Metop-C AVHRR Winds Product Validation Report
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## Document Change Record

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<th>DCN. No</th>
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1 INTRODUCTION

1.1 Purpose of this Document
The purpose of this document is to present the new AVHRR winds products extracted from Metop-C data, with the goal of setting this product to operational status and to authorize its full dissemination.

1.2 Algorithms and Products Involved
The algorithm used to extract AVHRR winds from Metop-C data using two or three consecutive images is exactly the same as the one used for Metop-A and Metop-B. The version 3.1 is running unchanged. Only the processing rules were updated to accommodate the new satellite data source.

1.3 Structure of the Document
The document is organised in the following sections:

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1.4 Reference Documents

The documents listed here are referenced in the text of this document. All the documents listed are available on the EUMETSAT Technical Documents web page.

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<th>Ref</th>
<th>Title</th>
<th>EUMETSAT Reference</th>
</tr>
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<tbody>
<tr>
<td>RD1</td>
<td>AVHRR L2 Wind product ATBD</td>
<td>EUM/RSP/SPE/14/781004</td>
</tr>
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1.5 Acronyms and Abbreviations

<table>
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<th>Acronym</th>
<th>Meaning</th>
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<tr>
<td>AMV</td>
<td>Atmospheric Motion Vectors</td>
</tr>
<tr>
<td>CTH</td>
<td>Cloud Top Height</td>
</tr>
<tr>
<td>CTT</td>
<td>Cloud Top Temperature</td>
</tr>
<tr>
<td>EBBT</td>
<td>Effective/Equivalent Black Body Temperature</td>
</tr>
<tr>
<td>ECMWF</td>
<td>European Centre for Medium-Range Weather Forecasts</td>
</tr>
<tr>
<td>FC</td>
<td>Forecast</td>
</tr>
<tr>
<td>GS</td>
<td>Ground Station</td>
</tr>
<tr>
<td>IASI</td>
<td>Infrared Atmospheric Sounding Interferometer</td>
</tr>
<tr>
<td>QI</td>
<td>Quality Index</td>
</tr>
<tr>
<td>RMSV</td>
<td>Root Mean Square Value</td>
</tr>
<tr>
<td>RMSVD</td>
<td>Root Mean Square Value Deviation</td>
</tr>
</tbody>
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2 OVERVIEW OF THE PRODUCTION

The process of Metop-C AMV products was deployed as follows:

<table>
<thead>
<tr>
<th>Deployed on</th>
<th>date</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPE environment for Single Mode</td>
<td>4 December 2018</td>
</tr>
<tr>
<td>OPE environment for multi-satellite operations</td>
<td>17 January 2019</td>
</tr>
</tbody>
</table>

Real-time monitoring tools were updated to handle Metop-C products. The monitoring is based on the PPF reports and on the statistics extraction on the output products, all stored on /tcenas/fbf/tcdras/store directories. All the data are saved in a database for further investigation. The plots are generated by this monitoring framework and accessible directly on a dynamic web server.

Limitation: if some files are not pushed to TCE rolling archive, the corresponding products appear as missing even if they were produced.

The production parameters (counts, timeliness, etc...) are accumulated over one hour. The time series of the parameter are on the left of the figures, moving averages are plot in thick solid lines. The value distributions are resumed in a violin plot on the right. The median and average values of the distributions are shown by red and black horizontal lines, respectively.

In the document, the mode AMV_02 refers to the single satellite mode operation, using data from the same satellite for the reference image and the search area. The mode AMV_2D refers to a multi-satellite mode operation, using data from one satellite called as reference platform for the reference image and the data from another satellite that overlaps the region for the search area. The mode AMV_2T is also a multi-satellite operation, including in addition to the mode AMV_2D the data from the previous orbit of the reference platform.
2.1 First products

Figure 1: First PDU processed over the Northern Polar Region with Metop-C data in the single mode AMV_02.

Figure 2: First PDU processed over the Southern Polar Region with Metop-C data in the single mode AMV_02.
Figure 3: First PDU processed in the dual mode (AMV_2D) using Metop-C as reference platform and Metop-A data as the second satellite.

Figure 4: First PDU processed in the dual mode (AMV_2D) using Metop-B as reference platform and Metop-C data as the second satellite.
2.2 Number of products generated

The counts of non-empty products generated on GS1 are shown on Figure 5: Non-empty products (AMV count > 0) for AVHR_AMV_02 (in red), AVHR_AMV_2D (in blue) and AVHR_AMV_2T (in green) produced on GS1 for M03 as reference platform.

For the AVHR_AMV_2D processing type it should be 20 per hour with few exceptions usually on tropics. For AVHR_AMV_02 and AVHR_AMV_2T only generated on Polar Regions, the median value is 10 non-empty products per hour, normally in the range of 8 – 12, with an average value above 10. There is no difference between AMV_02 and AMV_2T behaviour.

2.3 Performance

The User Time and the Elapsed Total Time are extracted from the PPF reports to perform the analysis.

2.3.1 Processing Time

*Error! Reference source not found.* shows the respective elapsed time to process one hour of products for the different processing modes. For one hour of input data, the average processing times for AVHRR data is as follows:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Metop-A (M02)</th>
<th>Metop-B (M01)</th>
<th>Metop-C (M03)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMV_02</td>
<td>~ 160 s</td>
<td>~ 160 s</td>
<td>~ 160 s</td>
</tr>
<tr>
<td>AMV_2D</td>
<td>~ 340 s</td>
<td>~ 360 s</td>
<td>~ 380 s</td>
</tr>
<tr>
<td>AMV_2T</td>
<td>~ 270 s</td>
<td>~ 275 s</td>
<td>~ 280 s</td>
</tr>
</tbody>
</table>
This gives a total of ~810 seconds to process the three modes for one reference platform. In the case of extreme sum, elapsed time is less than 1000 seconds for one hour of processing.

The jobs are dispatched on two virtual nodes (#13 and #14).

These values are similar than the values observed for Metop-A and Metop-B.

![Cumulated Elapsed Processing Time](image)

**Figure 6**: Cumulated elapsed processing time (hourly) for AVHR_AMV_02 (in red), AVHR_AMV_2D (in blue) and AVHR_AMV_2T (in green) produced on GS1 (v3.1) for M03 as reference platform.

**2.3.2 Timeliness**

The next figures presents the timeliness for the three processing modes on GS1. Timeliness of AMV_02 and AMV_2D are similar since the individual PDU processing times are similar. The processing time for AMV_2T is higher than for AMV_02, resulting a slight delay.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Metop-A (M02)</th>
<th>Metop-B (M01)</th>
<th>Metop-C (M03)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMV_02</td>
<td>~ 67 mn</td>
<td>~ 37 mn</td>
<td>~ 70 mn</td>
</tr>
<tr>
<td>AMV_2D</td>
<td>~ 67 mn</td>
<td>~ 47 mn</td>
<td>~ 71 mn</td>
</tr>
<tr>
<td>AMV_2T</td>
<td>~ 67 mn</td>
<td>~ 50 mn</td>
<td>~ 75 mn</td>
</tr>
</tbody>
</table>
Figure 7: Average product timeliness for AMV_02 products with M01 (in red), M02 (in blue) and M03 (in green) produced on GS1.

Figure 8: Average product timeliness for AMV_2D products with M01 (in red), M02 (in blue) and M03 (in green) produced on GS1.

Figure 9: Average product timeliness for AMV_2D products with M01 (in red), M02 (in blue) and M03 (in green) produced on GS1.
The operational monitoring showed that the new version of the IASI L2 PPF got a significant impact on the product timeliness. It was decided to suspend the use of IASI_SND_02 as mandatory input products in the work orders.

The impact on the product quality was monitored and no degradation was observed, so the actual production rules include this change.

![Image](https://via.placeholder.com/150)

Figure 10: Daily average of the AMV_2D products timeliness with M01 (in red), M02 (in blue) and M03 (in green) produced on GS2.

### 3 QUALITY MONITORING

The time series plots presented in this section are produced by the near-time monitoring tool developed. Since the usage of the AVHRR winds is principally over high latitude regions, for AMV_2D products, we only consider the winds derived over the Polar Regions. So we could compare the quality between the different processing modes over the same regions.

The quality plots consider separately the Northern and Southern Polar Regions. The accumulation period is the orbit pass.

#### 3.1 Total number of AMVs

Figure 11 and Figure 12 present the total number of wind vectors derived per orbit over Northern and Southern Polar Regions, respectively. The figures show that the number of vectors derived in the single mode for the Metop-C satellite are similar to the number of winds derived with the other satellites.
Figure 11: Total number of winds derived per orbit over the Northern hemisphere for AVHR_AMV_02 with M01 (in red), M02 (in blue) and M03 (in green) produced on GS1.

Figure 12: Total number of winds derived per orbit over the Southern hemisphere for AVHR_AMV_02 with M01 (in red), M02 (in blue) and M03 (in green) produced on GS1.

Similar consistency is observed for the dual mode.
3.2 Global AMV products in TriStar Metop configuration

The number of winds of the global AVHR_AMV_2D_M01 (Metop-B + Metop-A) product started to decrease rapidly since mid-December. The number of winds of the global AVHR_AMV_2D_M02 (Metop-A + Metop-B) also started to decrease in January.

The production rules were updated to consider the actual phasing of the Metop satellites and to get a consistent set of global AVHRR winds products including Metop-C: AVHR_AMV_2D_M01 (Metop-B + Metop-C), AVHR_AMV_2D_M02 (Metop-A + Metop-B), AVHR_AMV_2D_M03 (Metop-C + Metop-A).

Figure 13: Total number of winds derived per orbit over the Northern hemisphere for AVHR_AMV_2D with M01 (in red), M02 (in blue) and M03 (in green) produced on GS1.

Figure 14: Total number of AMV per day for AMV_2D products with M01 (in red), M02 (in blue) and M03 (in green) produced on GS1.
3.3 Quality index distribution

Figure 15 and Figure 16 present the monitoring of the percentage of wind vectors with quality index greater than 60, our criteria of “good” winds.

We expect similar statistics over the different satellites.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Metop-A (M02)</th>
<th>Metop-B (M01)</th>
<th>Metop-C (M03)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMV_02</td>
<td>52 %</td>
<td>50 %</td>
<td>50 %</td>
</tr>
<tr>
<td>AMV_2D</td>
<td>62 %</td>
<td>60 %</td>
<td>63 %</td>
</tr>
<tr>
<td>AMV_2T</td>
<td>36 %</td>
<td>37 %</td>
<td>40 %</td>
</tr>
</tbody>
</table>
### 3.4 O-B speed monitoring

O-B (Observation minus Background) statistics of the three processing types were compared. Figure 17 to Figure 20 present the O-B bias and RMS for Northern and Southern Polar Regions.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Metop-A (M02)</th>
<th>Metop-B (M01)</th>
<th>Metop-C (M03)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMV_02</td>
<td>55 %</td>
<td>55 %</td>
<td>56 %</td>
</tr>
<tr>
<td>AMV_2D</td>
<td>72 %</td>
<td>73 %</td>
<td>74 %</td>
</tr>
<tr>
<td>AMV_2T</td>
<td>47 %</td>
<td>49 %</td>
<td>49 %</td>
</tr>
</tbody>
</table>

**Figure 17:** Speed bias for AMV_02 products (in red), AMV_2D products (in blue) and AMV_2T products (in green) produced on GS1 (v3.1) for M03 as reference platform over the Northern Region.

**Figure 18:** RMS vector difference for AMV_02 products (in red), AMV_2D products (in blue) and AMV_2T products (in green) produced on GS1 (v3.1) for M03 as reference platform over the Northern Region.
Figure 19: Speed bias for AMV_02 products (in red), AMV_2D products (in blue) and AMV_2T products (in green) produced on GS1 (v3.1) for M03 as reference platform over the Southern Region.

Figure 20: RMS vector difference for AMV_02 products (in red), AMV_2D products (in blue) and AMV_2T products (in green) produced on GS1 (v3.1) for M03 as reference platform over the Southern Region.
The statistics are consistent with the products derived from the other satellites.

Figure 21: Speed bias over the Northern hemisphere for AMV_02 products with M01 (in red), M02 (in blue) and M03 (in green) produced on GS1.

4 FEEDBACK FROM USERS

Meteo-France, DWD, ECMWF and MetOffice prepared preliminary reports which summarize the monitoring and performances of the AVHRR wind product derived with Metop-C data.

4.1 Monitoring from Meteo-France
4.2 Monitoring from DWD

Validation of Metop-C single AMV wind product compared to Metop-B

Alexander Cross  
Deutscher Wetterdienst, Frankfurter Strasse 135, 603 Offenbach am Main, Germany  
alexander.cress@dwd.de

- Comparison of Metop-C AMV wind statistics with AMVs from Metop-B
- Separately for Northern and Southern polar regions and three different tropospheric levels

Obs. Minus FG statistics AVHRR polar winds  
2013120600 - 2013123121

Upper tropospheric winds (400 hPa - 50 hPa)  
Northern polar region (90°N - 60°N)

No significant differences between the quality of Metop-B and Metop-C polar AMVs in the upper troposphere of the northern polar region
Middle tropospheric winds (700 hPa – 400 hPa)
Northern polar region (90°N – 60°N)

No significant differences between the quality of Metop-B and Metop-C polar AMVs in the upper troposphere of the northern polar region.

Lower tropospheric winds (1100 hPa – 700 hPa)
Northern polar region (90°N – 60°N)

Higher bias of Metop-C AMVs compared to AMVs from Metop-B. Slighter higher RMS/Std of Metop-C.
Upper tropospheric winds (400 hPa – 50 hPa)
Southern polar region (90°S – 60°S)

Higher Bias and slightly higher RMS/Std of Metop-C AMVs

Upper tropospheric winds (700 hPa – 400 hPa)
Southern polar region (90°S – 60°S)

No significant differences between the quality of Metop-B and Metop-C polar AMVs in the upper troposphere of the northern polar region
4.3 Monitoring from ECMWF

Preliminary results for Metop C single and dual winds

Katie Lean and Niels Bormann

Good agreement between single winds

Very close similarity in vertical pattern of statistics
Overview

- Single winds
  - Metop A, B and C show very similar statistics of speed bias, RMSVD, observation number and OI dependence both in magnitude and pattern
  - Any differences are small

- Dual winds: comparison between pairs CA and AB
  - Significant differences in statistics and observation numbers between the two pairs
  - More CA pairs, especially in the tropics
  - Although patterns in the statistics are similar, the magnitude is very different with CA pairs showing much better agreement with the background
  - CA show smaller positive speed bias in tropics and negative speed bias at high levels in extratropics
  - This result is quite surprising and the reason for the difference is not clear

Single winds: set up

- Data treated separately for Metop A, B and C
- Experiment uses Metop winds passively (i.e. model background is generated from a system where no Metop winds assimilated)
- Time period: 6 days 29th Jan – 3rd Feb 2019
- Data presented here are without any screening or thinning
Good agreement in speed bias

Metop B  Metop C  |Metop C| - |Metop B|

Spatial patterns similar and noisy differences in small data sample

Dual winds: set up

- Data treated separately for pairs Metop C-A and Metop A-B
- Experiment uses Metop winds passively (i.e. model background is generated from a system where no Metop winds assimilated)
- Time period: 11 days 24th Jan – 3rd Feb 2019
- Data presented here are without any screening or thinning

- B-C not yet looked at
More C-A pairs

Many more winds for C-A in the tropics

Generally higher number’s CA pairs in all regions

Fewer winds for AB and more scatter in statistics

AB pairs

CA pairs
Significant differences in data quality

AB pairs

CA pairs

Speed bias

Tropics and high levels show much better agreement with model in CA pairs

Similar patterns but different magnitudes: speed bias

Larger speed biases for AB pairs by 1-2 m/s in mid/upper levels
4.4 Monitoring from MetOffice

Overview

- 10/01/2019 – 31/01/2019
- Max differences: time = 60 s, distance = 10000m

Collocation

C-A  

C-B  

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**Map**

- Comparable to Metop-A and B NWP SAF map plots

**Zonal plots**

- Comparable to Metop-A and B NWP SAF zonal plots

**Time series**

- Number of winds, bias and rms comparable. Bias possibly slightly better (but too soon to say). Timeliness similar to Metop-A. Metop-B benefits from Antarctic ground dump.
5 CONCLUSION AND RECOMMENDATION

Results show a stable production of the three wind products extracted from Metop-C over the studied periods. The product quality is similar with the quality of winds from other Metop satellites for both single, dual and triplet modes.

Feedbacks received from Meteo-France, DWD and ECMWF confirm our monitoring results.

Based on these results and users feedbacks, we recommend a full dissemination of all the AVHRR winds products extracted from Metop-C (single, dual and triplet modes), with an operational status.