ALADIN : April 2000 - April 2001
A short review of the main events and developments

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1. Life of the project

1.a ALADIN events

♦ €The 10th birthday of ALADIN will be celebrated on May 31th, together with the signing of the new Memorandum of Understanding.

♦ €A new, 15th, partner has just joined the ALADIN project : Tunisia.

♦ €The last IFS cycle (24) gave us a lot of worry along the last six months, so that work concentrated mainly on maintenance, rather than on research. There are still problems with ARPEGE and ALADIN configurations.

1.b Changes in operations

♦ €a new pre-operational application, in Croatia

♦ €dynamical adaptation of low-level wind at very high resolution now operational in Hungary (and Slovenia, where it was designed)

♦ €4 runs per day in France

♦ €blending assimilation now operational for LACE

1.c ALATNET events

ALATNET is now one year old. It is a Research Training Network supported by the E.U., implying :

♦ €a 4-years research program in NWP

♦ €5 research centres (NMSs of France, Belgium, Czech Republic, Hungary and Slovenia)

♦ €open advanced training courses in NWP :
May 2000 : High resolution modelling, Radostovice (Cz)
June 2001 : Data assimilation, Gourdon (Fr)
2002 : Numerical methods (Si)

♦ €pre-doc and post-doc grants, open to European students

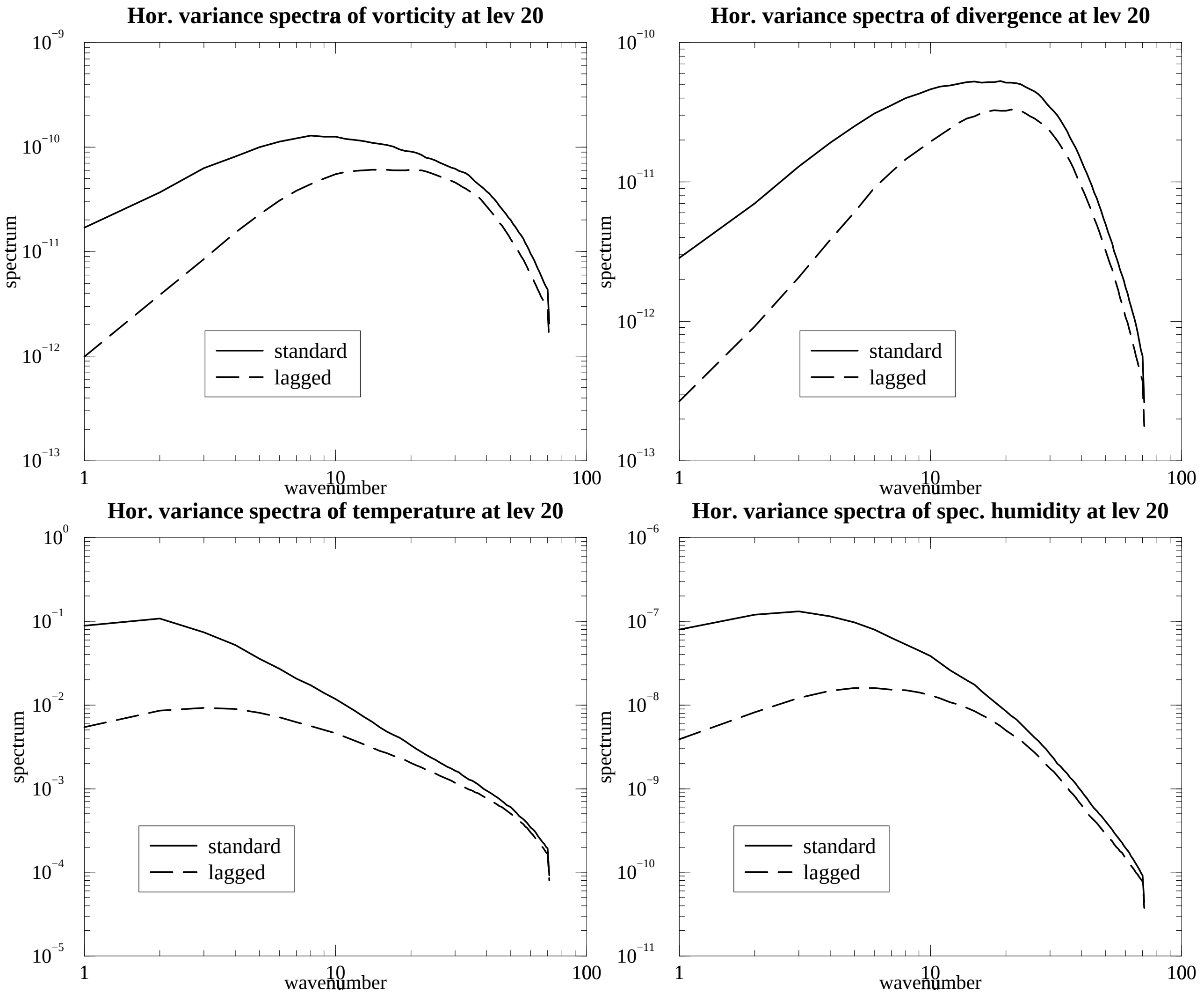
♦ €a web-site : **http://www.cnrm.meteo.fr/alatnet/**

2. Data assimilation

2.a Variational assimilation

♦ €Use of "lagged" NMC background error statistics
ALADIN domains are usually smaller, with a maximum extension of 3000 km, and of higher resolution (10 km on average) than the large HIRLAM domains where assimilation is performed. Hence lagged statistics are used for variational assimilation, considering that the largest scales are already well analysed by the coupling mode, rather than standard ones, more suitable when all scales are to be analysed in the Limited Area Model.
The difference in the computation lies in the choice of the lateral boundary conditions. Usually NMC statistics are based on the differences between 36h-forecasts and the 12h-forecasts starting just one day later. For standard ones, consistency with the coupling model is ensured for the long and the short forecast. For lagged ones, both runs use the same, oldest, lateral boundary conditions.
Such statistics are already available for the Hungarian, French, Moroccan and LACE domains, for winter periods. The first summer statistics were computed for LACE, but seasonal variations received little attention up to now. Hungary is now addressing the impact of the length and age of forecast.
The difference between lagged and standard statistics is illustrated hereafter (Figure 1). Horizontal lengthscales are also reduced, especially for temperature and specific humidity.

Figure 1 : Some variance spectra for lagged and standard NMC background error statistics, computed for the LACE domain (horizontal resolution is 12 km; level 20 lies around 850 hPa)



♦ Tuning of observation and background error statistics

According to Talagrand (1999), the averaged value of *min (Jo+Jb) / P* should converge towards ½ for long series of 3d-var analyses if the system is well balanced. Here *Jo* is the observation cost-function, *Jb* the background cost-function, *P* the number of individual observations effectively used, and *min* refers to the final point of the minimization. Several versions of the ARPEGE and ALADIN/France 3d-var analyses were evaluated, using statistics over 30 days, without cycling. A global retuning of both sets of statistics was performed afterwards, to optimize the ALADIN 3d-var.

♦ Initialization

Experiments have shown that an incremental digital filter initialization is to be used with 3d-var assimilation using lagged statistics. While filtering model fields, most of the impact of analysis is lost.

♦ Combination with blending

The combination of 3d-var assimilation using lagged statistics with spectral blending by digital filter initialization is under test and looks quite promising.

♦ Sensitivity studies using the tangent-linear and adjoint models

A very small sensitivity to lateral boundary conditions was underlined. But experiments focusing on the sensitivity to initial conditions were quite fruitful. The part of simplified physics will now be addressed.

2.b Blending

♦ Principle

It aims at combining the "large scales" resolved by the ARPEGE analyses with the "mesoscale" features provided by the short-range ALADIN forecast. This is usually associated to a more frequent renewal of initial conditions, building an assimilation suite with no direct use of observations.

♦ Blending of spectral fields using digital filter initialization

The initial blended state is computed as : $x^{b}_{ALD} = x^{g}_{ALD} + \mathit{filter}(x^{a}_{ARP}) - \mathit{filter}(x^{g}_{ALD})$,

where $x^{a}_{ARP} - x^{g}_{ALD}$ is the additional, large-scale, information brought to the ALADIN forecast by the ARPEGE analysis, and *"filter"* denotes a double filtering, in space and time, designed as follows :

¬ projecting fields onto an ALADIN domain with the same gridpoints and a lower spectral resolution,

- applying a digital filter initialization,

® going back to the reference ALADIN domain.

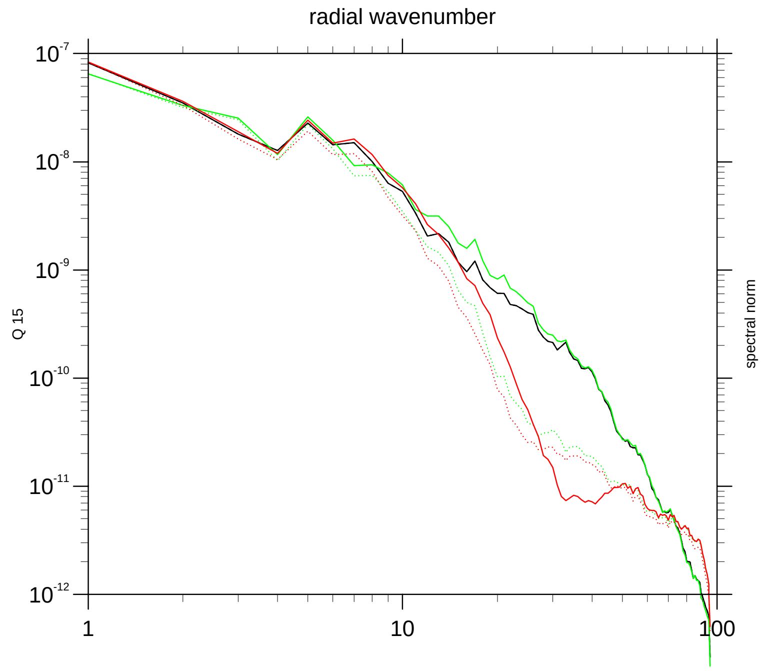
An additional digital filter initialization may be applied afterwards to eliminate the residual noise.
For example, the spectral resolutions (described here by the smallest wavelength) used in the French test suite are :

ARPEGE :
forecast : 57 km
4d-var : 421 km (external minimization loop)
ALADIN :
forecast : 30 km
"low resolution" : 89 km

A Dolph-Chebyshev filter with a stop-band edge period of 5h is used for incremental initialization at low resolution.

The resulting combination of spectra is illustrated in Figure 2, just besides :
spectral field : specific humidity, at model level 15 (~ 500 hPa)

in black : blended initial state
in red : ARPEGE analysis



in green : ALADIN guess
dotted line : after filtering

♦ Blending of surface variables

Principles :

The information from observations must be used, which is possible only via ARPEGE surface analysis.
The resolution of the observation network is usually lower than that of the ALADIN grid.

€€The structure of surface fields is mostly dictated by the physiography of the model surface boundary (orography, vegetation, ...), but not so well known.
€€The ALADIN guess provides useful fine-scale information.
Formulation :

$$x^{b}_{ALD} = check\_limits \{ (1 - r) . [x^{g}_{ALD} + x^{a}_{ARP} - x^{g}_{ARP}] + r . x^{a}_{ARP} \},$$

where $x^{a}_{ARP} - x^{g}_{ARP}$ is the ARPEGE analysis increment projected onto the ALADIN grid, r modulates the relaxation towards ARPEGE (i.e. initial conditions in pure dynamical adaptation mode), and *"check_limits"* is a final control of consistency.

♦ €Perspectives : combination with 3d-variational assimilation or soil/surface assimilation within ALADIN, case of nested models

2.c O.I. analysis for nowcasting

The Optimal Interpolation analysis for ALADIN was modified and retuned to allow the production of "diagnostic" maps, where the forecast is strongly restored towards available observations. Such analyses are performed at a high frequency (every hour), without any subsequent forecast. The resulting fields are the basis to the production of warning indices for extreme events (e.g. CAPE and moisture convergence for convection). This application, called "Diag-Pack", is pre-operational in Hungary for one year and a half, and under evaluation in France.
The required retuning of statistics is illustrated in the table hereafter. The first guess is usually the freshest available forecast, taking into account production delays.

Tunings of surface analysis for Diag-Pack and assimilation suites

			T2m		H2m		V10m	
model	use	Δx	σ^g	λ^g	σ^g	λ^g	σ^g	λ^g
ALADIN/ France	diagnostic	10 km	3.0 K	65 km	20 %	65 km	5 m/s	80 km
ALADIN/ Hungary	diagnostic	8 km	3.0 K	50 km	30 %	50 km	6 m/s	50 km
ALADIN/MAROC	assimilation	17 km	2.5 K	200 km	20 %	100 km	6 m/s	200 km
ARPEGE	assimilation	20 km 240 km	2.0 K 2.6 K	320 km 370 km	15 % 19 %	280 km 320 km	no analysis	

σ^{o} = 1.4 K for T2m, 10 % for H2m, 2 m/s for V10m

Input observations
Now : SYNOP and TEMP (T2m, H2m, V10m, Pmer)
Next : visibility, precipitations, aircraft data
No use of : surface observations over mountains : Zobs > 1500 m or | Zobs - Zmod | > 800 m
observations over sea

2.d Use of new observations

The work focused on O.I. analysis and SYNOP data : snow cover, visibility.

3. Non -hydrostatic dynamics

Significant progress was achieved recently in this domain. This is described in a specific paper.

4. Physics

4.a "Functional Boxes" approach for moist processes

This is described in a specific paper.

4.b Snow cover parameterization

The interaction with the vegetation cover was addressed. Its main characteristics (type, coverage, leaf area index, albedo) are now better taken into account.

4.c Lakes

Some studies were devoted to the improvement of the temperature of lakes : better initialization of climatological and initial fields, sensitivity studies, design of a simplified parameterization within ISBA, coupling to the Hostetler model.

4.d Physiographic databases

The following changes are planned, and partly tested :
Orography : from GLOB95 (global, assumed resolution 2'30")
to GTOPT030 (global, initial resolution 30" degraded to 2'30" since derived fields are required)
Soil : from "Webb" (global, resolution 1°)
to FAO (global, resolution 5')
Vegetation : from "Wilson & Henderson-Sellers" (global, resolution 1°) and "Champeaux-1" (Europe, resolution 6')
to "Champeaux-2" (global, assumed resolution 1 km degraded to 5')

4.e Evaporation over sea

Tests were performed, reducing the basic roughness length while taking into account convective precipitations in the formulation of evaporation. The impact is neutral or slightly positive (in the Tropics, on the global balance).

4.f Orography

♦ Tuning of spectral orography

In ARPEGE and ALADIN, the spectral orography is obtained by minimizing a cost function, so as to avoid large Gibbs waves over oceans. Two different cost functions, with domain-tunable parameters, are available. The first one showed more suitable for "continental" domains, the second one for domains with a significant fraction of ocean. Both were recently modified as follows, to take into account the gridpoint sea-fraction and thus improve the description of coasts and islands :

Jerczynski's formulation : $\mathbf{J}= \sum\omega(i)\,[W(i)\,|Rf(i) - R(i)|^2 + (QCONST\,|Rf(i) - R(i)|)^{QPOWER}]$,

$$W(i) = \mathbf{(1 + \mathit{XINCOC}\ S(i)\ )\ [}\ QMIN + (QMAX\text{-}QMIN)\ e^{-R(i)/HMIN}\ \mathbf{]}$$

Bouteloup's formulation : $\mathbf{J}= \sum\omega(i)\ [\,|R(i) - Rf(i)|\,/\ HDIM]^{W(i)}$,

$$W(i) = QMIN + (QMAX\text{-}QMIN)\ \mathbf{[1 + \mathit{XINCOC}\ S(i)\ ]}\ e^{-R(i)/HMIN}$$

R : initial orography Rf : final orography S : fraction of sea ω : constant in ALADIN
The introduction of the new terms (in bold characters) luckily does not affect the previous tunings.

♦ Lift parameterization

The so-called "lift" parameterization aims at representing the transversal forces applied by the mountains on the wind flow. It has been used for some years in large-scale global models, where it led to the suppression of the "envelope" orography. However several attempts to implement it in ALADIN failed, whatever the representation of the mountain height. The last study showed that, while the impact of the "form-drag", "lift" and "envelope" parameterizations are of similar magnitude at large scales, this is no longer true in a mesoscale model. The impact of "lift" is far larger than that, essentially local, of "form-drag", and is itself too weak to allow a full suppression of the "envelope".

4.g Boundary layer parameterization

The related studies are described in the paper discussing changes in operations for ARPEGE and ALADIN.

5. Support

5.a Coupling

The problems encountered, in the forecast of the 1999's Christmas storms and in sensitivity studies, led to the search for a new a coupling method (to replace Davies'one).

5.b Linear grid

In the "linear grid" approach, the relation between the spectral resolution (*Ns*) and the number of gridpoints (*Ng*) in one direction reads : $Ns^L \sim Ng^L/2$, instead of $Ns^Q \sim Ng^Q/3$ for the usual "quadratic grid" one. The noise problem present in the first experiments is solved by computing the spectral orography at a lower resolution, that corresponding to the "quadratic grid" approach with the same gridpoints (i.e. at $Ns^Q \sim 2/3\ Ns^L$).

5.c Post-processing, changes of geometry

♦ €Improved post-processing of boundary-layer fields

The initial procedure for the post-processing of 2m-temperature (T2m, as an example) is the following :

¬ extraction of monthly climatological surface temperatures on the initial and final grids : Tsc^i and Tsc^f

- interpolation of $Ts^i - Tsc^i$, using the initial and final land-sea masks

® computation of Ts^f: $Ts^f = Tsc^f + inter(Ts^i - Tsc^i)$

¯ computation of $T2m^i$ on the initial grid, from surface constants, surface fields (Ts^i, Ws^i, Sn^i, ...) and upperair fields at the lowest model level ($T_L{}^i$, $q_L{}^i$,...)

° interpolation of $T2m^i - Ts^i$, using the initial and final land-sea masks

± computation of $T2m^f$: $T2m^f = Ts^f + inter(T2m^i - Ts^i)$

The new one ensures a better consistency between fields on final grid :

¶ extraction of monthly climatological surface temperatures Tsc^i and Tsc^f *(idem for other surface fields)*

· interpolation of $Ts^i - Tsc^i$, using the initial and final land-sea masks *(idem for other surface fields)*

¸ computation of Ts^f: $Ts^f = Tsc^f + inter(Ts^i - Tsc^i)$ *(idem for other surface fields)*

¹ interpolation of upperair fields at the lowest model level

º computation of $T2m^f$, on the final grid, from surface constants, interpolated surface fields (Ts^f, Ws^f, Sn^f, ...) and interpolated upperair fields at the lowest model level ($T_L{}^f$, $q_L{}^f$,...) *(idem for other boundary layer fields)*

and leads to an improvement of scores (computed on a regular latitude-longitude grid, not on the model grid, at Météo-France), as illustrated by Figure 3. The impact is less for relative humidity and wind.

♦ €Improved initialization of the temperature of lakes

When a lake or an island is created along a change of geometry with the initial procedure :

- The initial and final land-sea masks are of no use in step - and °. An average over the surrounding land / water points on the initial grid is affected to the new water / land point of the final grid, which is usually detrimental to the diurnal cycle of surface and boundary layer fields.
- Sharp and sometimes unrealistic land / sea contrasts in climatoloigical fields may also enhance problems.

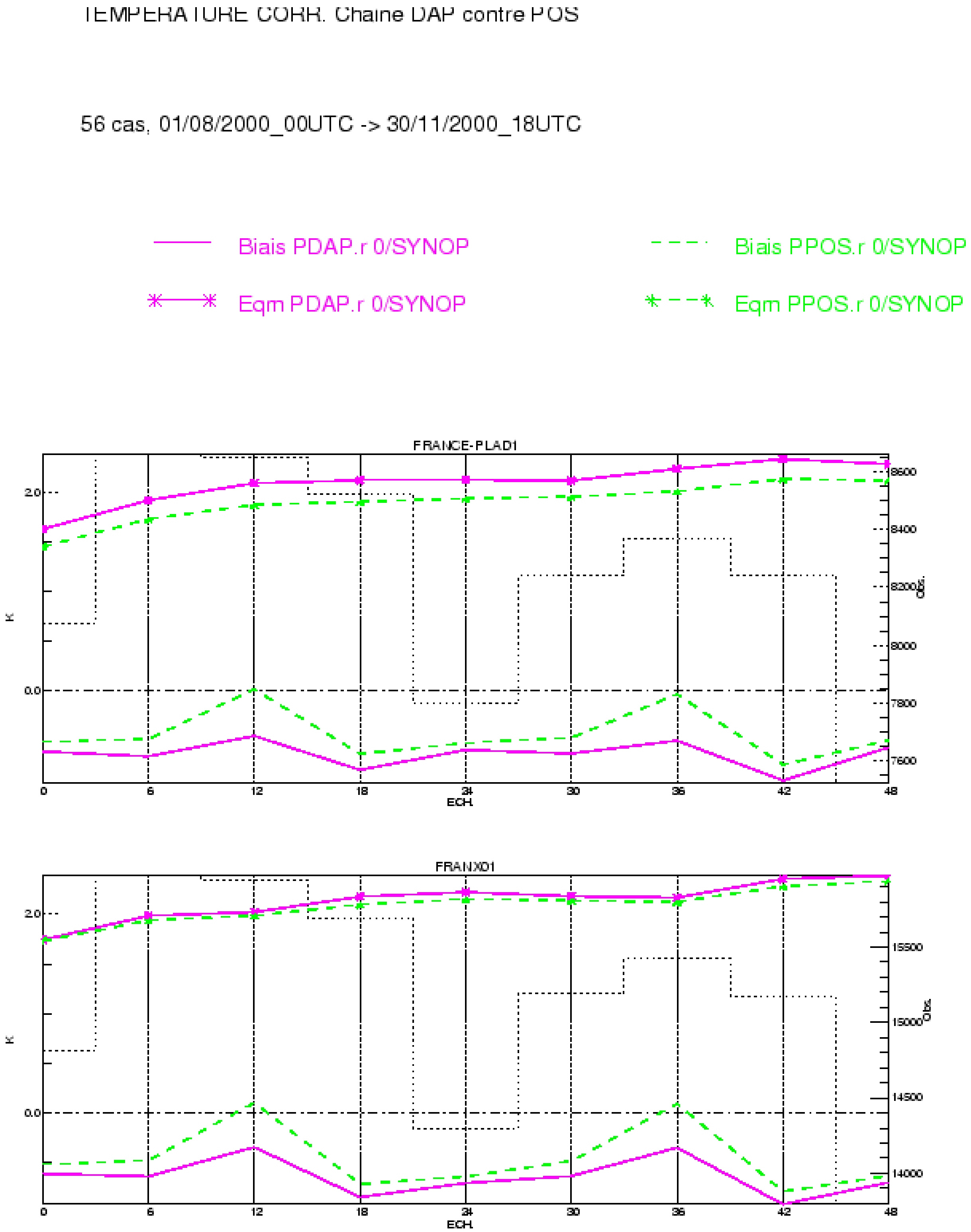
This may now be improved by :

- identifying such isolated points along steps - or ·, or via the land-use type on the final grid;
- affecting a climatological value to the surface field on the target grid : $Ts^f = Tsc^f$ instead of steps ® or ¸;
- improving, whenever possible, the climatological surface temperature of lakes (etc ...).

♦ Test of new interpolation methods

For surface and boundary-layer fields, 12-points interpolation was compared to 4-points interpolation and a monotonic 12-points interpolation (i.e. with limits applied to avoid overshootings).

Figure 3 : Impact of the new post-processing on scores for 2m-temperature



6. More details ?

Explore the ALATNET web-site !