ALADIN RELATED PHYSICS

Input for common HMG-CSSI meeting to be held on the 5th of June 2005

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Aims and strategy

In the march towards the higher resolutions the weight of physics part inside the NWP models is continuously increasing in order to permit a realistic representation of more and more complex physical processes, especially the moist ones.

The main goal for the next years is to ensure a continuous evolution of the mesoscale physical parameterisations with different degree of sophistication/complexity (while keeping a good quality/cost ratio) appropriate for the scales where they are to be applied ranging from 2 –3 to about 20 km. In terms of required manpower this development means a substantial effort and it can be achieved only in a large collaborative framework.

Our common strategy was progressively built, after important initiatives of Jean-Francois Geleyn concerning the ensemble structure and those of RC-LACE on the operational environment, followed by large and vivid discussions. It considers ARPEGE-ALADIN-ALARO-AROME as a continuous entity, unified by a flexible and operational 'externalised surface' and boundary conditions, even if each component has specific calendar and targets, trying to minimize the development and maintenance cost.

From the beginning AROME was designed for resolution of 2-3 km, intended to be ready for operations in 2008, while ALARO aim was thought to permit a smooth transition towards these scales. ALARO has to be considered rather a *framework* than a model, enabling in the future each Partner to configure its LAM, based on its own choice of physics options, from ARPEGE to AROME/Meso-NH options, with possible intermediate choices.

The ALARO physics choice (and subsequently the plans) is based on the crucial contribution of Jean-Francois Geleyn including as well suggestions from the ALADIN partners. For sure, it is less ambitious from the scientific point of view but it is also justified by its position between the space/time scale limits (climate – meso-gamma) where more sophistication is required.

The key issue for such approach is the dynamic-physics interface. Considerable efforts (a "Synthesis document about a consistent set of interfacing proposal" was prepared by a ALADIN-2 and HIRLAM small group at the Training Course and Working Group on Physical/Dynamical Interfacing, Prague - November 2004, followed by deep debates) have be done for the interface design, complemented by the work on equations, in order to reach

a very flexible but solid scientific frame for the forthcoming physics evolution. This will allow the exchange of physical packages (or parts of them) and an easy comparison of them (with the price of a rule set constraints) while getting maximum benefits from the development of each component.

As a short time issue, a minimum interface will make possible the call ARPEGE/ALADIN and AROME physics, while the development of a more generalized interface in the next years, allowing as well the inclusion of the HIRLAM physics in the system.

Medium term scientific topics

Since the AROME is treated in a unified way by a separate documents, the following list of topics are considered important for the physical parameterise at scales beyond of 4-5 km, even if some of them are common with the physics development for high resolutions.

A special effort will be dedicated for the development and implementation of the physics dynamics interface with a maximum degree of generality with respect to the existing choices above the interface.

The interface is to be designed following a commonly agreed set of reference equations. A proposal was presented at the TCWGPDI in Prague (included in the document issued after the meeting, mentioned above). The equations (in the case of complex microphysics considering the ice phase) are derived using a full thermodynamic system including condensation, auto conversion and evaporation and in a barycentric system. None of the ARPEGE/ALADIN, ALARO or AROME models has such full system but all of them could use the same equation system under the condition of inventing the missing "pseudo-fluxes" (following the idea of Francois Bouttier), sometimes with the price of modifying the so-called "delta m=1" option (little used yet but likely to become the default option in the new system).

Besides the dynamic-physics interface all components of the physical parameterisation package should be progressively improved (not ordered on priorities level):

- ***Surface parameterisation***
  The use of the externalised surface package is one of the bricks assuring the unity of the ARPEGE-ALADIN-ALARO-AROME system. Its implementation has thus a high priority but the related problems are treated in a specific document. Once implemented, more sophisticated ISBA versions (diffusion scheme for temperature and water, snow scheme, tiling, fluxes over open water) could be validated. Implementation of ECOCLIMAP physiographic database is of interest too. We are interested to know what are the HIRLAM plans concerning the surface, especially if they intend to use the externalised package.

- ***Turbulence***
  The implementation of a prognostic moist TKE scheme, in relation with the cloudiness scheme (the use of the sub-grid variances instead of climatological critical values) is foreseen for all models of the system. A comparison between different versions is

necessary to evaluate the possibility to converge towards a common code in a few years time.

An intermediate approach for the improvement of the diagnostic treatment of turbulent flux is to consider a prognostic equation for turbulent kinetic energy but keeping some part of the current diagnostic computations. Even simpler, this formulation could be more appropriate for the ALARO frame, in preparing the convergence with AROME, concerning the stability and vertical staggering aspects.

- ***Microphysics***
  The improvement of simple microphysics scheme(s) suitable for long time-step (Lopez type) could be reached gradually. The comparison with the sophisticated microphysics scheme of Meso-NH will contribute to this process.

  While classically the microphysics is applied only to the stratiform precipitation, the work of Luc Gerard open the way towards an integrated scheme for the grid scale and convective precipitation.

- ***Radiation***
  Evaluation of the possibility to combine a sophisticated and a more simple radiation codes to improve the temporal representation of cloud/radiation interactions (starting from the two radiation codes used currently in the ALADIN model based on Fouquart-Morcrette and the so called ACRANEB_new schemes).

- ***Convection***
  The convection parameterisation will continue to be a hot topic. It starts to be accepted that even at resolution about 1 km the convection cannot be simply switched off. The complexity of the problems is increased for the so-called “grey zone” (either it is seen as a scale problem or a question of complementary between distinct parameterisation). As it was emphasized at Tartu workshop, for the use of the convection schemes based on mass-flux approach it is necessary to review the concepts and assumptions involved. The research concerning the closure assumption (importance of humidity convergence, CAPE, CIN, sub grid scale turbulence, etc), entrainment, transition between shallow and deep convection, etc., will continue.

  The long-term challenge is the achievement of a unified convection-turbulence scheme. The work of Luc Gerard (on the prognostic convection) and Jean-Marcel Piriou (on the convection causality and on the concept of bulk convective condensation) could be considered as steps in this direction.

Studies concerning the sensitivity of the schemes to the time step variation and comparisons between different schemes or parts of them are foreseen as well. Comparisons against observations sites (Cabauw, Palaiseau, Chilbolton, Sodankyla, Lindenberg, etc.) should be encouraged to validate clouds, radiation, turbulent fluxes, but also soil moisture and surface fluxes. Collaboration is already established between HIRLAM and Meteo-France to compare model forecasts on Sodankyla and Cabauw.

The validation environment should evolve correspondingly:

- Development of comparable physical diagnostics (DDH type *–Diagnostics par Domains Horisontaux*- and/or new ones) between models. The comparison between Cloud Resolving Model (AROME, Meso-NH) and lower resolution models should be made easier.
- Development of the 1D model framework. This is a very interesting tool for physics developments that requires some improvements. A reference version with all physics (ARPEGE, ALADIN, AROME, HIRLAM) should be available at each new cycle. The possibility of including it in the 2D model should be investigated.

Plan for 2005-2006

Concerning ALARO model, the aim is to have a new version by the end of the 2006 (appropriate at least for 10km), which will be an improved ALADIN, still preserving further "re-convergence" with AROME.

ALARO-10 km physics will be independent of the scientific AROME constraints but take care of the algorithmic condition of a future convergence with it. As a first approximation it will contain modified ARPEGE/ALADIN versions of deep convection and gravity wave drag, a more accurate parameterisation for radiation, use of the externalised surface. The use of a sophisticated microphysics package is postponed and will be revisited in the context of the convection closure.

- ***Radiation***: the present scheme (ACRANEB) with its new functionality (completely modified thermal computations (called either every time step in „statistical" mode, either at chosen time steps in „ self-learning" mode) but with transmission functions closer to RRTM scheme.
- ***Orographic forcing***: a modified version of ARPRGE parameterisation (ACDRAG) routine, including revised dependencies of the drag on the Froude number and a lift orthogonal to the geostrophic wind)
- ***Microphysics***: a simple microphysics by including in the current scheme of resolved precipitation scheme (ACPLUIE) the prognostics variables for condensed liquid water, ice, rain and snow and corresponding fluxes.
- ***Turbulence:*** Implementation of a mixed type TKE scheme
- ***Convection:*** Evolution of the convection scheme ACCVIMP/ACCVIMPD to follow the ideas of Jean-Marcel Piriou (on the parameterised convective water cycle, on cloud stationarity hypothesis, on microphysics in updraft and on the entrainment rate) and to prepare for those of Luc Gérard.
- ***Externalised surface scheme*** that interacts with the turbulence parameterisation scheme.

The improvements of the large-scale physics in ARPEGE (NWP and CLIMAT) are potentially suitable for ALARO. These modifications include the ECMWF radiation code (RRTM for thermal radiation and Fouquart with 6 spectral bands for solar

radiation) with Tegen's aerosols climatology and the Lopez/Smith large-scale precipitation scheme planned before of the end of 2005. The used of a prognostic TKE scheme is planned for 2006.

Besides the efforts dedicated to the evolution of the above parameterisations an important effort should be considered to articulate them into a coherent system. All developments, fundamented by the work on equation will follow the rules of dynamics-physics interface.

The important task to validate the new version of ALARO will be shared between the partners.

Ongoing activities

1. ***Equations/Interface***: the work concerning the reference equations system and the level of approximations used by ALADIN, AROME and Meso-NH in respect with this system is quite advanced, and accordingly, on the minimum interface.
2. ***Diagnostics***: Implementation of the required modifications (barycentric velocity), introduction of new cloud prognostic species, microphysics phase changes in the DDH has already started.
3. ***Radiation:*** retuning the statistical model, use of the gaseous RRTM transmission function for computation of the optical depth.
4. ***Turbulence:*** harmonization of the PBL computation (a revised Ayotte formulation) with an interactive formulation of the mixing length; evaluation and possible modification of the ARPEGE prognostic TKE scheme (TKE on full levels, implicit treatment of TKE evolution) in order to follow the principles of interfacing and diagnosis; development of a mixed type TKE scheme with emphasis on the stability problems.
5. ***Microphysics:*** tests using Lopez microphysics, introduction the prognostic condensed water species in the current resolved scale precipitation scheme.
6. ***Convection*****:** closure assumptions**,** triggering of convection, prognostic convection.
7. ***Validation, case studies, sensitivity studies***