Study of spinup properties in AROME RUC 3DVAR

Météo France stay report, december 2007

Jure Cedilnik
Environmental Agency of the Republic of Slovenia

Supervisors: Pierre Brouseau and Pierre Benard

1) Introduction

Following the experience with ALADIN RUC 3DVAR, a need arose to diagnose the existence of small waves in AROME RUC 3DVAR. These waves in temporal pattern in surface pressure were observed in ALADIN 3DVAR and identified as gravity ones with an amplitude of around 0.5 hPa and frequency of a few minutes. Incremental digital filter was found to be a very useful cure for such clutter in ALADIN 3DVAR RUC and is presently used in double suite.

The aim of this stay was to diagnose similar patterns in AROME, together with any possible fibrillation issues aswell.

2) Experiment setup and case description

All the tests were performed with an AROME France domain (512x512 points, 41 vertical levels). (see Figure 1). The 3DVAR cycle had a frequency of 3 hours, and the coupling with the driving model was performed every hour. The cold start was on November 20 at 21hrs and the first assimilation cycle 3 hours later (at 00).
After the last assimilation at 12 UTC the next day, a 12 hour production run followed.
Echkevo has proven to be an especially useful tool for monitoring temporal evolution in some points of the domain; the points where it was used are also marked in Figure 1 and specified in detail in Table 1.

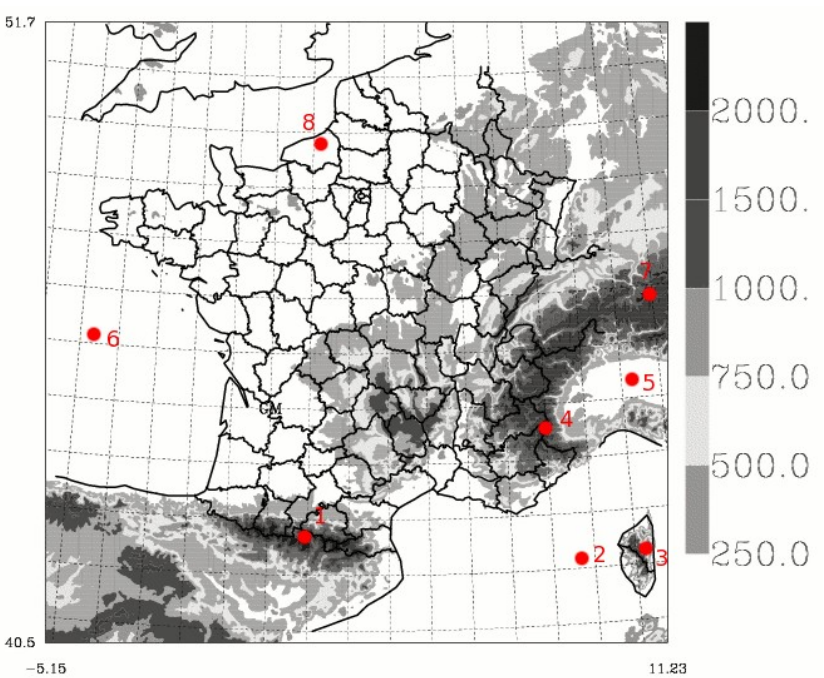

Figure 1: The domain used: 512x512 points and 41 levels. The grid points marked by red dots are the ones used by echkevo for producing time series output.

Table 1: Description and coordinates of points used for echkevo output.

Point No	Description	LAT	LON	I (index in LAT)	J (index in LON)
1	Pyrenees – south of Toulouse	42.72	1.27	220	87
2	Mediterranean sea – west of Corsica	42.18	8.24	450	70
3	Corsica – eastern slopes	42.10	9.45	490	70
4	Alps – east of Briançon	44.75	7.28	411	182
5	Po valley	45.50	9.62	482	217
6	Bay of Biscay*	46.33	- 4.7	40	270
7	Alps – near Innsbruck*	46.72	10.40	500	278
8	Normandy**	0	0	220	400

* The points are already within the coupling zone
** It is not clear, why the point's coordinates were not displayed.

The chosen period for the experiment was November 20-23, 2007. During those days, a very cold air broke towards south over western Europe. Its consequence was a rather large PV anomaly (see Figure 2) just west of Atlantic coast of France and strong southerly flow aloft over most of France (Figure 3).

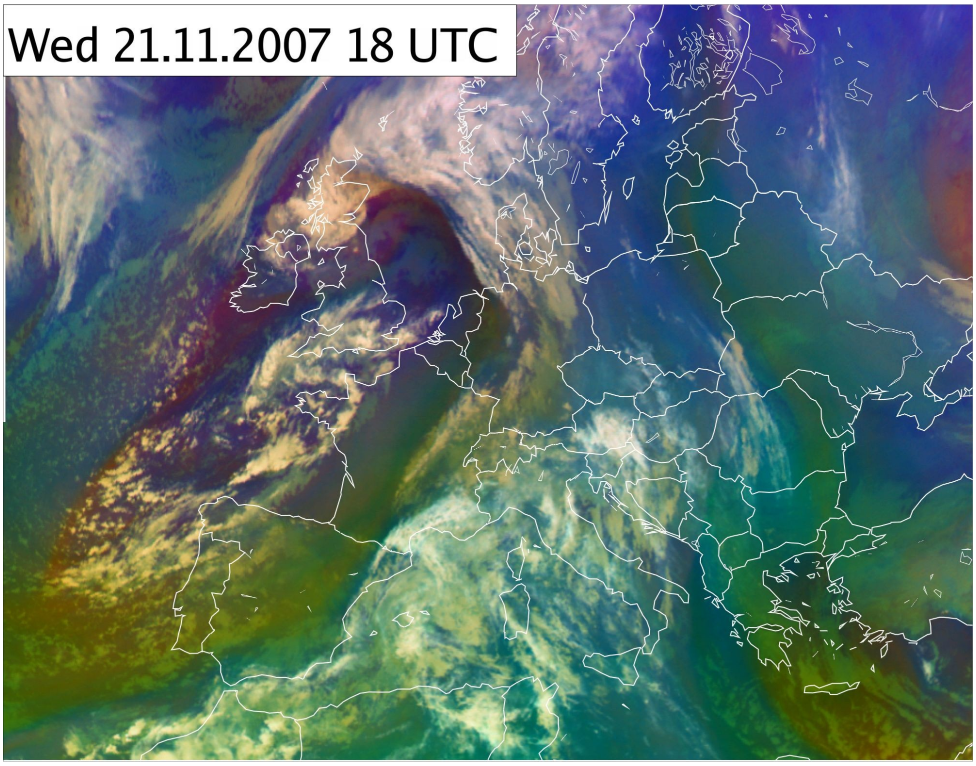

Figure 2: Airmass composite satellite image of synoptic situation for the date shown.
The cold stratospheric air (west of France) can be identified by redish or pinkish colour.

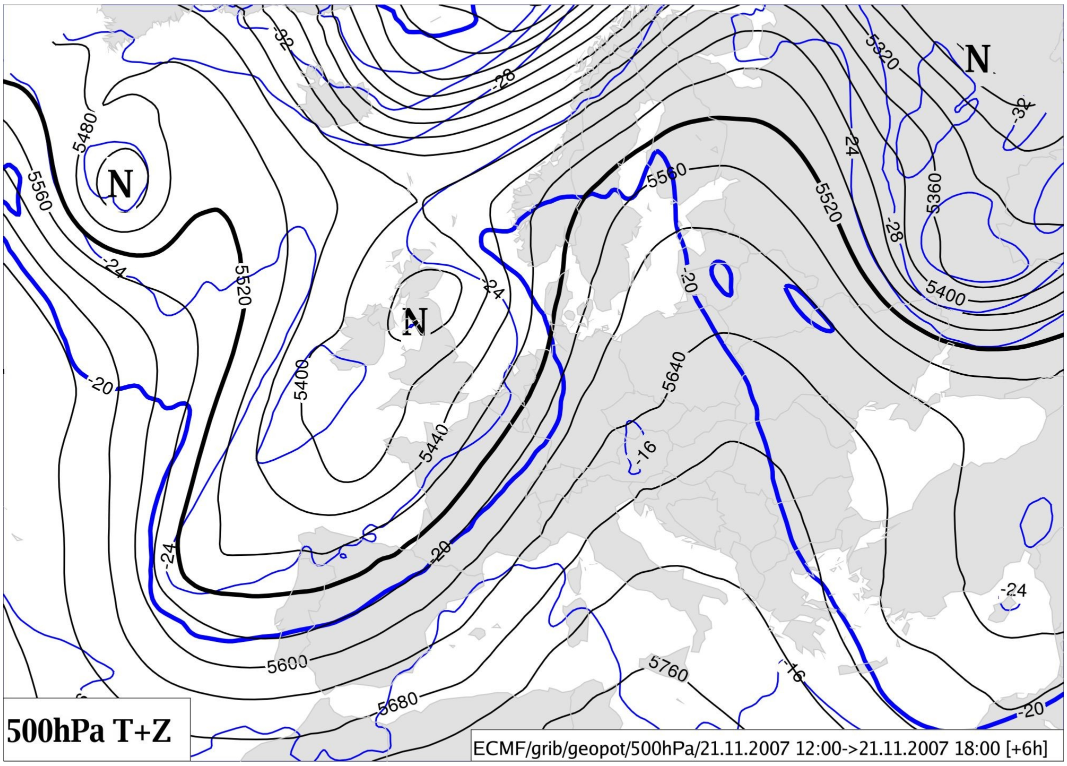

Figure 3: Synoptic chart (temperature and geopotential height) for 500hPa surface for the same date as Figure 2.

3) Results

The most interesting results were the ones showing temperature evolution. Figure 4 shows temperature evolution at the lowest model level for all the 8 different points for the 27 hour period, starting on November 21, at 21 UTC.
The oscillations seen at point in the Pyrenees are very striking. Their amplitude can be as high as 4 degrees. For a close-up of this detail, see Figure 5. Similar oscillations can be seen in some other grid points aswell (see Figure 4, for example violet and blue curves). These do not occur only at the very beginning, but also at every analysis update, again see Figure 5. Another interesting feature of this pattern is that it is not a typical kick and relaxation afterwards, but that the maximum value of amplitude needs some time to develop.

Although the oscillations are much more pronounced in the mountaneous grid points, they are present elsewhere too. See for example point in the Poo valley (cyan line in Figure 4) or in the bay of Biscay (yellowish line in Figure 4).

The case shown on Figures 4 and 5 is a more extreme one, other runs (starting one day before or a few days after) didn't show such amplitudes and such a long damping time. However, the pattern is still present in other cases too.

To study the nature of these oscillations, a test was conducted by making the TKE scheme overimplicit. By default, the value of *beta* is hardcoded to 1.0, and for our purpose it was modified to 1.5. This test was following an assumption that the TKE scheme – being the most stiff part of the model – is the likely cause of this oscillating pattern. However, as shown in Figure 6, this doesn't seem to be true in this case. The experiment with overimplicit scheme is only slightly different than the original one. Another way of seeing that the fibrillations are not in question here, is to see that the exhibited pattern is the one of $2\Delta t$ nature, but not $2\Delta z$. This can be very easily seen by plotting the temporal evolution on three lowest model levels (see Figure 7) – the minima and the maxima in the vertical match – a minimum at timestep 10 in a minimum on levels 39, 40 and 41.

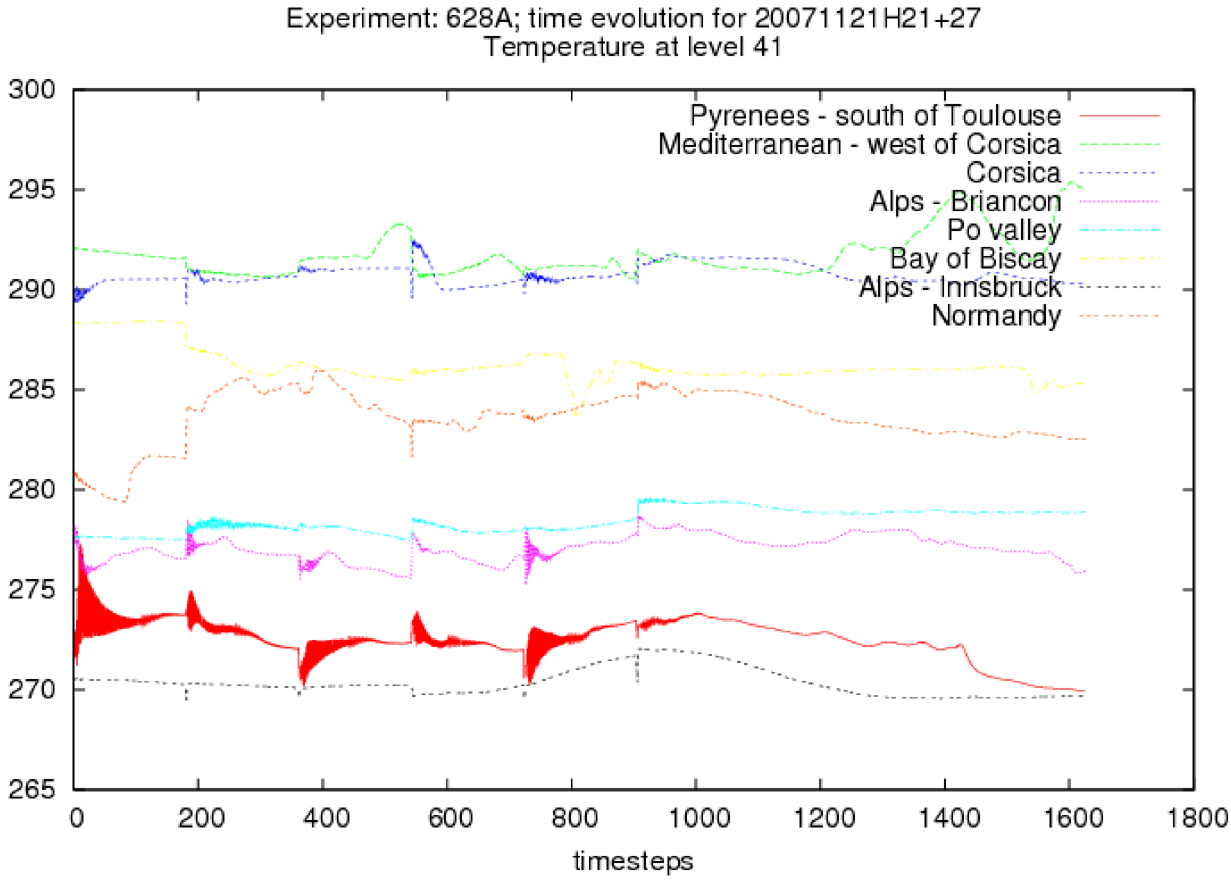

Figure 4: Time series of temperature at the lowest model level for experiment starting at 20071121 at 21UTC.

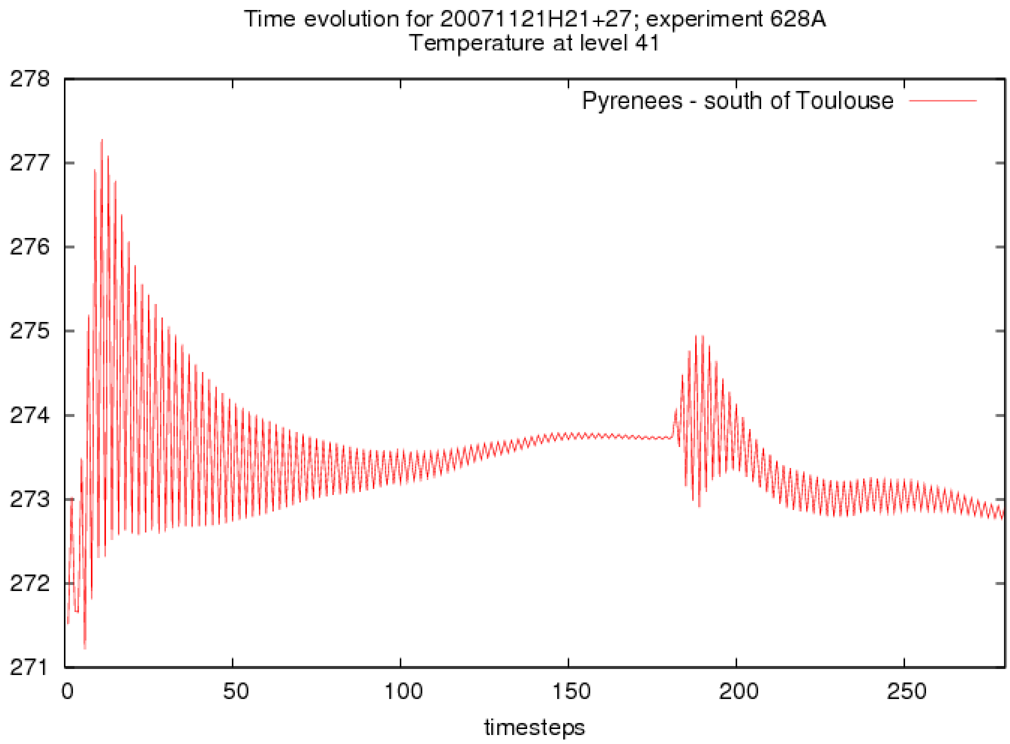

Figure 5: Same s Figure 4, but close-up, and only point no. 1.

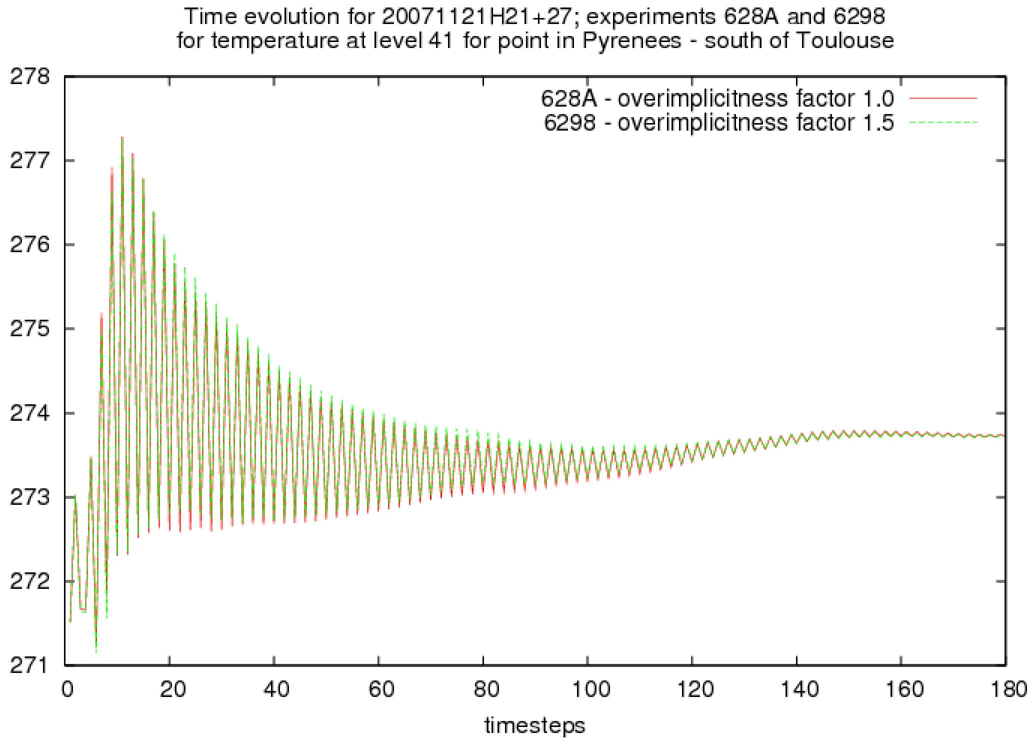

Figure 6: Time evolution at point no.1 for the first three hours for experiment with overimplicit treatment and without.

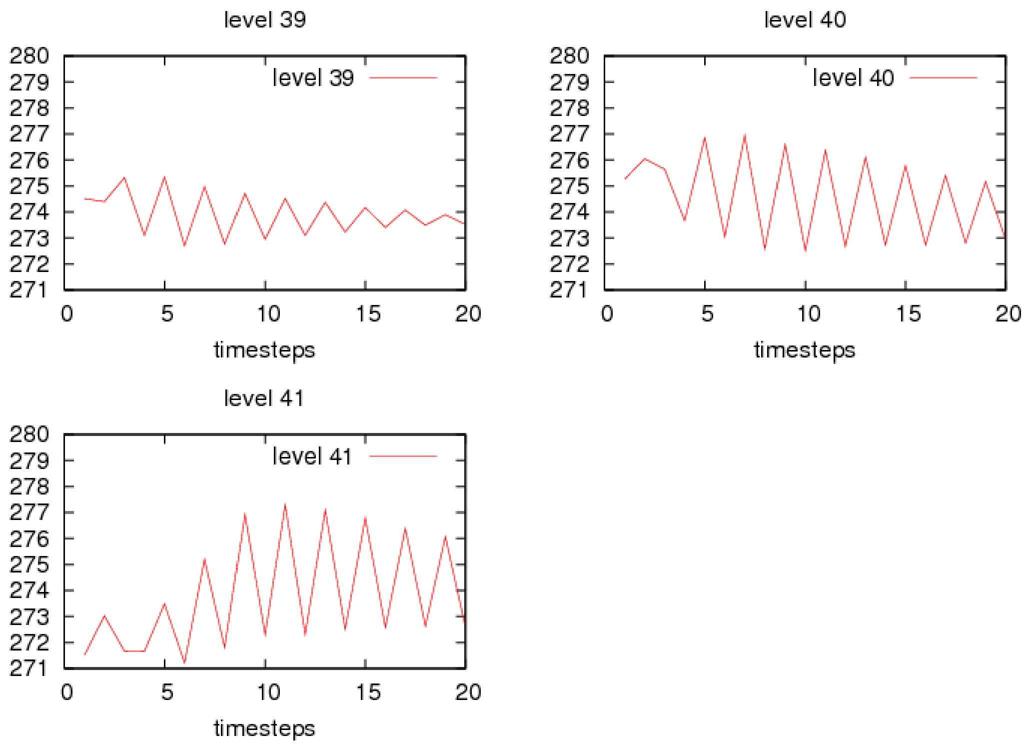

Figure 7: Same as Figure 5, but another close-up on for the three lowest model levels.

An interesting feature on Figure 7 is the fact that at initialization the lowest temperature layer is colder than the two above. This is rather strange for a point on the mountain ridge (see Figure 8) and with the winds at the lowest model level of around 10m/s (see Figure 9) (the wind was mostly from the south – the v part of the wind velocity was roughly 10 times bigger than the u one). However, this was also the case of the driving model – the 3 hour ALADIN forecast used to initialize the cold start of AROME had its lowest layer colder than the few above. It should be mentioned at this place, that the lowest levels of the models are identical.

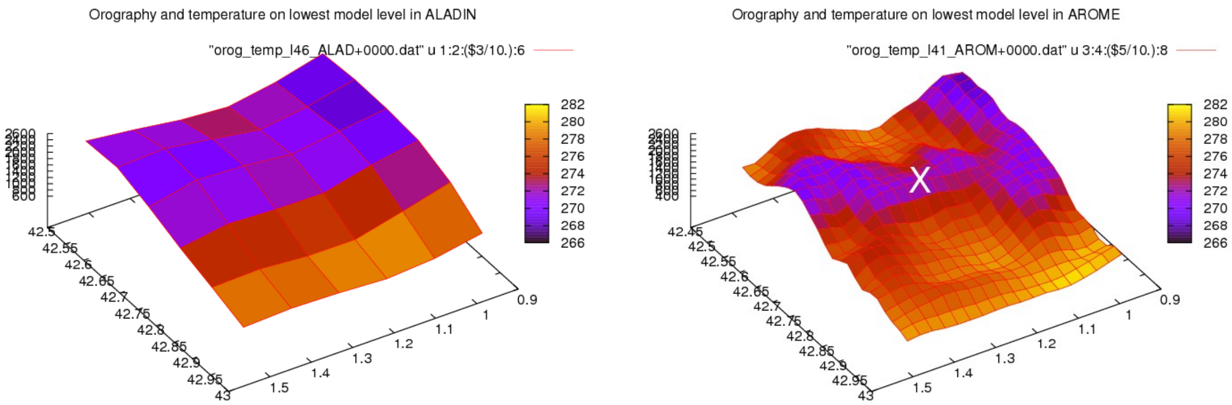

Figure 8: Orography and temperature at the lowest level of the model around point 1: Pyrenees ridge just south of Toulouse viewed from a point approximately above Albi. On the left side for ALADIN and on the right for AROME. The point no. 1 is marked by 'X' on the right side.

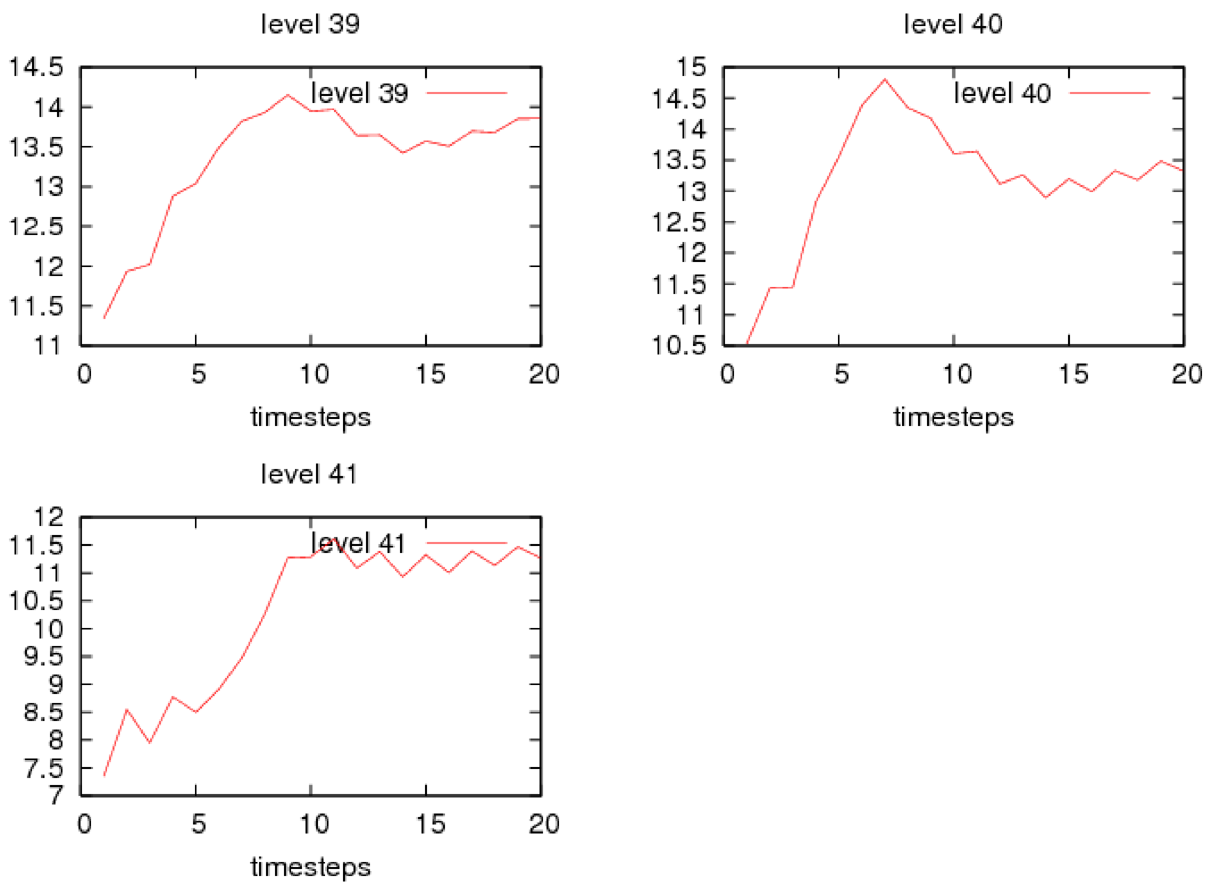

Figure 9: Same as Figure 7, but for v – wind speed in direction of north (perpendicular to the mountain ridge).

4) Digital filter

The focus so far was kept on temperature purely for the reason that that was the most peculiar result. The results for surface pressure are much less noisy (Figure 10), however they do resemble the results shown by Fischer (2007). Small oscillations with an amplitude of around 0.5 hPa and frequency of a few minutes can be identified as gravity waves.

One of the performed tests was to see what is the impact of pure (nonincremental) digital filter. Figure 11 shows the evolution of surface pressure for an experiment with a digital filter. The impact is not very large and it is not very easy to say that the results with the digital filter exhibit much less noise. However, digital filter has a rather large impact on the time series of temperature for the famous point no. 1 (the Pyrenees ridge). Figure 12 shows the evolution of temperature at the lowest model level for the experiment with the digital filter. The temperature oscilations are much lower. This can be easily explained by the fact, that the field are much better in balance after a digital filter is performed and that the biggest portion of oscillations took part already in the digital filter part of the experiment.

However, it seems that normal digital filter is still very brutal. Besides the noise it is filtering a large portion of the signal aswell. This can be shown by looking at the precipitation field (Figure 13). The peak values of 3-hour precipitation are better in agreement with observations for the run without than for the one with digital filter.

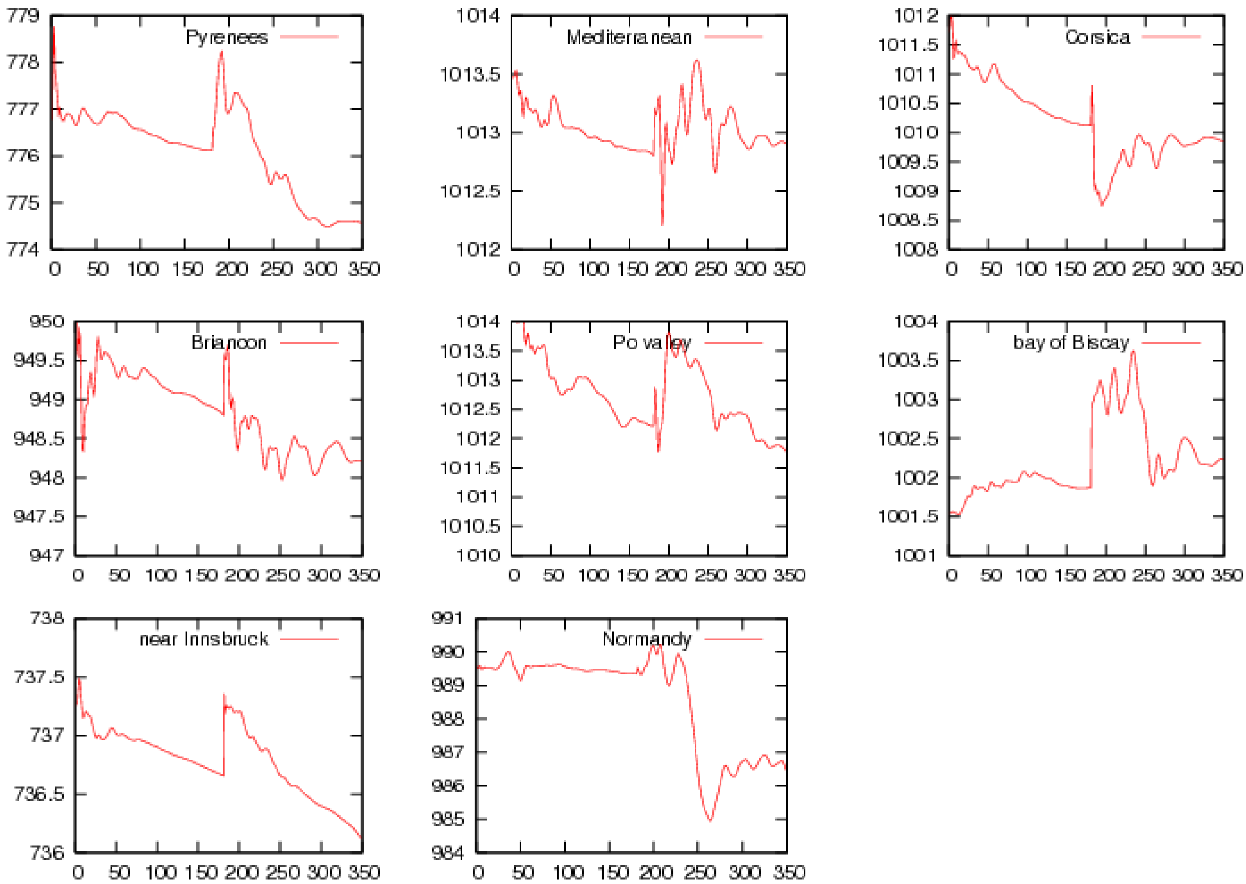

Figure 10: Time series for surface pressure for the first six hours of integration. An analysis is performed at step 180.

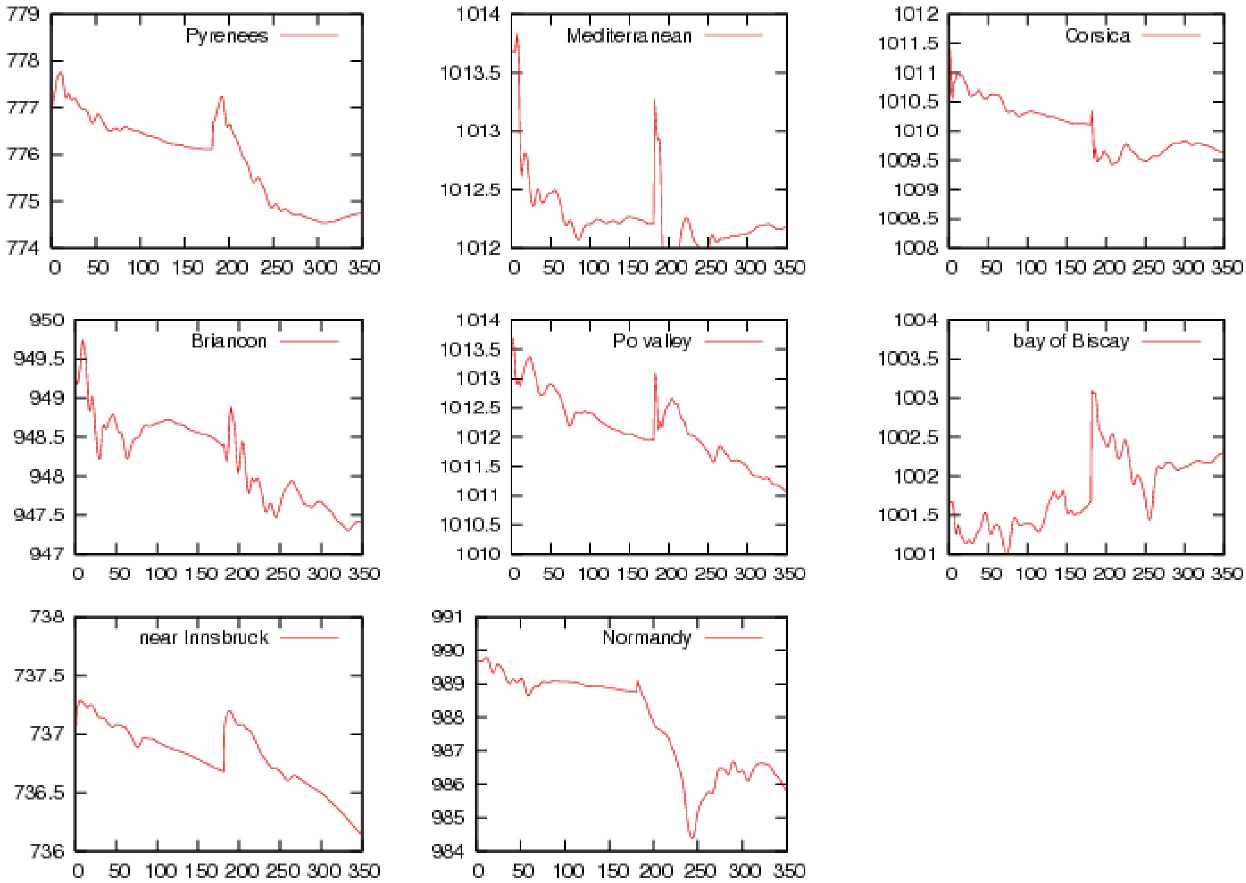

Figure 11: Same as Figure 10, but for an experiment with (normal) digital filter.

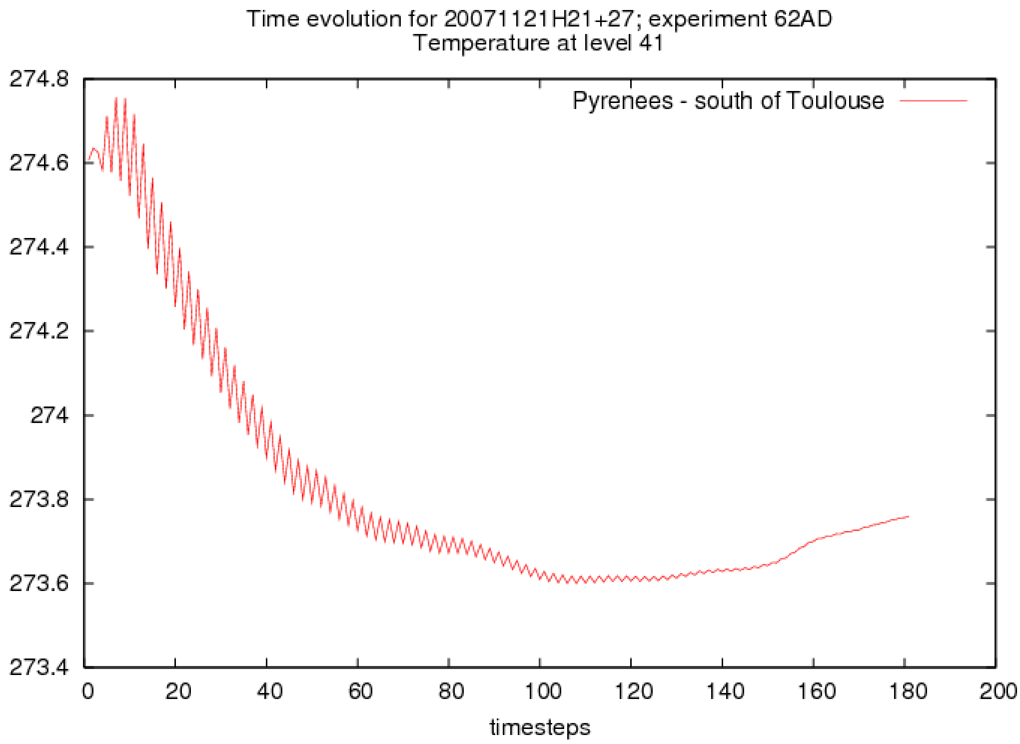

Figure 12: Temporal evolution of temperature for the lowest model level after initialization with digital filter.

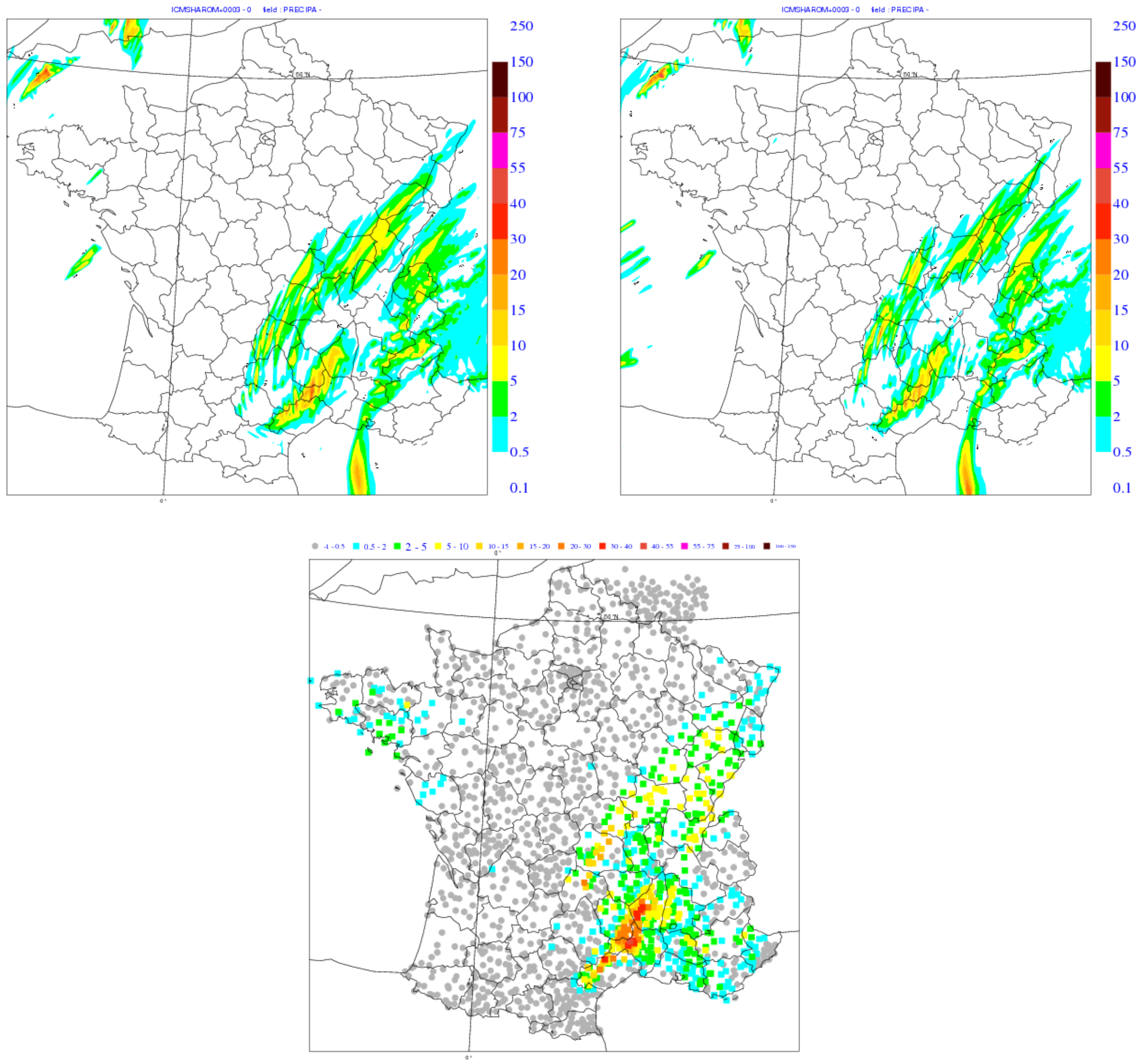

Figure 13: Precipitation patterns for: run without digital filter (above left), experiment with digital filter (above right
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A test was performed also with a use of incremental digital filter. The idea is to filter the guess field and substract the unfiltered guess from the filtered one – thus obtaining a bias, and the following step is to substract this bias from the filtered analisys. This was implemented in the experiment following the current ALADIN double suite, but it failed to work properly – after the initialization in the final forecast part, the model crashed in the shallow convection routine of MesoNH physics. The lowest level temperature fields (the one from analysis and the result of incremental digital filter) are shown on Figure 14.

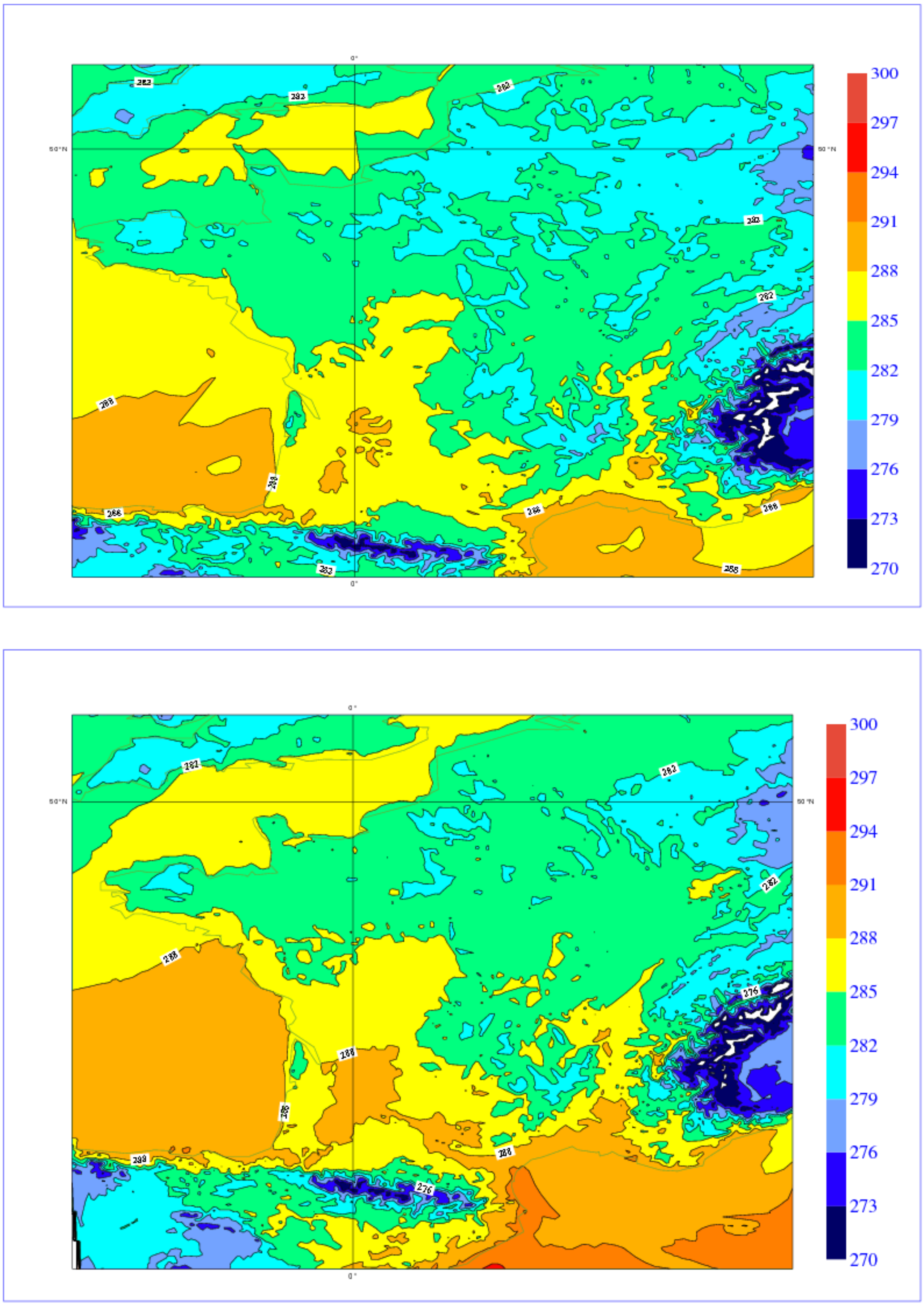

Figure 14: Temperature for the lowest model level; above: after minimisation step (analysis) and below: after incremental digital filter. For 21 Nov, 2007 at 21 UTC.

5) Technical documentation

OLIVE swapp environment was used for all the experiments. They can be found under swapp environment, under user mrpa669. The most imporant experiments used and their description are presented in Table 2:

Table 2: Experiment names and their descriptions for the few most important ones.

Experiment name	description
627G	reference; latest spectral diffusion tuning and full RUC; for 3 dates (starting at 20112007 21UTC, until 23112007 12 UTC)
628A	To complement 627G with echkevo output
629M	Same as 627G, but with 1.5 overimplicit coefficient
6298	To complement 629M with echkevo output
62AY	Same as 627G, but starting 3 hours earlier, only one date (21112007 at 18 UTC)
62B6	To complement 62AY with echkevo output
62B0	Incremental digital filter – set up according to ALADIN double suite

6) Literature

Fischer, Claude; 2007: Internal talk on assimilation meeting, Toulouse, October 2007; *cougar:* ~mrpe722/3DVAR/TESTCASES/3DVAR_IDFI.ppt