THE USE OF METEOSAT WINDS WITH QUALITY INDICATORS WITHIN THE MÉTÉO-FRANCE GLOBAL NWP MODEL

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ABSTRACT

The use, in a global uniform version of the ARPEGE model, of the Atmospheric Motion Vectors (AMV) produced by EUMETSAT, from Meteosat 5 and 7 platforms, in BUFR form, is investigated. These data are produced every 90 minutes with a Quality Indicator, coming from an Automatic Quality Control (AQC) performed by EUMETSAT.

The study of the quality against the background (short range forecast) indicates a potential to use the QI, as a selection criteria within the screening of the data in the analysis.

Several experiments are investigated, and compared with the current operational NWP system, which uses only the AMV in SATOB format, a subset of higher quality than the BUFR AMV, but disseminated every 6 hours only. A first experiment, where all observations are used, leaving the choice of active data to the screening procedure during assimilation (operational asymmetric first guess check) appears not to be good enough. Three other experiments (one with some thresholds of QI relaxed at high levels and at mid-levels over the sea in the mid-latitudes, another with the AQC only as selection criterion, and the last one, with some thresholds more restricted than in the previous experiment) give similar results, against the operational NWP system :

- a reduction of root-mean-square (rms) increments at high levels over West Africa and in the Southern Hemisphere on the Meteosat coverage, and at low levels in the Southern Atlantic.
- a global neutral impact in forecasts, but slightly positive over Europe and Australia.

The third experiment (with restricted thresholds), giving a better fit of BUFR AMV to first guess and analysis, appears to be the most robust. Finally, a last experiment, as the third but with a blacklist of data in extra-tropics mid-levels, very biased in zonal component, gives the best result, whilst increasing the number of AMV from Meteosat 5 and 7 for the assimilation by a factor 5, against the operational use of SATOB data.

1. INTRODUCTION

The Atmospheric Motion Vectors (AMVs) are winds data derived from cloud tracers observed in infrared (IR), visible (VIS) and water vapour (WV) channels or from the displacement of clear sky features, observed also in water vapour channel (WVW).

EUMETSAT produces routinely and in near-real time these data, every 90 minutes, from their geostationary satellites Meteosat 5 and Meteosat 7, respectively positioned by 63° East (Central Asia and Indian Ocean) and 0° (Europe and Africa), IR and WVW channels at low resolution (160 km), VIS and WV at high resolution (80 km).

It uses an Automatic Quality Control scheme (AQC) based on the properties of the vector itself and its consistency with other vectors and a short-range forecast issued from the ECMWF. Some corrections are applied in areas/levels where bad performance has been experienced (Holmlund and al, 2001).

A final Quality Indicator (QI) is produced, between 0 and 1, at 0.01 of resolution, where 0 indicates poor quality and 1 high quality.

Only data with QI above 0.3 are finally disseminated on the Global Transmission System (GTS) in a BUFR format, with their QI value.

A higher quality subset of this product (QI > 0.8) is also disseminated in SATOB code, but only in IR, VIS and WV cloud channels and every synoptic hours at 00, 06 ,12 and 18 UTC, without the mention of their QI value and with other limitations. This subset was traditionally the one used by the Numerical Weather Prediction Centres, and in particular at Meteo-France.

The purpose of this study is to replace, in the operational global model ARPEGE/IFS code, this subset in SATOB code by the data in BUFR format, using the QI information and in the hope to benefit from their higher temporal frequency within the framework of the 4DVAR assimilation technique. The data issued from the displacement of features in clear sky (WVW data), are not studied, up to now not used in our NWP system.

As a first step, the quality of the BUFR AMV is evaluated against the ARPEGE background, in the aim to define some QI thresholds, as selection criteria within the screening of the data in the analysis.

Then, one investigates several experiments, for which the results are evaluated in analysis and forecast performance terms by objective scores.

2. THE QUALITY OF THE QUALITY INDICATOR

BUFR AMV are monitored for a three week period, from 1–21 November 2002 against the ARPEGE background (a 6 hour forecast), through the screening. The screening is the first step in the assimilation process. It consists notably in computing the departure between the background and the observations and in retaining the active data for evaluating the state of the atmosphere.

Based on these calculations, one can compute some statistics as shown in Figures 1, 2 and 3, following the method in Rohn et al (1999) and Butterworth (2001). These statistics are collected in QI bins of 0.05. A statistic for a QI class is plotted at the upper value of the interval. For example, the point at QI = 0.9 represents a statistic for QI included between 0.85 and 0.9. The rms departures are marked by the solid lines, the speed bias in dotted style, the background wind speed as dashed line. The histogram shows the number of observations in each QI class. Statistics about METEOSAT 5 are shown in red, and in blue for METEOSAT 7. Lines with symbol represent observations over land, and lines without symbol observations over sea. The northern and southern extra tropical regions are distinguished (respectively lat > 20° and lat < -20°) and the tropics (-20° < lat < 20°), as well as three tropospheric layers, low level (p > 700 hPa), mid level (700 hPa > p > 400 hPa) and high level (400 hPa > p).

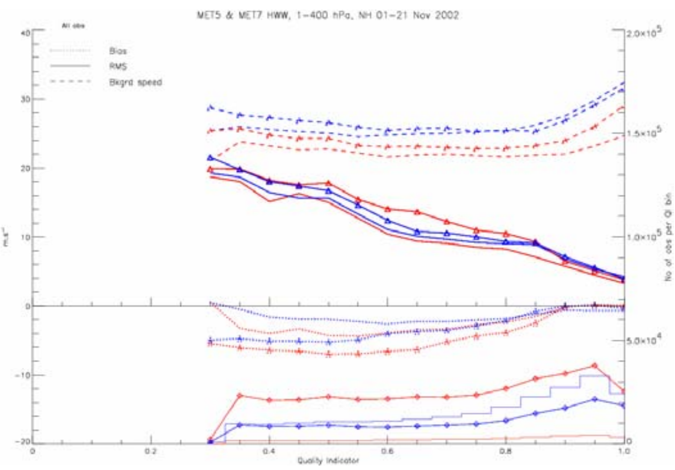

Figure 1 : Monitoring of northern hemisphere high level HWW winds from Meteosat 5 and 7 (1-21 November 2002)

In Figure 1, the monitoring of the high level HWW winds in the northern hemisphere is shown. Figure 2 represents the monitoring of the low level IR winds in the tropical area. On both figures, one can notice a decrease of the rms and of the bias when the QI value increases. One can see two steps in this decrease, one at about QI = 0.6 and another one about QI = 0.85. The bias becomes negative when the QI decreases. At high levels, it is probably due to the bad perception of the thin cirrus. At low levels, this negative bias appears specially for observations over land, suggesting an orographic effect (Figure 2).

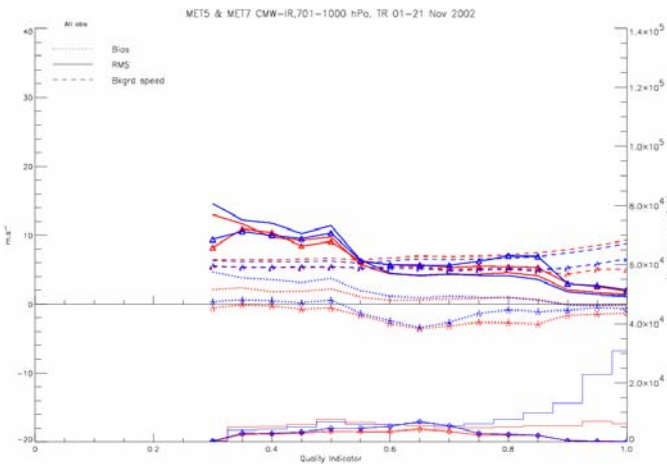

Figure 2: Monitoring of tropics low level IR winds from Meteosat 5 and 7 (1-21 November 2002).

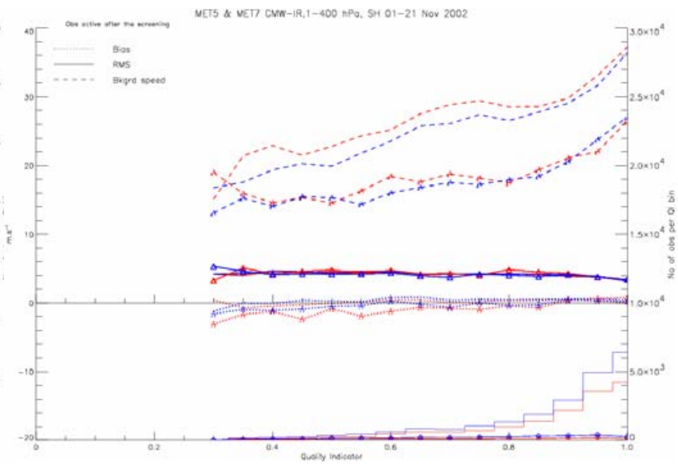

Figure 3: Southern hemisphere high level IR winds from Meteosat 5 and 7, active for the assimilation.

As indicated before, the screening allows to choose the data active for evaluating the state of the atmosphere. For the AMV, an asymmetric first guess check is used. When an observation is too far from the background, it is rejected. The condition is more restrictive when the observed speed is slower than the background, especially at upper levels, the objective being to prevent a negative bias near the jet streams (Bormann and al, 2002). One can see in Figure 3 that this check allows to suppress the bias, but also to obtain an homogeneous set of point from a statistical point of view, independently of the QI. This check appears to be a big constraint on the choice of the active data.

Otherwise, it seems reasonable to use the QI for choosing the data for the assimilation.

3. DESCRIPTION OF THE EXPERIMENTS

For numerical cost reasons, an uniform version of ARPEGE (not stretched), 4DVAR T359, is used, between 23 December 2002 and 12 January 2003 (some experiments were stopped before the end of this period).

For the AMV, only data which are within a circle of 50° from the sub-satellite point are used. Data from Meteosat 5 and 7, over land north of 30° North, are blacklisted.

One observation per thinning box is used. The horizontal size of the thinning box is 1.2°, and the vertical extent is centred around each standard level (10, 20, 30, 50, 70, 100, 150, 200, 250 , 300, 400, 500, 700, 850, 925, 1000 hPa).

The control experiment uses the AMV from the Meteosat 5 and 7 in SATOB form:

- data every 6 hours only
- 160 km of resolution, QI > 0.8, speed > 2.5 m/s
- only the best wind for each EUMETSAT segment determined from the QI value
- IR and VIS winds above 995 hPa, WV above 400 hPa.

In addition, in our experiments, data over land and below 700 hPa (p > 700 hPa) are blacklisted to suppress the orographic effects.

A new condition on the thinning step is that one keep the data in each thinning box which has the highest QI value.

As suggested before, in the first experiment, QI thresholds are not fixed, leaving the asymmetric first guess check the role to eliminate the observations which are of poor quality. This experiment is run for 10 days, until 01 January 2003. In Figure 4, the deviation of the BUFR AMV against the background is shown as black solid lines and the analysis as black dashed lines. The control experiment is shown in blue. In the middle of the panels, the number of data used is written in black, and in blue the difference with the reference (positive value indicating more data used in the new experiment).

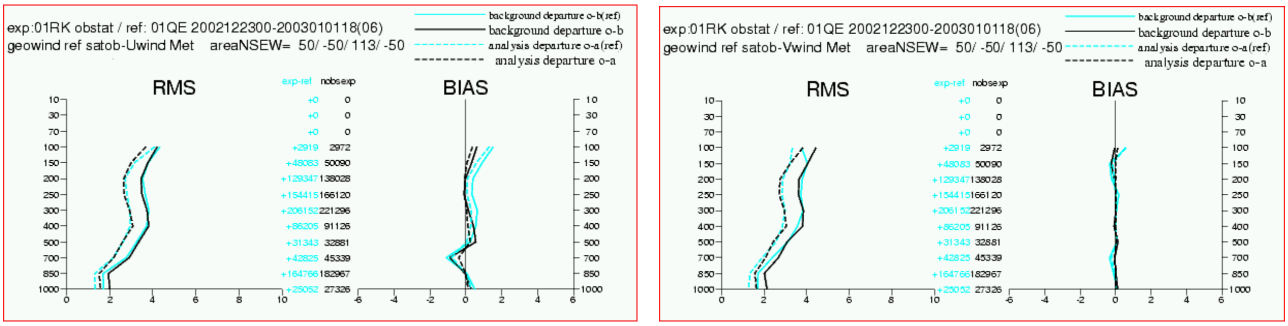

Figure 4: Departure of active BUFR AMV, without QI thresholds (black), from background (solid) and analysis (dash) against SATOB AMV (blue), within the area covered by both Meteosat platforms, from 23/12/2002 to 01/01/2003, for all analyses (00, 06 , 12 and 18 UTC)

The bias is seen to be improved against the reference, but unfortunately, the rms is generally degraded. Otherwise, one can see an exception between 300 and 200 hPa, suggesting some possibilities at this level. This experiment being unlikely to be used as such, it was then stopped.

Then, three other experiments are run, with different QI thresholds, as described in the Tables 1, 2 and 3:

- **EXPERIMENT CALLED 01UQ**

The QI thresholds are relaxed at mid-latitudes at high levels and at mid-levels over sea (Table 1).

		700 – 1000 hPa	400 – 700 hpa	1 -400 hpa
Northern H.	IR	QI > 85	QI > 0.60 over sea QI > 0.85 over land	QI > 0.60
	HRV	QI > 85	Not used	Not used
	HWW	Not used	QI > 0.60 over sea Not used over land	QI > 0.60
Tropics	IR	QI > 85	QI > 85	QI > 0.60
	HRV	QI > 85	Not used	Not used
	HWW	Not used	Not used	QI > 0.90
Southern H.	IR	QI > 85	QI > 0.60 over sea QI > 0.85 over land	QI > 0.60
	HRV	QI > 85	Not used	Not used
	HWW	Not used	QI > 0.60 over sea Not used over land	QI > 0.60

Table 1: Experiment with QI thresholds relaxed at mid-latitudes at high levels and mid-levels over sea.

One can see in Figure 5 the fit to the observations of the background and the analysis (black), compared always to the control with data in SATOB form (blue), during a full period, from 23-12-2002 to 12-01-2003.

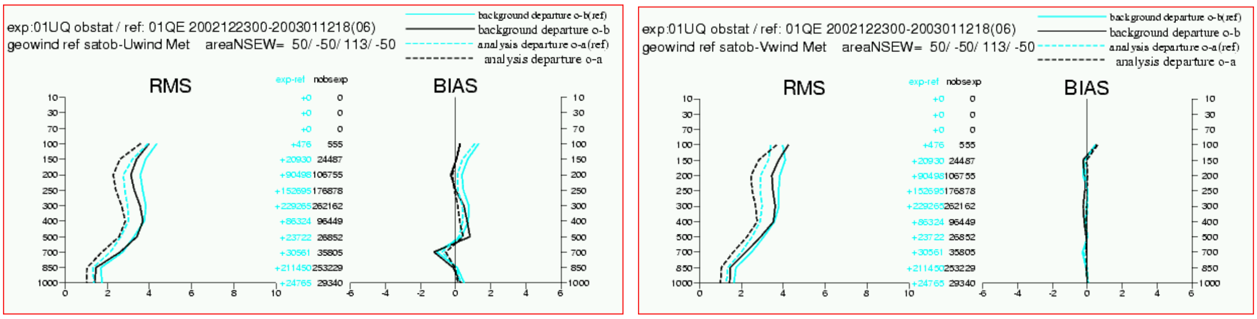

Figure 5: Departure of active BUFR AMV, with relaxed QI thresholds (black), from background (solid) and analysis (dash) against SATOB AMV (blue), within the area covered by both Meteosat platforms, from 23/12/2002 to 12/01/2003, for all analyses (00, 06 , 12 and 18 UTC).

The rms is generally improved or equal, except for the zonal component around 500 hPa. Statistics by channels indicate that this degradation is due to the IR channel in the extra-tropical areas, and particularly in the northern hemisphere. The bias is generally equal or improved, especially at high levels, but degraded at mid-levels for the zonal component, because of IR and HRV channels, always in the extra-tropical areas.

- **EXPERIMENT CALLED 01V4**

In the second experiment, the thresholds recommended by EUMETSAT are applied (Table 2).

Channel	QI threshold
IR	QI > 0.80
HRV	QI > 0.65
HWW	QI > 0.80

Table 2 : QI thresholds recommended by EUMETSAT.

Statistics obtained for this experiment are very similar to those of the previous experiment, but with a degradation at high and low levels, in both components, and a very slight improvement at mid-levels and for the bias.

- **EXPERIMENT CALLED 01YC**

In the third experiment, more restricted thresholds are applied (Table 3), generally 0.85, (0.90 for HWW in the tropics). This threshold of 0.85 corresponds to a significant improvement in the quality of the data, according to the statistics shown in Figures 1 to 3.

		700 – 1000 hPa	400 – 700 hpa	1 -400 hpa
Northern H.	IR	QI > 0.85	QI > 0.85	QI > 0.85
	HRV	QI > 0.85	Not used	Not used
	HWW	Not used	Not used	QI > 0.85
Tropics	IR	QI > 0.85	QI > 85	QI > 0.85
	HRV	QI > 0.85	Not used	Not used
	HWW	Not used	Not used	QI > 0.90
Southern H.	IR	QI > 0.85	QI > 0.85	QI > 0.85
	HRV	QI > 0.85	Not used	Not used
	HWW	Not used	Not used	QI > 0.85

Table 3: Experiment with restricted QI thresholds.

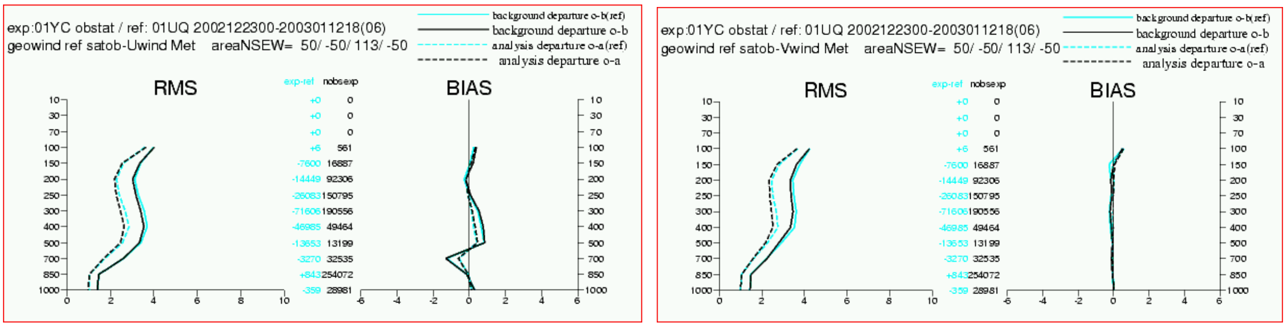

Figure 6 : departure of active BUFR AMV, with restricted QI thresholds (black), from background (solid) and analysis (dash) against BUFR AMV, with relaxed QI thresholds (blue), within the area covered by both Meteosat platforms, from 23/12/2002 to 12/01/2003, for all analyses (00, 06 , 12 and 18 UTC)

This experiment improves the rms in the mid and high levels against the experiment 01UQ, but the bias is degraded for the zonal component at mid levels, and against the control experiment (figure 4) too. The data responsible for degrading the bias, are exactly between the pressure levels 350 and 775 hPa (corresponding to the plot points 400, 500 and 700 hPa on the figures). An ultimate experiment is tested.

- **EXPERIMENT CALLED 020W**

BUFR AMV between 350 and 800 hPa are not used. These data are less numerous in this layer too. The selection is summarised in Table 4.

Extra-tropics H. (|lat| > 20°)

	p>800hpa*	800-350hpa	p<350hpa
IR	QI > 0.85	Not used	QI > 0.85
HRV	QI > 0.85	Not used	Not used
HWW	Not used	Not used	QI > 0.85

Tropics (|lat| < 20°)

	p>700hpa*	700-400hpa	p<400hpa
IR	QI > 0.85	QI > 0.85	QI > 0.85
HRV	QI > 0.85	Not used	Not used
HWW	Not used	Not used	QI > 0.90

Table 4: Experiment with restricted thresholds and data not used in the extra-tropics mid-levels.

This experiment runs until the 05 January 2003. The departure of the active BUFR AMV is shown in Figure 7. The comparison is performed with respect to the control experiment.

With this last experiment, the rms departure of the active observations set is significantly improved against the reference. The data, very biased in zonal component at mid-levels, are suppressed (note that the statistic in the northern hemisphere, around 150 hPa, is not significant, the sample being too small (only 7 observations)). One can see some residual bias in the meridional component in the tropics around 400 hPa, but the statistics on the zonal component are improved.

Then, in spite of the restrictions of this experiment, the number of active AMV from Meteosat 5 and 7 platforms against the operational use with SATOB form, is increased by a factor 5.

4. ANALYSIS AND FORECAST IMPACT

For each experiment with QI thresholds, the impact on the analysis and the forecast, until +72 hours are studied. This impact is very similar between the different experiments. Figure 8 shows the difference in rms increment (background minus analysis) at 250 hPa between the last experiment 020W and the control experiment. Red indicates reduced rms increments, and then a positive impact, blue a negative impact.

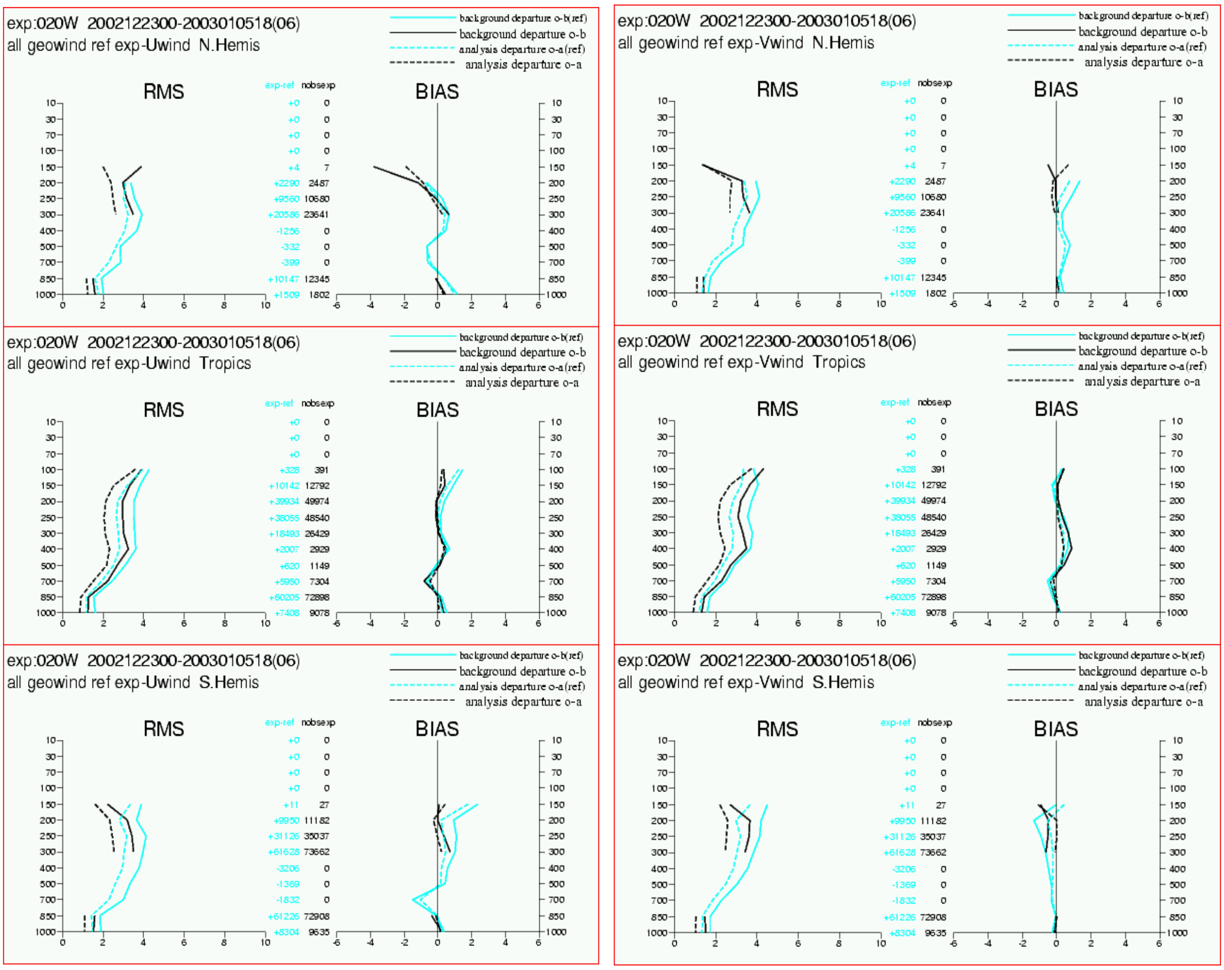

Figure 7: Departure of active BUFR AMV, with restricted QI thresholds and blacklist in extra-tropics mid-levels (black), from background (solid) and analysis (dash) against SATOB AMV (blue), within the area covered by both Meteosat platforms, from 23/12/2002 to 05/01/2003, for all analyses (00, 06 , 12 and 18 UTC), by tropics and extra-tropics areas.

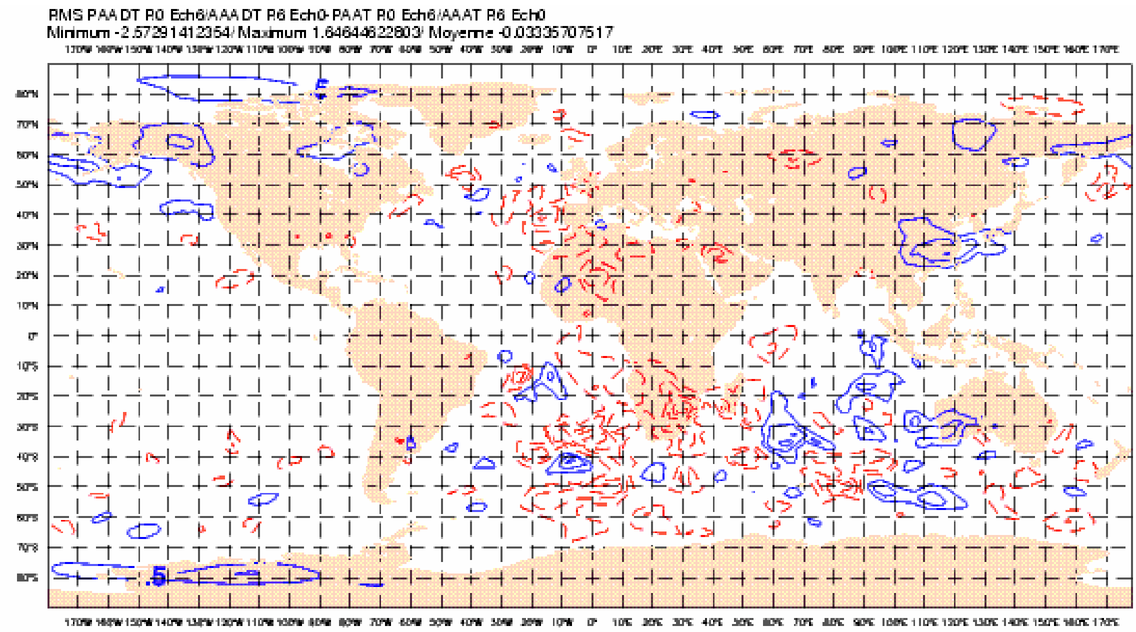

Figure 8: Difference in rms increments of the geopotential at 250 hPa between the experiment 020W and the control experiment.

One can see a slight positive impact off Western Europe, over Western Africa and in the Southern Hemisphere over the Meteosat coverage. A slight positive impact is seen at low levels in the Southern Atlantic too.

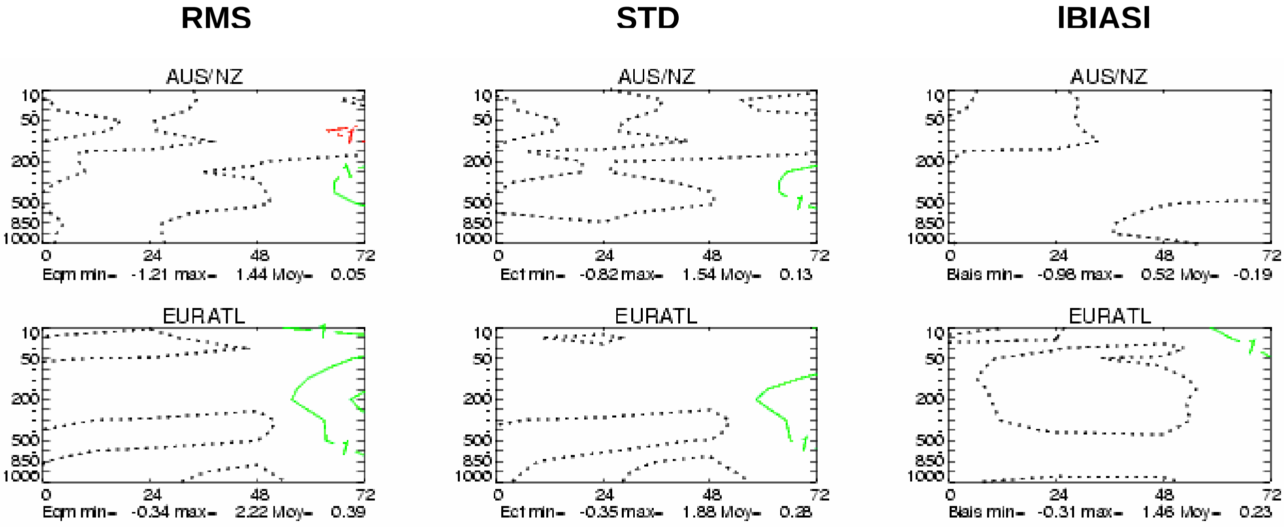

Figure 9 : Difference of forecast scores between 020W experiment and control experiment, against their own analysis. Green indicates positive impact, red negative impact.

On the forecast until +72h, the impact is overall neutral, slightly positive over Europe and Australia (Figure 9).

5. CONCLUSION

The use, in the 4D-Var NWP global model ARPEGE uniform, of the AMV produced by EUMETSAT from Meteosat 5 and 7 platforms and disseminated on the GTS in BUFR format, is investigated. These data are produced every 90 minutes with a Quality Indicator, coming from an Automatic Quality Control (AQC), performed by EUMETSAT.

A monitoring of these data indicates the possibility to use the AQC Quality Indicator, as an additional criterion to select active data for the assimilation in ARPEGE.

Several experiments, with different thresholds of Quality Indicator, are tested. These experiments give similar results in term of forecast performance : overall neutral, slightly positive over Europe and Australia. But the more restricted experiment, with QI thresholds set at 0.85 (0.9 for HWW at high levels in the Tropics) and the blacklist of data, too biased in zonal component in Extra-Tropics between 350 and 800 hPa, appears to be the most robust, with the best fit of the active data to the background and the analysis. The number of these AMV data used in the assimilation is increased by a factor 5 against the operational use with SATOB form.

This study might inspire some further thought. Firstly, the definition of a sample influences the statistics which are produced. In our case, some defaults of the data set appear when the wind-components are studied (instead of the speed), by thin layers (instead of larger layers), showing that for the AMV data, the bias errors can cancel each other out in a too large sample. This structure of bias error suggests a problem of height assignment of the observations, and particularly in the extra-tropical mid-levels.

Secondly, in our experiments, the observation errors used are those used by the operational model, tuned for the AMV data in Satob form, a subset of higher quality from the BUFR AMV. It is interesting to see that the selected QI thresholds for the BUFR AMV are finally close to the threshold for the data in SATOB form. To relax these thresholds reduces the quality of the sample against the model, but it seems to have some possibility to tune the errors of observations in function of the QI of the data.

Finally, the asymmetric check applied during the screening for selecting the AMV data for the assimilation appears to be very robust and a big constraint on the choice of the active data, that can be detrimental for the innovation in the poor areas or near some misplaced meteorological structures.

The investigations will be pursued in these directions in the next years.

6. REFERENCES

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