QUALITY CONTROL OF WINDS FROM METEOSAT 8 AT METEO FRANCE : SOME RESULTS

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Abstract

The quality of a 30-days sample (in March 2005) of cloud winds from Meteosat 8 is estimated against the first-guess (FG) from the operational global model ARPEGE used at Météo France and the Eumetsat FG-Quality Indicator (QI). Whereas the observations are generally distributed around the First-Guess, and knowing that this distribution improves when QI increases, a check is necessary in order to reject observations too far away from the model and to remove their biases. In addition, it seems necessary within the framework of a variational assimilation, to tune the observation errors according to QI, if one intends to relax the thresholds of QI used for data, in particular over sea in the Tropics.

The quality of these observations is particularly studied over land, with the objective to better use them in the assimilation. A comparison between data over land and data over sea, retained for assimilation after the quality control, shows that bias over land is more negative for weak measured speed below 2500m above ground-level. But on the other hand, the control is insufficient to remove the bias from data, over land and over sea, for measured speed weaker than 6 $m.s^{-1}$, this bias becoming more negative as both measured speed and QI decrease.

A modification of the first-guess check to improve this point and the used asymmetric test is proposed. An impact experiment on analysis and on forecast using this modified first-guess check is overall positive, but negative on forecast over Europe beyond 60 hours. In the end, other developments are looked for.

• 1. INTRODUCTION

The Atmospheric Motion Vectors (AMV), produced by several meteorological spatial agencies, are used as wind observations in Météo France operational global model ARPEGE. The data used are derived from the displacement of cloud targets, observed by imagers from satellites in different channels, infrared (IR), visible (VIS) and water vapour(Cl WV).

Each data has many quality indicators, useful for their selection in the assimilation and which are supplied by several agencies. The indicator used in ARPEGE, comes from an Automatic Quality Control scheme, developed by EUMETSAT, Europe's meteorological satellite agency, and adopted by every meteorological spatial agencies. This scheme is based on the properties of the wind vector itself, its consistency with other neighbouring vectors and a short-range forecast (Holmlund, 1998). A final quality indicator (QI) is produced, ranging from 0 and 100, where 0 indicates poor quality, and 100 high quality.

From a study on the satellites Meteosat 5 and 7, a tight use was set up, data which have QI below 85 (or 90) being rejected, with a wide blacklist based on geographical areas and atmosphere layers criteria (Payan and Rabier, 2004). The extension of this use for data from other geostationary satellites (from NESDIS, JMA) shows an overall positive impact, in term of analysis and of forecast.

Meteosat 8 is the first geostationary weather satellite of the second generation, operated by EUMETSAT. It is operational since January 2004. Positioned 3.4° West, it replaces Meteosat 7 and covers the Europe-Africa area. It produces four times more wind measurements compared to its predecessor, with twice the geographical resolution and twice as many channels.

As a first step, the quality of data against the ARPEGE background and as a function of QI is estimated. Then, the role of the quality control in the model for the chosen data in the assimilation is studied, and some ways of improvement are proposed. In conclusion, results on analysis and forecast, with a quality control modified, are presented compared to the operational.

• 2. QUALITY OF CLOUD MOTION VECTORS FROM METEOSAT 8 :

Cloud Motion Vectors from Meteosat 8 are monitored against the operational ARPEGE background (a 6 hours forecast in a not-stretched version), through the screening, over a 30-days period, from 2 to 31 March 2005,. The screening is the first step in the assimilation process. It consists to select data for the analysis. First, a blacklist, based on geographical areas, atmosphere layers and QI-thresholds criteria, is applied. A first-guess check and a final thinning for reducing the correlation errors are then made.
In this monitoring, winds data come from channels Cl WV-6.2µ, Cl WV-7.3µ, IR-10.8µ and VIS-0.8µ, with no blacklist. The first-guess check rejects data too far away from the background. Finally, the observation, which pass this check and with the highest QI in a thinning-box of 2.5° and vertically centred around the standard levels, is kept for the assimilation.

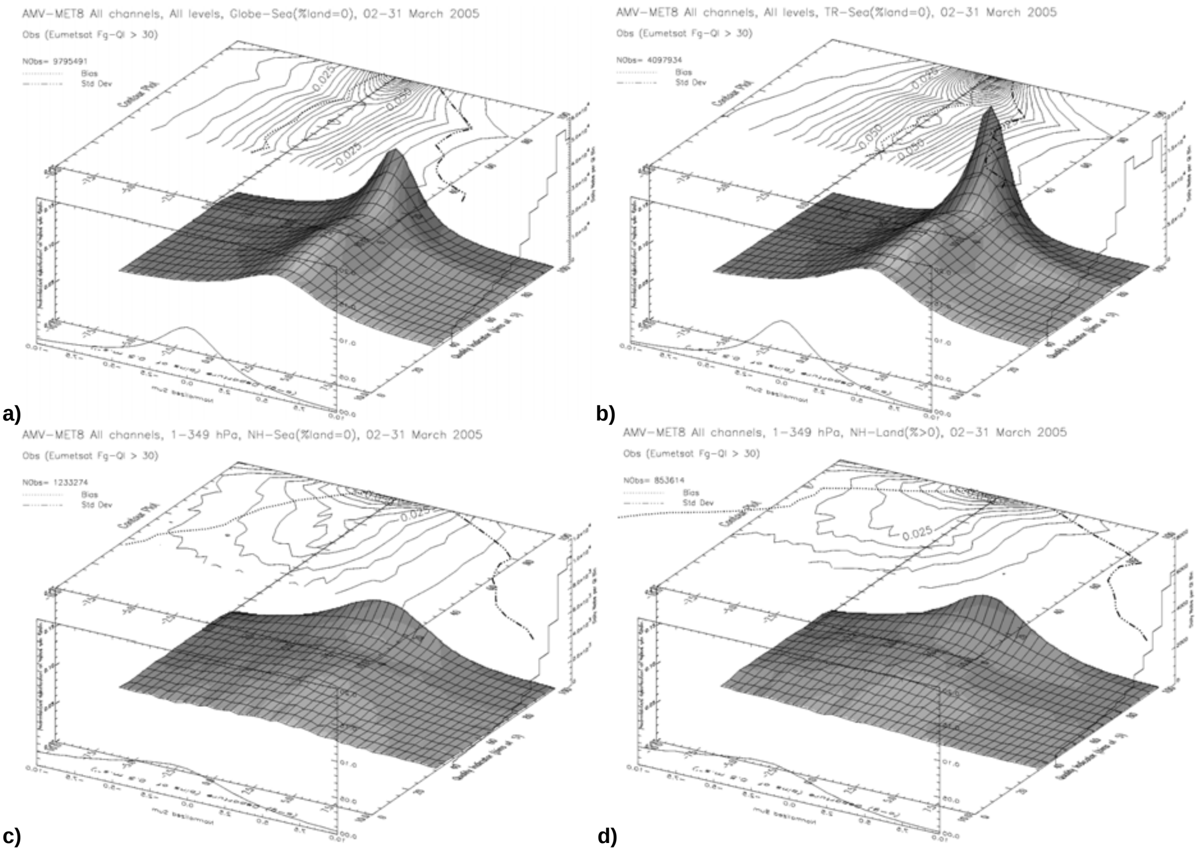


***Figure 1*: Normalized distribution (vertical axis), in function of QI (right axis, 5 bin) and (measured speed – background) departure (left axis, 0.5 m.s^{-1} bin). 2-31 March 2005. On the right vertical plan, daily number of observations per QI bin. On the left vertical plan, normalized distribution on the total sample (QI > 30). The upper plan is an horizontal projection of the distribution (one isoline every 0.005 or 0.5%), with bias (dotted line) and standard deviation (dot-dashed line) in function of QI. (a) over sea, (b) over sea in the Tropics, (c) over sea in the Northern Hemisphere, pressure < 350 hPa, (d) over land in the Northern Hemisphere, pressure < 350 hPa.). The value Z=f(X,Y) corresponds to statistics on]X-Bin$_X$,X] and]Y-Bin$_Y$,Y] intervals. Rule valid for all figures.**

Figure 1-a) shows the normalized distribution of the departures (measured speed – background) over sea, as a function of QI. The peak of this distribution is near the zero value, but the spread of the distribution increases when QI decreases. The standard deviation curve indicates different steps in this distribution (QI>75,QI>60,QI>45). The bias is always negative, and it broadly increases when QI decreases. A relative minimum value of bias for]75,80] QI-class is due to a small shift towards the positive values of the peak of the distribution. This shift is due to data in the Tropics, between 300 and 550 hPa (not shown). This phenomenon is amplified over land. Otherwise, negative bias is in general

due to observations which strongly underestimate the guess speed, as when it is synthesized on the normalized distribution of the total sample, and with the symmetry of the gradient of the distribution near and around zero. This point validates the approach for the use of a first-guess check for selecting data for the assimilation. The distribution of the departures near the first-guess, considered here as the best description of the state of the atmosphere, approaches a Gaussian distribution, and data too far away from the first-guess are probably incorrect. This distribution is naturally modified with atmosphere layers, channels, geographical areas… as shown by some examples in figures 1-b), c) and d). In particular, data have a better quality in the Tropics than in the Extra-Tropics Hemispheres.

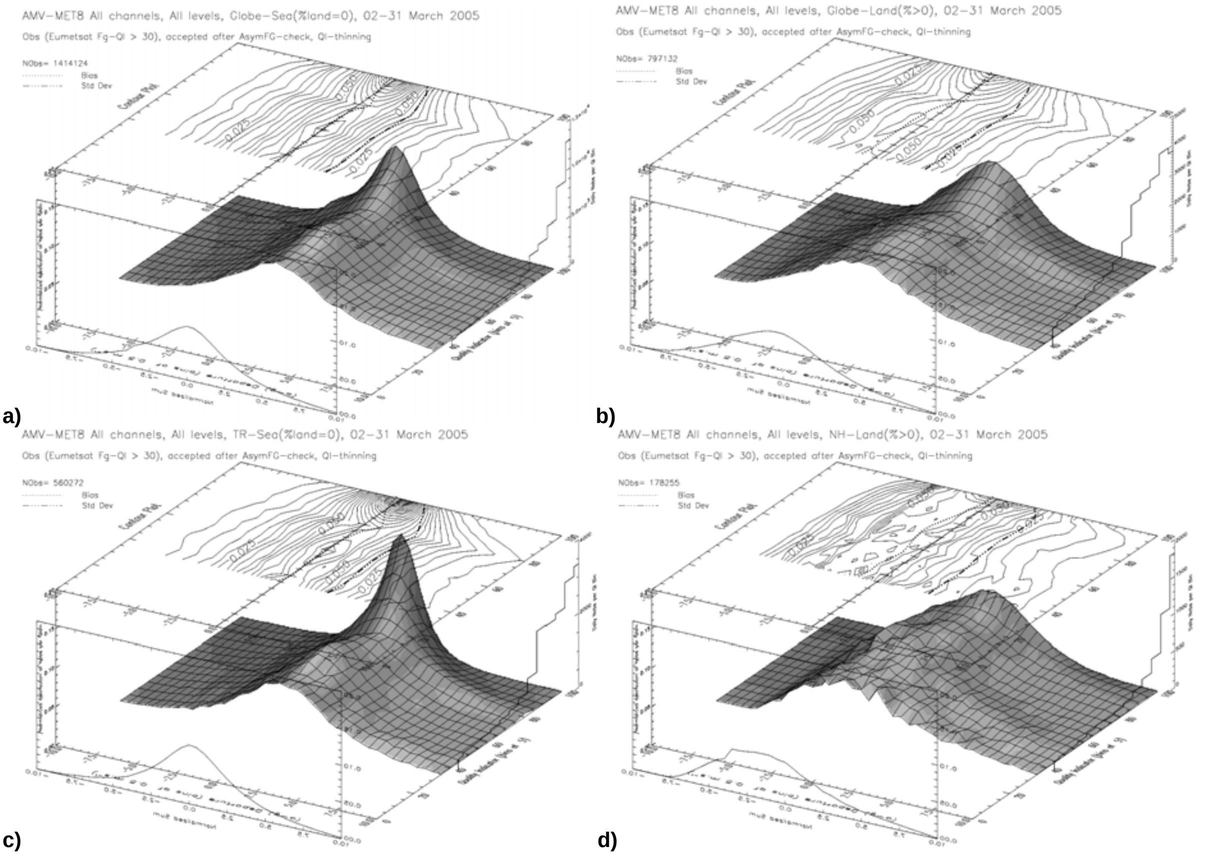


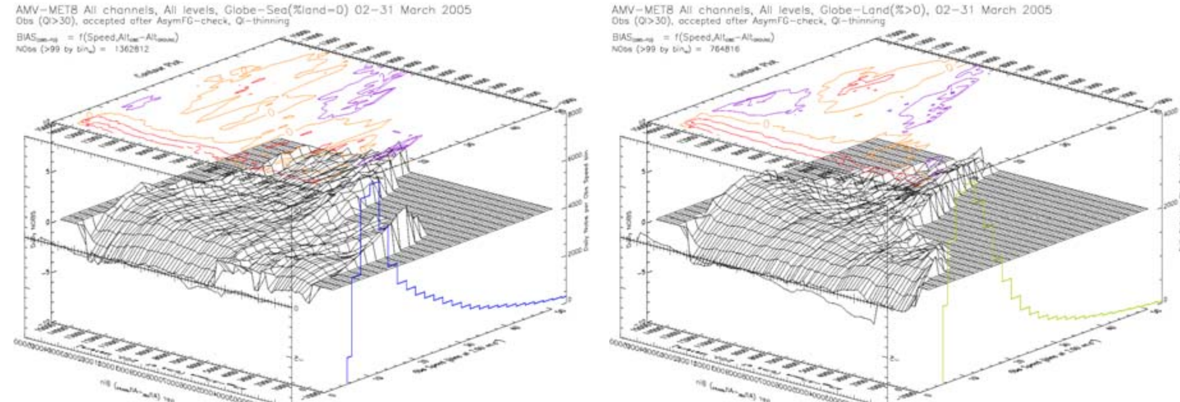
***Figure 2*: As figure 1, but with data, which pass the asymmetric first-guess check and the QI-thinning. (a) over sea, (b) over land, (c) over sea in the Tropics, (d) over land in the Northern Hemisphere**

But these are data, which pass the first-guess check and the QI-thinning, shall be considered for the assimilation. The first-guess check compares quantity (1) with quantity (2) :

(1) $$1/2 \times (\Delta_u^2 / \sigma_{b_u}^2 + \Delta_v^2 / \sigma_{b_v}^2)$$

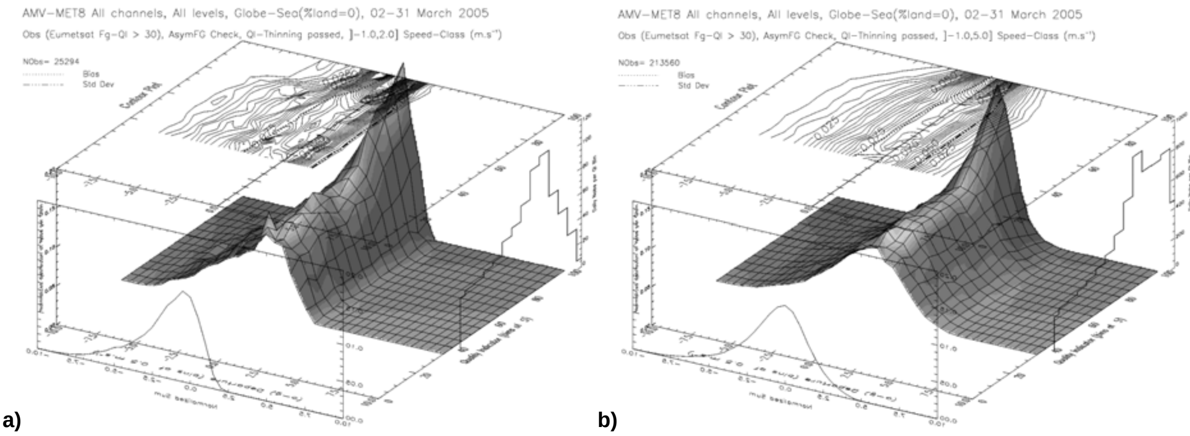
(2) $$\left[1/2 \times \left(\sigma_{o_u}^2 / \sigma_{b_u}^2 + \sigma_{o_v}^2 / \sigma_{b_v}^2\right) + 1\right] \times K_1 \times K_2\left(L_p, Lat, \Delta_{ff}, ff_b\right)$$

where *u* and *v* are the wind components, *o* denotes the observation value, *b* the background value, Δ the departure (observation – background), σ the error of the observations or of the background and K_1 and K_2 are adjustment factors. If (1) is inferior to (2), the observation is considered as correct and is accepted for the assimilation, otherwise it is rejected. K_1 is a constant value, common to all the observations. K_2 is fixed by a decision tree, which depends on the pressure level of the observation (L_p), the latitude (*Lat*) and the departure between the measured speed and the background (Δ_{ff}), with an asymmetric test. If the measured speed underestimates the background by more than 4 m.s^{-1}, K_2 is reduced, until 0 in the Extra-Tropics areas, if L_p<*700hPa* and if the background speed (ff_b) is higher than 60 m.s^{-1} (thus all data are rejected).



a) b)

***Figure 3*: Speed bias of (observation – background) after quality control (vertical axis), in function of measured speed (right axis, 2 m.s^{-1} bin) and height above ground (left axis, 200 m bin), i.e altitude for data over sea, (a) over sea, (b) over land. 2-31 March 2005. Altitude is approximated from pressure level with the Laplace equation (standard atmosphere). On the right vertical plan, daily number of observations per Obs Speed bin. On the left vertical plan, bias on the total sample (QI>30) per height bin. Bias is calculated only on]X-Bin$_X$,X] and]Y-Bin$_Y$,Y] intervals, where number of data is higher than 99 else bias is equal to 0. The upper plan is an horizontal projection of bias, with an isoline every 1 m.s^{-1}.**

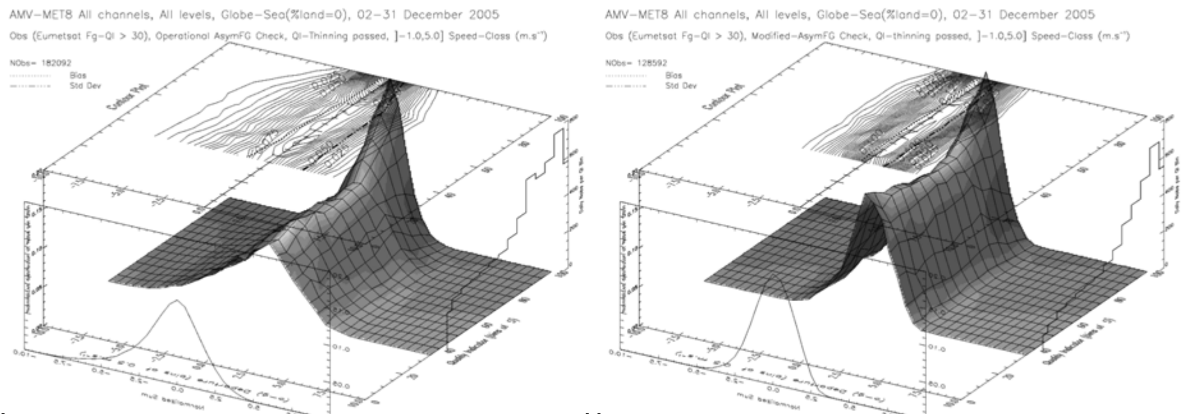


a) b)

***Figure 4*: As figure 2 (asymmetric first-guess check, QI-thinning passed) but with data over sea, whose (a) speed is weaker than 2 m.s^{-1}, (b) speed is weaker than 5 m.s^{-1}.**

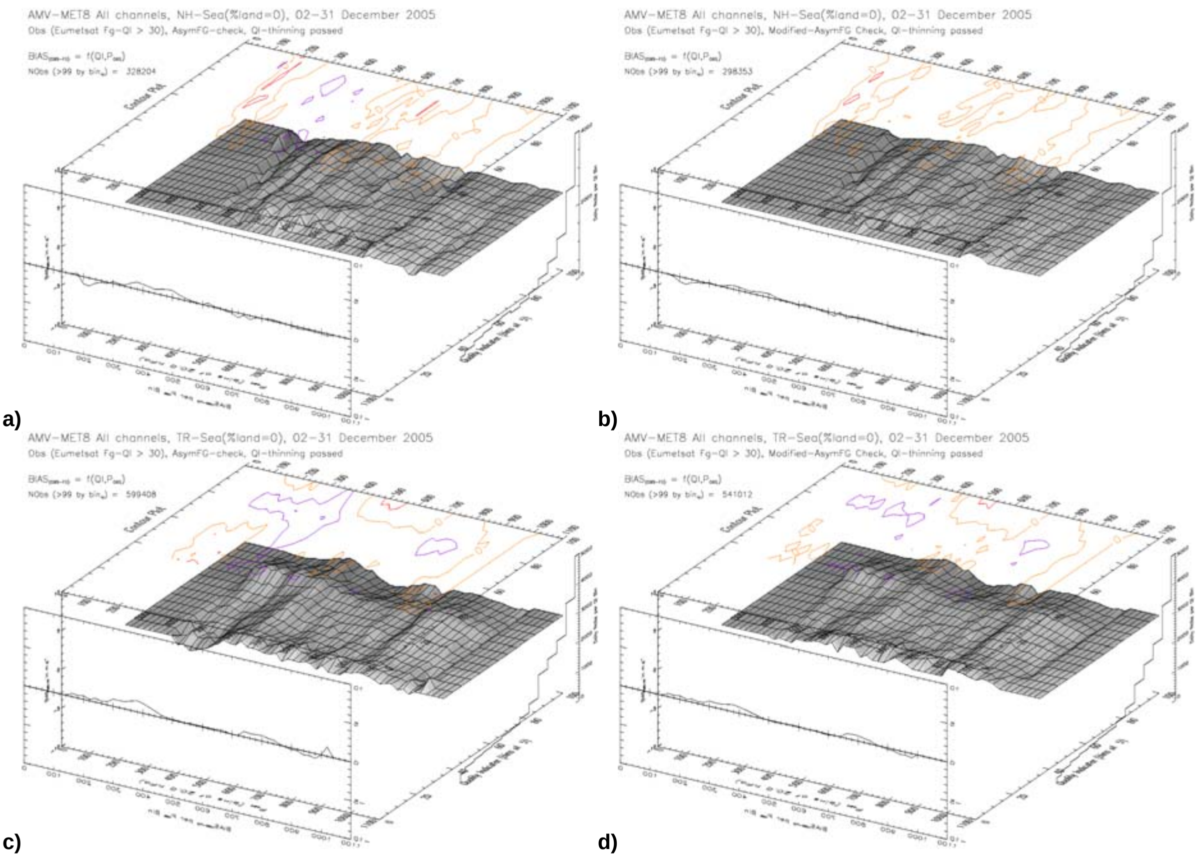
The effect of the quality control is shown by comparing figure 2-a) with figure 1-a) (data over sea). Data are globally unbiased. The QI dependence of the standard deviation is reduced, but is still there for QI > 75. This QI dependence is particularly true for data over sea in the Tropics (figure 2-c). But for these data from the Tropics, the positive bias around QI=77, as mentioned above, persists with a maximum value of 1.3 m.s^{-1}. The standard deviation for data over land (figure 2-b) is similar to those for data over sea. But these data are not completely unbiased, and in particular in the Extra-Tropics areas (Northern Hemisphere in figure 2-d), with a negative bias which increases when QI decreases.

To understand this difference of bias between data over sea and data over land, biases of the active data with QI>30 are compared in function of measured speed and of height above ground, i.e altitude for data over sea (figures 3-a) and b)). The bias of data over land is more negative (between 1.0 and 1.5 m.s^{-1}) for height lower than 2500 meters and for measured speed weaker than 6 m.s^{-1}. In these figures, the bias of measured speed higher than 10 m.s^{-1} appears to be dependent on the height assignment. For speed weaker than 6 m.s^{-1}, the bias becomes, on the other hand, linearly more negative as the speed decreases, and this independently of the height, except in the low levels over sea, where this effect is less. Structures of bias are similar with samples reduced to QI>50, with or without quality control (not shown). The distribution of the departures against the background for weak measured speed of active data in function of QI (figures 4-a) and –b)) shows that the negative bias is reduced for higher QI, but increases when QI decreases. On the other hand, the distribution of the positive departures is regular and almost independent of QI.



a) b)

***Figure 5*: Normalized distribution of speed departure (observation - background) of data over sea, whose speed is weaker than 5 m.s^{-1}, which pass the quality control, with (a) the operational first-guess check, (b) the modified first-guess check. 2-31 December 2005.**



a) b) c) d)

***Figure 6*: Speed bias (vertical axis) of (observation – background), in function of QI (right axis, 5 bin) and pressure level of observations (left axis, 20 hPa bin). 2-31 December 2005. On the right vertical plan, daily number of observations per QI bin. On the left vertical plan, bias on the total sample (QI>30) per level pressure bin. Bias is calculated only on]X-Bin_X,X] and]Y-Bin_Y,Y] intervals, where number of data is higher than 99 else bias is equal to 0. The upper plan is an horizontal projection of bias, with an isoline every 1 m.s^{-1}. (a) with the operational first-guess check in the Northern Hemisphere, (b) as (a) but with the modified first-guess check, (c) as (a) but in theTropics, (d) as (b) but in the Tropics.**

• 3. A MODIFICATION OF THE QUALITY CONTROL ? :

As it has been shown previously, a negative bias of weak measured speed against the background persists in spite of the quality control operated by the data assimilation pre-processing. Therefore, a specific formulation of K_2 is proposed for observations, whose the speed (ff_o) is weaker than 6 m.s^{-1} :

(3) $$K_2 = ff_o / 10 \times \left(0.08 - 0.0125 \times \left(6 - ff_o\right)\right)$$

A new formulation of K_2 is proposed in case of asymmetric test too, when the measured speed underestimates the background of more than 4 m.s^{-1}. Indeed, the figure 1-b) suggests this asymmetric test is not necessary for data in the Tropics. In this case, K_2 is relaxed to 0.2 for L_p>*700hPa*, to 0.1 for L_p<*700hPa* (instead of respectively 0.15 and 0.07). In the extra-tropics areas and for L_p<*700hPa*, the K_2 dependence to ff_b allows to reject data, whose speed underestimates the background (by more than 7.5 m.s^{-1} according to figure 2-d)). This introduces a dissymmetry in the distribution of the departures, with data, whose speed overestimates more than 10 m.s^{-1} the background, accepted by the quality control (figures 2-a) to 2-d)). I suggest to suppress the K_2 dependence to ff_b in the asymmetric test, and to replace it by two constant values (K_2=0.05 for L_p<*300hPa*, K_2=0.07 for *300hpa*<L_p<*700hPa)*. On the other hand, to all data, a reduction to K_2, dependent of the departure to the background and of the speed of the background, is applied if $\left|\Delta_{ff}\right| > ff_b \times \exp^{-ff_b/10}$:

(4) $$K_2 = K_2 \times ff_b \times \exp^{-ff_b/10} \Big/ \left|\Delta_{ff}\right|$$

For testing this new first-guess check, two screenings are run in a similar way as in part 1 (no-blacklist, QI-thinning), but over a new 30-days period, from 2 to 31 December 2005, one with the operational first-guess check, the other with a first-guess check modified as described above. This period corresponds to modifications by Eumetsat in the height assignment of winds from Meteosat 8. The effect of the modified first-guess check on weak measured speed is shown in figures 5-a) and -b). The distribution of the departures becomes more symmetric with the modified first-guess check, with only a residual negative bias. In figures 6-a) to –d), the bias, plotted in function of QI and the pressure level of observations, is reduced too, and in particular the residual positive bias around 350 hPa in the Extra-Tropics, above 400 hPa in the Tropics, for data with QI around 80. The counterpart of this new first-guess check is a reduction of around 10% of assimilated data over sea (15% over land).

• 4. ANALYSIS AND FORECAST IMPACTS :

The new first-guess check, described above, has similar effects on the other winds from GOES-10 (GOES-W), GOES-12 (GOES-E) and MTSAT-1R, compared to Meteosat 8, with an overall bias reduction, and in particular a reduction of the negative bias for weak measured speed.

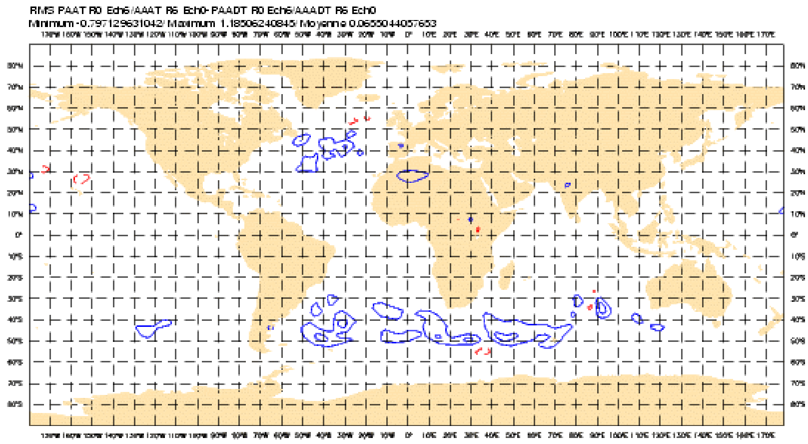


Figure 7**: Differences in root mean square analysis increments of the geopotential at 250 hPa between the experiment with the new first-guess check and the experiment with the operational first-guess check. From 20 February to 13 March 2006, analysis every 6 hours. Solid line indicates a reduction of increments with the new first-guess check, dashed line an increase, compare to the operational. One isoline every 0.5 gpm.**

If in the long term, the main goal is take to benefit from observations with a weaker QI (as suggested by Rhon et al, 2001), and a reduced blacklist, after adjustment of the errors of observation, within the framework of the 4D-VAR assimilation, the impact of this new first-guess check on the assimilation and the forecast is evaluated firstly in the frame of the operational use of the AMV in ARPEGE.

This use is quite restrictive, with no data used over land below 700 hPa level and Northern of latitude 30°N, over sea between the longitudes 55°W and 100°W and Northern of latitude 30°N, in the Extra-Tropics between levels 350 and 800 hPa, and if QI < 85 (90 for Cl WV in the Tropics).
Two experiments are run between 20 February and 13 March 2006, with forecasts produced from 0 hour analysis. One experiment is with the current first-guess check, the other one with the new first-guess check.
Figure 7 shows the difference in root mean square analysis increments of the geopotential at 250 hPa between both experiments. The new first-guess check reduces the increments, over the Southern and Northern Atlantic Oceans and the Southern Indian Ocean (solid line). The areas, where these increments increase (dashed line), are reduced. In addition, the increments are broadly equal or slightly reduced at 500 and at 850 hPa (not shown). This weak impact on the assimilation cycle is normal, because used data have a good quality (wide blacklist and QI above to 85 or 90), and the role of the first-guess check in the quality control is reduced. Nevertheless, the new first-guess check has a rather positive impact on the analysis, despite using fewer observations. Figure 8 shows the forecast impact for geopotential on different areas (the Northern and Southern Hemispheres, the Tropics, Europe) and up to 96 hours, with radiosondes as control. The impact is generally slightly positive for the new first-guess check, but with a negative impact over Europe beyond 60 hours. Results are similar to the proper experiment analysis taken as control (not shown).

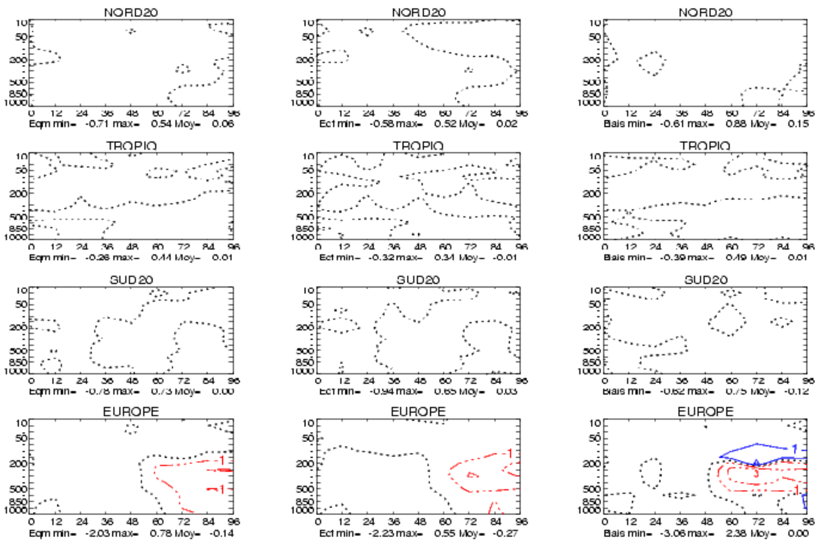


***Figure 8*: From left to right, root mean square, standard deviation and bias differences on the geopotential forecasts between the experiment with the new first-guess check and the operational first-guess check, with radiosondes as control, on different areas. From 20 February to 13 March 2006. Solid line indicates a positive impact with the new first-guess check, dot-dashed line a negative impact and dotted line a neutral impact. One isoline every 1 gpm.**

- ## 5. CONCLUSION :

A 30-days monitoring of cloud motion winds from Meteosat 8 shows that bias and standard deviation against a background from the operational model ARPEGE, are in general degraded by observations far away from this background, and in particular with a weak QI. Data with QI between 75 and 80 in high levels in the Tropics are an exception with a normalized distribution of the departures (measured speed – background), which is shifted towards positive values.
A first-guess check, with an asymmetric test when the measured speed underestimates the background, improves the quality of selecting data for the analysis, but is nevertheless insufficient for correcting a negative bias for weak measured speed, and too loose for data, whose speed overestimates too much the background. Finally, the asymmetric test is not necessary in the Tropics.
A new formulation of the first-guess check is proposed, which improves these points.
An assimilation experiment over a three weeks period with this new first-guess check and the restrictive operational use of cloud motion winds shows on the geopotentiel field the most impact in the reduction of the analysis increments at 250 hPa over the Southern and Northern Atlantic Oceans and the Southern Indian Ocean, with a neutral impact elsewhere. The impact on the forecast is on

average positive over the globe but negative over Europe beyond 60 hours, Europe which is the main target in the prediction improvement process at Météo France. For this reason, the choice is to keep the current first-guess check, while waiting for further investigations. The idea is to preserve a specific check on weak measured speed, to tune the errors of observation, in particular according to the QI, by using a new objective method (G. Desroziers et al, 2006) and to take into account in a simple way the errors of correlation with a multiplicative factor (P. Butterworth et al, 2002). Then, the next step will be a relaxation of the QI-thresholds and in the other criteria of the blacklist, then eventually a new impact experiment with the modified first-guess check proposed here. For the moment, the gain of this modified first-guess check is insufficient in the operational forecast system of Météo France.

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