FOURTH ALADIN MEDIUM-TERM RESEARCH PLAN (2006-2008)

MAIN OBJECTIVES AND CONSTRAINTS

summary prepared for the 10th Assembly of ALADIN Partners

Note

The previous research plan, initially designed to cover 2002-2004, has been significantly updated after the move from ALADIN-1 to ALADIN-2 and in practice extended to 2005. This explains the gap in periods covered by plans.

BACKGROUND

MAJOR CHANGES IN OPERATIONS

All ALADIN teams do schedule major upgrades of their operational suites within 2008, such as : implementation of a data assimilation system (or refinement of the present one) for upper air and/or surface, use of a more sophisticated physics, longer forecast ranges and/or more frequent runs, increases in horizontal and/or vertical resolution for the main forecast domain, extension of applications at very high resolution (including implementations of AROME), more focus on nowcasting, contribution to a common Ensemble Prediction System (EPS).

Evolutions will be performed in 3 steps. First, a few individual upgrades are scheduled within the present framework, with scientific and/or technical changes likely to lead to an increase in cost. Besides, all teams must do their best to update operational libraries. By mid-2006, the ALARO framework should be ready for operational implementation. Then all teams should jump simultaneously to the new library, for it implies significant changes in working environment. This step will be a technical one, at more or less equal cost. Afterwards, ALADIN teams will be able to move to more sophisticated and expensive applications, more or less progressively according to their needs and means.

A very large effort will be required for building then validating these new operational systems.

HIRLAM PARTNERSHIP

Code convergence with HIRLAM is expected to be nearly achieved by the end of this plan. This will for sure bring a burden of maintenance, even if HIRLAM scientists take on a large part of the extra work. But this will make also new tools available, and the closer scientific cooperation between the two consortia will boost innovation, help for the heavy validation work required, and allow to face the most difficult scientific challenges. And there are many !

NETWORKING

The decentralization of research may now be considered as nearly achieved. This is a major difference with the previous plannings. As counterpart, a high level of networking will have to be maintained, and common training actions organized.

MODEL CORE

DYNAMICS

The past developments on non-hydrostatic dynamics and semi-Lagrangian horizontal diffusion provided a safe basis for the march towards higher resolution, combining accuracy, efficiency and stability. Research will go on, both to address longer-term issues and to maintain a high level of expertise. Interfacing with physics (see below) and with data assimilation (tangent-linear and adjoint versions of hydrostatic dynamics) will receive special care.

COUPLING

High priority should now be given to work in this domain, addressing first problems already identified for years. A new, mathematically well-posed, formulation of lateral boundary conditions must be designed as an alternative to the empirical Davies' relaxation. Solutions exist for grid-point models, but their adaptation to a spectral model is a real scientific challenge. The time dimension must be considered in parallel : since tools are now available, it is high time to define (local) strategies to face situations such as the rapidly moving December 99's storm.

Besides, nesting strategies, when going to very high resolution and more sophisticated applications, especially on small domains, must be defined and carefully evaluated. Coupling problems have been met from the very first real case studies at very high resolution..

ATMOSPHERIC PHYSICS

There is a general agreement that a lot of work is still required here, with significant improvements required and difficult issues to face. Along the next years, operational limited-area models will move from the "convection" grey

zone to the "turbulence" one, a "grey zone" being defined as the range of horizontal scales where a processus is neither fully parametrized nor explicitly represented (i.e. 4-20km and 2-3 km here). And at the same time there will be profusion of schemes to be evaluated, improved, and compared : ARPEGE, Meso-NH, HIRLAM, new ALADIN ones.

As a consequence, priority must be given on the one hand to the work on equations and the definition of a common interface, on the other one to the design of common diagnostic tools, for in-depth validations. Among the scientific issues to be addressed, at all scales : coupling between the descriptions of turbulence, convection and micro-physics, dependency on horizontal and vertical resolutions, moist turbulence, algorithmic aspects. And 3d aspects will have to be considered at very high horizontal resolution, whereas the 1d approximation has been widely used so far.

DATA ASSIMILATION

BACKGROUND

Any sophistication in the forecast model requires a consistent improvement in the definition of initial conditions, hence a general trend to the implementation of variational data assimilation (aimed by many ALADIN partners within 2008). Such an evolution is desirable, but one must be aware of the associated additional burden of local maintenance, at least 3 times more work, and of the long preliminary validation work, since most choices depend on local implementations.

Besides, the code convergence with HIRLAM will imply in-depth changes in the variational code to prepare for 4d-var, further weakening the research effort in this domain.

OBSERVATIONS

Observations of high density, in space and time, are required to feed high-resolution data assimilation systems. And observations management is not a minor task. All steps must be considered : acquisition and storage (to have data available in time and in the right format), quality control and bias corrections, geographical and time selection for very dense networks, design of observation operators consistent with the model physics, extensive impact studies.

Beside further retuning for those data already used in ALADIN 3d-var, the use of new observation types is considered, from advanced satellite sounders (addressing the problems linked to land and cloud or precipitation affected data, and using SAF products whenever available), ground-based GPS or radars (reflectivity and wind).

METHODS

Only assimilation systems based on 3d-var are likely to be used in operations within the end of this research plan. The time-dimension will be addressed through the lengths of the assimilation cycle and of the time-window for observations, or via the derived 3d-FGAT configuration, where observations are compared to forecast at the right time. However a"4d-var in a nutshell" will be made available for research.

As concerns cost functions, "ensemble" methods are now considered as best suited for the description of modelling and observation errors, and the combination of data assimilation and ensemble prediction systems will be investigated. The use of wavelet functions, to better represent anisotropies, no longer negligible at small scales, is also taken for granted. With the newly available variational blending and "a-posteriori validation" methods, one has a reduced but efficient (once completed) toolbox for the definition of new data assimilation systems.

Application at very high resolution will however bring new questions, with an increased dependency on physics, coupling, situation, ...

APPLICATION TO NOWCASTING

Operational plans for the next year put emphasis on very short-range forecasts at (very) high resolution. A few different approaches have already been addressed : use of 3d-var (with a specific retuning) instead of optimal interpolation for diagnostic analyses (from DiagPack to VarPack) and extension to more observations and higher resolutions, design of very high resolution analyses of atmospheric fields (as in the Austrian INCA project), assimilation suites with a very short cycle (1 hour) and very short range forecasts. Specific developments and validations should go on. Interactions with other domains of upper-air or surface data assimilation must be paid attention.

SURFACE ISSUES

EXTERNALIZATION

One of the changes brought by the ALARO framework (from an AROME choice) is the externalization of surface parametrizations, including the associated initialization procedures. A similar externalization of the corresponding assimilation tools will be considered afterwards.

Hence the first step will be to complete the coupling of the surface and atmospheric models, considering all model configurations but only the present operational surface scheme, with mid-2006 and minimum changes to operations as targets.

PHYSICS

Once the "ALARO jump" performed, more sophisticated descriptions of land surface exchanges will be available. However associated initialization procedures will have to be defined, and more validations, in a NWP framework, performed. For sea surface, the current available schemes will have to be compared and improved, and, further, coupling to a sea model can be considered. But one starts from zero for lakes for instance, so there is still place for deeper research.

DATA ASSIMILATION

ALADIN is quite late in this domain, with negative impacts on daily forecasts. As first priorities are fine-scale analyses of snow cover and sea surface temperature, taking advantage of the cooperation with HIRLAM, and using the available SAF products.

The analyses of 2 m temperature and humidity, which provide crucial information for the correction of soil temperature and moisture, must be improved, if not changed, to better take into account anisotropies linked to e.g. orography or coastal contrast. For the initialization of soil variables, a quick move from "statistical" to "dynamical" optimal interpolation is recommended, since it has proved to lead to a more sensible soil moisture and it will make the adaptation of assimilation to more advanced schemes easier.

Besides, work will continue, or start, on longer-term challenges, such as the use of new satellite data or the problems linked to tiling.

PHYSIOGRAPHY

After the switch to ALARO (and the associated externalization of the surface stuff), the first available improvement in the description of soil and vegetation will be the use of the global ECOCLIMAP database, with informations at a resolution of 1 km (after a careful validation of course). Besides, further improvements of this dataset will be considered, using more recent land-cover maps and satellite observations.

The implementation of applications at very high resolution implies the search for finer data to describe orography. The resolution of the present databases (2'30) will be too coarse. Coordination will be required to build a common high-resolution dataset, for the corresponding informations are usually available only locally.

PREDICTABILITY

Ensemble prediction for the short range based on high-resolution limited-area models is an attractive but very new research domain, the scientific bases of which are still to be defined. One cannot simply use the same tools as for global long-range forecasts, since quite different processes are involved. For example, humidity and surface characteristics become very important factors, and the impact of the coupling model must be considered too.

Several strategies to define ensembles have already been tested by some ALADIN teams, but a careful scientific analysis is still missing, and an efficient coordination is required. Besides, equal care must be given to the definition of verification tools.

VALIDATION ENVIRONMENT

DIAGNOSTIC TOOLS

A wide range of common validation tools, external or embedded in the model, must be made available to developers, as well as a library of well-documented reference situations. It is worth to mention it twice.

VERIFICATION METHODS

The tools used in operations for objective verification are known to be not well suited to high resolution, and the discrepancy will increase in the next years. New procedures are to be designed, based on new observations (e.g. satellite or radar data) or new methods (such as pattern recognition). It is also felt important to evaluate the quality of the model from the feedback of downstream applications.

INTER-COMPARISONS

Inter-comparisons are useful not only for the validation of new developments, but also in an operational framework, to help in the detection of problems. Hence the "common objective verification" project, started within the previous research plan, must be pursued and extended.

SUBJECTIVE EVALUATION

The interpretation and the evaluation of the reliability of deterministic forecasts at very high resolution are not straightforward. Hence it is important to both simultaneously address predictability issues, and prepare forecasters to such a change.

TECHNICAL ENVIRONMENT

CODE MAINTENANCE

It will remain a crucial issue.

CODE MANAGEMENT AND USER INTERFACE

To ensure efficiency, similar tools should be used by all teams. New, common, tools for source code management, operational monitoring, and complex experimentation, must be designed, with two major constraints : use of open-source softwares and user friendliness. The present compilation tool, widely enjoyed, will be kept for the next years, and optimized.

FILE FORMAT

The reference ALADIN file format is not likely to change within 2008, for such evolutions must be prepared very early. However some optimizations will be considered, both to improve flexibility and reduce size : more efficient compacting, reduced number of grid-point fields or partial use of "frames" for coupling files, improved interface to HIRLAM and IFS files, and any other sensible proposal.

In the meantime the question of a new file format must be addressed, in concertation with HIRLAM.

NAMES

ALARO is a working framework, or library, where improved and unique interfaces (to atmospheric physics, to the externalized surface module) allow to switch easily between a wide range of options (or between ALADIN, AROME or HIRLAM).

AROME is the name of the model when all the following ingredients are used : horizontal mesh-sizes below 3 km, non-hydrostatic dynamics, Meso-NH physical package, dynamical adaptation mode or 3d-var data assimilation (no known constraint on vertical resolution nor surface assimilation).

Any other configuration may be named ALADIN, unless maybe if 4d-var data assimilation and the HIRLAM physical package are used (rather unlikely for ALADIN partners within 2008).