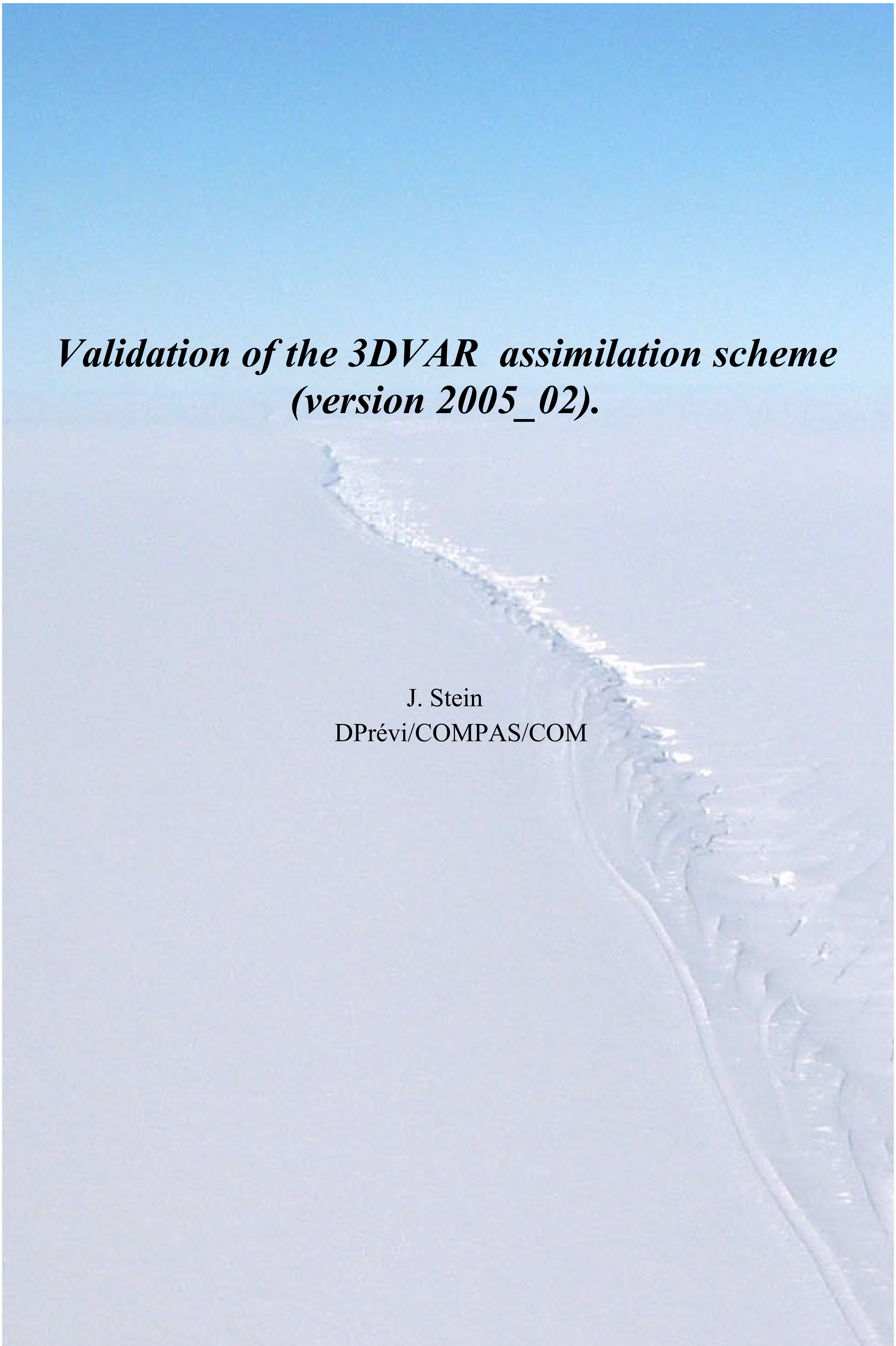

Validation of the 3DVAR assimilation scheme (version 2005_02).

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Abstract:

From the 25 July 2005 at 6 UTC, the ALADIN model starts from its own 3DVAR variational analysis and it is no more only a dynamical adaptation of the ARPEGE model. This is a very important modification. The 3DVAR scheme provides an analysis for the altitude fields. There is no surface analysis and the surface fields are deduced by spatial interpolation from the ARPEGE ones. An assimilation cycle with 4 assimilations per day with long cut-off has been created. The guesses of the analyses are provided by 6 hours forecasts, whose boundary conditions are given by the ARPEGE forecasts of the assimilation scheme. A production cycle has also been created and their analysis uses the same first guess as for the assimilation cycle but the analysis cut-off is reduced compared to the assimilation cycle.

The assimilated observations are the same as for ARPEGE but limited to the ALDIN simulation domain. Nevertheless, the satellite data QUIKSCAT are not used and the SEVIRI radiances coming from METEOSAT 8 are added. For the observations used by both models, there is no specific extraction from the databases for the ALADIN. The same coefficients are used for ALADIN as for ARPEGE to remove the bias of the satellite radiances ATOVS.

The SEVIRI radiances, which are the originality of this analysis are issued from a specific product elaborated by the laboratory CMS LANNION at full resolution. We assimilate 5 of the 8 channels (IR 3.9 and 13.4 micrometers and O3 9.7 micrometers are blacklisted) and use the cloud classification to select the data, one pixel every 5 leads to an effective resolution of 25 km. A specific removal of the bias is applied to these Meteosat 8 radiances.

The initialisation with digital filters is still present with the same amplitude as for the dynamical adaptation. The analysis before this filtering is not stored. Moreover, there is no change in the forecast model.

Among the main points, we note:

- Important rain reduction during day J with a reduction of the false alarms between 0 and 12
- The error for the wind field is reduced by 50 % in the initial state and a less important but still visible improvement is present for the temperature and the humidity. These improvements are continuously reduced and are negligible after 12 hours of simulation
- A small warm bias (0.1 to 0.2K) at the low levels (1000- 925hPa) between 12 et 15UTC (day D, and strongly reduced for day D+1), is probably related to a lower surface soil moisture than in the dynamical adaptation, but without a noticeable increase of the CAPE.
- A positive bias of 0.3hPa for the reduced pressure is present between 0 et 12H (this point must be further analysed in the next months).

The ALADIN outputs are available with a 5 minutes delay in comparison with the actual situation, because of the analysis time, even if this analysis is performed on 5 processors of the Fujitsu (VPP5000). The ALADIN-FRANCE model (PLAD0) starts from its own 3DVAR analysis with an ultra-short cut-off. This model is coupled with the PACOURT version of ARPEGE (with also an ultra-short cut-off) and is therefore delayed by 5 minutes .

References **:**

Documentation GCO :

http://gco.meteo.fr/qualite/doc/memo/cy29t1.pdf

http://gco.meteo.fr/qualite/doc/chaine/aladin/aladin_3dvar.pdf

1. Impact of this new version

1.1. Development of the comparison

The comparison has been performed in two steps: the first part extends from 02 June 2005 until 15 June 2005 and has been marked by the discovery of a major bug in the selection of the SEVIRI data according the cloud classification. The second part has started from the 16 June 2005 and stopped the 25 July 2005 with the transformation of this test version into the operational one. This validation has followed a first unsuccessful trial to render operational a preliminary test version of the 3DVAR assimilation.

1.2. Monitoring of ALADIN 3DVAR from 16/06 until 25/07

A monitoring of the observations assimilated by the ALADIN model has been developed and is independent of the ARPEGE one. We present on Figure 1 the mean numbers of assimilated observations, classified by observation type. We note that the surface data are the most numerous at 0 UTC because the temperature and humidity at 2 m AGL are used in the analysis of the altitude fields. Moreover, the data coming from the French RADOME network have been added to the SYNOP messages. Another important point is the low number of satellite data (HIRS, AMSU-A et AMSU-B) assimilated by the ARPEGE model over the ALADIN domain. Because of the short cut-off of the production cycle, we see that the AMSU-A data are completely absent. The SEVIRI satellite data, used at a very fine resolution, provide thus a very important supplementary source of information for the ALADIN assimilation scheme to complement the radio soundings and the airplane data.

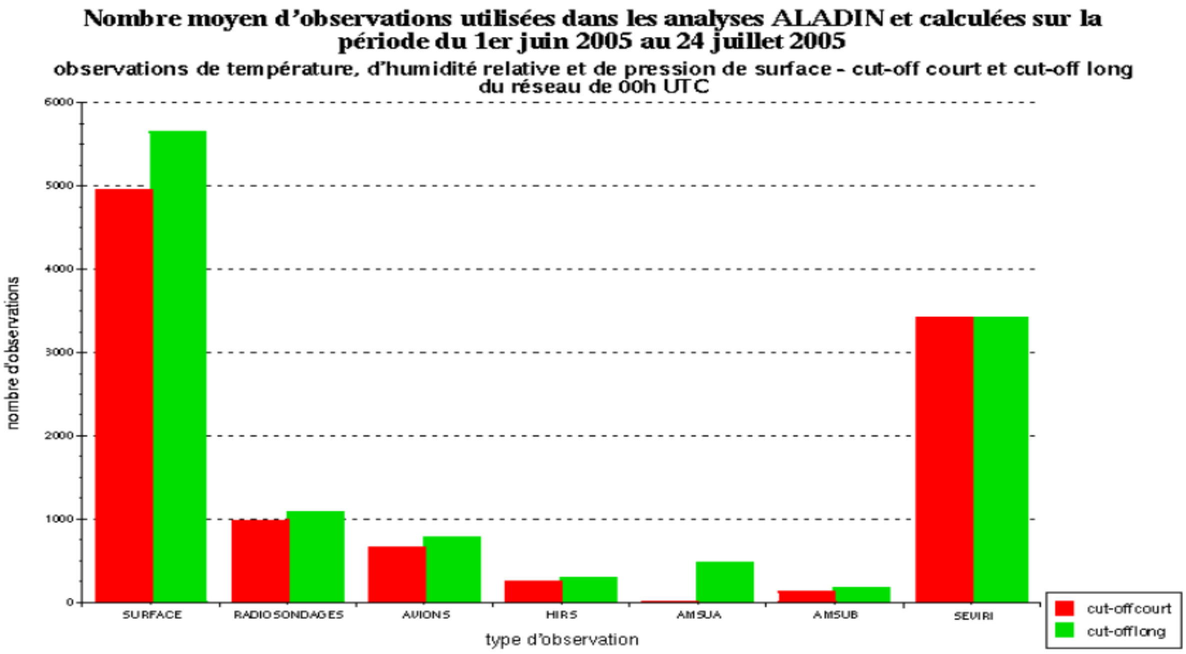


Figure 1 : Mean numbers of observations used by the 3DVAR assimilation scheme for ALADIN in the period from 01/06/2005 until 24/07/2005. These numbers are classified along the observations types. The red columns correspond to the production cycle and the green ones to the assimilation cycle. We only consider in these calculations the temperature, humidity and surface pressure data.

The comparison of the numbers for the two cycles shows a strong increase of the AMSU-A observations and a relative stability for the other types of observations. We can follow on the monitoring of the channel 8 of SEVIRI (Figure 2) that the removal of the instrumental bias is not correct. This has lead to add this channel to the blacklist for the ALADIN assimilation on the 23 June. This was justified by a further increase of this bias after this date!

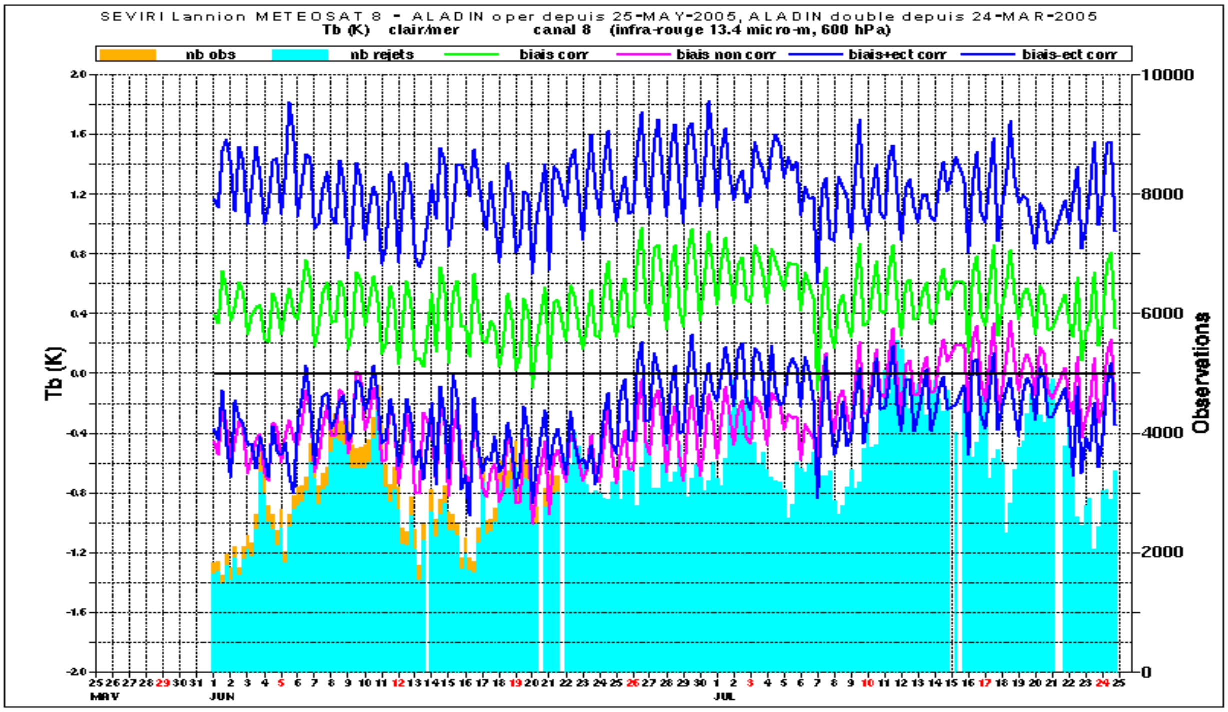


Figure 2 : monitoring over 2 months for the channel 8 of the instrument SEVIRI of Meteosat 8 : histograms of the numbers of observations taken into account (yellow) and rejected (blue); curves of the bias before (pink) and after (green) the bias reduction. The two blue curves represent the borders of the interval corresponding to + and – the standard deviation.

1.3. Objective scores of the 3DVAR ALADIN version

The first reference to evaluate the behaviour of this new version of the model is provided by the radio soundings located in the simulation domain. Their number is equal to 48 spread quasi uniformly in this domain.

We plot on Figure 3 the mean errors over the domain FRANX01 (roughly the whole Europe) averaged over the second temporal period of the comparison.

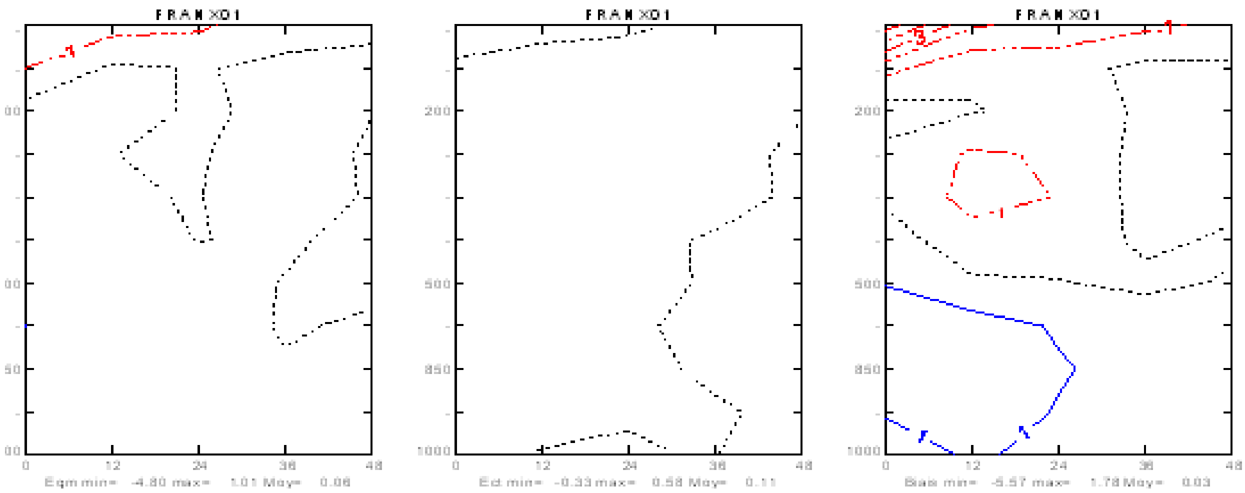


Figure 3 : diagram of the difference of the errors for the geopotential height (in m) of the operational version of ALADIN and its 3DVAR version: root mean squared error (left), standard deviation (centre) and absolute value of the bias (right). The horizontal axis corresponds to the duration in hours of the simulation and the vertical axis corresponds to the pressure. The reference is provided by the radio soundings over the domain FRANX01. The results are temporal averages from 16/06 until 25/07. The isolines are plotted every meter and the blue isolines correspond to an improvement in the quality of the forecast for the 3DVAR version and red ones to a deterioration.

The 3DVAR version performs a better job in the low troposphere (+1m) for the bias during the first day. Both version have the same quality for the 2 other parameters in the whole troposphere. Moreover, the bias for the 3DVAR version is stronger in the upper troposphere (-1 m) and get worse with the altitude leading also to a worsening of the root mean squared error above 150 hPa. This feature can be explained by the reduction (in comparison to the previous version 2005_01 of the 3DVAR ALADIN) of the coefficient of the return toward the observations. In the 3DVAR assimilation it has a value similar the ARPEGE one. The wind error (Figure 4) is still in favour of the 3DVAR version but the improvement is reduced in comparison to 2005_01 still for the same reason. This reduction remains important and about a quarter of the RMS error for the wind vector is removed with this 3DVAR version of ALADIN.

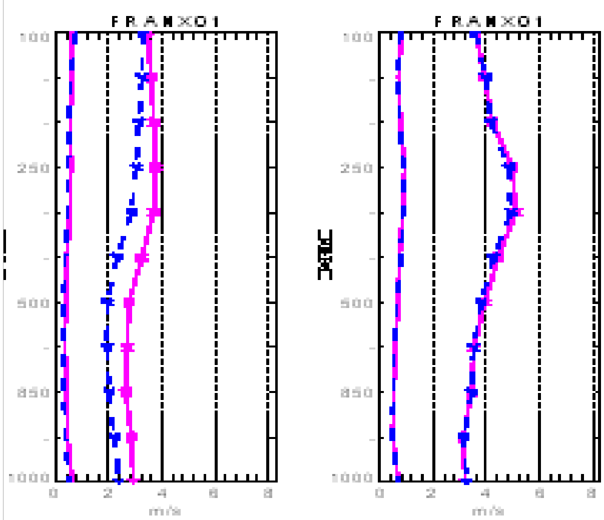


Figure 4 : vertical profile of the bias and of the RMS error for the vectorial wind of the 3DVAR version (blue) and of the operational version (pink) for 0 UTC (left) and 12 UTC (right). The reference is provided by the radio soundings of the domain FRANX01.

Figure 4 shows that the improvement in the 3DVAR version doesn't significantly last more than 12 hours. Figure 5 helps us to follow the temporal evolution of the different errors for the wind and to check that this new version is neutral in comparison to the operational dynamical adaptation after 12 hours.

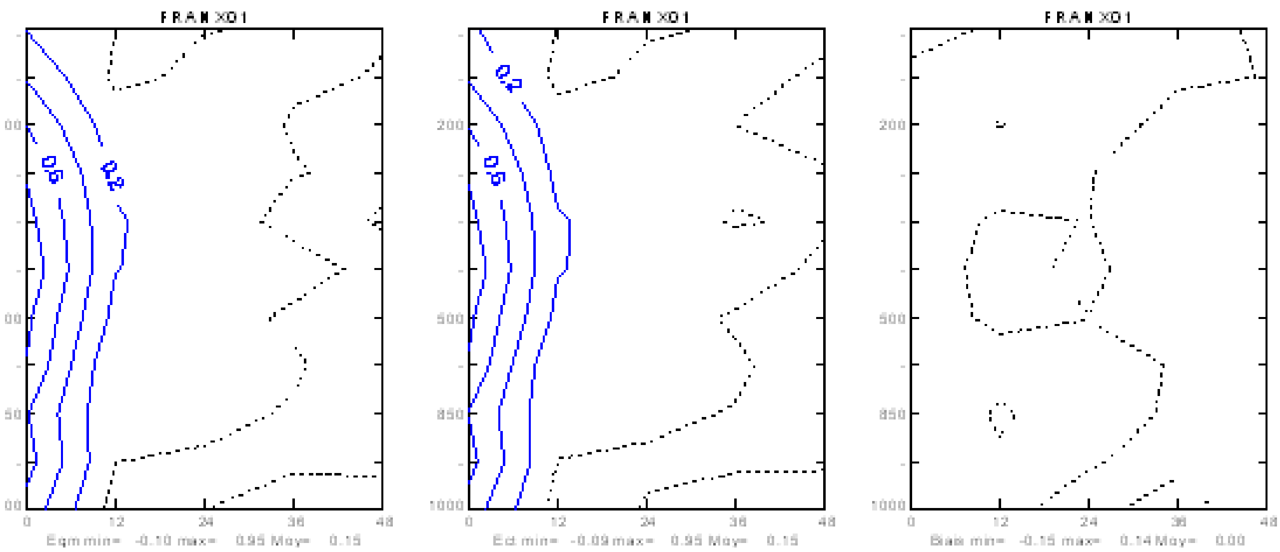


Figure 5 : same legend than Figure 2 but for the vectorail wind. The isolines are plotted every 0.2 m/s.

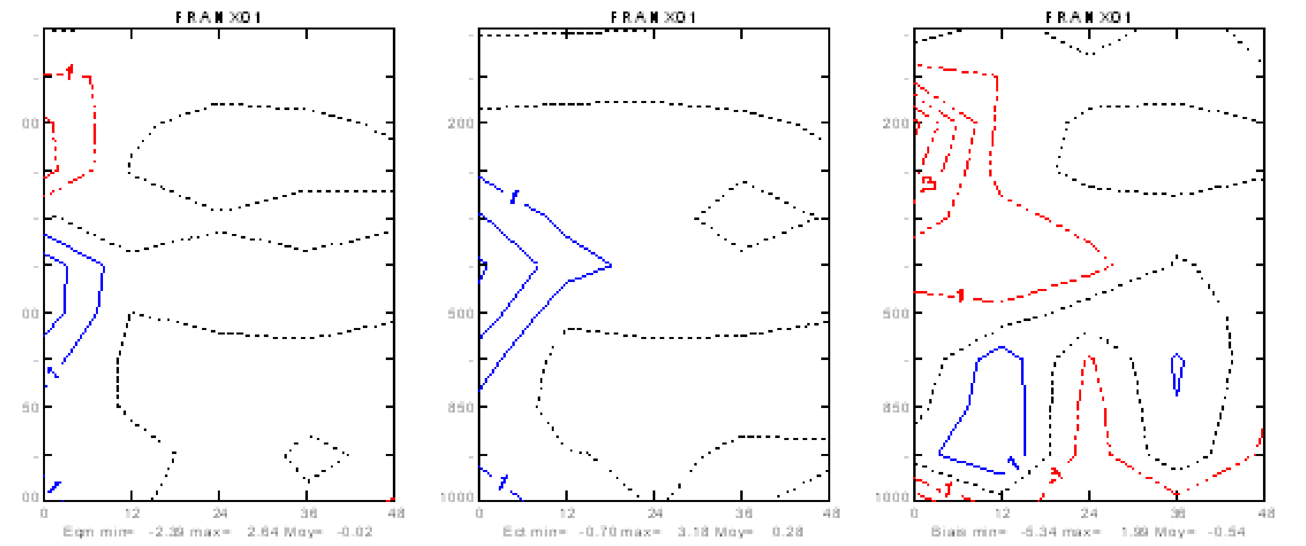


Figure 6 : same legend than Figure 2 but for the the relative humidity. The isolines are plotted every %.

The humidity scores (Figure 6) show that the 3DVAR analysis brings a useful information in the troposphere with a decrease of 3 % for the RMS error in comparison to the operational version. As for the wind, this improvement is only limited to the first 12 hours. We can also note some problems at the tropopause linked with a bias increase in the 3DVAR version.

We now present the comparison of both ALADIN versions with a new reference: the analysis of the ECMWF on the same spatial domain FRANX01 but with a spatial resolution of 0.5° in latitude and longitude instead of 0.1° (nominal resolution of the ALADIN outputs). We will name this domain FRANX05.

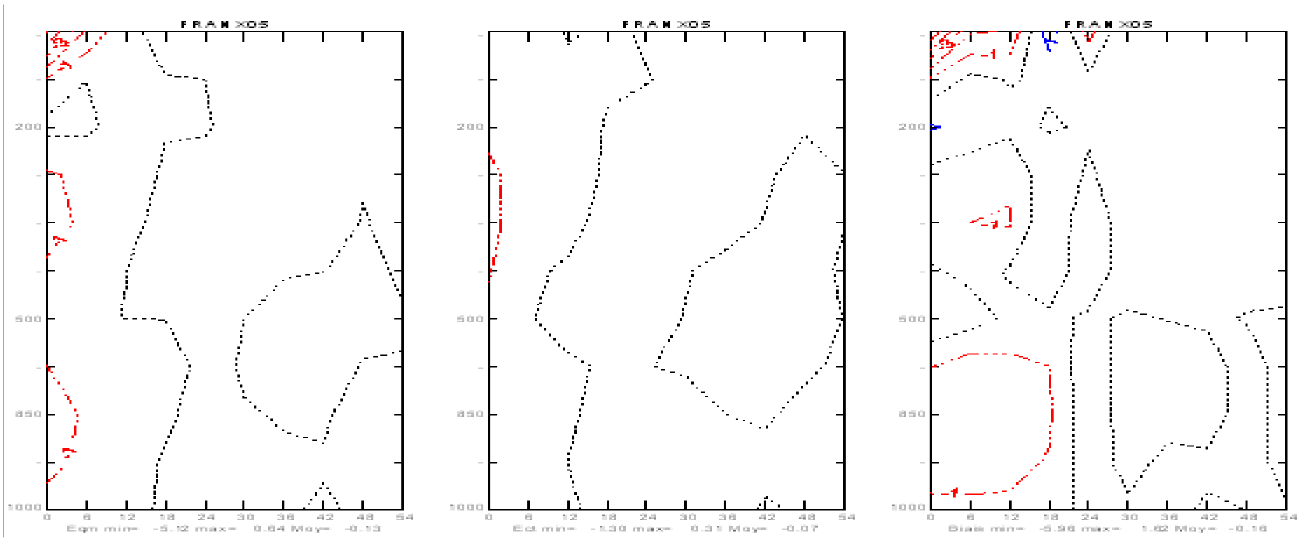


Figure 7 : same legend than Figure 3 but the reference is the ECMWF analysis of the geopotential height. The isolines are plotted every meter.

The stratospheric bias for the geopotential height also exists with this new reference (Figure 7) but its amplitude decreases more quickly with time than with the radio soundings. Moreover, the worsening of the bias against this reference confirms that the ALADIN analysis is nearer to the observations than the larger scale analyses. After 6 hours, the RMS error is negligible and the 3DVAR and operational forecasts are equivalent.

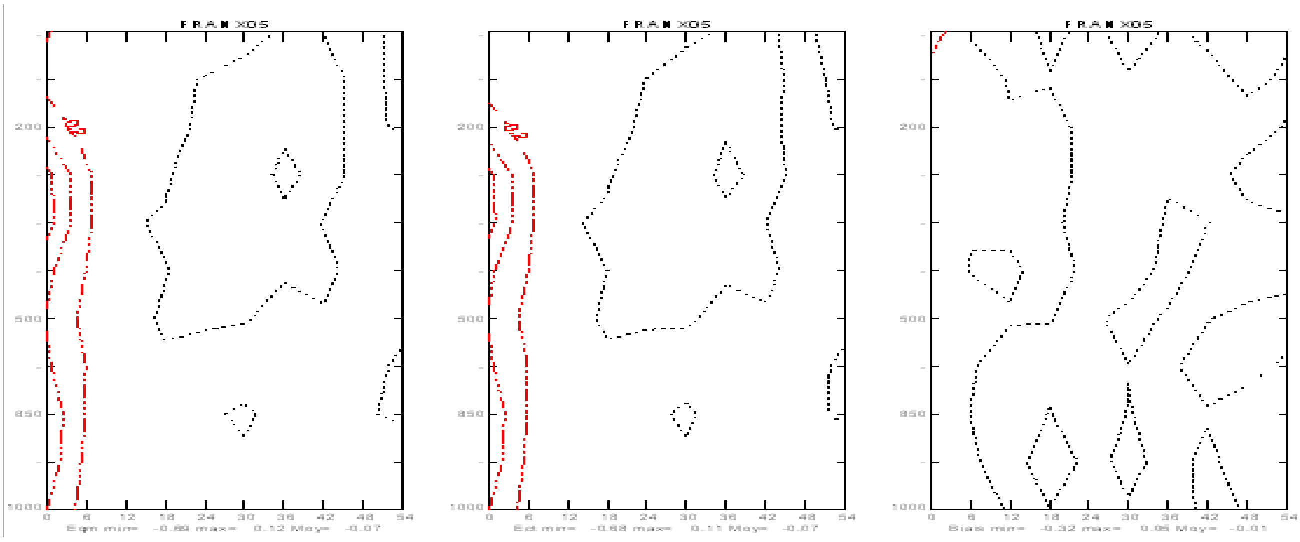
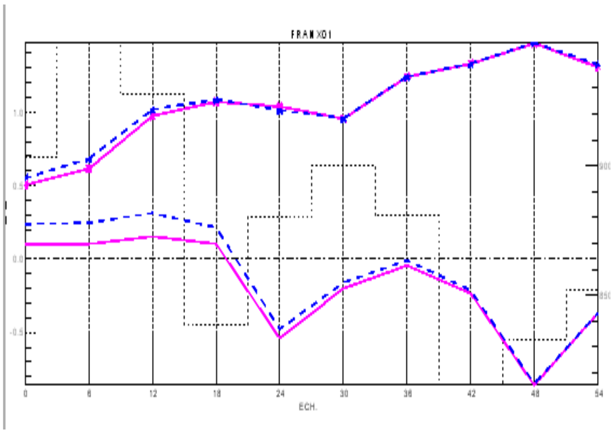
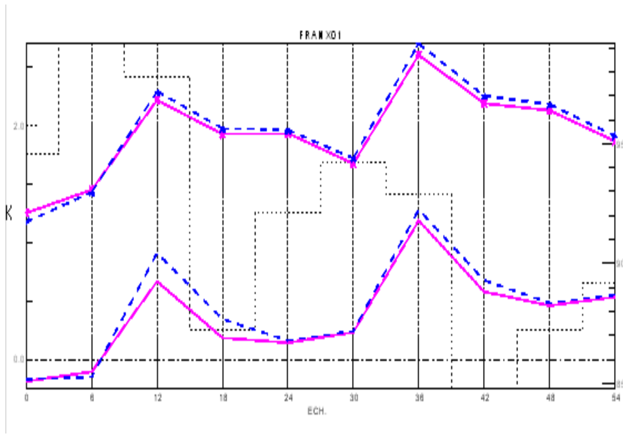


Figure 8 : same legend than Figure 5 but the reference is the ECMWF analysis of the vectorial wind. The isolines are plotted every 0.2 m/s

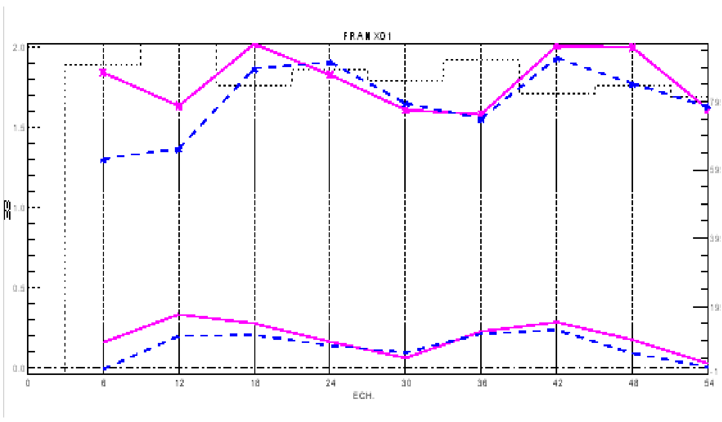
We note that all the improvements of the 3DVAR analysis (maximum of 0.8 m/s) correspond to a worsening of the scores with the reference given by the ECMWF analysis (minimum of –0.6 m/s). As for the geopotential height, we have no significant signal after 6 hours.



(a)



(b)



(c)

Figure 9 : bias et RMS for the domain FRANX01 in function of time (0-54 hours) for the reduced pressure in hPa (a), the corrected temperature in K (b) and the daily accumulated precipitation in mm (c). The reference is provided by the SYNOP messages and the operational model results are plotted in pink and the 3DVAR ones in pink.

The examination of the scores for the surface data shows that the bias of the test version is higher by 0.25 hPa during the first 18 hours in comparison to the operational version. Then, the biases become similar. The RMS errors are not significantly different. For the temperature, only the bias at 12 hours is increased by 0.2 K but no signal is present on the RMS errors. For precipitation, there is a strong improvement with a reduction of the bias and the RMS error until 18 hours. Then, the signal is less clear. We add the study of the precipitation scores by the analysis of the contingency tables for both versions. The accumulated rain between 6 and 12 hours (Table 1) show a clear advantage for the 3DVAR version with a strong increase of accuracy (or fraction correct) for the 3DVAR due to a better forecast of the no-rain class. The simulations, starting from the 3DVAR analysis, have a strong correct tendency to generate less rain during the beginning of the simulation. For the heavy rain category, we note a positive impact of the 3DVAR version with a joint improvement of the false alarm and non-detection rates.

PREVISION ALADIN DOUBLE ECHEANCE 12 H.					
OBS/PRE	Nulles	0.1<=P<2	2<=P<10	10<=P	Total
Nulles	**69.1%**	17.0%	1.9%	0.1%	88.1%
0.1<=P<2	1.6%	**4.1%**	1.4%	0.0%	7.2%
2<=P<10	0.2%	1.5%	**2.2%**	0.3%	4.2%
10<=P	0.1%	0.1%	0.1%	**0.2%**	0.5%
Total	71.1%	22.7%	5.6%	0.6%	5042
onnes Prévi :	75.6%	0.65	Heidke :	0.31	
TFA 0,1 :	66%	TND 0,1 :	17%		
TFA 2 :	55%	TND 2 :	41%		
TFA 10 :	67%	TND 10 :	62%		

PREVISION ALADIN OPER ECHEANCE 12 H.					
OBS/PRE	Nulles	0.1<=P<2	2<=P<10	10<=P	Total
Nulles	**61.8%**	21.6%	3.4%	0.2%	87.0%
0.1<=P<2	1.3%	**4.6%**	2.0%	0.1%	8.0%
2<=P<10	0.1%	1.8%	**2.2%**	0.4%	4.5%
10<=P	0.0%	0.1%	0.2%	**0.1%**	0.5%
Total	63.2%	28.1%	7.9%	0.8%	5317
Bonnes Prévi :	68.7%	0.58	Heidke :	0.26	
TFA 0,1 :	69%	TND 0,1 :	11%		
TFA 2 :	66%	TND 2 :	41%		
TFA 10 :	84%	TND 10 :	74%		

Table 1 : Contingency tables between precipitation accumulated from 6 until 12 h TU observed (line of the tables) and forecasted by the ALADIN test version (left) and the operational one (right). We give under the table the fraction correct (Bonnes Previ in french), the Heidke score, the false alarm rate (TFA) and the non-detection rate for 3 different thresholds.

The contingency table for accumulated rain from 6 to 12 hours (Table 2) for the day after (i.e. between 30 and 36 hours of simulation) shows a reduced impact of the 3DVAR version of ALADIN. We only note still a progress in the forecast of the no-rain class. This leads to an improvement by 3 % of the correct forecast fraction. On the contrary, its false alarm and non-detection rates are similar to their operational counterparts.

The temporal evolution of the fraction correct for these 2 versions, plotted every 6 hours (Figure 10) shows the superiority of the forecasts starting from the 3DVAR analysis, which is maximum during the first hours of simulation but stabilizes after 18 hours around 2 %. This temporal evolution is coherent with the temporal evolution of the bias or the RMS errors for the precipitation (Figure 9c). The Heidke score is a bit different regarding the relative long-term behaviour of the precipitation for both versions because the improvement is present only during less than 12 hours and the Heidke scores of both versions are equal after.

PREVISION ALADIN DOUBLE ECHEANCE 36 H.					
OBS/PRE	Nulles	0.1<=P<2	2<=P<10	10<=P	Total
Nulles	**69.5%**	15.3%	3.1%	0.1%	87.9%
0.1<=P<2	2.0%	**3.5%**	1.6%	0.1%	7.3%
2<=P<10	0.5%	1.6%	**2.0%**	0.3%	4.3%
10<=P	0.1%	0.1%	0.2%	**0.0%**	0.5%
Total	72.1%	20.5%	6.9%	0.5%	4904
Bonnes Prévi :	75.0%		Heidke :	0.28	
TFA 0,1 :	66%	TND 0,1 :	21%		
TFA 2 :	66%	TND 2 :	48%		
TFA 10 :	91%	TND 10 :	92%		

PREVISION ALADIN OPER ECHEANCE 36 H.					
OBS/PRE	Nulles	0.1<=P<2	2<=P<10	10<=P	Total
Nulles	**65.7%**	18.0%	2.8%	0.2%	86.6%
0.1<=P<2	1.9%	**4.1%**	1.9%	0.2%	8.0%
2<=P<10	0.5%	1.9%	**2.1%**	0.2%	4.7%
10<=P	0.1%	0.2%	0.3%	**0.1%**	0.6%
Total	68.1%	24.2%	7.0%	0.7%	5317
Bonnes Prévi :	72.0%		Heidke :	0.28	
TFA 0,1 :	66%	TND 0,1 :	18%		
TFA 2 :	65%	TND 2 :	50%		
TFA 10 :	86%	TND 10 :	85%		

Table 2 : same legend as Table 1, but for the accumulated rain from 6 et 12 h UTC of the day after.

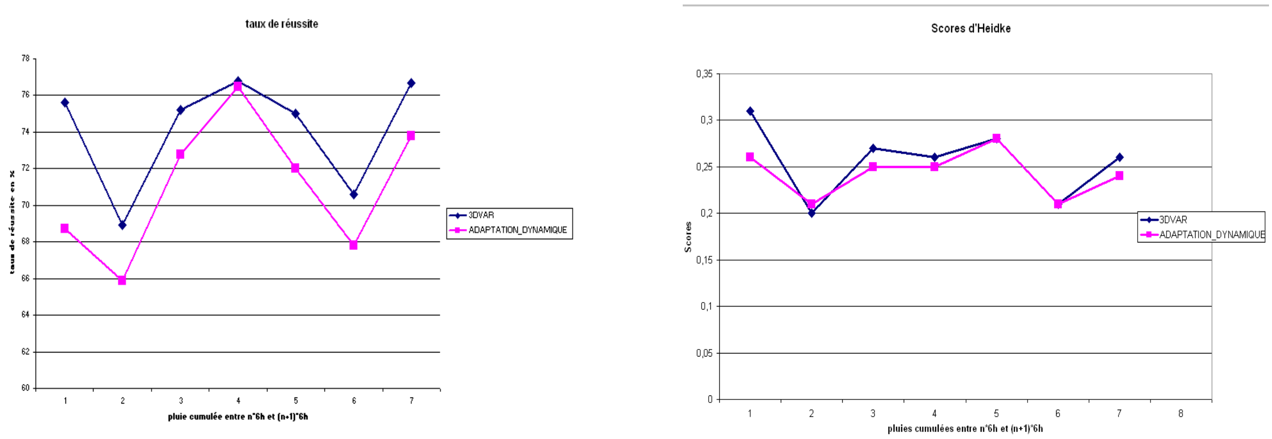


Figure 10 : Temporal evolutions of the success rate (left) and the Heidke skill score (right) of the 3DVAR ALADIN version in blue and of the operational version in pink every 6 hours starting from the accumulated rain from 6 until 12 hours of simulation.

1.4. subjective validation

The subjective control of this test version has been realized in the COMPAS team over France and by the forecasters of the regional centre of the South-East of France (CMIRSE) over their own region. The number of situations studied by COMPAS (37 cases from 2 June until 11 July) is the double of the number of situation for the CMIRSE (20 cases from 8 June until 30 June). Nevertheless, the conclusions of both subjective controls are consistent. The summaries on the impact of the 3DVAR version are collected in the following table:

	positive > 9 hours	positive < 9 hours	neutral	negative
COMPAS	8	5	19	5
CMIR SE	8		8	4

We list the most remarkable points of this comparison:

- The forecasts starting from the 3DVAR analyses present more balanced structures than those coming from the spatial interpolation of the ARPEGE analysis. This leads, in the test version, to a strong decrease of light rain occurring during the first hours of simulation of the operational version. This change is visible in the false alarm rate which is strongly reduced.
- We have noted a decrease of the convective activity due to the decrease of the wet potential temperatures in the low levels of the atmosphere. This gives less triggering of the convection scheme. This is likely a consequence of the use of the temperature and humidity at 2 m AGL in the altitude assimilation scheme, which provides this useful correction. This gives an important decrease of the convection but also of the grid-point storms in the test version.
- The positive bias for the rain accumulated during 24 hours, is reduced in this test version.

Nevertheless, the improvement of the 3DVAR test version is mixed with by some spurious convection triggering in this version. This happens frequently when the wet potential temperatures of the boundary layer are high. This sometimes produces (case of the 9 and 10 July) forecasts which are not informative on the distribution of the convection aver France. Thus, during the 4 episodes of orange alert, which have occurred during the period of comparison, the 3DVAR version has not brought significantly better information in all cases:

(1) 13 June (convection over the South-East of France) neutral
(2) 23 June (strong convection over Paris) non-detection by both models
(3) 24 June (convection over the Centre-East and South-East of France) models not informative
(4) 27 June (convection over the South-West of France) The storm which happens over Bordeaux was forecasted offshore.

We can add to these 4 cases, the night between the 3 and 4 July, where both models have forecasted strong convection in the North of France, which was lightly under-estimated but informative regarding the storm which has been observed.

1.5. Conclusion

A new version of the operational ALADIN model has started from the 25 July 2005: this model has its own assimilation scheme based on the 3DVAR method. This analysis assimilates the observations of the ARPEGE model after the same screening but also the SEVIRI radiances of METEOSAT 8 and the temperatures and humidity measured at 2m AGL in the altitude analysis. The scores of the forecasts starting from this analysis are better than those of the dynamical adaptation. This is mainly visible during the first hours of simulation for the wind and the temperature, when we compare them with the radio soundings data. This improvement is also present for the precipitation: we observe a strong reduction of the bias due to a reduction of the false alarms of convective rains during this summer period. A bias of 0.25 hPa exists for the reduced pressure in the first hours of simulation and we have to monitor it during the next months.