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### **GLOBAL AVHRR WINDS FROM DUAL-METOP OPERATIONS**

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#### ABSTRACT

Atmospheric Motion Vectors (AMVs) are currently derived operationally with geostationary satellite data or single polar orbiting satellites. The geostationary AMVs generally cover a latitude band between 60 degrees south and 60 degrees north, whereas polar orbiting satellites are used for the derivation of polar cap winds, covering generally speaking high latitude areas beyond 60 South and 60 North. Due to the difference characteristics of the products, high viewing angle for the geostationary satellites, limited overlap for the polar satellites, the 10 degree latitude band around 60 degrees North and South are not well covered. In addition research missions like MISR that would provide global coverage have not yet achieved full operational maturity for the products. With the launch of Metop-1 (entering operations as Metop-B) EUMETSAT will be in a unique position to acquire global AVHRR data at a 1 km resolution from two spacecrafts in the same orbit. The foreseen orbit separations is roughly 48 minutes providing roughly a half-a-swath overlap at the equator for the two AVHRRs onboard Metop-A and –B, and better in the high latitudes. Therefore there is an unprecedented opportunity to derive global AVHRR winds using data from these two spacecrafts, providing a significant increase in data in this data sparse band around 60 North and South. In addition the global AVHRR winds provide an excellent opportunity to perform consistent cross-validation between AMVs derived from polar orbiting satellites and all geostationary satellites.

This paper will introduce the justification and concept for the global AVHRR winds from dual-Metop operations comparing the differences imposed on the derivation as compared to pure polar cap winds as derived from a single spacecraft.

### 1. INTRODUCTION

Atmospheric Motion Vectors (AMVs) currently derived operationally with geostationary satellite data or single polar orbiting satellites constitute an important part of the global observing system, which is demonstrated by recent studies presented also in this publication (IWWS11, 2012). These winds are generally derived by tracking atmospheric features, mainly clouds but also water vapour in consecutive images, with height assignment based on the radiative properties of the clouds and the foundation of quality control is based on consistency checks with adjacent winds and stability of the tracking over time. Depending on the satellite system, the time span between the consecutive images ranges from 15 minutes to more than a 100 minutes. In addition, rapid scan data with image repeat cycles down to 5 minutes are used operationally for the derivation of AMVs.

The geostationary AMVs generally cover a latitude band between 60 degrees south and 60 degrees north. Polar orbiting satellites are operationally used for the derivation of polar cap winds using single satellite data, covering generally speaking high latitude areas beyond 60 South and 60 North. Due to the difference characteristics of the products, high viewing angle for the geostationary satellites, limited overlap for the polar satellites for a single satellite approach, the 10 degree latitude band around 60 degrees North and South are not well covered.

In addition to single satellite derivation methods, the possibility to use data from several polar orbiting satellites is exploited. This provides more frequent imaging and even the possibility to derive winds a lower latitudes than 60 North and South. However, for the medium and low altitudes the possible coverage that could be achieved is patchy and sparse.

And finally, it should be noted that the combined use of geostationary and polar orbiting satellite data can also be used to derive winds, where specific attention is required to deal with the varying characteristics like resolution of the different satellite instruments. For further details on the good potential of these winds see Hoover at al., 2012.

Figure 1 shows the coverage provided by GOES 15, clearly demonstrating the capping of the data around 60 degrees North and South. The coverage provided by other satellite operators like EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites), CMA (Chinese Meteorological Administration, and JMA (Japan Meteorological Agency) provide similarly limited coverage for the high latitudes.



Figure 1. Data coverage from GOES 15 AMVs as monitored by ECMWF (European Centre for Medium range Weather Forecasts 11.12.2011 – 31.01.2012.

Figure 2 present the current coverage of polar winds from NOAA-18 AVHRR and Terra WV data. The problematic areas around 55-60 degrees North and South are highlighted and is similar for other satellites of the same kind.



Figure 2. Data coverage form polar winds based on NOAA-18 AVHRR (left) and Terra WV (right) data as monitored by ECMWF11.12.2011 – 31.01.2012..

In addition to the use of consecutive images from the same spacecraft the research mission MISR (Multi-angle Imaging SpectroRadiometer) on board the Terra satellite is able to provide global coverage using the multi-angle viewing capability of the MISR instrument and providing height assignment based on stereo imaging. However, the MISR wind products have not yet achieved full operational maturity.

With the launch of Metop-1 (entering operations as Metop-B) EUMETSAT will be in a unique position to acquire global AVHRR (Advanced Very High Resolution Radiometer) data at a 1 km resolution from two spacecrafts in the same orbit. The foreseen orbit separations is roughly 48 minutes providing an almost half-a-swath overlap at low latitudes for the two AVHRRs onboard Metop-A and –B, and better in the high latitudes. Therefore there is an unprecedented opportunity to derive global AVHRR winds using data from these two spacecrafts, providing a significant increase in AMV coverage data in the data sparse band around 60 North and South. In addition the global AVHRR winds provide an excellent opportunity to perform consistent cross-validation between AMVs derived from polar orbiting satellites and all geostationary satellites.

This paper will introduce the justification and concept for the global AVHRR winds from dual-Metop operations comparing the differences imposed on the derivation as compared to pure polar cap winds as derived from a single spacecraft.

## 2. CONCEPT AND COVERAGE

The current state of the art polar winds derived from AVHRR use a set of three consecutive overpasses from the same spacecraft to derive a pairs of vectors based on tracking the same atmospheric feature from image 1 to 2 and then from image 2 to 3. In order to derive global winds from two Metop satellites in the same orbit a principal change will have to be introduced. Due to the swath width of the AVHRR instrument and the orbital characteristics of the Metop satellite, there is not sufficient overlap (medium and low latitudes no overlap) from two consecutive orbits from the same spacecraft. Therefore deriving global winds will have to be based only two images; one from each satellite in the same orbital plane. Figure 3 illustrates the approach.



Figure 3. Illustration of the overlap provided by dual-Metop operations. In this figure Metop-1 has already completed the coverage over the South-Atlantic region (green) and Metop 2 is flying south providing coverage in red/brown leading to the overlap region for wind extraction (mixed green-red/brown). Please note that there are some spurious coverage in this view that should be ignored.

# 3. QUALITY

The use of only two images has the advantage of reducing the time period over which targets are traced. It has in the past been demonstrated that for geostationary satellites the optimal time separation for the derivation of AMVs is strongly related to the image resolution. Normally, for geostationary satellites, this time separation is between 15 and 30 minutes for an image resolution/sampling distance of 3-5 km. This is further confirmed by looking at the quality of winds from rapid scan data, where the increased image frequency does not provide immediate benefits in quality, however, there is a slight increase in yield. With data from a single polar orbiting satellite, the image separation is of the order of 100 minutes, and using an image triplet leads to an overall tracing time of 200 minutes of the observed atmospheric features. Thus the relationship between the actual wind and derived displacement vectors will be weaker. However, using a triplet does provide a better utility for quality control. With two Metop satellites in the same orbit the image separation time in the overlap region is of the order of 48 minutes. This is significantly better, however, with the down side of not having wind vector pair that can be used for quality control.

In order to improve the coverage of the polar winds and to prepare for global winds from dual-Metop operations, the current EUMETSAT implementation of polar AVHRR winds is based on image pair only. Figure 4 shows a comparison of the achieved coverage from using triplets vs. image pairs from the Metop satellite.



Figure 4. The coverage of potential targets over the North Pole as derived by image triplets (left) and image pairs (right).

The overall derivation approach for the global AVHRR winds will be the same as currently used at EUMETSAT for polar winds. For further details see Dew and Borde (2012). Hence, there is no significant deterioration anticipated from the derivation approach and the main aspect driving the overall quality that can be achieved by using image pairs only.

Figure 5 shows the distribution of forecast consistency for the final winds derived by image triplets (prototype) and image pairs (operational). It is evident that the percentage of high quality winds, as measured by consistency against the forecast, is somewhat reduced and more winds end up in the lowest quality category. However, there is still a significant and high overall yield of good quality winds, indicating that a derivation based on image pairs only has the potential to derive winds with adequate quality. The results are also confirmed by independent monitoring of the quality of the operational EUMETSAT polar AVHRR winds (based on image pairs) and comparing that to AVHRR polar winds derived by NOAA (based on image triplets. For further details on the quality of the EUMETSAT polar AVHRR winds see Dew and Borde (2012).



Figure 5. The distribution of the forecast consistency of winds derived with AVHRR data over the South Pole based on image pairs (blue) and triplets (red).

This finding is further confirmed by the monitoring performed by ECMWF. Figure 6 shows a comparison of first guess departures of the operational EUMETSAT polar AMVs (based on image pairs) vs NOAA-18 polar AMVs (based on triplets). The overall departures are similar in nature. The figure also neatly demonstrates the improved coverage that can be derived, with some wind data appearing in the latitude bands 50-57 degrees North and 57-62 South.



Figure 6. Mean First guess departures as monitored by ECMWF 31.12.2011 – 20.02.2012 for EUMETSAT polar AMVs (left) and NOAA-18 AMVs (right).

### 4. CROSS VALIDATION OPPORTUNITIES

The derivation of global AVHRR winds will give an excellent opportunity to directly compare the quality of AVHRR based winds with geostationary AMVs. Such comparisons can provide valuable insight into the performance and potential problems in the two data sets under comparison.



Figure 7. A comparison of MISR derived heights against Meteosat-9 heights for collocated AMVs (Lonitz and Horvath, 2011).

Figure 7 presents the comparison of heights for collocated winds derived from MISR and Meteosat-9 data. The scatterplot show significant agreement for most winds, however also a clustering of features where the two data sets differ. These clusters can be traced to specific geographical areas and cloud types, identifying potential problems in the height assignment approach used for those cases. For further details see Lonitz and Horvath (2011).

## 5. SCHEDULE

The preparation work for the derivation of polar AMVs is ongoing. The required software modifications have been prepared, however only limited testing has been done, due to the lack of two Metop satellites in orbit. Currently the launch of Metop-1 (designated to become Metop-B in orbit) is planned for August 2012. Autumn 2012 is therefore focusing on the commissioning and validation activities of the Level-1 data from the Metop instrument and the baseline Level-2 products, including the AVHRR Polar Winds. Initial testing of the global AVHRR winds will start during the autumn and first releases of the new data sets are anticipated for early 2013.

## 6. SUMMARY

This paper has introduced the justification and concept for the global AVHRR winds from dual-Metop operations highlighting the differences imposed on the derivation as compared to pure polar cap winds as derived from a single spacecraft. It is anticipated that the quality of the derived global AVHRR winds will be similar to that of the operational EUMETSAT Polar Winds, hence providing the potential for a new truly global wind product. This new approach will also enable new opportunities for comparing various data sets from various satellites in a consistent manner.

Currently, the launch of Metop-1 (designated to become Metop-B in orbit) is foreseen in August 2012, with entry into full operations early 2013. Around that time, first demonstration products of the dual-Metop winds are anticipated.

### References

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