Report from the CIPN (Comité Informel sur la Prévision Numérique) ad-hoc working group meeting

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In short:

In the context of the introduction of the new AROME project, a new willingness to merge gradually and as far as possible the different modelling projects (ARPEGE-CLIMAT, ARPEGE-ALADIN and Meso-NH), has arisen at Météo-France.

The idea is to maintain only two branches, namely the global applications and the very high resolution applications (note that the present ALADIN model sits midway between these two branches).

This translates in the following actions:

1) The ARPEGE model remains with its 1D physics the basic global model, providing lateral boundary conditions to the Limited Area Models.

2) Convergence must be searched between ARPEGE-CLIMAT and ARPEGE-NWP (ALADIN) Physics; a new physics-dynamics interface will be realized in concertation with the ECMWF.

3) The AROME model (intended for meshes below 3 km) will use the non hydrostatic ARPEGE-ALADIN dynamics and possibly its data assimilation (this shall be further discussed), together with the Meso-NH (3D) high resolution physics.

A simpler version of the AROME physics will be developed for meshes around 10 km, but remaining still computationally significantly more expensive than the recent ARPEGE-ALADIN physics.

4) Since AROME could be for a long time out of computer capacity for many ALADIN countries but also for specific applications, the interest of the ALADIN physics at high resolution remains, and particularly the developments intended to mesh sizes between 7 and 3 km. These resolutions require specific refinements in the physics, particularly for the convective processes whose scales are partly resolved by the model grid.

Météo-France prefers to focus on AROME-3km and *it is a challenge for the ALADIN community to carry out research and its applications (in a continued ARPEGE-type phasing context) for these intermediate resolutions.*

A sensibilisation and discussion workshop is planned on 11 and 12 April 2003 in Prague.

1) Introduction

Following the decisions made by CIPN in December 2002, a meeting of the so-called ad-hoc enlarged working group of CIPN was scheduled for the end of January 2003. The main goal of this meeting was to review the work accomplished by the CNRM teams to respond to the strategy decided last December and to discuss with Météo-France Directors an analysis of the ALADIN and AROME convergence and a proposal on how to proceed. The agenda contained still some smaller items, like information on the recent parallel suite results, information and demands from forecasters etc., as well as a technical part on the interfacing of the mesoscale physics. The meeting was attended by the Director for Strategical Issues (over phone from Paris), head of CNRM, head of the NWP unit (GMAP), head of the climate unit (GMGEC), head of the mesoscale modelling unit (GMME), chief of AROME, key experts from the above mentioned units, representatives of the forecasting division and two members of CSSI invited from outside. There were two major items concerning ALADIN in the agenda, both linked to the model physics, which are reported here below.

2) Perspective of the convergence of ARPEGE-NWP and ARPEGE-CLIMAT physics

The physics of ARPEGE-CLIMAT has gradually drifted away from the operational ARPEGE physics, corresponding to new specific needs for the climate. This resulted in various switches deciding to call different parameterizations following the kind of run being performed.

To limit double work or perpetual overhead and delays in cycling, but also in regard to the limited impact of "screwdriver tunings" in the NWP model, it was decided that a convergence of both models should be searched in a reasonable time.

The advantage of the convergence of the two models would be first a neater code, easier to understand and to handle. The operational constraints of NWP can be quite different from those of Climate runs, but it will now translate mainly in differences in use, which should all be clearly justified, while the code should satisfy the two uses without acrobatics.

We could summarize the differences as next:

- The use of the Fouquart-Morcrette radiation scheme in CLIMAT, which is an accurate scheme called every 3 hours, opposed to the simplified radiation scheme of `ACRANEB`, much quicker to compute and called every time step.
- For the climate model, additional parameterisations of ozone, different kinds of aerosols give an important input to the radiation scheme, while they have no impact in NWP.
- The surface and vegetation scheme ISBA from CLIMAT has successfully been applied in the NWP applications, where it uses only one layer below the surface instead of three.
- ARPEGE-CLIMAT has used a diagnostic Turbulent Kinetic Energy scheme (TKE, Mellor and Yamada) for several years, and now a prognostic TKE scheme has been developed. The goal was to get a better representation of the diurnal cycle in the model. The TKE field is not advected and doing it would not be easy since the variable was coded on the half levels of the model. The NWP model still uses a classical Monin Obukhov approach, while only preliminary work has been achieved for a TKE scheme at full levels.
- Stratiform cloudiness and precipitation are handled differently in the two models, the present diagnostic scheme of the NWP is very crude. This is in close relation to the developments in microphysics (next point).
- Work has been performed in both teams about the representation of cloud water.
  a) In ARPEGE-CLIMAT, the scheme developed by Ph. Lopez has been successfully tested.
  b) Parallelly in the frame of ALADIN some tests have been performed on a slightly modified adapted version of Lopez’s scheme (keeping a separation of ice and liquid phases)
- New CAPE and mass flux-based shallow convection parameterisations have been tested in ARPEGE-CLIMAT
- The diagnostic convection scheme is still common to both models, but for the NWP, important developments have been started on a prognostic convection scheme, addressing cloud water and that should also solve the conflicts between subgrid and resolved precipitation at high resolutions.
- ARPEGE-CLIMAT also uses a scheme for the convective drag, which is represented the same way as the orographic gravity wave drag.

On many topics, the convergence between the two models seems feasible in reasonable time, with still some unavoidable specificities for the different operational constraints.

The following actions are proposed:

- For the radiation, the Fouquart-Morcrette has been tested in NWP, tests of a call at each time step is also planned. But this stays too heavy for NWP, so the possibility of an intermediate complexity scheme is still investigated.

- For the surface scheme, the convergence is practically realized. Some enhancements have been achieved in the NWP context, as the introduction of surface ice.
- A prognostic TKE scheme with continuity at the surface and large scale advection (requiring that TKE be defined at full levels) is the best choice.
- The cloud water scheme from Lopez seems a good choice, as its adaptation with a separate advection of ice and liquid has succeeded, and current developments around deep convection for NWP are compatible with this scheme. (The NWP should probably be able not to call the prognostic option for the precipitation itself.)
- The precipitating convection parameterisation is presently under important developments. It will benefit of the work performed in both contexts, and going to a more prognostic closure condition, associated to the moist TKE scheme, could help to solve together the shallow and deep convection.
- For the mountain drag, the NWP will suppress the use of the envelope orography, and one will assess the behaviour of the convective drag in the same frame (the code is identical). Common work will search the better equilibrium between gravity wave drag, form drag, lift and convective drag.

3) Problem of the AROME vs ALADIN physics

Chief of the AROME project prepared an analysis of the problem on the AROME/ALADIN convergence together with proposals on possible solutions, as he was charged by CIPN. This document is of a restricted distribution and it was submitted to the Météo-France Directors and summed-up at the meeting. The general problematics of the AROME and ALADIN convergence was discussed shortly, and it appeared that the Director was satisfied with the analysis. Then CSSI members were invited to express the needs of ALADIN Partners and their point of view. They stated that the reactions on the ALADIN side to the CIPN decision are very few for the time being and the main reason is probably a lack of proper information in order to get the right picture of the practical aspects of the policy decided by CIPN. The Director then concluded that a workshop ought to be organised with the ALADIN scientists and ALADIN Partners representatives. The head of GMAP was put in charge of the organisation of this workshop.

Then, within a short discussion it was re-confirmed that the most difficult item of the AROME and ALADIN convergence is the model physics. While for the dynamics and data assimilation it can be considered that these are de-facto joint and that the research and development work in these domains made in ALADIN shall contribute directly to AROME and vice versa, the best solution on the strategy for the development of an ALADIN-type physics is difficult to be found.

To sum up, the problem for a follow-on of the present ALADIN strategy lies in the requirements below:

- The need for a parametrization of convection suited for the 7-3 km scales, which is a tough challenge;
- The need for parameterization schemes which should by their philosophy and quality approach those of AROME but be closer to ARPEGE for their cost. This seems to be an issue difficult to solve but a crucial one for ALADIN Partners;
- It was proposed to start by testing the Meso-NH parameterizations in the ARPEGE/ALADIN 1D model first and when successful to proceed to 3D model (and to add the 3D turbulence only later) while keeping the 1D-type interface in AROME compatible with the present interfacing practice of ALADIN. This action responds to a need of AROME but also to most of the interface question for ALADIN 7-3 km semi-cheap physics;
- However the existence of this semi-cheap physics will have to be ensured by developers from the ALADIN Partners of Météo-France. It should be well understood that the 1D lower resolution AROME physics is meant for about 10 km scales, that it will be about twice more

expensive than our current ARPEGE-like 10 km physics and that it still does not solve the moist convection problem of 7-3 km scales;

- The need for the maintenance of the physics specific to ALADIN (see above) and, in very specific cases, of its interface;
- The need for an anyhow increased maintenance effort when both ALADIN and AROME physics will coexists in some code.

At the same time there are already first steps made to cope with the requirements of the AROME's physics interface, like how to solve the organisation of the time-step, how to introduce new necessary variables, how to access 1D versions of the schemes.

The first outline of the time-step with 3D AROME physics may be described as follows:

a) inverse spectral transforms;
b) adaptation step of the physics;
c) evolution step of the physics depending on the previous adaptation;
d) preparation of the dynamical source terms;
e) addition of the tendencies of the steps b) and c) to the prognostic variables in the semi-Lagrangian interpolation buffers (to obtain these quantities at the origin point of the trajectory by sometimes monotonous- interpolations);
f) 3D minus 1D computations needing local information, processed within the semi-Lagrangian halo at the same part of the code when the interpolations are made;
g) semi-Lagrangian advection;
h) second adaptation step of the physics;
i) rest of the dynamical computations and direct spectral transforms;
j) spectral semi-implicit solver and possibly other spectral computations.

Compared to the current organisation of the model time-step a reader can easily imagine what would mean the interfacing of the AROME 2.5 km physics. One part of these computations will be iterated in the predictor-corrector schemes (from the step d) to the step j)).

For the introduction of new variables needed for the AROME physics, an analysis was already made together with ECMWF and there will be new data flow structure, treating via F90 descriptors the various attributes of model variables (spectral or gridpoint, needing derivatives or not, being advected or not, being coupled or not and so on) in a single framework (except for the big six variables part of the semi-implicit scheme for which the current structure will remain unchanged). After handling the attributes at the level of the setup, the data flow will become transparent to the user and the addition of a new variable will become far more easier. In a first step this will apply only to upperair variables of KLEV vertical extension. As a first consequence, model will have to use as a spectral variable the quantity *RT* instead of *T* (a first challenge for the ARPEGE/ALADIN community). The major rewriting of the code will take place in late spring early summer and new library is hoped to be available in late summer (preliminary component of cycle 27).

4) Conclusions

The important point of the meeting was the decision to organise an ALADIN-AROME workshop in order to explain well the new practical and political issues of the convergence of the two models. At the same time it remains clear that this convergence will bring important benefits to both sides but also has some potential drawbacks for small or medium computing resources, if some appropriate reorganization of efforts are not taken-on in parallel by the ALADIN Partners of Météo-France.