SECOND MEDIUM-TERM (1999-2001) RESEARCH PLAN FOR ALADIN

OBJECTIVES AND MEANS

Introduction

Here is a revised version of the Second Medium-Term Research Plan for ALADIN, coming at a turning point when the model is operational or nearly by most Partners. The scientific content is the same as for the initial version which was presented and approved (for its purely scientific aspects) at the third ALADIN Assembly of Partners (Prague, 6/11/98). Only some priorities have changed, according to the problems recorded last winter. However the presentation is completely different so as to underline the different steps and the required work and means. Three main axes of research were identified for ALADIN. The first one concerns inevitably the maintenance and the improvement of the current version, addressing problems encountered in operational exploitation. The second one is related to high resolution modelling, the natural evolution of any LAM, especially when global models steadily go to finer and finer grids. The third one focusses on data assimilation, the most debated, since expensive, issue. Preliminary studies show that 4d variational assimilation in ALADIN is quite promising, but the other assimilation tools must be maintained as well. The last part of this document addresses the delicate but essential question of means, involving the problems of dedicated manpower but also training and source code maintenance.

A. Maintenance and improvement of the operational versions

A.1 Model verification

A.2 Dynamics

A.3 Physics

A.4 Coupling

A.5 Applications

B. High resolution modelling

B.1 Non-hydrostatic dynamics

B.2 Coupling

B.3 Physics

B.4 Validation

C. Data assimilation

C.1 Observations management

C.2 Optimal Interpolation analysis (CANARI)

C.3 Variational analysis

C.4 Coupling

D. Means

D.1 Local ALADIN teams

D.2 Training

D.3 Maintenance

A. Maintenance and improvement of the operational versions

A.1 Model verification

This point is not exactly a topic of research but is to be mentioned here since it provides the basis for the definition of priorities. Routine subjective and objective verification, including the comparison to observations, to other ALADIN models, to other forecasting systems, and between operational and test suites, is crucial to track deficiencies and steer further developments.

Project	Task	Constraints	Importance
Objective verification	Building a coordinated objective verification procedure	Management of local observations databases Definition of common rules Monthly collection of results into a unified database	High
Subjective verification	Routine control of model performance by forecasters	Selection and archiving of interesting cases Definition of common rules for reports	Medium
Case studies	Detailed study of some model failures, either testing the impact of new developments or using more sophisticated procedures	Selection and archiving of interesting cases Detailed documentation	Medium

A.2 Dynamics

Considerable progress has been achieved in this domain along the last years, leading to an enhanced stability and efficiency of dynamics. However current studies show that significant improvements can be introduced at a quite reasonable cost, and help in the further evolution towards very fine grids. In the meantime it is worth underlining the potential use of ALADIN for some small scale applications.

Project	Task	Constraints	Importance
Improvements in the semi-lagrangian advection scheme	Using recent results to improve the semi-lagrangian advection scheme, the tuning of horizontal diffusion and the physical-dynamical interface	Close cooperation between contributors Support to the PhD theses of I. Gospodinov and F. Vana	Medium to High
Radiative upper boundary condition	Resolution of residual problems and validation		High
Very small scale dynamical adaptation	Enhanced use of ALADIN for the very small scale dynamical adaptation of low-level wind, vertical velocity and precipitations	Support to the PhD thesis of M. Zagar Maintenance of the procedures Improvement in the description of fine-scale orography	Medium

A.3 Physics

Developments in this domain are now essential to improve the forecast of sensible weather. Changes are required anyway to go to higher resolution. The set of topics is quite large and part of the work can be easily deported. However the importance of validation is to be emphasized : at the local scale (using ALADIN in its 1d and 3d versions), at the global scale (to check balances and meet a larger set of situations, at least), with the combination of several developments, and in assimilation mode. Furthermore the corresponding modifications in other domains (e.g. handling and initialization of new fields, post-processing, assimilation, ...) must not be neglected.

Project	Task	Constraints	Importance
Liquid water and ice as prognostic variables	Development of a parameterization following the ideas of Rasch and Kristjansson	Support to the PhD thesis of D. Banciu Cooperation with HIRLAM	Medium
Radiation	Improvement of the radiation scheme		High
Orography	Cross-validation and tuning of orography related parameterizations	Involving physics, dynamics and 923 (description of orography)	High
Convection	Various improvements in the parameterization of convection	Efficient coordination	High
Snow cover	Implementation (development or adaptation) of a new parameterization	Simultaneous implementation of a snow cover analysis in CANARI	High
Land surface	New strategy of initialization for water on the leaves Moving to several (stacked) layers into the soil, ...	Simultaneous adaptation of surface analysis (for both items) Coordination with other developments at Météo-France	Medium Long term
Water surface	Improvement of evaporation over sea Improvement of lakes representation	Importance of global aspects Collection of observations, modifications in 923 and 927 as well	Medium
Vertical diffusion	Implementation of a parameterization of Turbulent Kinetic Energy	Introduction of a new prognostic variable Interface with the other parameterizations	Medium
Ozone	Test and tuning or improvement of the parameterization of ozone	Involving significant modifications in other parts of the code for a correct management of related fields	Long term
923	Resolution of residual problems in interpolations Adding new fields whenever required	Coordination with other developments in physics	Medium

A.4 Coupling

No major problem arises with the present coupling method, only some occasional problems in digital filter initialization and the need for some further sensitivity studies to define the "best" strategies, especially in the framework of higher resolution models, have been mentioned so far. The choice of another method is not excluded but must be worth the significant effort required for such a change. These are anyway rather long-term oriented projects. The diffusion of results is crucial here to avoid a useless scattering of experiments.

A.5 Applications

A close cooperation between Partners is strongly advised for the exploitation of ALADIN outputs, from the computation of derived indices to the coupling to other models (as statistical, air pollution, snow or hydrological ones) or to ensemble forecasting (as a long-term project).

B. High resolution modelling

B.1 Non-hydrostatic dynamics

As the model resolution continuously increases the use of non-hydrostatic dynamics will be required at one stage anyway. Though the general background has been implemented some years ago, some basic work is still required to allow it run at an acceptable cost, solving the current instability problems. This is one of the main issue to be addressed in the march to high resolution NWP.

Project	Task	Constraints	Importance
Vertical plane model	Development of a 2d vertical version of ALADIN to make work on non-hydrostatic dynamics easier	Maintenance	Vital
Semi-lagrangian advection	Development of a stable two-time-levels semi-lagrangian advection scheme, to enable larger timesteps	Using the vertical plane model for preliminary studies Using an updated set of reference simulations	Vital
Radiative upper boundary condition	Adaptation of the radiative upper boundary condition to non-hydrostatic dynamics, to control gravity waves	Using the vertical plane model for preliminary studies Using an updated set of reference simulations	High
Control of elastic waves	Vertical mode selective temporal decentering in semi-implicit computations, to damp elastic waves	Using an updated set of reference simulations	High
Lower boundary condition	Identification of potential instabilities and development of a clean solution if required	Using the vertical plane model for feasibility studies Using an updated set of reference simulations	Medium
Thin layer hypothesis	Relaxation of the thin layer hypothesis in equations, introduction of vertical Coriolis terms		Long term
Diabatic aspects	Exact introduction of diabatic forcing		Long term

B.2 Coupling

As previously there is no major problem to underline here. Sensitivity studies will be required to define the best choices for the relative horizontal and vertical discretizations of the coupling and coupled models, as well as coupling frequencies. The coupling of the surface pressure tendency instead of surface pressure itself seems also worth to be studied. Some refinements may also be brought to the current coupling method between a hydrostatic and a non-hydrostatic model.

B.3 Physics

Moving to higher resolutions will require at least some more validation and tuning of physical parameterizations, but more likely deeper changes. A close cooperation is required to avoid an irrealistic increase in the number of parameterization schemes and make cross-validations easier.

Project	Task	Constraints	Importance
Finer surface representation	Using higher resolution data for the definition of surface characteristics	Collection of data	Low
Adaptation to higher resolution	Refinement or tuning of physical parameterizations as finer horizontal and vertical resolutions are used	Keeping consistency between models Coordination	Medium
Interface with dynamics	Analysis of the calling sequence Adaptation to non-hydrostatic dynamics	Coordination	Medium
Updrafts and downdrafts	Parameterization of small-scale convective processes	Support to the PhD theses of D. Banciu and L. Gérard	Medium
New parameterizations	As required considering preliminary experiments or new proposals	Keeping consistency between models Coordination	Medium

B.4 Validation

To complete the set of individual tests performed by developers and specific case studies, it is strongly advised that a "neutral" team assumes the responsibility of a very careful validation of the changes required in the march to high resolution applications. This is a huge but essential task, that can be considered as a project itself. This includes the following tasks :

- design of a reference configuration (which may involve embedded models)
- choice and documentation of reference situations
- intensive validation in non-hydrostatic dynamics to track potential instabilities
- cross-validation of tunings or changes in physical parameterizations and documentation of feed-backs
- cross-validation of developments in physics and dynamics

This implies significant computational resources and a close coordination with other research teams.

C. Data assimilation

C.1 Observations management

This is the key point for a further use of ALADIN in data assimilation mode.

Project	Task	Constraints	Importance
Observations databases	Implementation and management of local observations databases	Implementation of an interface to the model and adaptation to changes in the model Coordination in the definition of data handling procedures, to avoid duplication of work	Vital
Monitoring	Quality control for observations	Coordination in the definition of criteria, to ensure consistency	Vital
New observations	Implementation or development of pre-processing tools for new observation types		Long term

C.2 Optimal Interpolation analysis (CANARI)

Though efforts in high resolution data assimilation should focus on 4d-variational assimilation, it is really important to maintain and improve the optimal analysis code, CANARI. First CANARI is already used by some partners in data assimilation mode, which implies its maintenance till better solutions are available. Second it will be still be required afterwards for surface data assimilation, since studies on surface variational assimilation are just beginning. Third it has proved useful in other applications : objective verification of forecasts (through the Verif-Pack package), monitoring of observations, diagnostic-oriented analyses (i.e. using available observations to provide an improved representation of the atmosphere to forecasters).

Project	Task	Constraints	Importance
Adaptation to high resolution	Separation between upperair and surface analyses Scale dependent tunings Adaptation of surface analysis to fine-scale orography	Close cooperation between contributors	High
Diag-Pack	Using CANARI as a diagnostic tool, for very short range forecast (e.g. of convective events)	Once CANARI tuned for high resolution applications Downstream exploitation of analyzed fields	High
Upperair analysis	Improvements in upperair analysis Analysis of new variables (e.g. specific humidity)	As far as data assimilation is already required in operational suites	Low or High
Surface analysis	Improvements in the assimilation of soil/surface moisture and temperature Implementation of a snow cover analysis		Long term for ALADIN
"Diagnostic" analyses	Development of analysis schemes for new fields (e.g. precipitations)		Long term

C.3 Variational analysis

3d-variational analysis is to be considered here as a crucial step towards 4d-variational analysis rather than a future operational data assimilation scheme. Coordination with developments in dynamics and physics must be ensured.

Project	Task	Constraints	Importance
3d-Var	Validation and improvement of 3d variational analysis	Access to and implementation of minimization package	Vital
4d-Var	Implementation, validation and improvement of 4d variational assimilation	Access to and implementation of minimization package Once 3d-Var working	Long Term
Variational applications	Development of applications based on the same tools as variational assimilation	Access to and implementation of minimization package Coordination with developments in variational assimilation	Long Term

C.4 Coupling

The problem of coupling in data assimilation mode is still an open one, some of the issues addressed here are still debated while new strategies are to be designed.

Project	Task	Constraints	Importance
Blending	Definition of a new initialization procedure where only large scales are imposed by the coupling model	Considering spectral and gridpoint fields (solutions may differ) Considering the interaction with digital filtering	till debated
Coupling for 4d-Var	Definition of a strategy for ALADIN 4d-Var		Long Term
Bogussing	How to correct the coupling model using high resolution forecasts from the coupled one.		Medium

---

D. Means

D.1 Local ALADIN teams

The existence of operational (or pre-operational) ALADIN suites among almost all Partners gives the opportunity for a new burden of research, with the emergence of deported actions. In the meantime the maintenance of operational applications is an heavy task, which may easily suffocate research and thus prevent further improvements of the model if means (mainly the size of ALADIN teams) are not increased accordingly or a closer cooperation between teams not established. This is true if even the prospect is limited to the minimum (axis A), but the problem is all the more acute since more ambitious projects are considered, especially for data assimilation.

D.2 Training

The necessary widening and renewal of NWP teams implies a recurrent need for a basic ALADIN training. However needs may strongly differ between Partners, e.g. in time or level, depending on local recruitment policies. In the meantime experience is now widespread among ALADIN teams and the code can be run nearly everywhere. This militates in favour of a local training of newcomers on (pre-)operational ALADIN suites. This would be quite beneficial for both research and operations. Research actions would draw already trained and maybe more motivated people, well informed of the needs and constraints of operational suites. Experimented persons would receive some help in the maintenance of operational applications and get some free-time for prospective.

ALADIN training schools will remain necessary, at least to teach the basic knowledge for new research axes. As an example such an exercise would be useful for high resolution modelling, where the previous team is to be renewed. But these operations are expensive and can succeed only if each Partner agrees to send experts as teachers and certifies that trainees will effectively work on the corresponding topics afterwards.

D.3 Maintenance

Maintenance is essential to ensure a sensible evolution of the code, allowing everyone to benefit from any new improvement. It covers the following tasks :

a. Phasing exercises, when code developments from the different Partners and ARPEGE/IFS are merged together, usually twice a year. Due to the emergence of deported developments, of new research axes, and the necessity to ensure portability and consistency with ARPEGE, these operations will remain heavy. To face the recurrent problems encountered along the last years, the following rules are suggested :

- 1. ALADIN phasing is realized in two steps, as for ARPEGE : first "forecast" configurations, then "data assimilation" aspects
- 2. In each ALADIN team, responsibles for maintenance are elected : one for small teams (less than 4 full-time persons for instance), at least two, including one experimented person, else.
- 3. These persons must be able to participate to phasing operations in Toulouse once a year.
- 4. An additional participation is required for consequent deported developments.

b. Code optimization, to improve portability, efficiency or solve identified problems. The development of diagnostic tools or simplified research versions, the elaboration of "benchmarks" to check the portability of future technical changes, have also to be mentioned here.

c. Documentation, with its several facets :

- 1. Complete in-line and external documentation of any scientific or technical development, necessary to make phasing and further use easier
- 2. Detailed information on new versions, gathering informations from contributors and spread using the new ALADIN www server
- 3. Detailed information on technical problems, forecast failures, changes in operations, ..., spread using the new ALADIN www server or "help" mailing lists
- 4. Easy access to the last version of the source codes (through the creation of an automatically up-to-date export branch and the elaboration of simple extraction rules)