# *Research and developments in Toulouse*
# *July – December 2004*

**D. GIARD with contributions from**

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# 1. Introduction

Research around ALADIN restarted in La Réunion (in the Indian Ocean), the corresponding work is described in a separate report.

Not described hereafter are all the tasks related to project management and support to Partners (not at all a minor contribution). They are partly mentioned in the Editorial part.

# 2. Source code maintenance

## 2.1 Introduction

As along the first 6 months of 2004 there was no rest for the phasing teams, from the delivery of cycle 28T1 early July to the latest contributions to cycle 29T1 at the end of the year. However the task was somehow alleviated since :

1. Many ALADIN phasers came to help. Thanks to Andrey BOGATCHEV, Nihed BOUZOUITA, Alex DECKMYN, Stjepan IVATEK-SAHDAN, Cornel SOCI, Oldrich SPANIEL, Piet TERMONIA, Alena TROJAKOVA, Filip VANA, and to the distance support !

2. A rotating supervision of phasing started. Claude Fischer was efficiently replaced by Ryad *EL KHATIB* for cycle 28T3, and by Ryad *EL KHATIB* and Yann SEITY for cycles 29 and 29T1. The next team will involve Gwenaelle HELLO and Patrick MOLL (29T2 and 30).

## 2.2 Cycles 28T1 and 28T2

### 2.2.1 July 2004

Cycle 28T1 is described in the previous Newsletter.

A new cycle, 28T2, was created just afterwards. No export version was delivered, since it was built as a reference for the summer parallel suite in Météo-France (see the report on operations).

### 2.2.2 Contributions to 28T2

✔ From Christophe PAYAN *(uti)*

- Management of QuickSCAT observations

✔ From François BOUYSSEL, Eric BAZILE, Yves BOUTELOUP, Jean-François GELEYN *(arp, sat)*

- Changes in the ARPEGE radiation scheme (FMR15) : new 2d monthly fields for ozone and aerosols
- Vertical diffusion : changes in Louis' functions for the stable case, and in the computation of interactive mixing lengths
- Writing the short-wave downwards flux at surface in historical files
- Model-to-satellite tool based on RTTOVS : cautions ! (new namelist NAMMTS not yet working)
- Changes in the ALADIN radiation scheme (ACRANEB_new)

✔ From GCO *(uti)*

- Latest modifications for the extraction of observations

✔ From Jean-Marc AUDOIN *(uti)*

- New fields (chemistry model) and new domains in PROGRID; new name for brightness temperature.

✔ From Patrick Moll *(arp)*

- One database per observation type, use of BUFR data for AIRS
- Variational quality control
- Assimilation of AMSU-B, EARS, AIRS, QuikSCAT data

## 2.3 Cycle 28T3

### 2.3.1 August 2004

This step aimed at providing a cleaner, more portable, code for the update of operational suites, taking into account the problems encountered in the porting of cycle 28T1 and some intermediate developments.

### 2.3.2 A new export version was created in September, including the following :

- ✔ Use of AIRS and AMSU-B (thinning, blacklisting, std dev.)
  *Thomas AULIGNÉ, Patrick MOLL, Florence RABIER, Delphine LACROIX*
- ✔ Bugfix on restart scheme
  *Ryad EL KHATIB*
- ✔ Bugfix on interactive mixing lengths (not yet active)
  *Eric BAZILE*
- ✔ Bugfix for configurations with NFLEVG=1
  *Françoise TAILLEFER*
- ✔ Various bugfixes, mostly related to portability
  *Ryad EL KHATIB and ALADIN teams*
- ✔ Bugfix for the use of the linear grid in ALADIN (initialization of RNLGINC)
  *Ryad EL KHATIB under the control of Jean-François GELEYN*
- ✔ "model to satellite" code temporarily put off
  *Ryad EL KHATIB*
- ✔ Developments on the new ALADIN radiation scheme
  *Jean-François GELEYN via François BOUYSSEL*
- ✔ Bugfix on the adding of physical tendencies in the Eulerian scheme
  *Jozef VIVODA*
- ✔ Bugfix for coupling in case of d4 variable (NH)
  *Gwenaëlle HELLO*
- ✔ Bugfix to use the "10 meters" wind SHIP data at the proper height in CANARI (when screening is not called before)
  *Françoise TAILLEFER*

More explanations are available in the mails sent by D. GIARD on September 10th, and M. DERKOVA on December 1st.

## 2.4 Cycle 29

### 2.4.1 September-October 2004

This was a common cycle with IFS, with no scheduled export version. Hereafter is a short description of contributions, from the ARPEGE memorandum prepared by GCO and the Minutes of the ARPEGE-IFS coordination meeting help on November 10th. For more detailed descriptions, see the mail sent by D. Giard on February 15th.

Note that there is still a problem in RTTOV8, introduced by ECMWF. However, since they didn't manage to solve it, the position is now : "we'll do with".

### 2.4.2 ECMWF contributions to cycle 29 (starting from cycle 28)

- ✔ CY28R1

  - Humidity control variables generalised to arbitrary numbers of levels

  - Start of ODB port to Linux

  - METAR data monitored (new subtype under type 1) / ERS2 Scatterometer CMOD5 (update of CMOD4) / Passive monitoring of MSG clear-sky radiances / AMVs - use of GOES

  - Diagnostic tool for influence of observations (LANOBS=.TRUE.)

  - Modification to trajectory for first time-step, Noise reduction for vertical trajectory in the stratosphere (LSVTSM)

  - Higher top for 91 levels

- ✔ CY28R2

  - Modifications to get Linux version working (for benchmarks) / More GSTATS

  - Wavelet Jb coding (IFS wavelets) / New tests for 4D-Var components (LTESTVAR: Global switch for tests, LCVTEST: Change of variable test, LADTEST: Adjoint test, LTLTEST: Tangent linear test, LGRTEST: Gradient test, old LTEST)

  - Clean-up of *LARCHE*

- ✔ CY28R3

  - 1D-Var rain assimilation / Cloud detection of AIRS / RTTOV-8 introduced / New variables in blacklist (rejection of SYNOP/METAR depending on local conditions)

  - Variational bias correction (tests started – interactions with the triggering of spurious vertical modes in the stratosphere in the trajectory computation have been noticed)

  - Improvements in model error term in 4D-Var / Optional new control variable for O3

  - TL and AD of spectral RT (used in combination with grid-point Q)

  - Singular vectors to be orthogonal to a set of vectors

  - Random number generation with multiple independent seeds for EPS

  - More flexible handling of trajectory (grid-point and spectral fields) / SL buffer optimisation with respect to GFL attributes

  - Bugfix for GRIB header

- ✔ CY28R4

  - Changes to scripts

  - Modifications to *OBSTAT* for satellites

### 2.4.3 ARPEGE/ALADIN changes from 28T3 to 29

- ✔ Merge with the IFS developments
- ✔ Cleaning of NH dynamics (removing now useless options)
- ✔ Update / cleaning of *CPGTL* and *CPGAD* (split as for *CPG* some time ago)
- ✔ Cleaning of physics interface (*APLPAR* etc.)
- ✔ Merge of *CNT4* : no more duplicated routines in the model libraries !
- ✔ Diagnostics on physical tendencies (from Tomislav KOVACIC et al.)
- ✔ Warning indices in configuration 001 (from Piet TERMONIA)
- ✔ SLHD developments (from Filip VANA)
- ✔ Use of GRIBEX in FA files (from Denis PARADIS, see the dedicated paper)
- ✔ Introduction of "radar" tables in *odb*

- ✔ Full-Pos optimization (starting)
- ✔ etc ...

## 2.5 Cycle 29T1

This is mainly a "cleaning" cycle, with some developments on top. Or rather this will be, since there are still validation problems (mid-February).

The main advances are the following :

- ✔ Cleanings and bugfixes
- ✔ Merge with the ARPEGE parallel suite : interactive mixing lengths, use of AMSU-A AQUA...
- ✔ Xu-Randall cloudiness and other developments in physics (from Radmila BROZKOVA)
- ✔ New setup for horizontal diffusions (from Filip Vana, report available on the ALADIN web site)
- ✔ New SL interpolations (from Filip Vana, see the dedicated paper)
- ✔ Some more for radar and SEVRI observations
- ✔ Further improvements for portability (especially Linux)
- ✔ Update of 923 (yes !), but only for parts 2-10 unfortunately

## 2.6 Towards an improved portability

A huge cleaning of keys in the *xrd* library (and elsewhere) started last autumn (see e.g. the stay report of Nihed BOUZOUITA), and the test of the new cycles on various platforms (VPP, IBM, PC Linux) in now part of Toulouse validations. But there is still a lot of work.

A further step, as proposed by Jean-Daniel Gril, will be :

- first, to take the FA/LFI package (or more generally I/Os packages) out of the auxiliary library,
- second, to convert the FA/LFI code to F90, since it is now a rather peculiar mixture of F77 and F90, uneatable for some (many ?) compilers. Both "automatic" and "manual" changes will be required. Help will be welcome !

Jean-Daniel Gril also updated PALADIN (mainly phasing up to most recent cycles) and other tools. Please don't forget to send him informations on any problem you met or any improvement you brought, so that everyone may benefit from it.

## 2.7 2005 program

### 2.7.1 Cycle 29T2

Starting in March, with the help of Jozef VIVODA and Adam DZIEDZIC !

Here is a provisional list of contributions collected by Claude FISCHER :

- ✔ phasing of the AROME prototype (*Yann SEITY*)
- ✔ NH developments :

  "3TL Eulerian PC" (*Jozef VIVODA*)

  advection of vertical velocity ("LGWADV", for d3 and d4 options) (*Jozef VIVODA*)

  reorganization (*Karim YESSAD*)

  cleaner call to physics in Predictor-Corrector scheme (*Martina TUDOR*, *Gwenaëlle HELLO*)
- ✔ some more refinements for semi-Lagrangian horizontal diffusion (SLHD, *Filip VANA*)
- ✔ changes for ARPEGE physics (*François BOUYSSEL*, *Yves BOUTELOUP*) :

  simple micro-physics (Lopez scheme)

  changes in radiation (RTTM)
- ✔ new rotated tilted Mercator geometry (*Jean-Daniel GRIL*)

- ✔ "Jk" cost-function in ALADIN 3D-Var (*Bernard CHAPNIK, Claude FISCHER*)
- ✔ ($T_s$ - $T_L$) in control variable (*Ludovic AUGER*, see the paper on Var-Pack)
- ✔ corrections for the monitoring of radar observations (*Eric WATTRELOT*)
- ✔ + ...

More changes may be included, provided they are carefully validated and sent before mid-March.

#### 2.7.2 Cycle 30

There should be only one common cycle with IFS in 2005, with phasing starting in May.

The main IFS contributions put forward in November were the following (cf mail DG 15/02) :

- ✔ new observations (AQUA, TERRA MODIS winds, NOAA-18, MSG winds, SSMI/S and AMSR, rain-affected microwave radiances, ground-based GPS water vapour, METAR data, ...)
- ✔ improved pre-processing of observations (variational radiance bias correction, Huber-norm for VarQC, ...)
- ✔ 4D-Var : better interpolation of trajectory and increments, grid-point q and O3 in inner loops, new *M1QN3*, cleaning of SL AD/TL, removing Jb from *STEPO*, pruning LOBSTL=.FALSE. ?
- ✔ some more changes in the data flow
- ✔ new PBL scheme, ...

The reorganization of NH dynamics shall be continued. To propose other ALADIN contributions, do contact Claude FISCHER !

#### 2.7.3 Cycle 30T1 ?

One more cycle may be expected by the end of 2005, to take into account developments related to :

- ✔ the externalization of the surface scheme (the proposed roadmap is now available at : *http://www.cnrm.meteo.fr/aladin/scientific/reunions_surfex_190105d.pdf*),
- ✔ the physics-dynamics interface (APLXX calling all physical packages : Meso-NH - APLAROME with a careful handling of missing fluxes –, ARPEGE/ALARO – with a management of missing variables and the reduction of the $\delta m$=1 option to a few dynamical and interfacing terms -, HIRLAM ... for more details please contact *jean-francois.geleyn@chmi.cz*),
- ✔ the improvement of portability,
- ✔ etc ...

## 3. Dynamics, geometry and coupling

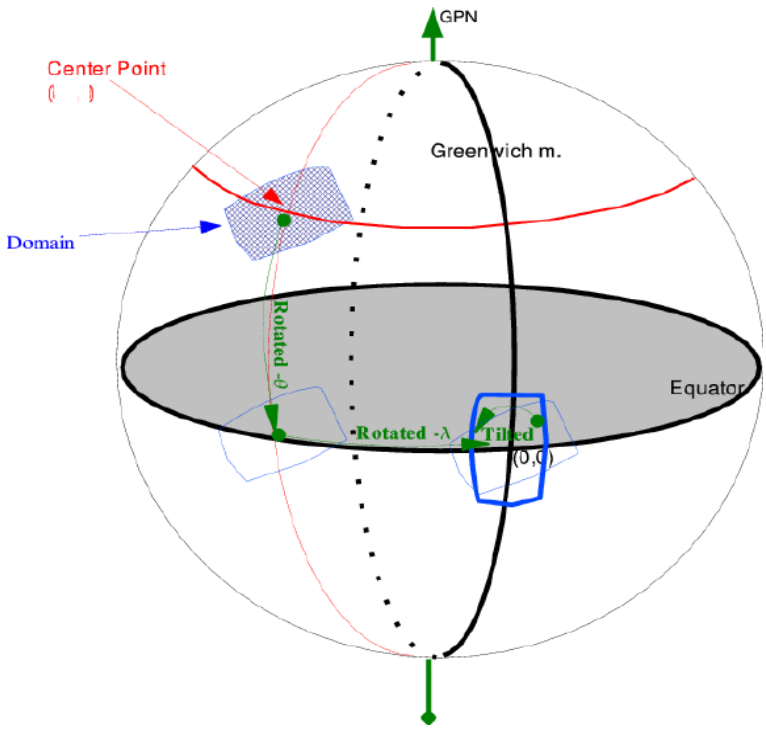
### 3.1 Design of ALADIN domains

#### 3.1.1 Rotated tilted Mercator geometry

This new projection allows to focus on any part of the world, cumulating the abilities of the 3 previous types.

Besides, but most important, it should allow to better account for distorsions of the mapping factor (here a simple function of Cartesian coordinates $m=\cosh(y/a)$ ) in the semi-implicit formulation (using penta-diagonal operators as in ARPEGE), hence to run ALADIN-NH dynamics on very large domains.

A detailed documentation was written by Pierre BÉNARD and should be soon available on the web site. The code should be available soon, too. The new definition has already been coded and validated in PALADIN and in the model by Jean-Daniel GRIL. The Full-Pos implementation is on the way and should be ready for cycle 29T2 (i.e. March).




### 3.1.2 Clim files

Configuration 923 was partly updated, taking into account the new definition of domains, the new configurations, and some bug corrections introduced by Ryad EL KHATIB between AL15 and AL29 (Dominique GIARD, Stjepan IVATEK-SAHDAN). Parts 2-10 can now be run with cycle 29T1. The new options are :

8 : constants for ozone description
9 : aerosols
10 : aqua-planet (all fields in 1 run)

Besides work started around scripts, for Olive (Véronique MATHIOT) and for multi-domain updates (Françoise TAILLEFER).

All the "clim" files used operationally in Toulouse, including those for coupling domains, were updated by Eric BAZILE : they now include ozone-related and aerosol fields, and the additional surface albedos required for the new snow scheme.

## 3.2 Vertical discretization

### 3.2.1 Definition of the vertical grid

A flexible procedure to define sensible hybrid $\eta$ levels (i.e. to compute the required A and B arrays) was written and documented by Pierre BÉNARD, considering the finite-difference approach. Everything is available at : *http://www.cnrm.meteo.fr/gmapdoc/modeles/procedures/AandB.html* . It must be underlined that additional constraints appear when using a vertical discretization based on finite elements.

Besides, an increase of vertical resolution was evaluated in ARPEGE, adding 5 new levels in the stratosphere to improve the assimilation of satellite observations.

### 3.2.2 Study of the Vertical Finite Elements (VFE) discretization in view of non-hydrostatic (NH) modelling

The IFS model currently uses a VFE discretization based on cubic spline functions with compact support (Untch et Hortal, QJRMS, 2004). In view of possible future NH modelling, ECMWF has recently asked the ALADIN group whether the current NH dynamical core of ALADIN could be extended for global modelling with their current VFE discretization.

This requires two main tasks : (i) extending the current LAM NH dynamical core to the global context, which appears as a relatively technical task, mainly involving some modifications in the design of the semi-implicit scheme; (ii) extending the current finite-differences NH discretization to the VFE context. This task appears as more scientifically challenging. A preliminary study showed that a direct application of the current VFE discretization to the NH dynamical core was not appropriate (Bénard, 2004, *http://www.cnrm.meteo.fr/gmapdoc/modeles/Dynamique/vfememo1.pdf*).

The reason is that the current VFE discretization does not fulfils some mathematical constraints required for the vertical operators used in the semi-implicit part of the NH system (these constraints were not required for the primitive equation system). As a consequence, the current VFE scheme applied directly in the current NH kernel would result in an unstable model.

Several simple alternative formulations, requiring only slight changes in the design of the VFE scheme, were examined, but even if some of them could be expected to work properly, none appeared to be fully satisfactory. As a consequence, further studies, possibly considering deeper changes in the VFE scheme itself or in the general architecture of the semi-implicit kernel, were recommended.

## 3.3 Coupling

### 3.3.1 Monitoring the Coupling-Update Frequency

TERMONIA{,}The underlying idea is to apply a high-pass recursive filter to model fields (in practice only to $\ln(Ps)$ ) along the integration of the coupling model, and write the corresponding diagnostic field in coupling files. With a well-chosen cut-off period related to the coupling interval, this should provide information on whether there is a risk to miss a rapidly moving system between two coupling updates. More details in :

P., 2004 : Monitoring the Coupling-Update Frequency of a Limited-Area Model by Means of a Recursive Digital Filter. *Mon. Wea. Rev.*, **132**, 2130-2141.

Piet TERMONIA introduced a large part of the required code modifications during the summer : setup, additional fields and constants, filtering along configuration 001, writing fields in historical files. The corresponding changes in configuration 927 are now to be addressed.

### 3.3.2 Transparent lateral boundary conditions in a spectral model

This is the continuation of the preliminary study of Piet TERMONIA on how to port Aidan Mc Donald's ideas to a spectral model. Fabrice VOITUS started a dedicated PhD work last summer. More details in the "PhD theses" section.

### 3.3.3 Coupling surface-pressure tendency

This issue is definitely closed for the Toulouse team. Jean-Marc AUDOIN performed some more experiments, using embedded domains with high orography along part of the lateral boundaries. The differences between coupling fields versus tendencies are negligible.

## 3.4 (NH) dynamics

Beside the cleaning effort described in Part 2, the investigation of the impact of diabatic forcing was pursued, addressing real case studies and moist processes. The equations were derived and the corresponding changes coded in the AROME prototype. The first set of experiments, on the "Gard" case (08/09 September 2002) at a resolution of 2.5 km, show an improvement in the precipitation pattern and intensity when using an exact treatment of diabatic forcing instead of hydrostatic adjustment. More details in the stay report of Alena TROJAKOVA.

## 4. Physics & Co

### 4.1 Equations and interface with dynamics

A lot of exchanges, resulting in a set of equations together with both short- and long-term solutions for the physics-dynamics interfaces. More details in the papers by Bart CATRY and Jean PAILLEUX respectively.

### 4.2 Meso-NH physics

Siham SBII and Martina Tudor spent 1.5 month in the GMME team for training on Meso-Nh physics. Besides, Siham worked on the phasing of the 1d version of AROME, while Martina studied the problems of stiffness, nonlinear instability and oscillations for the various Meso-NH parameterizations, using the 3d prototype. Significant "$2\Delta t$" oscillations (up to 1 K in temperature for a time-step of 60 s) were identified, which are damped by the predictor-corrector scheme (but not completely suppressed). The methods were the same as for ARPEGE physics a few years ago : sensitivity to a "local" change of the time-step (divided by 2 before the chosen parameterization with output fluxes multiplied by 2 afterwards) for stiffness or of the depth of layers for nonlinear instability, evaluation of the impact of time-step, horizontal resolution, H versus Nh dynamics, ...

The stay report of Martina Tudor provides a useful introduction to Meso-NH physics and its AROME interface for ALADINists. It is available on the ALADIN web site :
*http://www.cnrm.meteo.fr/aladin/publications/Report/Martina_Tudor.pdf*

The complete Meso-NH documentation (version of December 2001, with physics in the last sections) is available at :
*http://www.aero.obs-mip.fr/mesonh/dir_doc/book1_14dec2001/book1_14122001.html*

### 4.3 The externalized surface module (SURFEX)

#### 4.3.1 Training

Bodo AHRENS, Andrey BOGATCHEV and Laszlo KULLMANN were trained on SURFEX by Patrick LEMOIGNE, a famous former ALADIN and football expert : intensive reading of the available bibliography on the various parameterization, and off-line experiments to learn how to run it first.

A User's Guide is now available on the ALADIN web site (ALADIN-2 page, temporarily).

#### 4.3.2 Testing

Several case studies were performed :

- ✔ sensitivity to the frequency of upper-air forcing (every 1, 3 or 12 h, for a time-step of 300 s in SURFACE), over a small Hungarian domain (forcing from ALADIN-HU),
- ✔ sensitivity to the snow scheme : 1 versus 3 snow layers, for small Hungarian and Bulgarian domains, with significant differences in temperature for the Bulgarian snow storm,
- ✔ sensitivity to the number of vertical layers in the soil : 2, 3, 5 or 10 (the so-called ISBA-dif option) for an Hungarian domain,
- ✔ climate-type simulations for a domain covering Austria with a resolution of 12.2 km and forcing by ARPEGE analyses, over January 1999 and September 1999 : the simplest scheme was compared to an intermediate one, with 3 layers in the soil and 3 snow layers, but the resulting

differences on net radiative fluxes keep small.

At that time, the reference snow scheme in SURFEX was the one of H. DOUVILLE, neither the old nor the new ARPEGE ones (cf Newsletter 22).

#### 4.3.3 Improving

These tests enabled to discover some problems in SURFEX, most concerning setup, and to start correcting them (this e.g. allowed Bodo to use a large domain). The parameterization of soil freezing should be revisited by Laszlo in Budapest. And Andrey dived into the advanced F90 code to introduce the present operational (in ARPEGE) snow scheme.

Besides, work started at GMME to allow the use of SURFEX in ARPEGE/ALADIN and improve the off-line mode. Discussions between GMME, GMAP and the ARPEGE-Climat team (GMGEC), resulted early 2005 in a common proposal of work plan for an operational implementation, available at : *http://www.cnrm.meteo.fr/aladin/scientific/planscientif.html* .

#### 4.3.4 Coupling

Work on an efficient coupling between ARPEGE physics (and its many declinations) and the externalized surface module (id.) restarted, with Pascal MARQUET (GMGEC) as leader.

### 4.4 ARPEGE physics

New ingredients were evaluated : convection schemes from ARPEGE-Climat, Lopez micro-physics (with adaptations differing from those performed by Luc Gerard and described in a dedicated paper, for the while), RRTM/Fouquart radiation scheme (François BOUYSSEL and Yves BOUTELOUP).

A new computation of PBL height, following Troen and Mahrt, together with an interactive formulation of mixing lengths, was coded and is under test in a parallel suite : more details in the paper by Eric BAZILE. See the PhD and stay reports of Andre Simon too (parameterization of friction with respect to Ekman layer relationships and cyclogenesis).

The problem of spurious triggering of subgrid-scale precipitations, and the impact of horizontal resolution, was addressed using an aqua-planet configuration (Cecile Loo). Not so many answers up to now ...

### 4.5 The ALARO-10 prototype

Dramatic months for ALARO-10 !

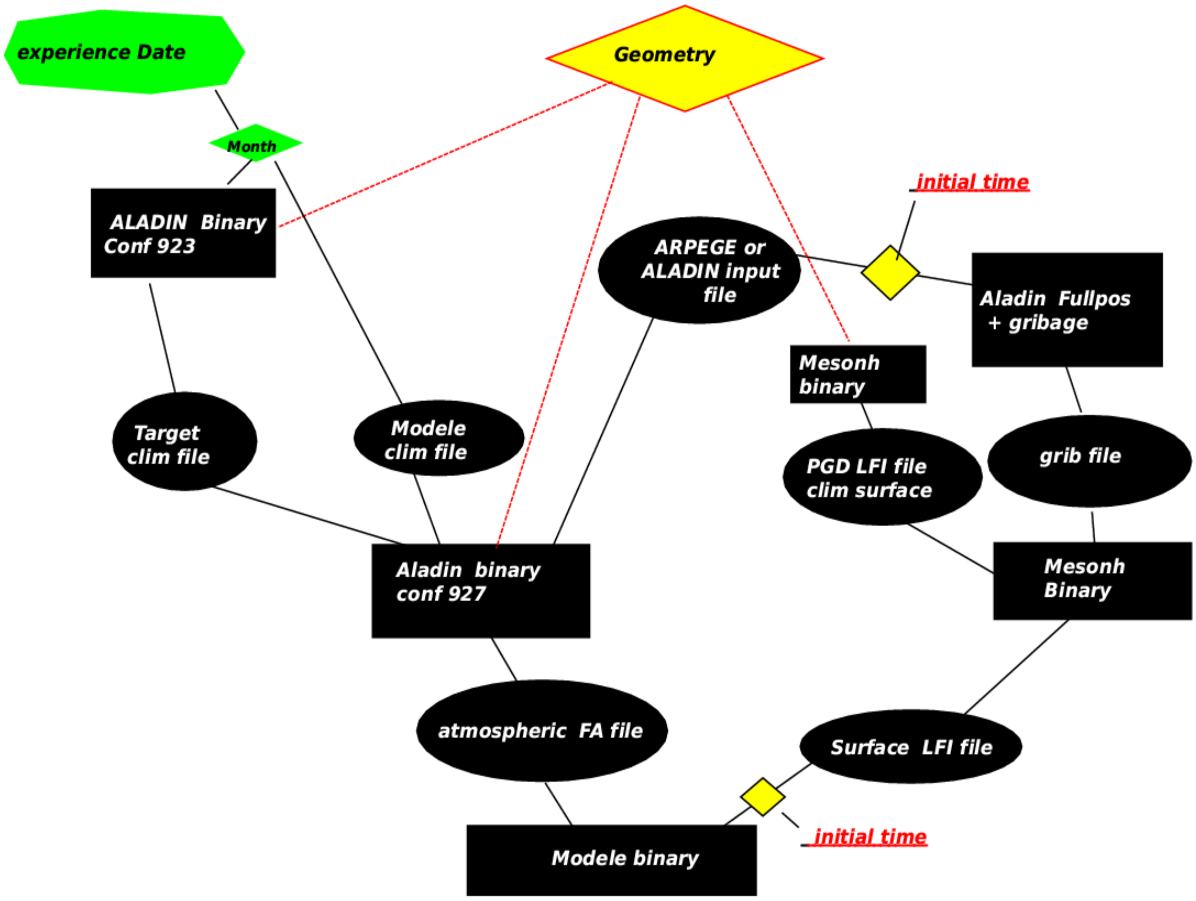
Early in the summer, the results of the first case studies were published, with a very limited dissemination at that time. They were not as good as expected, and new experiments confirmed the initial feeling. The situation at that time is illustrated in the ALADIN group report, available on the SRNWP web site. Thus an emergency alternative was then designed by Météo-France.

Later in the autumn, Tomislav KOVACIC and Jure CEDILNIK further investigated the problem with Gwenaëlle HELLO. A first major advance was the discovery of a bug in diagnostics, with subgrid-scale (convective) precipitation not taken into account in the previous comparisons. The patterns and intensities predicted by the prototype were far more sensible after the correction, and now comparable to the operational ones on the two situations examined (see the dedicated paper). Besides, the sensitivity of precipitations either to time-step, or to horizontal resolution (5 vs 7 km) and the convection scheme (on vs off) were studied.

### 4.6 The AROME prototype

Improved launching environment, code optimizations, and first real case experiments, for

French and Romanian domains ... See the dedicated paper on AROME for more details and the following diagram, illustrating the present data flow.




## 5. Data assimilation

### 5.1 3D-Var assimilation

There was a very intense activity in this domain, benefiting from the availability of Claude Fischer (no longer supervising directly phasing), and aiming at a parallel 3D-var assimilation suite for spring 2005. The corresponding work is described in 2 dedicated reports.

Various aspects of background error statistics ("Jb") were addressed : comparison of 2 approaches in ALADIN-france 3D-Var, redaction of 2 papers on "Ensemble" statistics by Simona STEFANESCU and Loïk BERRE, promising evaluation of complex wavelets (versus Meyer ones) and planification of the corresponding code modifications for ALADIN by Alex DECKMYN and Loïk BERRE.

Besides the PhD work of Vincent GUIDARD went on (slower since he had to leave GMAP) with a further evaluation of the "Jk" approach (see his PhD report), while the thesis of Bernard CHAPNIK (described in a joint paper) found its first applications in the design of tools for retuning observation error statistics ("Jo"), for use in ARPEGE or ALADIN.

### 5.2 Var-Pack or Diag-Pack ?

See the dedicated paper on Var-Pack, by Ludovic AUGER and Lora TASEVA.

The Var-Pack configuration, with $(T_s - T_L)$ instead of $T_L$ in the control variable, modified background error statistics in the lowest levels and use of all screen-level observations (including T2m), was also evaluated within a 3D-Var assimilation cycle (i.e. exactly what was considered as nonsense some years ago) over July 2004 (questions to Ludovic Auger).

Besides, Françoise TAILLEFEr achieved the update of Diag-Pack to cycle 28T3, with problems met in the post-processing of the specific CAPE or MOCON fields.

## 5.3 3D-FGAT

Beside phasing, Cornel SOCI further investigated the problem of significantly different analysis increments between 3D-FGAT and 3D-Var, and costs issues too.

First it was realized that backgrounds were not the same for the two analyses : a 6 h forecast for 3D-Var, an integration based on 3 h, 6 h and 9 h forecasts for 3D-FGAT. Second, the initial experimental framework was not consistent regarding physical packages.

A comparison based on the configuration of ALADIN-France assimilation gave the corresponding figures for cost :

- memory : 3D-FGAT only 1.3 times more expensive than 3D-Var if the trajectory is stored every time-slot (i.e. every hour) instead of every time-step,
- CPU : 3D-FGAT 8 times more expensive than 3D-Var, due to the calls to physics.

## 5.4 Digital filtering

### 5.4.1 Optimisation of Digital Filtering in the ARPEGE 4D-Var

Here is a summary of the work performed by Adam DZIEDZIC, with help from François BOUYSSEL, Gérald DESROZIERS and Dominique GIARD, to evaluate the impact of the DFI constraints in (ARPEGE of course) 4D-Var on the spin-up of physics.

Digital filters (Lynch and Huang, 1992, Lynch et al 1997) are used twice in the ARPEGE 4D-Var. First, a Jc-DFI term is added, as a weak constraint, to the cost function (Gauthier and Thépaut, 2000). DFI is also applied to filter the last analysed state in the incremental process, that includes two minimizations each followed by a full-resolution update of the model trajectory. Because some important features of 4D-Var have changed since the implementation of DFI under that form, the aim of the present study was to check that the current use of DFI is still valid or at least well optimised.

An ensemble of 4D-Var experiments have been performed in order to evaluate the optimal combination of Jc-DFI and digital filtering of the last trajectory, called respectively inner and outer DFI hereafter.

A first set of experiments showed that incremental outer filtering (that is the present operational formulation) gives better results than non-incremental filtering, that tends to filter the fields too much.

The second set of experiments aimed at evaluating the impact of the use of the inner filtering performed inside the minimization itself. In the operational configuration, the Jc-DFI constraint is applied to all spectral fields (vorticity, divergence, temperature, humidity and surface pressure) and this term is weighted by a factor $\lambda$ that was tuned by Gauthier and Thépaut (2000). An increase of $\lambda$ by a factor 5 (as in the operational implementation of Jc-DFI at ECMWF) slightly improves the spin-up at very short range but at the expense of a degradation of the fit of the analysis to observations. Finally the application of the Jc-DFI to the divergence field only, with the amplification of the factor $\lambda$ (as at ECMWF) did not show any particular improvement.

It has also been noted that the results obtained with and without outer DFI are very close but that the spin-up at very short range is degraded when inner and outer DFI are removed simultaneously. As a consequence, the conclusion of these different tests is that the present ARPEGE 4D-Var configuration in terms of DFI, including both inner and outer filtering, appears satisfactory.

Gauthier P. and J.-N. Thépaut, 2000 : Impact of the digital filter as a weak constraint in the pre-operational 4D-Var assimilation system of Météo-France, *Mon. Wea. Rev*., **127**, 26-45.

Lynch, P. and X.Y. Huang, 1992 : Initialization of the HIRLAM model using a digital filter. *Mon. Wea. Rev*., **120**, 1019-1034.

Lynch, P., D. Giard and V. Ivanovici, 1997 : Improving the efficiency of a digital filtering scheme for diabatic initialization. *Mon. Wea. Rev*., **125**, 1976-1982.

### 5.4.2 Digital Filter initialization and ALADIN 3D-Var

The impact of initialization on ALADIN 3D-Var assimilation was carefully studied by Claude Fischer, and initial options reconsidered. See the paper on ALADIN-France 3D-Var.

## 5.5 Observations

### 5.5.1 In ARPEGE, in short

- ✔ From pre-processing to impact studies for satellite data (AMSUB, HIRS, AMSUA AQUA, AIRS, QuickSCAT and MODIS winds, SSM/I, ...)
- ✔ Introduction of a bias correction for radiosondes (from the IFS one)
- ✔ Starting to work on GPS data

### 5.5.2 Status and plans for developments on radar data

The technical work required before addressing the problem of 4D-screening in ARPEGE / ALADIN is now ended. Presently we have radar reflectivity data in ODB file and we have achieved the main work to obtain a technical monitoring system for this observation type.
In particular, a new subroutine (`REFLSIM`) is called within the vertical interpolation of model fields, to compute and simulate the model-equivalent reflectivity at the observation point. This reflectivity observation-operator is an adaptation of the reflectivity simulator developed in the Meso-NH model. In particular the code organization does not allow horizontal integration as is required for radio-occultation data. However the vertical integration takes into account the radar-beam geometry, considering the radar-beam width at each observation point.

But in fact the physical interfacing is not satisfying and the required physical fields to simulate the equivalent reflectivity are not easy to obtain. So, to start with 4D-screening, we have used the diagnostic cloudy parameters (liquid water and ice) computed by ARPEGE/ALADIN physics, and the first trials show that most reflectivity data are rejected, due to too big obs-guess departures. According to this last point, the most important work is now to obtain the best required physical fields in order to have a better first guess. A new observation-operator will be built, with snow, rain and graupel as input : diagnostic fields, derived from precipitation fluxes, in the case of ARPEGE/ALADIN, prognostic ones for AROME.

Moreover we have to optimize the thinning boxes and besides improve the quality control. In particular, the impact of the new quality flags provided by the CMR ("Centre de Météorologie Radar"), stored in new radar BUFR and consequently in ODB, is to be evaluated. Maybe one could also improve screening by using a variational quality-control.

In parallel we intend to elaborate an inversion method, to provide some corrections of ($T$, $q$) profiles as retrievals from departures between the simulated and observed radar reflectivities.

## 5.6 Else ?

**SEVIRI data in ALADIN** : See the dedicated paper by Thibault MONTMERLE.

**Initialization of soil moisture** : See the PhD reports of Karim BERGAOUI.

**LAM EPS** : See the paper bu Edit HAGEL. Research on EPS is temporary in stand-by at Météo-

France since Jean NICOLAU is now too busy with other duties on top PEACE, while the RECYF team is waiting for a new member to start such activities.

Hoping none is missing !

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