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

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ABSTRACT

EUMETSAT currently derives meteorological products operationally from four geostationary satellites. Additionally products from the latest addition to the EUMETSAT fleet, the second Meteosat Second Generation satellite (MSG-2), are derived routinely in support of the MSG-2 commissioning. In the coming years there will be some re-organisation of the constellation of the EUMETSAT satellites when the primary service from the 0^o longitude will be provided by the second generation satellites only and the Indian Ocean Data coverage will be continued by the first generation Meteosat-7 replacing Meteosat-5. This paper will give an overview of the current Atmospheric Motion Vector (AMV) products derived operationally at EUMETSAT and the changes since the previous International Winds Workshop will be described. Furthermore the upcoming changes and specifically those related to the relocation of the geostationary satellites will be described.

1 SATELLITE CONFIGURATIONS AND WIND PRODUCTS

EUMETSAT is currently operating five geostationary satellites, namely the three Meteosat First Generation (MFG) satellites Meteosat-5, -6 and -7 and the two Meteosat Second Generation (MSG) satellites Meteosat-8 and Meteosat-9. Until mid-2006 Meteosat-5 was providing the Indian Ocean Data Coverage (IODC) service from 63^{o}E, Meteosat-6 the Rapid scan service form 10^{o}E and Meteosat-8 the primary service from 3.4^{o}W. Meteosat-7 was providing backup services from 0^o and Meteosat-9 (MSG-2) was still in commissioning. All satellites were used for the derivation of meteorological products, particularly Atmospheric Motion Vectors. Figure 1 gives an example of Atmospheric Motion Vectors (AMVs) derived with Meteosat-8 and -9 on 30 January 2006 at 1245 UTC. It is encouraging to note that already during the early commissioning phase the results derived with Meteosat-9 are very similar to those of Meteosat-8. It should however be noted that some striping in the water vapour 6.2 micron images of Meteosat-9 have been detected and the impact of this behaviour on the generated products has to be assessed.

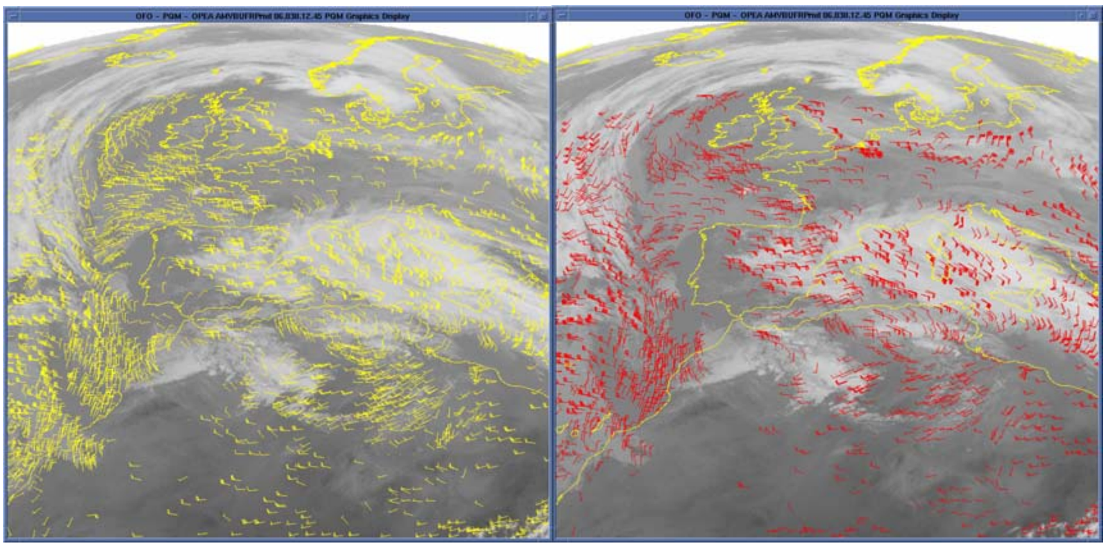


Figure 1. A comparison of the operation AMVs derived with Meteosat-8 and the corresponding data derived with Meteosat-9 during commissioning.

The resolution of the AMVs from the first generation satellites is 160 km for IR, low resolution visible and clear sky water vapour winds and 80 km for the high resolution visible winds and for the water vapour cloud tracked winds. The resolution of the AMVs derived with the MSG satellites is 80 km, except for the High Resolution Visible (HRVIS) winds that are derived with an average vector density of 32 km. Figure 2 gives an example of low level AMVs derived with HRVIS and low resolution visible data from Meteosat-8 on 7 December 2005.

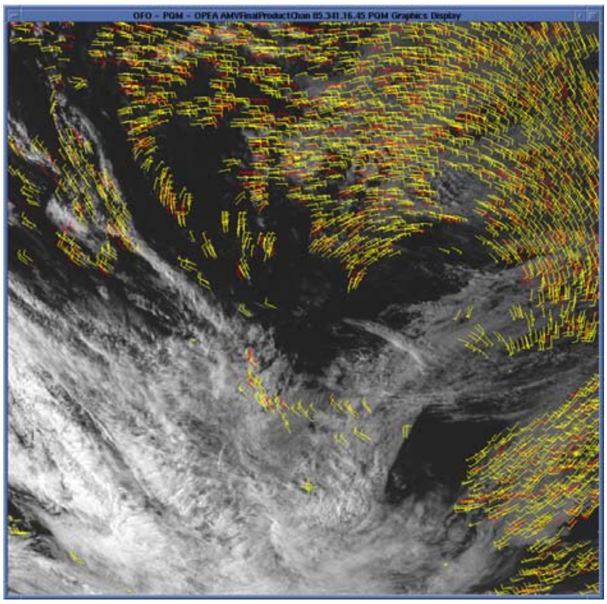


Figure 2. Low level AMVs derived with visible data on 7 December 2005 at 1645 UTC. HRVIS winds are presented in yellow, low resolution visible winds in red. Only winds with a QI > 0.8 are presented

As the derivation of the AMVs for the MFG satellites is based on image triplets, the full field of view products are derived every 90 minutes. The rapid scan products from Meteosat-6 are due to the 10 minute image repeat cycle available every 30 min. The products from the MSG satellites are derived on an hourly basis and use four 15 min images. For further details on the derivation of AMVs please consult the EUMETSAT web-site www.eumetsat.int or e.g. Holmlund (2002) and for current status on height assignment methodologies Borde (2006) and de Smet (2006). All products are derived in near-real time and disseminated via the GTS in BUFR. Some products are additionally distributed over the EUMETCast dissemination scheme, using commercial telecommunication satellites (For further details visit the EUMETSAT web-site www.eumetsat.int). A limited set of data from the MFG satellites has also been available in the SATOB format. However, it is foreseen to terminate the SATOB formats later in 2006.

The main change in the 2006-2007 time frame is the expected operational readiness of Meteosat-9 in summer 2006. This will enable the relocation of Meteosat-7 to support the IODC mission. Currently it is planned to have Meteosat-7 relocated by the end of 2006, well in time before the end-of-life due to lack of fuel of Meteosat-5. Meteosat-5 will be re-orbited in 2007. Due to limited battery capacity, Meteosat-7 will not be able to provide Data Collection Platform (DCP) services and hence the re-location of Meteosat-6 is also required in support of the IODC CDP mission. The relocation of Meteosat-6 is planned to commence at the beginning 2007 at which time the rapid scan service has been terminated. The possibility to use a MSG type satellite to provide rapid scan services is currently under investigation. In case of technical confirmation and an established of user requirement for rapid scan services with the MSG satellites, the service could start early 2008. In such a case the current assumption is that the image repeat cycle would be 5 minutes, enabling a synchronisation with the repeat cycles of current weather radars.

2 CHANGES SINCE THE 7TH INTERNATIONAL WINDS WORKSHOP

The main improvements have been focused on the height assignment for the MSG AMVs. The 7th International Winds Workshop made a recommendation to keep the height assignments used to derive the final heights separate and not to mix various methods. For further details see Gustafsson (2006) or de Smet (2006). The modified approach was introduced in December 2004. Additionally in 2004 the scenes selection, e.g. cloud detection was refined. In 2005 a cloud-base height assignment was introduced and for the CO_2-ratioing approach the 10.8 micron channel was replaced with the 12.0 micron channel. The latter change was introduced in December 2005 simultaneously with an improved correction of the impact of atmospheric absorption over clouds (see Gustafsson, 2006).

Additionally to the height assignment changes the Automatic Quality control was improved in 2004 by further tuning and the introduction of an image correlation test. The quality of very weak winds (speed < 2.5 m/s) is since October 2005 reduced.

Regarding tracking the only changes was the switch from the cross-correlation technique to the Euclidean distance for clear sky targets in December 2004.

Furthermore the observation time has now been adjusted to reflect the central time of all the image data used, i.e. it is now 30 minutes past the hour instead of 45 minutes, i.e. the image data used range from 00 minutes up to 60 minutes past the hour.

Last, but not least, the HRVIS winds were introduced in March 2005.

3 UPCOMING CHANGES TO THE AMV GENERATION SCHEME

The introduction of the Recursive Filter Function (RFF) will finally take place during the 3rd quarter of 2006. The RFF will provide additional quality information and is foreseen, in the future, to be part of a specific Height Quality Indicator (HQI). For further details see Dew (2006). Further improvements are also expected for the height assignment schemes as is shown by Borde (2006) and de Smet (2006). Also these changes will enable the derivation of a dedicated HQI, which is foreseen to be introduced towards the end of 2006.

In the second half of 2006 the AMVs will also be used to derive divergence fields. These fields can be used for e.g. assessment of Numerical Weather Prediction model performance and to analyse convective systems (Schmetz et al. 2002) or for general weather analysis (Holmlund, 2006).

Other changes that are not directly related to the AMV generation, but that will potentially have a significant impact on the quality of the derived vectors and their heights is the use of RTTOV as the main Radiative transfer model, the use of higher resolution forecast data and improved calibration.

Last, but not least, the processing area will be increased to provide a better coverage for high latitudes and also an increase in the product resolution from an average density of 80 km to 50 km. will be considered. Figure 3 shows an example of high density winds derived with Meteosat-8 infrared data. The extraction grid is 12 * 12 providing an average vector density for the Meteosat-8 3-km sampling distance of 40 km in cloudy areas.

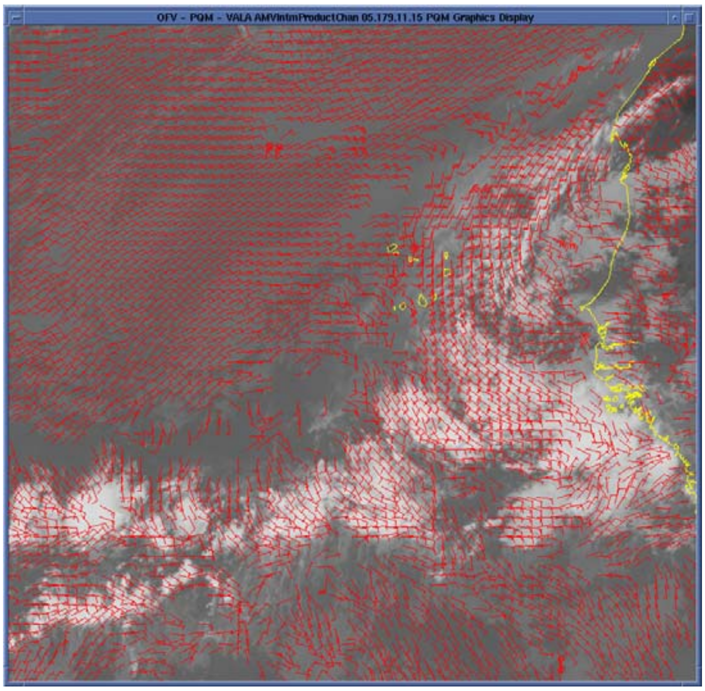


Figure 3. High resolution infrared AMVs derived from Meteosat-8 data on 28 June 2005 with an extraction grid of 12*12 pixels providing an average vector density of 40 km.

4 VERIFICATION AND VALIDATION

The verification and validation of the AMV products is a routine task performed at EUMETSAT. The routine statistics are based on AMVs collocated with radiosonde or aircraft observations. Comparisons of the performance of various AMV products is however quite sensitive to various selection criteria like the selection of the quality indicator (QI) threshold. The QI thresholds, in case comparing various systems with each other, should be carefully selected in order to have similar representation of the two data sets. For a more detailed discussion on the problems related to verification and validation see Gustafsson (2006). Additionally, as many statistics are based on collocation with radiosondes, it is important to note the impact of the collocation box size has been discussed at the previous Winds Workshops and the 3rd International Winds Workshop (IWWS3, 1996) made a recommendation for the basics set of statistics to be derived fo the CGMS (Co-ordination Group for Meteorological SAtellties) statistics. Figure 4 gives an exam le of the impact of carious collocation box sizes on the normalised RMS error and bias. Currently the CGMS statistics assume a 150 km, but with the increased resolution of the current AMV products the collocation area issue may need to be revisited.

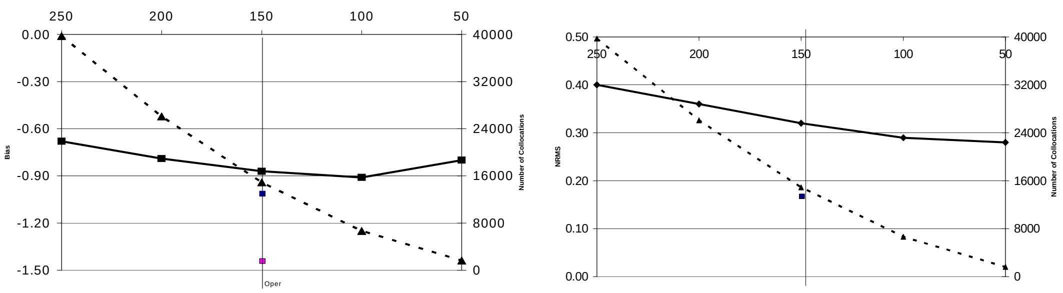
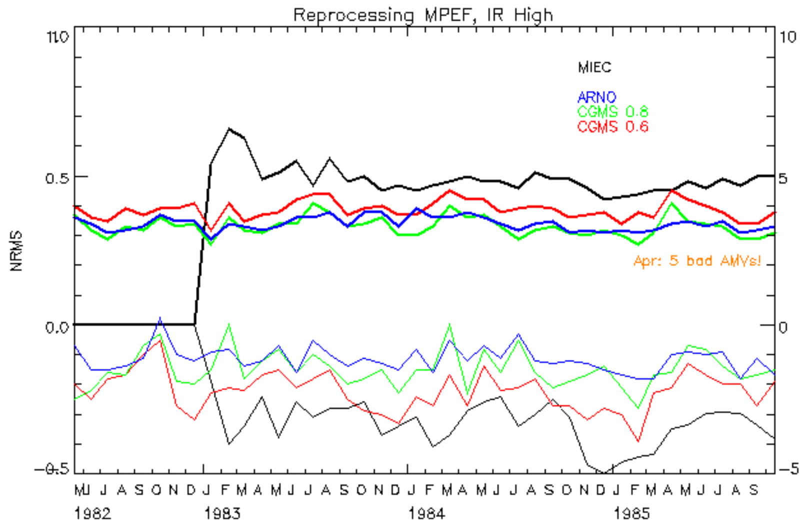


Figure 4. The impact of changing the collocation area on bias (left) and normalised RMS (right) represented by the solid lines. The number of collocation is represented by the dashed lines.

5 REPROCESSING ACTIVITIES

EUMETSAT has provided reprocessed AMVs in support of various re-analysis activities (e.g. Berg, 2006). The impact of reprocessing historical image data with state of the art algorithms is a significant improvement in quality. Figure 5 gives an example of the change in RMS error normalised with the mean winds speed (NRMS) for the AMVs generated in support of the ECMWF ERA-25 project versus the quality of the original data. The improvement in quality in both NRMS and speed bias is evident. Please note that no statistics for the operationally derived winds are presented before 1983.



Figire 5. The quality of the reprocessed AMVs versus the operationally derived AMVs as described by the normalised RMS (NRMS) and speed bias. The quality of the operationally derived winds is represented by the black lines, whereas two different CGMS statistics are shown (for two different QI thresholds; 0.6 in red and 0.8 in green). Statistics for the reprocessed winds most comparable to the statistics of the operational winds are represented in blue.

Additionally to improved quality the re-processing enables the use of all image data. E.g. in the mid-eighties Meteosat AMVs were only derived by tracking features in the infrared image data. The use of the water vapour and visible data will significantly improve the coverage of the products. In the latest re-processing activities image data from the nineties has been reprocessed. Also here an improvement in quality and amount of data has been seen, particularly due to the use of the quality indicator approach. Of particular interest is however the AMVs derive with the so-called ADC (Atlantic Data Coverage) and XADC (Extended ADC) data from the early nineties. From mid 1991 until mid 1995 Meteosat-3 was relocated to 55^{o}W and later to 75^{o}W due to failures in the GOES system. Figure 6 gives an example of the wind fields derived with the ADC data. The data has been delivered to ECMWF in support of the interim ERA project and is currently under evaluation.

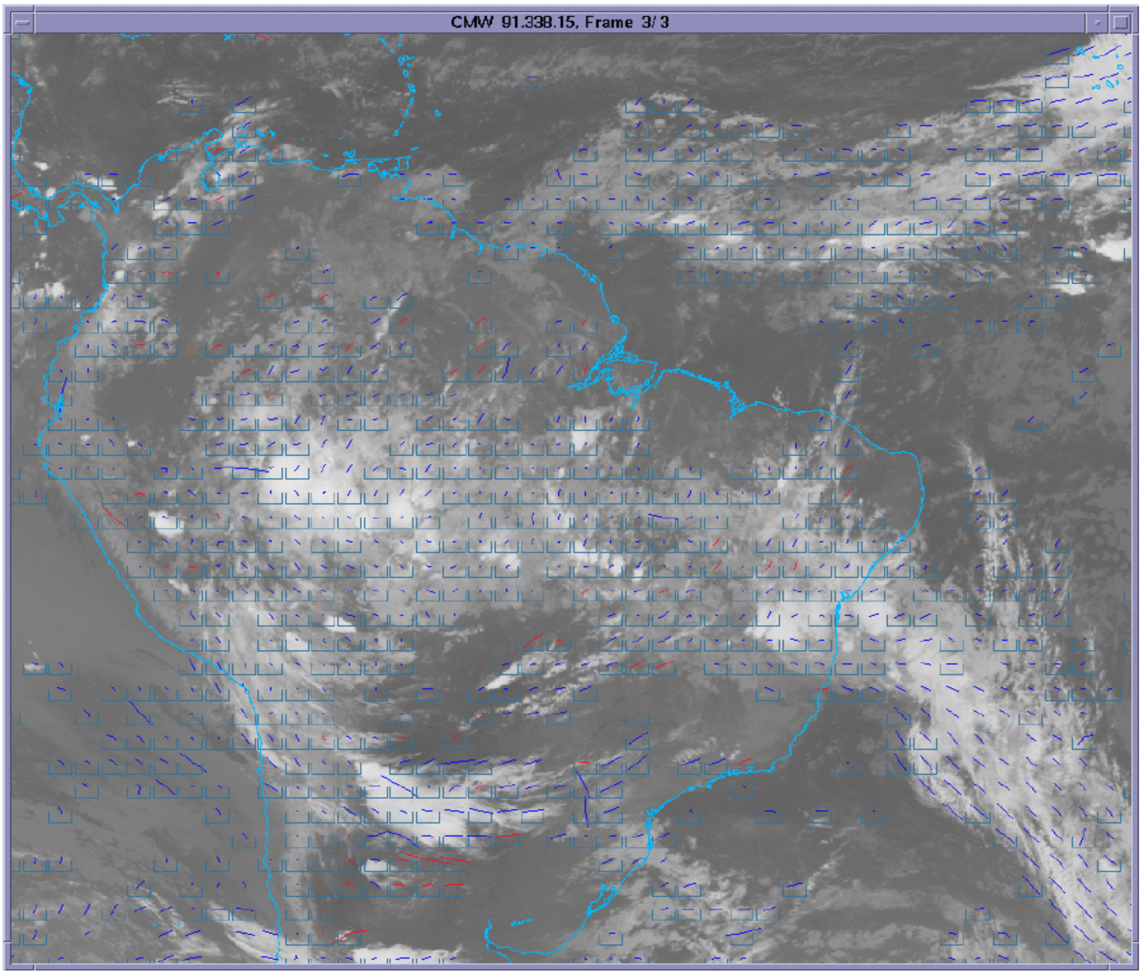


Figure 6. AMVs derived with ADC data by the EUMETSAT reprocessing facility in support of the ECMWF interim ERA project.

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.

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