).

1 SATELLITE CONFIGURATIONS AND WIND PRODUCTS

Since the previous International Winds Workshop, some major changes in the EUMETSAT geostationary satellite configuration have taken place. In December 2005 the second Meteosat Second Generation (MSG-2) satellite was successfully launched into geostationary orbit. The spacecraft was after commissioning re-located to 0-degree longitude and assumed the primary service over the European-African region in April 2007 as Meteosat-9. Since then, Meteosat-8, is the hot standby satellite and is now being prepared for a rapid scan service, covering Europe, to commence in May 2008. The availability of two MSG-satellites over the 0-degree primary service area also enabled the re-location of the last of the first generation Meteosat satellites, Meteosat-7, from 0-degrees to 57.5 degrees East. This ensures a continuation of the Indian Ocean Data Coverage service for many years to come. The service transition from Meteosat-5 to Meteosat-7 took place in December 2006 for all services except the generation of meteorological products. The operational transition for the latter, and hence also for the Atmospheric Motion Vectors, took place in February 2007. In April 2007 Meteosat-5, after having provided an operational service for roughly 15 years, with an in-orbit life time of ca 16 years, was finally re-orbited. The back-up services for IODC is provided by Meteosat-6.

Figure 1 presents the satellite transitions discussed above. In addition it gives an overview of the current planning up to 2013, indicating the launch of MSG-3 (designated to become Meteosat-10) in early 2011 and MSG-4 in 2013. Noteworthy is also the re-orbiting of Meteosat-6, due to lack of fuel for station keeping, in 2012.

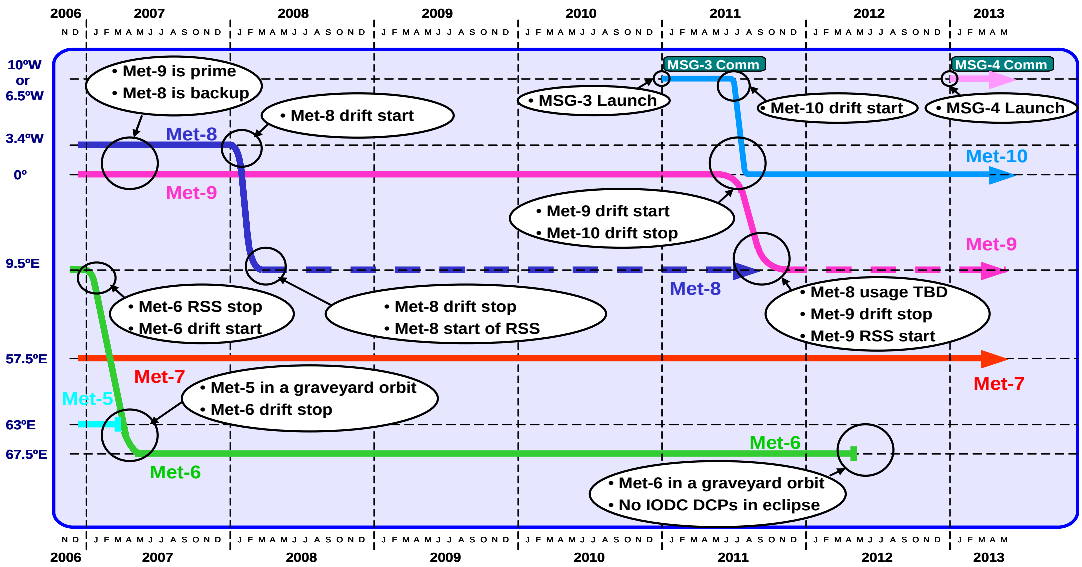

Figure 1. The EUMETSAT geostationary satellite configuration and changes in 2007 – 2013.

2 ATMOSPHERIC MOTION VECTOR PRODUCTS GENERATED AT EUMETSAT

Currently EUMETSAT is deriving operational Atmospheric Motion Vector (AMV) products from Meteosat-9, over the 0-degree primary service area and from Meteosat-7 over the IODC area. Meteosat-8 and Meteosat-6 provide the respective standby services. In May 2008, it is foreseen to commence the generation of AMVs also from Meteosat-8 rapid scan data in support of the rapid scan service for the European region. Table 1 gives an overview of the current products. All products are available in BUFR over the GTS and some also over EUMETCast. For further details please consult the EUMETSAT web-site.

Table 1. The EUMETSAT AMVs. All products are available in BUFR over the GTS and some also over EUMETCast. Further details available at www.eumetsat.int.

Product	Satellite	Region	Bulletin Headers	Product Times
Clear Sky WV Winds	Met-7	IODC NH IODC SH	IXCN01-IXCN03 IXCS01-IXCS03	Every 1.5 h 00:00,01:30…
Expanded Low Res. Cloud Motion	Met-7	IODC NH IODC SH	IXCN05-IXCN11 IXCS05-IXCS11	Every 1.5 h 00:00,01:30…
High Res. WV Winds	Met-7	IODC NH IODC SH	IXCN13-IXCN22 IXCS13-IXCS22	Every 1.5 h 00:00,01:30…
High Res. Visible Winds	Met-7	IODC NH IODC SH	IXCN24-IXCN29 IXCS24-IXCS29	Every 1.5 h 00:00,01:30…
Atmospheric Motion Vectors	Met-9	NH 0-90W NH 0-90E T 0-90W T 0-90E SH 0-90W SH 0-90E	IUVA01-IUVA89 IUVD01-IUVD89 IUVE01-IUVE89 IUVH01-IUVH89 IUVI01-IUVI89 IUVL01-IUVL89	Hourly 00:45,01:45...

3 CHANGES SINCE THE 8TH INTERNATIONAL WINDS WORKSHOP

In addition to the change in the satellite configurations as described above, the introduction of an operational divergence product for the MSG satellites in April 2007 was a highlight since the previous International Winds Workshop. The basic approach for the derivation of the divergence is the same as already used by Schmetz et al.(2000) and is based on an improved Barnes interpolation scheme as described in Holmlund (1999).

Throughout the period several minor changes have been introduced that mainly affect cloud detection. As the cloud detection information is fed into the wind processing it may in specific cases affect the derived wind vectors. However, the impact on the AMVs is generally negligible. The main changes affecting directly the AMVs are given in a chronological order in Table 2.

Table 2. The changes affecting the Atmospheric Motion Vector products introduced since the previous International Winds Workshop in Beijing in April 2006.

Date	Major impact
13 February 2007	Meteosat-7 takes over IODC with improved calibration
11 April 2007	Meteosat-9 (MSG-2) becomes prime
19 April 2007	Introduction of the Meteosat-9 divergence product
22 March 2007	A substantial revision of AMV height assignment. Further details in section 3.1. Increased processing area, mitigating the observed gap in Atmospheric Motion Vectors between geostationary observations and polar winds
4 September 2006	Introduction of RFF: no change in operational product, but re-adjusted height disseminated. In addition: additional quality information and minor modifications to height assignment, removal of low illumination vis AMVs

3.1 The AMV Change 22 March 2007

The MSG-satellites provide a unique opportunity to perform various types of corrections for thin clouds. In particular the semi-transparency correction method already used with the first generation satellites and the CO_2-ratioing method, are seen as the most suitable operational correction schemes available (Holmlund et. al, 1999). The main pre-requisite to a successful height assignment, and correction for thin clouds, is reliable cloud detection and clustering scheme for the information available. The initial clustering scheme for the MSG satellites was based on merging data within specific, 200 hPa thick, layers. This approach has some caveats as it may merge together clouds at different levels, or as the levels are fixed, may split up a single cloud into two separate clusters. The inadequacy of this approach has been documented eg. by Borde (2006). It was therefore decided to introduce a new clustering method and after various novel approaches had been tried out, the decision was taken to base the new clustering on the already operational clustering used with the Meteosat first generation satellites. This clustering is based on the approach described in the MSG MPEF (Meteorological Product Extraction Facility) Algorithm Specification Document (EUMETSAT, 2008). The method performs three independent Gaussian fittings to the pixel histogram, which is built on initial estimates of the pixel pressure. Peaks within ca 1K of each other are merged and the remaining cluster are then submitted for semi-transparency correction.. In addition to this change modifications in scenes selection and specific height assignment methods were introduced:

- Dynamic Clustering with low-level scenes merging instead of layering
- Selection of scene with coldest EBBT
- AMV located at point of maximum local SD instead of max difference
- Enhancement of CO2 method in temperature inversion areas.
- STC and IR/WV heights used for a narrow selection of AMVs (all channels)
- Cloud Base Height assignmen corrects now downwards only
- Inversion Height Correction corrects now downwards only
- Inversion Height Correction disabled for 6.2 and 7.3 AMVs
- Modified Final AMV averaging.

For detailed information of the change please consult the EUMETSAT web-pages: http://www.eumetsat.int/Home/Main/Access_to_Data/Meteosat_Meteorological_Products/Product_History/index.htm?l=en

The overall impact of the changes described was a general increase in AMV pressure, small for high levels, bigger for low levels. An increased number of High-QI AMVs for high levels (all channels) and at low levels (IR 10.8, VIS 0.8 and HRV), together with a reduced numbers of outliers at medium levels. For further details on the impact of the change see de Smet (2008).

4 UPCOMING CHANGES

A major change affecting all products generated with MSG-satellites (Meteosat-8 and -9) is the transition of the radiance definition from spectral to effective radiance. This change will clear the discrepancy between the current Level 1.5 product definition and the user expectation (i.e. effective radiance):

$$L^{15} = B_\nu(EBBT) \quad \Longrightarrow \quad L^{15} = \frac{\int B_\nu r_\nu d\nu}{\int r_\nu d\nu}$$

The impact of the change is a change in temperature, which is temperature dependant. Figure 2 presents the effective radiance From Meteosat 8 – Meteosat 9 versus temperature for an idealised blackbody scene and thus gives and indication of the differences to be expected. For further details please consult the EUMETSAT web-pages.

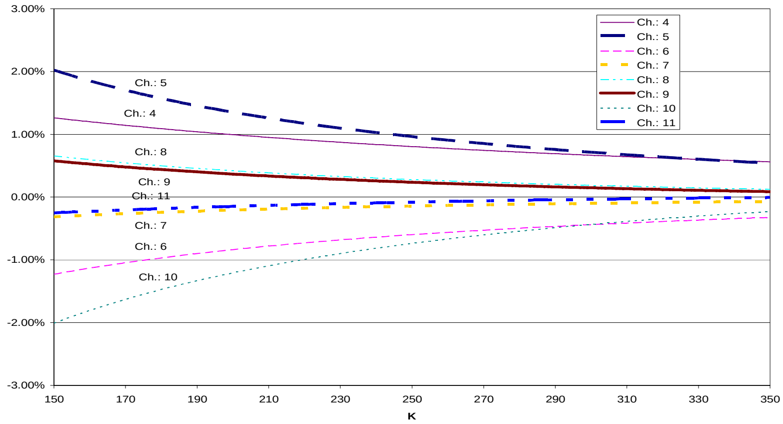

Figure 2. The effective radiance From Meteosat 8 – Meteosat 9 versus temperature for an idealised blackbody scene Please note that this figure gives no physical information, just the numerical difference.

In order to assess the impact of this change on the products generated at EUMETSAT and in order to give the users sufficient time to assess the impact of this change on their products and operations, data was over an extensive period disseminated in parallel with the old and new definition. The main observations of the change can be summarised as follows:

Image Data Changes

- Channel 3.9 µm: Warmer with about 0.4 K
- Channel 6.2 µm: Warmer with about 0.5 K
- Channel 10.8 µm: Colder with about 0.5 K

Main Product Impacted:

- Cloud Detection and Analysis
- Clear Sky Radiance
- Calibration Monitoring
- Tropospheric Humidity
- Active Fire Monitoring

The changes noted were also confirmed by external monitoring provided by the users. Figure 3 present the Mean First Guess departures for the old and new approach for channel 10 (IR window) as monitored by ECMWF.

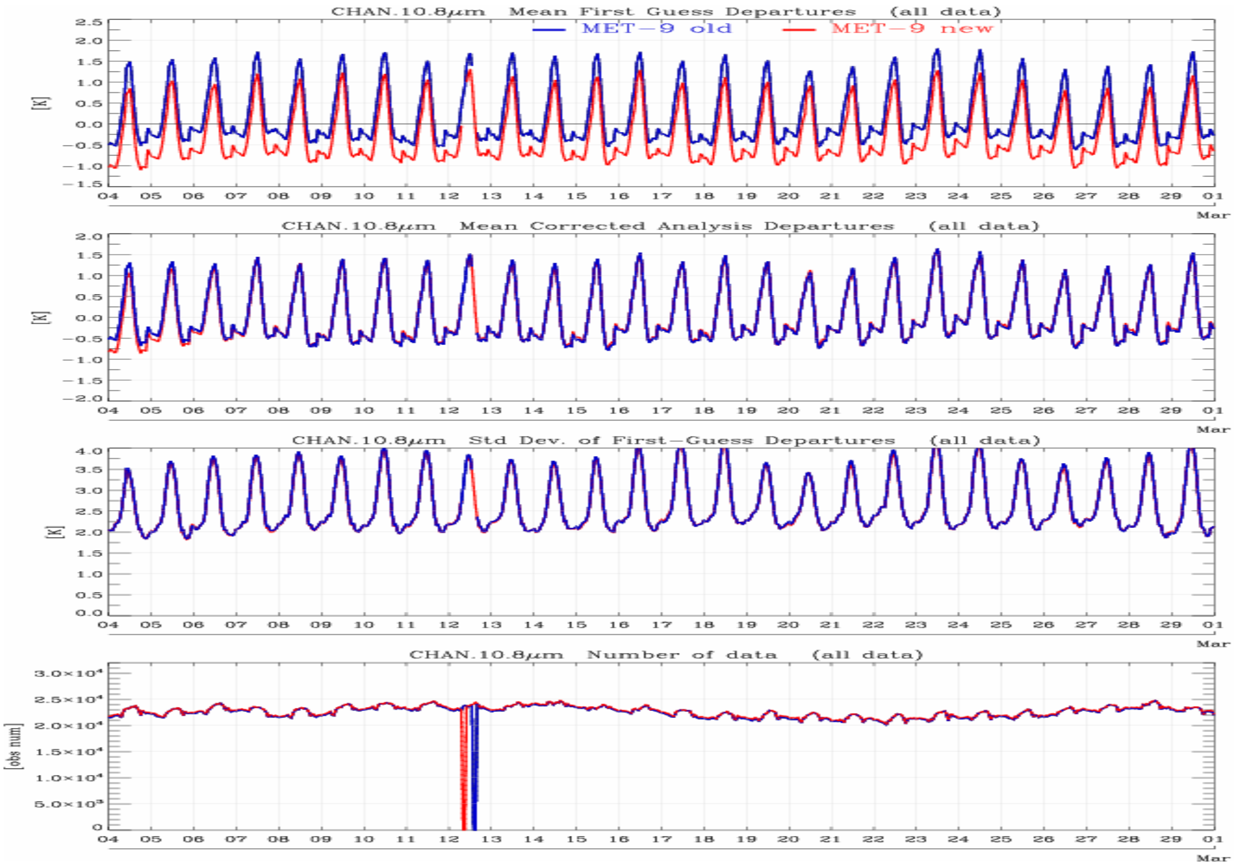

Figure 3. First guess departures for Channel 10 (IR window) for the old and new radiance definition scheme as monitored by ECMWF.

A summary of the noted change per channel is presented in Table 3.

Table 3. The impact of the radiance definition change for the various channels

Channel	Wavelength	Radiance change [%]	EBBT change [K]
4	3.9	1.71880	0.40
5	6.2	2.10557	0.54
6	7.3	0.34882	0.12
7	8.7	0.20165	0.10
8	9.7	0.03993	0.02
9	10.8	-0.78618	-0.50
10	12.0	-0.37752	-0.26
11	13.4	-0.32365	-0.21

5 UPCOMING CHANGES TO THE AMV GENERATION SCHEME

The AMVs are subject to continuous improvements and follow the recommendations of the International Winds Workshops. Some of the upcoming new ideas are presented in Borde (2008). In addition to improvements in the product generation itself there are also other changes under consideration. One of the main activities is the introduction of rapid scan products for Europe in May 2008. The product generation will be based on 5-min imagery and as for the full disc products, four images are used to derive the final product. Figure 4 gives an example of the upcoming product and its coverage. Please note that the provided example contains real rapid scan winds, however, overlayed on a collocated Meteosat-8 image portion. The rapid scan area is however in the north-south direction representative..

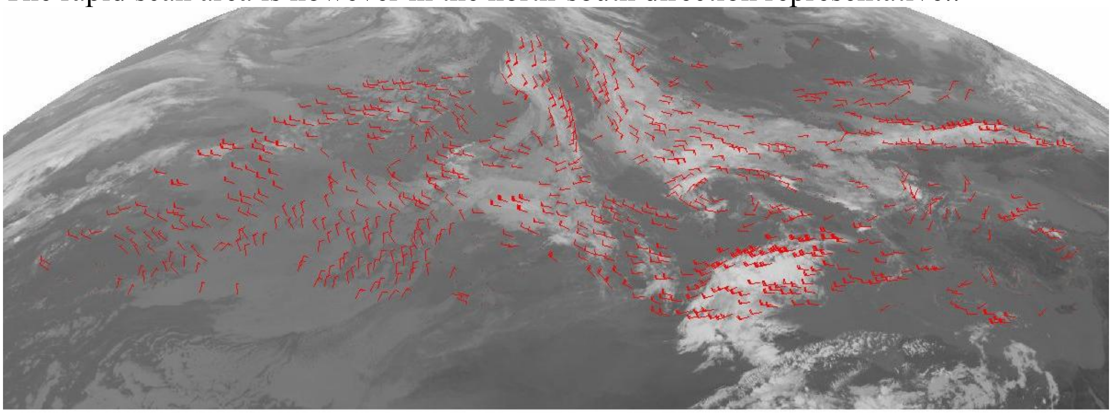

Figure 4. Rapid scan winds derived from 5 min imagery from Meteosat-9 overlayed on .a Meteopsat-8 image roughly capturing the rapid scan area.

Figure 5 presents a comparison between operational IR winds with corresponding rapid scan winds. The larger consistency and denser winds field with comparable quality as determined by the quality indicator is apparent.

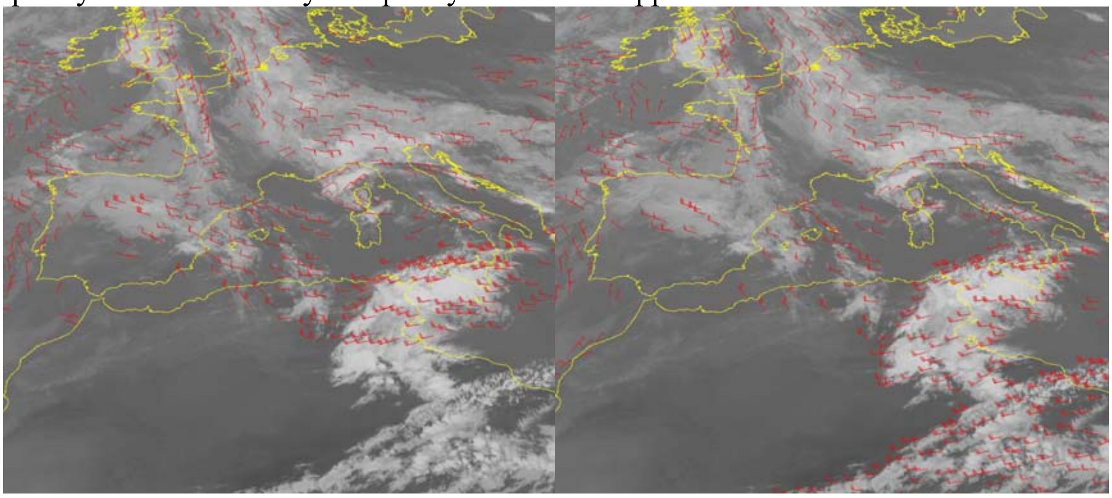

Figure 5. Atmospheric Motion Vectors derived with rapid scan IR image data (5 min imagery, left) and from normal image repeat cycle (15 min, right). Increased number of good quality winds (as defined by the quality indicator) is apparent.

Further changes expected in the near future are the introduction of RTTOV-9 as the baseline radiative transfer model and the Polar Winds from AVHRR (see Dew, 2008).

6 CONCLUSIONS

An overview of the current geostationary satellite system and the derived wind products has been given. Upcoming changes both with respect to the derivation of the products as well as to the satellite configuration has been given. Additionally a brief overview of the EUMETSAT reprocessing activities has been given.

References

Dew G., 2008: AVHRR Polar Winds Derivation at EUMETSAT: Current Status and Future Developments. Proc. 9th International Winds Workshop, Annapolis, USA, 14 – 18 May 2008. These Proceedings, available via EUMETSAT web-site, www.eumetsat.int.

De Smet A., 2008: AMV Height Assignment with Meteosat-9: Current Status and Future Developments. Proc. 9th International Winds Workshop, Annapolis, USA, 14 – 18 May 2008. These Proceedings, available via EUMETSAT web-site, www.eumetsat.int.

Borde R., 2006: AMV Height Assignment Methods with Meteosat-8. Proc. 8th International Winds Workshop, Beijing China, 24 – 28 April 2006. P 47, Available via EUMETSAT web-site, www.eumetsat.int.

Borde R., 2008: A direct link between feature tracking and height assignment of operational AMVs. Proc. 9th International Winds Workshop, Annapolis, USA, 14 – 18 May 2008. These Proceedings, available via EUMETSAT web-site, www.eumetsat.int.

EUMETSAT, 2008: MSG Algorithm Specification V4, EUM.MSG.SPE.022, Available from EUMETSAT web-site, www.eumetsat.int.

Holmlund K., 1999: The use of observation errors as an extension to Barnes interpolation scheme to derive smooth instantaneous vectorfields from satellite-derived Atmospheric Motion Vectors. The 1999 EUMETSAT Meteorological Satellite Data Users' Conference, Copenhagen, 6 – 10 September 1999, EUM P 26, available from EUMETSAT.

Holmlund K., A. Arriaga, S. Tjemkes, H-J. Lutz and M. König, 1999: Cloud height determination for Atmospheric Motion Vectors using Meteosat Second Generation. Proc. The 1999 EUMETSAT Meteorological Satellite Data Users' Conference, Copenhagen, 6 – 10 September 1999, EUM P 26, available from EUMETSAT.

Schmetz, J. Holmlund K., H-P Roesli and V. Levizzani, 2000: On the use of rapid scans. Proc. 5th International Winds Workshop, Lorne, Australia, 28 February – 3 March 2000. EUM P 28, available from EUMETSAT.