Impact of Atmospheric Motion Vectors from Meteosat 8 on the analyses and forecasting system of DWD

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Abstract

AMV wind vectors derived from tracking clouds and water vapour features in image sequences taken by geostationary (METEOSAT, GOES) and polar-orbiting (TERRA, AQUA) satellites have been used to improve knowledge of atmospheric flow and represent and integral part of the global observing system for numerical weather forecast. Recent work on AMVs have been focused on the replacement of Meteosat 7 wind data by the new wind products from the first Meteosat Second Generation, Meteosat 8, satellite. First comparison results indicate higher quality of Meteosat 8 winds in the infrared and visible channels and slightly lower quality of Meteosat 8 winds derived from the water vapour channel. After extensive monitoring and tests with different QI thresholds, the current experiments show a neutral to slightly positive impact for both Hemispheres and Europe.

1. Introduction

Atmospheric motion vector (AMV) winds derived from tracking clouds and water vapour in images sequences taken by geostationary satellites have been used to improve knowledge and description of atmospheric flow over the oceans and represent an integral part of the global observing system for numerical weather prediction. Operationally, the global assimilation system of the “Deutscher Wetterdienst (DWD)” uses AMV wind data from the geostationary satellites GOES 10/12 and METEOSAT 5/7 in BUFR format including data selection through quality information given by the QI-Index (Holmund, 1998).

The first satellite of Meteosat Second Generation (MSG) satellites – Meteosat 8 – became operational om 29 January 2004 and at the end of 2004, first usable AMV wind vectors, derived by Meteosat 8 were included in the observational data base system of the DWD and passively monitored by the global data assimilation system of the DWD. Meteosat 8 AMVs are produced by EUMETSAT from cloudy targets in the infrared 10.8 µm channel, the 0.8 µm visible channel and from cloudy and clear-sky images in the 6.2 µm and 7.3 µm water vapour channels. As a result of higher temporal and spatial resolution and the use of a second water vapour channel (7.3 µm) a larger number of AMVs are generated by Meteosat 8 compared to Meteosat 7. Additionally, due to the use of a second water vapour channel, winds derived from water vapour targets can be also used in the middle troposphere (700 – 400 hPa). Meteosat AMV wind fields can be derived every 15 minutes although products are extracted and delivered every half-hourly.

This report investigates the quality and statistics of the wind vectors derived by Meteosat 8 compared to Meteosat 7 against the model background and presents results from data assimilation and forecasting experiments using the global model (GME) of the DWD.

2. Monitoring of Meteosat 8

Comparisons of wind speed statistics against quality indicator between Meteosat 7 and Meteosat 8 winds (Fig. 1) indicate small differences in the Tropics and some larger differences for QI indexes smaller than 80 in the outer tropics on both hemispheres. Whilst the operational QI thresholds, which determined the AMVs actively used in the assimilation system, has been set around >60 for Meteosat 7, the results mentioned above indicates the use of a higher QI threshold for Meteosat 8 AMV wind vectors. This has the added merit of reducing the amount of Meteosat 8 winds used in the data assimilation system.

Regional coverage of wind speed biases from Meteosat 8 compared to Meteosat 7 are exemplary illustrated for the upper tropospheric water vapour channel in Fig. 2. Obviously, the Meteosat 8 wind speed coverage shows more detail, with a strong negative bias in the subtropical jet stream (weaker than the first guess) over northern Africa and the Arabian peninsula. Also remarkable is a strong positive bias of the water vapour cloudy winds in the 7.3 µm channel (not shown here) off the coast of south western Africa in the middle troposphere (700 – 400 hPa), maybe due to an incorrect height assignment of low to medium level strato cumulus clouds over the relative cold water off the coast of Namibia. Also, the bias on the southern extra-tropics hemisphere appears to be stronger for water vapour cloudy winds derived by Meteosat 8 than Meteosat 7 in the upper troposphere.

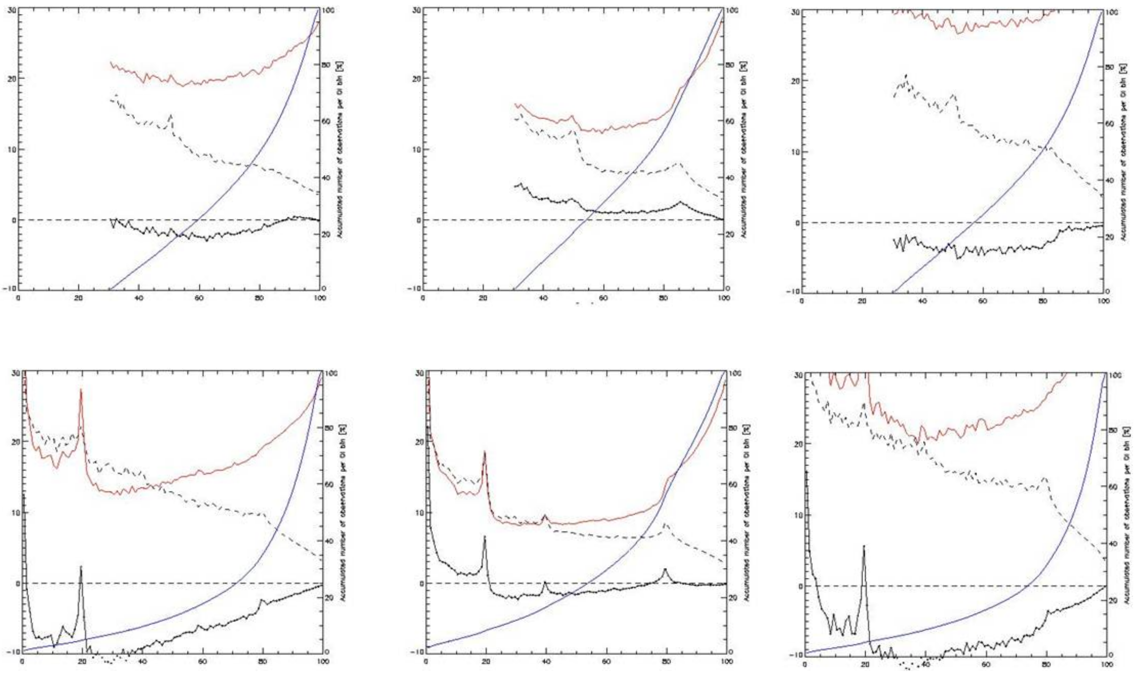

Fig. 1: First Guess departures (OBS-FG in m/sec) against Eumetsat QI for Meteosat 7 (above row) and Meteosat 8 (below row) for upper tropospheric (100 – 400 hPa) water vapour cloudy AMV winds for the Northern Hemisphere (left), Tropics (middle) and the Southern Hemisphere (right). BIAS (bold black line), RMS (dased black line), wind speed (red line) and relative number of observation per bin (light black line).

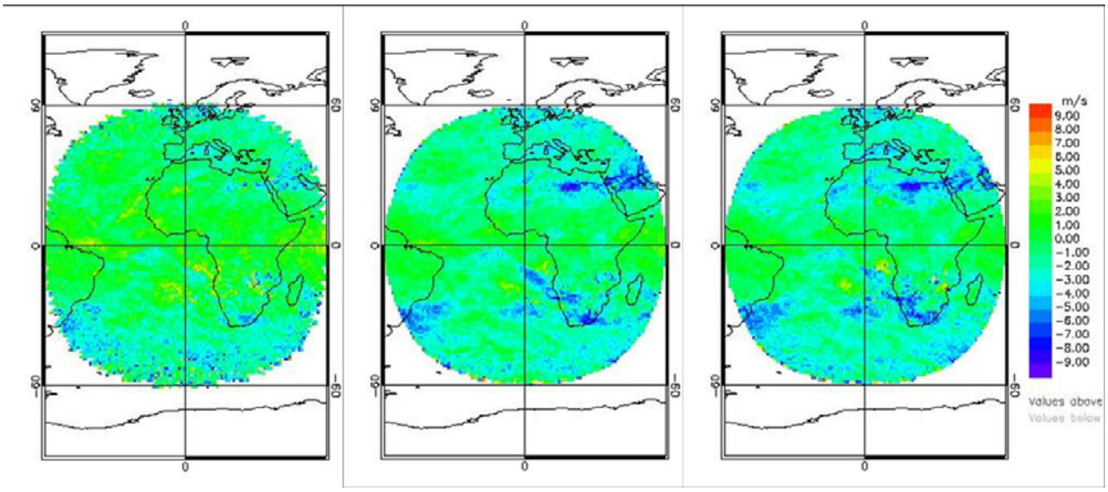

Fig. 2: Regional distribution of wind speed biases averaged of one month (May 2005) for water vapour cloudy channels of Meteosat 7 (left) and Meteosat 8 (6.2 µm; middle and 7.3 µm, right) and values of quality indicators larger than 80.

3. Assimilation of Meteosat 8 AMV wind vectors

Using the global assimilation and forecasting system of the DWD, an impact experiment for the period 15.11. – 15.12.2005 were conducted, to estimate the potential benefit of the AMV wind vectors derived from Meteosat 8 images compared to AMVs generated by Meteosat 7 images used operationally at the DWD. The experiment uses Meteosat 8 AMV winds with the following QI thresholds:

- IR winds: All available winds with QI larger than 85
- Vis winds: All winds below 700 hPa and QI larger than 65 (Tropics: larger than 85)
- WV cloudy: All winds above 400 hPa (both channels) and QI larger than 85
- WV cloudy: All winds (only 7.3 µm) on the Southern Hemisphere between 700-400 hPa) and QI larger than 80

AMV winds tracked from clear sky atmospheric motions in the water vpour channels were not used in the experiment. The experiment was compared to the operational analyses and forecasts (Control) which uses AMV wind vectors derived by Meteosat 7 at the synoptic times (00, 06, 12, 18 UTC). Both, the experiment and the control uses AMV winds only over sea. Besides the static QI thresholds, a thinning step is applied in the operational and experimental assimilation procedure in order to reduce the number of active wind observations for the assimilation and to take into account the high spatial correlation of the AMV wind vectors. The thinning process allocate one wind per thinning box and time slot. There are 16 boxes in the vertical, which correspond to standard pressure levels. The horizontal size of a thinning box is approximately 200km x 200km. The wind is selected by its QI index and to the closeness between observation time and model background time.

4. Results

The use of Meteosat 8 AMV wind vectors have some impact on the global analysis by introducing more detail wind structures in those areas covered by AMV winds. As Figure 3 illustrated, replacing the AMV wind vectors of Meteosat 7 by those from Meteosat 8 a reduction of mean RMS wind increments can be found. The reduction of RMS is larger in the upper troposphere than in the lower troposphere and more pronounced on the Southern Hemisphere and the Tropics. The reduction in RMS can partly be explained by the additional wind data using Meteosat 8 AMVs compared to Meteosat 7 winds but some part is also due to higher quality Meteosat 8 AMV wind vectors.

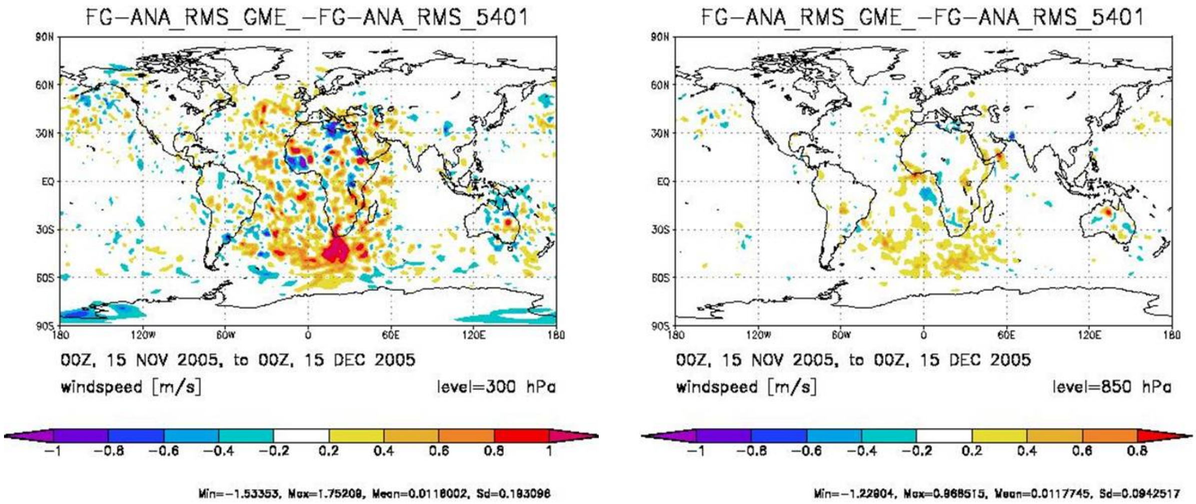

Fig. 3: Difference of mean RMS wind speed increments [m/sec] between the Control run and an experiment using Meteosat 8 AMV wind vectors for the period 15 November – 15 December 2005 00 UTC for 300 hPa (left) and 850 hPa (right)

Additionally, an increase of wind speed and a shift in position of subtropical jet stream areas over Africa can be found by using Meteosat 8 AMV winds (not shown).

The overall impact of forecast quality is small but positive for both Hemispheres and Europe for both the 00 UTC and 12 UTC forecasts. As an example, Fig. 4 shows time series of anomaly correlation coefficients for the 96 hour forecast range for the Northern Hemisphere (left) and Europe (right). Obviously, the forecast quality of the experiment using Meteosat 8 AMV wind vectors (blue curve) is almost ever higher than the forecast quality using Meteosat 7 winds (red curve).

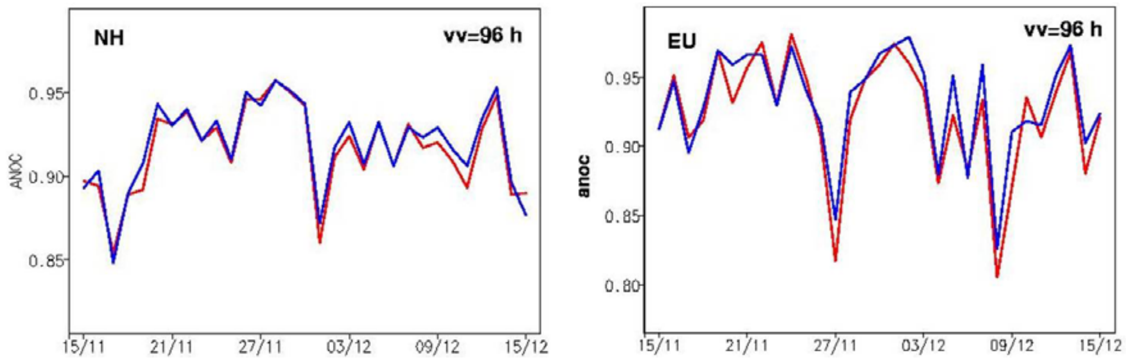

Fig. 4: Times series of anomaly correlation coefficient of the geopotential height in 500 hPa averaged over Europe (right) and the Northern Hemisphere (left) for the period 15 November – 15 Dezember 2006 for the Control run (red curve) and the experiment using Meteosat 8 AMV wind vectors (blue curve) for 96 hour forecasts

5. References

Holmund, K., 1998: The utilization of statistical properties of satellite-derived atmospheric motion vectors to derive indicators, Wea. Forecasting, 13, 1093-1104**.**

Holmund, K., Velden C., Rohn, M., 2001: Enhanced automated quality control applied to high-density satellite derived winds. Mon. Wea. Rev., 129, 517-529.