ALADIN 4-year plan (2009-2012) and its links with various NWP internal collaborations, especially HARMONIE

Second updated version, prepared after the 2009 ALADIN General Assembly
The ALADIN CSSI and PM

Foreword: Since the ALADIN Programme started evolving towards a new mode of management (end of 2005 – beginning of 2006) while getting closer and closer contacts with the HIRLAM community within the joint HARMONIE ambition, the planning procedure may have appeared as the Achilles heel of the transition. Indeed the former planning in the ALADIN community was rather of the bottom-up type (gathering of scientists in Toulouse in 1994, 1999 and 2001 were the occasion of jointly defining the next plans before the system of stays and training efforts would help refining the task allocation; a meeting in Prague in early 2004 tried with less success to apply the same method to the so-called ALADIN-2 endeavour). Opposite to that, the still ongoing reinforcement of the governance (new role for the CSSI, creation of the PAC, clearer definition of the Programme management [PM + LTMs + ST], more transversal budget approach for the 3 types of Partners [Météo-France, RC-LACE and others], …) obviously calls for a top-down approach. But, right from the start of the transition, it was recognised that this approach can only work if presented along a time-scale stratification: 10 year strategy, 4-year medium term gliding plan, yearly implementation work-plan. Establishing the two first steps however takes quite a long time and the Programme had to continue facing its on-going challenges in-between. It did it in a rather pragmatic way, continuing to rely on the stays and meetings to structure the definition of individual tasks but clearly involving more and more the LTMs in the control of the execution and relying more than in the past on the existing coordination lead by GMAP in Toulouse and by the RC-LACE management system. Unfortunately, various attempts to better publicise and harmonise the perception of this transitional situation failed, without this hampering too much scientific progress and its direct reporting, concrete realisations and cross-ALADIN or cross-HARMONIE cooperation. What suffered most is probably the perception by individual LTMs of the importance of their role in maintaining the cohesion of the ALADIN Programme through the control of local activities.

The present document thus aims at closing the above-mentioned pragmatic parenthesis by setting up the first version of the ALADIN 4-year plan, valid roughly from end of 2008 till end of 2012 and from which the 2009 work-plan will be extracted and further detailed before the end of 2008. Next spring the first gliding exercise for the 4-year plan will start taking place. This will be the occasion of completely forgetting the influences of the past situation. Indeed, it cannot yet fully be the case in this first version, which is written at a time where the 2008 work is an implicit declination of the priorities discussed and prepared for the 4-year plan on the basis of the strategic document, priorities in terms of topics and manpower endorsed and steered by the General Assembly at its 2007 Session in Ljubljana.

The present first 2009 upgrade of the document endorsed at the Cascais General Assembly of November 2008 concentrates on the areas where taking into account HIRLAM comments, queries and counter-proposals was judged of highest importance and constructive at the same time, i.e. for the parts concerning 'upper air physics' and 'system'. Those parts were substantially re-written in order not only to accommodate the said input within HARMONIE, but also to do it in the most consistent way, whenever feasible. Of course a further updating of the whole document is foreseen, but on a more 'local' basis within the text. This task will be performed in parallel with the preparation of the 2010 ALADIN workplan and/or with the 'externalisation' of some sub-parts of the present plan, for individual use, e.g. on 'dynamics' issues.

Given the new structure taken by the C-SRNWP Programme of EUMETNET at 1/1/2008, it was decided to structure the present document on the basis of the list of Expert-teams prepared for this new type of work at the pan-European level, even if sometimes the 'internal' definition at the ALADIN level is not fully encompassing the same aspects as the SRNWP one. This structure does not fully match the CCSI identified coordination tasks but nearly. The borderline issues relating to this accepted discrepancy have been treated as pragmatically as possible. We shall have therefore eight thematic Sections in the plan (sometimes split between Sub-sections when appropriate), followed by some short synthesis. It should be stressed that the chosen split is not at all random but based on a deep rationale that indeed shall have here priority over some ALADIN historical legacies.

Last but not least, each person (CSSI Member or PM) contributing to the redaction of the plan always had the ALADIN Strategy document as upper reference guideline when performing its writing task. It is thus hoped that possible unspotted discrepancies between the two documents, if any, are of minor importance. In any case, it is sure that they should not be interpreted as any willingness to supersede the 10-year strategic aims, especially on their shorter time-scale declinations, but rather as small adjustments of the means to reach these targets.

I) Data assimilation and use of Observations

First Sub-item of Section I: Data assimilation tools

Mesoscale data assimilation had until 2006 received relatively little attention within the HIRLAM and ALADIN communities. Most data assimilation efforts have been devoted to synoptic scale 3D-VAR and 4D-VAR, and research efforts for mesoscale had been focussed on modelling aspects. During 2007 there was a shift in the focus also for data assimilation, from the synoptic scales towards data assimilation for the mesoscale with model grid resolutions of a few km.

A joint planning meeting for mesoscale data assimilation between the HIRLAM and ALADIN communities was arranged in October 2006. During this planning meeting a strong consensus among the participants from the 2 communities for development of **A common HIRLAM/ALADIN mesoscale data assimilation system** was established. The planning meeting focused on a a first 4 year period (2007-2010), with the ambition of a gradual development and delivery of operationally applicable mesoscale data assimilation systems with increased degree of sophistication during the whole planning period. The strategy for the research and development includes:

- The question of dynamical/physical "balances" lies in the heart of the data assimilation problem. We must be able to project the observed information on structures that will survive initial oscillations (adjustment processes) during the non-linear forecast model integrations. The present state of knowledge on adjustment processes and "balances" relevant for the mesoscale data assimilation is very limited, and therefore it is necessary to establish the needed research. Contacts should be taken with academic institutions for initiation of research projects (PhD studies, for example) as well as establishment of collaboration across the NWP consortia borders, in order to achieve enough momentum in the research, for a rational share of the research and to avoid duplication of work.

- Variational techniques should continue to be the core of our strategy, in order to select challenges with the most likely substantial return of investments. However, we should be very open to improve the variational techniques by utilizing ensemble prediction input information.
- We need to pay more attention to surface and soil data assimilation, and for this purpose we need to utilize all available remote sensing data, in particular satellite data that will become available in the near future. Furthermore, as is the case with the surface parameterisation, it will (in the long run) be beneficial with an externalisation of the surface and soil assimilation, making it possible to force the surface and soil assimilation to a larger extent with observations and to make the assimilation modules available to a larger community.

Based on the experiences during the first year (2007), this plan has been updated and covers now the period 2008-2011.

WP1: Construction of a basic version of a common HIRLAM-ALADIN 3D-VAR data assimilation system

Slightly different 3D-VAR assimilation schemes exist in HIRLAM and ALADIN. Parts of the two 3D-VAR systems are very similar, for example the statistical balance background constraint. Other parts differ, for example observation operators. The HIRLAM and ALADIN observation operators were carefully documented and compared during 2007. It was concluded that the ALADIN observation operators could be used as a starting point for the common HIRLAM-ALADIN 3D-VAR, based on the IFS and the ALADIN 3D-VAR and with insertion of HIRLAM codes (or ideas), wherever needed. The following further actions are planned for this process of 3D-VAR code convergence:

1. Installation and testing of ALADIN 3D-VAR (including FGAT) within the HIRLAM community;
2. Possible adaptation of the extension zone treatment in ALADIN (especially needed for efficiency of 4D-VAR), see WP1.5 below;
3. Comparison and validation of ALADIN and HIRLAM 3D-VAR, in particular for synoptic scale forecasting on large domains (utilizing the polar-stereographic projection option).
4. Training of HIRLAM staff to work with common HIRLAM/ALADIN 3D-VAR

It is expected that a common basic HIRLAM/ALADIN 3D-VAR, also called the HARMONIE 3D-VAR, could be made available for pre-operational testing within the HIRLAM community by June 2008. For this purpose, a thorough validation and comparison with HIRLAM 3D-VAR is needed.

WP1.1: Technical adjustments for a flexible Extension zone

Due to the IFS-derived construction of both the variational control variable, and more importantly of the spectral semi-implicit LAM formulation, the Aladin (and later Harmonie) analysis increment is obtained in the spectral bi-Fourier space including the extension zone. As a consequence, analysis increments are bi-periodic, and a wrap-around of the signal is not avoidable (in 3D-VAR, one might think of a deep re-definition of the control vector space – for which the wavelet work can be thought of as a first step, see WP2.1 – but in 4D-VAR the E-zone and the spectral space will also be dictated by the TL and AD model formulations). Since several solutions have been tested and proved to fail in the past (compact support, mapping of sigma_b's on C+I as a strong or weak constraint), the technical solution is to let the increments damp over a suitably large E-zone. In 1D models with Aladin-type correlation functions, an E-zone three times as wide as the correlation length scale seemed acceptable. This ratio might need to be increased in the context of a full multivariate 3D B matrix. However, this "by-passing" solution obliges us to adapt the Aladin code with respect to two aspects:

- Grid point model computations run over the right-handed part of the E-zone (as the simplest model design, derived from the IFS, for distributed memory). This holds for both the NL and the linear models (TL/AD). For 4D-VAR, this extra computational burden is not acceptable. After initial brainstorming in 2007, the most tractable solution is to split the spectral space definition into two separate ones: one collocation grid and spectral space for the model computations (NL, TL, AD, obs operators) and one other for the Jb and control vector space. This solution will require a careful technical analysis, then coding within the IFS variational analysis configuration "131". Estimated work is about 4 pm.
- Geometry changes via I/O (fullpos) can be performed, enabling to change from narrow to wide E-zone characteristics at identical C+I content. This adaptation would allow for wide E-zones already in 3D-VAR.

A parallel work of the dynamics group, which consists in the study of Boyd's method for LBC, eventually has been abandoned in 2007. This method, which mimics at SL origin points a realistic instead of the mathematical E-zone solution, would have allowed eliminating the Extension zone from the model.

First technical specifications on the paper are expected by September 2008. Some documentation on past studies is available (a technical note by G. Boloni, some technical descriptions in V. Guidard's PhD manuscript).

WP2: Further development of the common HIRLAM/ALADIN 3D-VAR data assimilation system

The basic version of the common HIRLAM/ALADIN 3D-VAR data assimilation system, to be established in WP1, will be the subject to further common developments and improvements during the whole planning period 2008-2011. Core issues are introduction of heterogeneous, anisotropic and flow-dependent background error statistics and better treatment of moisture-related observations.

WP2.1: Formulation of a background error constraint based on a wavelet representation.

During 2007, the strategy for coding a wavelet Jb has been formulated, based on a mixed bi-Fourier/wavelet/gridpoint formulation. The wavelet transform package has been coded and plug-in into conf 131 is underway (Sept 07-June 08). The priority now is to validate this code technically and scientifically, using single- and full-observation assimilation experiments. Additional diagnostic studies may be also considered, such as: (1) representation of the vertical dependencies within the wavelet formulation; (2) representation of heterogeneities and anisotropy due to the lower boundary condition (Landelius and Lindskog); (3) avoiding the extension zone problem (Landelius and Höglund) and (4) treatment of heterogeneities due to steep orography (Thorsteinsson).

WP2.2: Representation of humidity heterogeneities

Humidity is one of the least homogeneous variables, and in order to take this into account, a relative-humidity based data assimilation control variable (RH*) has been implemented at ECMWF (Elias Holm). Ongoing efforts on RH* for the synoptic scale HIRLAM 3D-VAR, with extension to a simple statistical moisture balance relationship, will be completed during early 2008 and possibly considered for implementation in the common HIRLAM/ALADIN 3D-VAR. Within Aladin, the IFS code by E. Holm has been adapted and thus could serve as backbone to the Hirlam-based formulation, both being fairly close. Comparisons have shown that the ensemble analyses (see WP2.3 & 2.5) also can provide case-dependent humidity statistics which seem more realistic than the RH*-formulation, in the Arpège/Aladin framework. The flow-dependent formula of Undén (Rabier et al., 1998) may be also considered for the HIRLAM/ALADIN 3D-Var (it is also used in Arpège), as its test in Aladin has been rather positive.

WP2.3: Derivation of background error constraint (J_b) and large scale error constraint (J_k) statistics based on ensemble assimilations.

One option for the coupling between the large scale model and the mesoscale model during the data assimilation cycles is via a large scale data assimilation error constraint (J_k). Statistics for the large scale error constraint need to be determined in a consistent way together with the statistics for the background error constraint (J_b). This approach has been tried for the ALADIN 3D-VAR, and will possibly be applied also for the common mesoscale HIRLAM/ALADIN 3D-VAR. Furthermore, this technique is also planned to be tested for the synoptic scale HIRLAM 3D-Var during 2008. The activities will be closely coordinated during 2008 by a common team.
In Aladin, efforts will concentrate on a posteriori diagnostics, daily and flow-dependent aspects of ensemble-derived σb's, LBC perturbations and "operability" questions around analysis ensembles (in the frame of deported, coupled LAM applications) and further dissemination of knowledge (training of "Jb-contacts" in LACE countries).

WP2.4: Formulation of background error balance constraints based on the non-linear balance equation and the omega equation.

Non linear and omega balance equations enable e.g. dynamical effects of the jet to be taken into account in Jb, providing flow-dependent mass/wind auto- and cross- covariances. Rather complete versions of these equations are being tested within the framework of the HIRLAM synoptic scale 3D-Var statistical balance background constraint. More simplified versions (and thus easier to implement) of the same equations, following the ECMWF approach (M. Fisher), are now operational in the 3D-VAR of ALADIN-France and ALADIN-Réunion. For the HIRLAM/ALADIN mesoscale 3D-VAR, a common approach will be formulated and a joint team will carry out the work. This work must wait for the experiences from the implementation in the synoptic scale system. An important task will be to introduce also the moisture variable into the balance constraint, possibly through a heating term in the omega equation.

WP2.5: Flow-dependency through background error standard deviations based on ensembles.

Introduction of flow-dependency into the background error constraint is rather straightforward for the background error standard deviations, and this has been tried for HIRLAM 3D-VAR, using a diagnostic Eady-index of baroclinicity, and based on an ensemble of background states for ALADIN. The work based on ensembles will be continued for the common mesoscale HIRLAM/ALADIN 3D-Var. The first logical step is to provide gridpoint σ_b maps, and make the corresponding Jb code work for the LAM in configuration e131. This work has been achieved in early 2008, by reading and using existing global (Arpège or IFS) maps of σ_b's, and the corresponding code will enter the common libraries (CY33T1). An additional track would be to join efforts for adapting the Arpège/IFS randomization technique (which provides an estimate for Sigma_b in observation or in model space) to the LAM version. This would also help coding the calculation and writing of gridpoint σ_b files in the LAM geometry, as the basic code for this is close to the randomization one.

WP2.6: Flow-dependency through background error correlations based on ensembles.

An ensemble of forecast background states (for example) can be used to calculate background error covariances "of the day", with flow dependent effects. This is already achievable in the current spectral Jb, with the possibility e.g. to represent broader vertical correlations for days when the vertical instability is larger, and sharper horizontal correlations in convective situations. The representation of such flow dependent effects may be further enhanced later on, by using also a wavelet Jb, in order to incorporate the associated geographical variations. The plan is to examine this potential with diagnostic studies, and to establish a joint HIRLAM/ALADIN team for this important work.
Note: There will be a met.no contribution to this work package by a PostDoc, but the content of this work is yet not clear.
Note 2: HMS (Hungary) has started a development on ETKF which however would remain unstaffed in 2008 (temporary leave of P. Csomos). HMS might hire a new staff to resume this work (one candidate has been spotted). If she would accept the job position, then she partly would continue the work on ETKF.

WP2.7: Introduction of a more general NL balance Jb constraint, including diabatic forcing, in the common HIRLAM/ALADIN 3D-VAR

Investigations could start in the mid-term in order to add some diabatic (from physics: friction, moist processes, radiation ?…) forcing terms into the Jb balance constraint. This effort could converge with the search for more general formulations of a non-linear balance (prolongation of WP 2.4).

WP3: Development of common mesoscale HIRLAM/ALADIN 4D-VAR data assimilation system

4D-VAR is presently available only for HIRLAM. Efforts to establish an ALADIN 4D-VAR have started with the development of the TL and AD of the ALADIN Semi-Lagrangian (SL) time integration schemes in 2006-2007. A first version, common HIRLAM/ALADIN, of 4D-VAR will be constructed during 2008 by a joint HIRLAM/ALADIN team. This system will be the basis for construction of a complete common mesoscale HIRLAM/ALADIN 4D-VAR data assimilation system. This construction work includes solving demanding dynamical/physical research problems, for which we do not have even partial solutions available. One important example is the question of diagnostic balance relationships involving moisture to be applied in the 4D-VAR background error constraint, and the related problems of simplified and linearised moist physical parameterisation schemes for the 4D-VAR inner minimization loops as well as the non-linear physics to be applied in the 4D-VAR outer minimization loops. It will be very important to establish cooperation with academic institutions for initiation of PhD studies in this field.

WP3.1: Development of an initial HIRLAM/ALADIN 4D-VAR data assimilation system

Following the establishment of the common mesoscale HIRLAM/ALADIN 3D-VAR, an initial common mesoscale 4D-VAR will be developed. From the HIRLAM perspective, it is important that this common 4D-VAR system performs at least as good as the HIRLAM 4D-VAR for synoptic scale forecasting. This means that a number of critical components of the HIRLAM/ALADIN 4D-VAR have to be developed and validated. These components include: (a) Multi-incremental minimization; (b) Propagation of assimilation increments; (c) Generalization of the control vector to include control of lateral boundaries; (d) Initial TL and AD simplified physics (The very first version will include the “Buizza vertical diffusion” only and after that the Météo-France simplified physics package, possibly complemented with the TL and AD of the Lopez microphysics)); (e) A weak digital filter constraint and (f) Variational quality control. For computational efficiency it is also needed that the extension zone problem (work package WP1.5) will be solved.

WP3.2: Moist processes in the various elements of a variational mesoscale data assimilation

For several reasons it would be advantageous if physical parameterization schemes could be developed to simultaneously serve non-linear forecast models and 4D-VAR data assimilation. Essentially this means that we need to introduce a hierarchy of complexity during the development and coding of physical parameterization schemes. Ideally, there should be a clear separation between the “simplified parts”, that could be subject to regularization, linearization and subsequently applied in 4D-VAR, and the more complex and non-linear parts, that should be applied in the forecast model or in outer loop trajectory calculations in 4D-VAR only. A strategy for this development and coding of physical parameterisation needs to be established.

On another item, the question of which is the most appropriate description of humidity (in its various forms) for the control vector should be investigated. This issue however should be fairly intertwined with the sensitivity of various water species contents to initial conditions, microphysics spin-up times and the separation of slow and rapid adjustments or conversion processes. Presumably, total cloud water content would be a valuable extra control field (see also link with WP 2.2 & 2.7).

Furthermore, the group should remain in touch with developments on moist 1D-VAR techniques for IR and microwave radiances (cloud or rain-affected radiances).

A reduced working group will be set, in order to first elaborate a strategy for the future coding of the simplified physics, and clarify the link/needs with the control vector choice. Proposals for experimental evidence of first-order physics processes could be performed, for instance by comparing NL finite differences with TL incremental evolutions.

WP3.3: Inclusion of moist processes in the common HIRLAM/ALADIN mesoscale 4D-VAR

After establishment of the plan for internal research on moist processes in 4D-VAR (see WP3.2), decisions on details with regard to required staff resources and a time schedule of the work will be taken.

WP4: Experimentation with rapid update cycling and blending in of large scale information

When the common HIRLAM/ALADIN 3D-VAR has been constructed, the mesoscale data assimilation system will be tested for use with very short (hourly) data update cycles. In this way, the potential of the system for nowcasting and very short range forecasting purposes will be assessed. Experimentation has started in ALADIN groups in 2007 (Aladin-Hungary and Arome-France), HIRLAM groups will join 2008 and onwards. In ALADIN Hungary, the plan is to concentrate on 3h cycling and try the FGAT option at the same time. If it looks promising, these set-ups should then enter other LACE data assimilation suites too. For Arome-France, emphasis in 2008 will be on the evaluation of the first operational 2.5 km 3h 3D-VAR cycle, then studies on 1 hourly cycles might start (linked with investigations on spin-up properties in Arome, which are not described further in this plan).

WP5: Assimilation of ground-based remote sensing data

WP5.1: Radar reflectivities

For the assimilation of radar reflectivities, a common plan has been prepared, in the first instance building on a 1D-Bayesian retrieval of temperature and humidity profiles. The HIRLAM contribution to this plan is to improve the radar reflectivity observation operator and to work on the pre-processing and quality control of radar reflectivity data, in particular the problem of radar beam blocking will be addressed. On Aladin side, further work on the specification and evaluation of the raw 3D reflectivity from the data providers needs to be undertaken (in MF environment), along with the improvement of the experimental design mostly in the Arome framework in 2008. One left-over issue so far is the multi-physics performance of the reflectivity simulator, as different model versions (Aladin, Alaro, Arome) would provide the simulator different microphysics information.

WP5.2: Radar winds

As to radar radial winds, a portable pre-processing of radar radial wind data, including de-aliasing and super-observation processing, will be developed. This pre-processing package will first be used in connection with impact studies on the synoptic scale, before embarking on experiments on the mesoscale. The latter is not expected to start before the beginning of 2008. In Aladin, several radar radial wind data pre-processing codes have been developed for data selection, quality control and noise filtering. The evaluation of the Aladin radial wind operator probably will be performed both in the Aladin-France and Arome-France models.

WP5.3 GPS delays

Work on the development of data assimilation of GPS slant delays has started at FMI and KNMI with development of the observation operator and models for observation error statistics. A preliminary impact study has been carried at DMI. This work, and also continued work on GPS Zenith delays, will be continued in 2007/8. However, the currently used processing methods do not fully support production of slant delay observations. Data assimilation of the raw GPS pseudo-range data would be considered as an ideal solution. However, such an implementation is likely to be beyond the resources available in 2007/8. Instead, the following tasks are seen as possible development issues:
1. Development of a bias correction algorithm for zenith and slant delays. Possibility of using variational bias correction will be explored.
2. Further development of the observation operator. Co-operation with ALADIN staff will be in key role.
3. Characterization of the observation error statistics, in particular observation error correlation.
4. Completion of implementation of a non-diagonal observation error covariance matrix.
5. Proper handling of slant delay data assimilation in parallel computer platforms.
Solutions to the problem of slant delay processing will be searched in co-operation with experts in the field of geodesy.

WP6: Assimilation of high resolution satellite data (advanced sounders, clear/cloudy radiances and satellite cloudiness products)

More satellite data will be prepared for use in the upper air analysis, and the impact will be tested both at the mesoscale and at synoptic scales. In HIRLAM, the following actions will be undertaken:

- Research at SMHI and KNMI will focus on the assimilation of clear and cloudy radiances from imagers such as SEVIRI. This work will start with the HIRLAM synoptic scale 4D-VAR data assimilation, but gradually move over to the common HIRLAM/ALADIN mesoscale 4D-VAR, once this scheme is available. This work is coordinated with the corresponding ALADIN work (M. Stengel to keep contacts with GMAP/OBS team).
- The use of observations from advanced sounding instruments such as AIRS and IASI will be investigated by met.no, in the first instance with the synoptic scale HIRLAM 3D-VAR and 4D-VAR.
- Met.no will also focus on the assimilation of binary cloudiness information.

Generally speaking, the ALADIN side is expected to play the leading role within the use of satellite data. Most of the benefits are expected through the work commonly performed for the Arpège and Aladin models, but it will potentially be beneficial immediately for the common HIRLAM/ALADIN system:

- use of simplified linear regressions for cloudy and rainy SSM/I radiances using the IFS TCWV (1D-VAR) retrievals as predictands (R. Montroty, N. Fourrié, F. Rabier),
- start the specification work for a 1D-VAR approach to cloudy and rainy microwave and SEVIRI data (F. Karbou),

- assimilation of high resolution AIRS and IASI infrared radiances (N. Fourrié, V. Guidard),
- pursue the dynamical satellite-derived determination of surface emissivity and surface (skin) temperature (F. Karbou, Z. Sahlaoui),
- work on inter-channel observational error correlations (E. Gérard).

Most of this work will be also tightly coordinated with ECMWF in the frame of the IFS/Arpège collaboration, as satellite data assimilation is one of the traditional and strong axes of the latter. Use will be made of algorithms and software developed by the NWP SAF.

WP7: Improved utilization of conventional observations

Conventional observations are foreseen to be important also for mesoscale data assimilation. There exist, for example, several national very dense mesoscale networks of surface observations. These data need to be exchanged internationally, and there is a need to improve assimilation algorithms for an optimized use of, for example, 10 meter wind and 2 meter temperature and humidity observations. Also aircraft data should be potential useful for the mesoscale, and optimized thinning and data selection algorithms need to be developed, for example.

WP8: Observation processing and tools

In the ALADIN/IFS system, the preparation of observational input by ODB takes place within the model. The ODB system will therefore be installed and used by all meteorological institutes during the planning period (2008-2010), and during 2008 at least by met.no, SMHI, DMI and FMI. An ODB training course will be planned for autumn 2008. Other observation pre-processing tools might or will be shared, depending on national Centres' constraints and possible cross-consortium initiatives: raw observational database format (easily exportable and installable on another site), read/write from this raw database ("oulan" tool), transformation of various data formats (ASCII, BUFR, GRIB) into ODB ("bator" tool). Recommendations for data format standardization should come along with the SRNWP Interoperability Project. Note also that LACE will make a proposal soon for centralized data preparation resulting in inputs for "bator" (ASCII, BUFR, GRIB).

WP9: Cloud bogussing by pseudo-profiles of relative humidity

This work aims at the production of pseudo-profiles (in TEMP manner) of relative humidity obtained through the combined information of MSG cloud classification, the identification of convective cells by a cloud tracking algorithm (named "RDT", developed jointly by CNRM and DPrévi/PI in Toulouse), cloud top brightness temperature and radar information (for the cloud bottom height). This work is so far performed within Aladin, but a transposition to Arome is possible. Tests in more regular mode (pre-operational) are also envisaged at MF, but with no specific calendar so far. This R&D work is also sustained by the MF/DMN bilateral collaboration.

Second Sub-item of Section I: Tools for the use of observations

Introduction:

To achieve key deliverable of the ALADIN cooperation, e.g. a set of data assimilation tools that improve the short-range forecast using regional in situ observation, satellites and radars, the emphasis should be on facilitating the access of smaller ALADIN institutes to key ALADIN system components they cannot yet use because of insufficient local staffing (the data assimilation and nowcasting tools in particular). Implementation scenario for data assimilation expects 3D-Var data assimilation systems, at full deterministic model resolution, in all centres that will be organized to afford it or use of a lower-resolution regional data assimilation system (or, one run by another NWP centre) in the others by 2010. And by the end of planning period a consolidation of data exchange practices across European countries and increasing interest in data assimilation in all centres is foreseen, which will likely foster stronger cooperation inside regional groups of ALADIN countries that perform joint data assimilation, as well as rise of more advanced data assimilation algorithm such as 4D-Var in some NMSs.

Even if this additional goal is of longer term, all related efforts should be considered as potentially leading to even more ambitious endeavours like OSE/OSSE and data targeting procedures.

The staffing on data assimilation is a difficult issue in many ALADIN members. Among other reasons it stems from technical hurdles in observation pre-processing and installation of observation software. This makes it difficult to install operational applications of the existing data assimilation system in ALADIN. In this respect it is an important strategic choice to alleviate the above-mentioned technical hurdles by standardization and/or sharing of data pre-processing tools whenever possible.

Description of identified ancillary tools for data assimilation:

Observations preprocessing

The main goal of the observation preprocessing is to provide the analysis procedure with the observation in ODB format and all its necessary input.

At present ODB is produced by programme BATOR, which takes three kinds of input observation formats:

ASCII; this is so-called OBSOUL file produces by programme OULAN developed in Météo-France. The original format of the OULAN software reads data from the local database at Météo-France so it is not suitable for use at other sites. In order to use OULAN outside Météo-France it has to be customized to the local observation format. Within HIRLAM (in Met.no) OULAN version was developed to read data from BUFR files (instead of the local database).

BUFR; efforts are made to use the BUFR format as observation format in ARPEGE/ALADIN data assimilation system. Recently, a lot of observation has been moved from OULAN to be read in BATOR.

GRIB; one of available input data format for SEVIRI data only (NB: SEVIRI data can be read in BUFR format as well)

Currently only a few NMSs have any observation preprocessing tools working operationally. Thus before overly adopting the others tools (e.g. described above “OULAN” and “BATOR” tools), an overview (and detailed analysis also in coordination with HIRLAM) should be done to prepare as much as possible general, flexible and modular basis for development and maintenance of observation preprocessing tools., e.g. as much as possible share efforts for writing encoding/decoding program, local observation databases and convertors to ODB.

The overview or the current status and needs, available tools and coordination of efforts in preprocessing of observations is now having high priority.

Observational DataBase (ODB)
ODB is a tailor made database software developed in ECMWF to manage very large observational data volumes through the IFS/4DVAR system, and to enable flexible post-processing of this data. The problems for the use of ODB are on technical level and lack of information about all related issues and rather not in scientific/strategic plans of developments. The most difficult issue is quite complicated installation of ODB. The core development on ODB is done in ECMWF by database system developer, development on administrative level is done in connection with Météo-France, while most ALADIN partners are for the time being purely ODB users or very basic user developers (users knowing the main features of database, compilation and linking to be able to write simple programs working with ODB.

There is a very important role for contact points, who should be informed about the latest releases and developments by the database system developer, could help to solve the emerging problems and further spread the information inside the communities.

In summary, it is important to designate ODB contact persons and to train more ODB experts able to help the usual system installers to compile and test the ODB, as well as run the pre-processing tools (An ODB training course will be planned for autumn 2008 by HIRLAM.
The improvement of technical and practical documentation on the compilation and use of ODB should receive high priority; while the set up of some dedicated web page with documentation or some computer forum could be considered.

Observation monitoring
Monitoring is crucial task to check on the quantity and quality of observational data received and assimilated, as well as to identify data that should be excluded from the NWP assimilations or corrected prior to use. The production of statistical information on observation and model accuracy can also be exploited to optimize the assimilation algorithms.

A prototype of interactive web-based observation monitoring system for the ALADIN variational data assimilation systems (3D-VAR, 3D-FGAT) was developed within the RC LACE collaboration. The system allows visualizing the location, status and departure statistics of the different observation types for a given analysis date or for a selected set of analysis dates. Continuous extension of this (or similar) system to include more diagnostic tools and new observation types is highly desirable, as well as its maintenance and documentation.

The current high priority actions are the review of monitoring tools used in ALADIN and HIRLAM as well as the coordination and cooperation in development related to monitoring tools

A more detailed plan for interactive web-based observation monitoring system (RC LACE manager) encompasses:
- the technical and user documentation;
- the development related to surface analysis monitoring;
- the review of the design (prototype is based on a set of ASCII files that were created from ODB and as a result, only a limited number of data flags from ODB are available in the system. An implementation fully based on ODB (similar to standalone ODB package could be considered);
- an extension of the system for new observation types (e.g. radar).

Debiasing tools
In order to avoid problems in assimilation (e.g. suboptimal use of observations, biases in assimilated fields, non-physical structures in assimilated fields, extrapolation of biases due to multivariate background constraints, spurious trends due to changes in the observing system) caused by systematic errors in models and observations a bias correction should be performed. For bias correction global IFS-ARPEGE tools are being adapted for ALADIN and Météo-France has leading role in this task. As well as a strong cooperation with HIRLAM on these issues is anticipated.

In ARPEGE/ALADIN model the method suggested by Harris and Kelly (2001) for correcting radiance-biases remains in the IFS/AAAH for some time. But this procedure, involving several executables whose maintenance and porting can be an issue, will be progressively replaced completely by variational quality control, which is incorporated within the variational analysis itself and operates during the iterative minimization.

Specific efforts on compilation and portability of the Harris and Kelly code have low priority, since it will be replaced completely by variational bias correction (probably past CY36 in 2009). A high priority belongs to the adaptation variational bias correction for ALADIN and to the development of a bias correction algorithm for non-satellite data (e.g. zenith and slant delays, radar), where the possibility of using variational bias correction should be explored.

Data exchange
Conventional observations are foreseen to be important also for mesoscale data assimilation. There exist, for example, several national very dense mesoscale networks of surface observations. These data need to be exchanged internationally. However, these issues raise political aspects which will not progress before they are treated and solved at a quite wide and high European level (e.g. Eumetnet) as well as technical ones at the level of format specifications (cross-relation of SRNWP project for Interoperability could be considered).

Hence concrete plan concerning data exchange is limited to review of the currents status and needs, and promotion of the data exchange on „regional level“ (e.g. RC LACE, HIRLAM,. etc). As well as for small NMSs consideration of exchange of pre-processed observation is strongly recommended to decrease necessary maintenance for local installation (observational databases, decoding/encoding software).

The associated medium priority actions are for the time being:
- the review of standards and practices in coding observations (also part of Interoperability Project);
- an impact study to show benefits should be considered;

- the review of decoding software for observational databases, with emphasis on portability and user-friendliness.

Compilation and maintenance of all tools (This item has the cross-relation with system maintenance part of the four year plan**)**
A compilation of all ancillary tools and mainly of ODB itself is crucial point. Up to now main compilation tool (gmkpack) has been exclusively developed and maintained at Météo-France. There is an interest to share within the partners also the related maintenance duties for these tools.

One thus should put high priority on sharing maintenance duties for the compilation tool and training more ODB experts able to help the usual system installers to compile and test the ODB, as well as all the pre-processing tools.

II) Diagnostics, Validation and Verification

This section of the plan is in a preliminary state, reflecting the need for the Consortium to foster a difficult transition from 'classical' to 'high-resolution-compliant' verification methods. This effort will anyhow have to be linked with the R&D part of the SRNWP Verification action, e.g.:

"It is now a well-established fact that the verification of the precipitation forecasts of models with km-scale resolution cannot be adequately performed at that scale with the traditional scores. If it is done, the results are often systematically inferior to the results of models with coarser, even much coarser horizontal resolutions. The development of new verification methods for the precipitation forecasts suitable for km-scale models is today a very active field of research. It is necessary to assess one these new methods that NMS could use for their model version with the highest resolution. It is quite a new field of research. The interpretation of the results of these methods is still the object of discussion and, as for the traditional scores; each of them shows only one characteristic of the precipitation behaviour. At the present it would not be meaningful in this Proposal to dictate to the Responsible Member the method he should use. In Appendix 2, a few hints are given on some of these methods.

The SRNWP expert team on diagnostics, validation and verification will discuss and organise the evaluation of the newer scale-selective methods, and make recommendations. It will also encourage and organise the exchange of methods and code to implement them between consortia. Recent efforts to verify high resolution models are reported in Amodei and Stein (2008) for ALADIN, Mittermaier (2006) and Roberts (2008) for the Unified Model, Theis et al (2005) for COSMO, and Kok et al, 2008 for HIRLAM."

Getting now back more specifically to ALADIN, the 'verification' business is a long-standing point of debate within the programme community. To start with the present state, the situation is surely not disastrous. There is an on-going project of gathering and conventionally scoring all ALADIN operational results presented in an agreed common format, which was developed and is maintained by our Slovenian colleagues (with archiving of past realisations). The resulting comparisons are a useful tool for software enhancement decisions. Some ALADIN Partners participate directly to international inter-comparison exercises. This helps verifying that our system is among the best ones for LAM NWP. There have been sporadic efforts to score precipitation results against the nowcasting-oriented INCA analysis made by ZAMG. One is currently trying to organise this into a regular activity, which, coupled with INCA's extension to other Central European Services, could give in a few years time a nice complementary product to the Slovenian data. Last but not least, several Partners do have an in-house well-maintained system of measuring relative (to ARPEGE) and absolute progress and can use it for scoring parallel suites. This helps maintaining the quality-assurance of their own ALADIN operational declinations and, through circulation of the resulting information, the one of other Partner's versions, which shall only capitalise on 'measured' advances, even if a bit later

But all this does not lead to any concerted long-term planning, which should more and more be based on collective efforts and on some research plan. Excluding for the time being the EPS results verification (where the methodology is clearer and for which the march towards high resolution realisations is slower), one may consider the contribution to the research plan in this domain as a kind of project. The main idea standing behind it is a wide exploitation modern statistics and computational intelligence methods in development of new attitudes to diagnostic and verification tasks in the domain of meteorology - first of all fuzzy methods, pattern recognition, robust statistics, resampling, evolutionary programming and more. The final aim of the enterprise would be the development of new tools for mesoscale verification suitable in operational and R&D applications. On the four-year time scale this encompasses two groups of tasks: practically oriented- and research oriented ones.

Practically oriented tasks *(implementation and adaptation of 'fuzzy verification' for operational purposes; application of 'fuzzy verification' to model validation and comparison)*

The quickly increasing resolution of NWP models exerts strong pressure for implementation or adaptation of adequate mesoscale verification method(s) which can be combined with operationally exploited standard, point-to-point ones. Various kinds of fuzzy methods are among the solutions most commonly used in operational meteorology at the moment. Hence the choices for first implementations should be limited to this category. However selected method should be also appropriate for comprehensive models validations and comparisons. The last requirement imposes among others ability to effectively cope with various meteorological fields and scales and with data of different origin: from model, surface observing networks, various remote-sensing systems, especially satellite-born and radars.

Research oriented tasks (*developments in scale separation methods; improvements in meteorological data analysis and verification by application of robust statistics, resampling methods and missing data methods, developments in joint fuzzy and pattern recognition attitude to mesoscale verification)*

Spatial and temporal scales are ones of the key features characterizing atmospheric phenomena. Also different meteorological observing and forecasting systems work in various operational regimes and have specific technical features and limitations which result in different characteristic for their capabilities, scales. In order to take full advantage of all available observing networks and numerical models in analysis, prediction and verification tasks, one should work with adequate and comparable scales in space and time. Hence there is a great need to properly separate scales of interest in data obtained from different meteorological systems because only then appropriate comparison and merging procedures for data of various origins will be possible. There are many separation methods applied in meteorology (e.g. based on Fourier analysis and on kernel or wavelet methods) but still some meteorological fields (e.g. precipitations) or domains of meteorological applications require more adequate approaches. It means room for improvements of existing tools and/or developments of new ones.

Present verification methods usually suffer because of more or less serious deficiencies. Most of these deficiencies can be split into 3 categories: sensitivity to outliers, dependence on poorly founded or clearly false assumptions on error distribution and sensitivity to missing data. There is a need to develop and widely apply in research and operational work new verification methods avoiding the mentioned weaknesses. The new attitude should be built on achievements of robust statistics, resampling methods and missing data theory.

There are two noticeable classes of methods in contemporary applied mesoscale verification: fuzzy and entity-oriented ones. Both ways have their strengths and weaknesses. With advent of very high resolution NWP models none of them seems to be fully satisfying. Search for verification tools appropriate for kilometric scale is of prime importance: a combined fuzzy and pattern recognition method can be the most attractive and fruitful attitude. Adequacy of compared spatial scales (see above) should be kept in the method. Development of flexible and versatile verification tool(s) is expected within the frame of such a task.

Coming back to the central aim of this new effort (on verification):

It should first be stressed that common progress (and its measure against the output of other Consortia), even if shifted in time, requires to continuously assess who is currently 'leading the pack'. This is indeed one of the keys for perpetuating the ALADIN spirit for a truly common software which is both integrated (for ease of use) and flexible (for adaptation to local needs and means).

The other crucial key probably consists in efforts to understand (and concretise in actions) which high-resolution data are best to be used with new verification techniques. Of course, like it was already the case in the past, this last issue cannot be considered separately from the similar one concerning the use of high-resolution data for assimilation algorithms.

III) Dynamics and Lateral Boundary Coupling

First Sub-item of Section III: Overview and general issues

General context

The general context regarding the evolution of the dynamics in Aladin needs some attention. Individual and well identified topics (e.g. lateral boundary coupling) tend to become more and more complex, especially in view of the global complexification of the code kernel itself, but also due to the intrinsic complexity of the equation systems, discretisation algorithms and computer techniques which are used. Most scientific individual modifications devoted toward a new functionality of the system involve big and complex code changes, sometimes making modifications very hard to be designed and then implemented. The practical benefits from a new idea, scheme, technique are most often attained only after a very long time, and with more hazardous chances of success than most improvements linked to other parts of the system as e.g. in the observation usage or 4D-VAR assimilation. Another point is also a certain decrease through the years, of 'exciting and prestigious' new ideas for the evolution of the dynamical kernel, which may be likely to strongly attract young researchers in this field. To illustrate this we may cite the emergence of SL then NH systems in the past decades, which have no clear equivalent for time being. The main directions for progress now would be in the increase of the accuracy order of the vertical discretisation (through vertical finite elements or high-order finite-difference schemes), or the improvement of the behaviour of the lateral coupling (transparent and/or two-way nesting boundary coupling). Although this may be viewed as a rather pessimistic attitude, these thematics appears rather as quantitative improvements than as qualitative jumps in the concept of the dynamical kernel. This also participates to a progressive loss of attractiveness in the field of dynamics. Additionally, from the manpower point of view, the main feeling is that the critical mass for being able to sustain ambitious scientific and technical developments is progressively reaching the point of becoming insufficient, partly due to the fact that ALADIN persons are more and more solicited by short-term tasks linked to operational applications, and partly due also to the fact that HIRLAM and ALADIN communities must get used to work together on these subjects, which takes some time. In fact dynamics specialists seem to be very flexible people, able to fulfil on-demand other tasks as well and as efficiently as they do within their original domain of competency. Hence for lack of enough imagination for other solutions, or simply for lack of dedication to Consortium's pressing needs rather than to local short term priorities, we are witnessing a loss of manpower dedicated to dynamical issues, the number and importance of which is not at all diminishing. And since HIRLAM made the first step towards HARMONIE precisely because they were seeking help in front of a similar syndrome (for the NH implementation), we are paradoxically less well off than before, even when joining forces. However, there are still topics that are likely to significantly improve the quality of the dynamical kernel and they constitute the main substance of the work plan for the 4-years period considered here.

The spectral technique for 'new generation' LAMs

For 'new generation' LAMs, several desirable characteristics appear to be problematic in link with the spectral method adopted in the dynamical kernel of ALADIN:

- possibility of easy inclusion of large orographic terms (due to high-resolution), or more generally non-linear terms in the NH-SI scheme
- possibility of well-posed and/or transparent LBCs, thus offering a framework to circumvent the problems linked to the use of the current Davies relaxation scheme.
- possibility of two-way nesting (with a grid-point host model)
- possibility of inclusion of map factor variations in the NH-SI scheme for large domains

These aspects seem to plead for developing a local-type version (finite differences or finite elements) of the dynamical kernel.

However, some other developments might become even more difficult in a local-type framework than in the spectral one, e.g. the possibility of vertical finite elements for the NH kernel, because of the more intricate coupling of horizontal and vertical discretisations. On the other side, higher-order finite-difference schemes on the vertical may still remain relatively easy to implement in a non-spectral model.

For all these reasons, the relevance of developing a local-type version of the dynamical kernel should be prospectively considered, and a consensus on the question should be reached.

Then if this development is recognized as a prioritised task, it should receive the status of a well-identified project with the corresponding manpower devoted to it. This is far to be the case for time being due to a severe lack of manpower (vocations?) in the field of dynamics.
This project would represent a big work, and therefore HIRLAM should be associated to ALADIN in order to be able to fulfil the corresponding tasks. Due to the many associated uncertainties, it should also be accomplished in ascending compatibility with the well-known and stably-used spectral code, a fact that might plead in favour of finite elements rather than finite differences for the horizontal discretisation.

VFE-NH

In the context of the continuation of a spectral version of the dynamical kernel, the use of vertical finite elements (VFE) discretisation offers an attractive way to increase the spatial accuracy order of the system. A VFE scheme already exists for the Hydrostatic Primitive Equations (HPE) version of the model, as initially developed in IFS by ECMWF.
The extension of such a discretisation to the NH compressible version of Aladin raises several problems, most of them linked to the difficulty to secure the stability of the eigenmodes of the associated linear system (the one used in the SI scheme) altogether with a realistic spatial structure of these eigenmodes. Many progresses have been made during the four previous years in this field, and a version of the NH kernel with VFE is able to produce forecasts, with only a small part of terms still treated in the old finite-difference manner.
Collaboration with HIRLAM group is progressively becoming fructuous, allowing new ideas to emerge. The treatment of top and surface boundaries is a key point and formulations with alternative sets of functions near the edges should be examined in order to remove the artefacts of the current set at boundaries, and thereby allow a more flexible and natural way of controlling the eigenvalues of the eigenmodes.
Another direction of work, also proposed by the HIRLAM group is to try to concentrate on controlling the small imaginary part of eigenvalues of an operator which is real in non-discrete context, by purely algebraic an 'minimal' modifications of the linear system, taken as a whole, therefore abandoning the current paradigm which consists in seeking discretisations which intrinsically produce pure real eigenvalues for the considered operators (e.g. the operator of the Helmholtz equation which appears in the SI scheme).

Still in the topic of possible developments of VFE-NH schemes, the question of changing the set of prognostic variables in order to use the true vertical velocity "w" instead of a vertical divergence "d" should be examined and then closed (either with a positive or negative answer). This work was originating from a wish of ECMWF to get rid of the formulation with the prognostic variable "d", but the application of the LGWADV scheme (in which only the linear part of computations are made with the variable "d") could be a viable alternative which might create a consensus. This question also should be instructed and closed in the four-year term of this plan.

HDiff and links of Dyn with 3D-Turbulence

The behaviour of the current spectral linear horizontal diffusion has shown to be quite sensitive in AROME, especially in some convective situations, and this should be elucidated, even if a link with physical packages may also be suspected in this problem.

More generally, the functionality of non-linear (flow-dependent) operators (though the SLHD scheme) should be considered as a partial alternative. Potential problems encountered in a routine framework will be examined in order to make the scheme applicable to the large variety of applications. A potentially interesting issue would be to make the formulation closer to an "exchange coefficient" approach, in order to make it possible to include in the diffusion process a part of the 3D turbulence, by profiting from the 3D halo which is available in the SL part of computations. This would lead to a diffusion operator with more physically-based foundations, compared to the current linear diffusion.

Large domains

The possibility to use the NH model over very large domains with a constant-value linearisation of the map factor in the SI scheme is a priori not viable. A possibility to use a fitted value has been designed on the paper but still remain to be implemented, and the resulting scheme needs to be validated. As mentioned above, the problem is made more complicated in the spectral approach than in a pure grid-point approach.

Equation sets, multiphase aspects

When condensates are present as species represented by prognostic variables, and may have a separate kinematics from the gaseous flow, the physical system represented by the meteorological equations can no longer be considered as a mono-component fluid.
The phenomena related to the presence of a velocity departure between the condensed species and the gas must be taken into account or parameterized or ignored, as currently, but this latter option is of course a first-order approximation which may become a cause of significant errors in some cases with strong precipitations at high resolution.
The desirable form of meteorological equations for this multi-component fluid is still an open question (especially regarding the vertical momentum equation). The modification of the code in consistency with the resulting modified set of equations has not even been undertaken.
However, on this difficult and partly theoretical subject, no consensus has been obtained, and the critical amount of manpower does not exist.

Higher resolutions

The evolution toward higher resolutions often needs further research/development/validation.
It may be anticipated that in four-years, the horizontal resolution will be below 2 km in most operational applications, which is not a very serious challenge compared to the current AROME resolution. But the vertical resolution will certainly be significantly increased and this may result in more demanding preparative actions (the number of levels in four-years might be around one hundred in routine applications).
Beside this, operational applications for local short-range forecast and assimilation (e.g. over airport areas) is likely to become common practice, and this type of application would require resolutions around 100 m, which is quite challenging, especially over mountainous regions. The dynamical kernel (together with the physical package) must be prepared for this kind of application.

Second Sub-item of Section III: Numerical efficiency

The main purpose of the ALADIN project is to provide its members, national weather services, a state of the art numerical weather prediction model for the local operational weather analysis and forecast up to 48-72 hours in advance at the horizontal resolution and complexity affordable to the national weather service. This forecast is expected to have better forecast skill than the driving, synoptic or large scale model.

The expected improvement of the higher resolution or more sophisticated physics and dynamics is better prediction of the position and intensity of the predicted weather system as well as its details. Misplacing some intensive weather events, such as local precipitation maxima, leads both to double penalty in verification scores as well as the output forecast that is "wrong twice".

Better numerical efficiency should encompass usage of numerical schemes that allow numerical stability of the model when used with long time-steps and higher accuracy that allows more reliable deterministic forecasting of the intensity and position of weather features, especially in the cases with high impact weather when the time and position of the local precipitation and wind speed maxima are the crucial bits of the forecast.

The limit in the accuracy of the forecast should be remaining in the analyzed fields coming from the data assimilation algorithms. These inaccuracies in the initial input fields might come from the data assimilation procedure missing the initial small scale meteorological feature either due to the coarse resolution at which the data is assimilated or too coarse observation network. Hopefully, the same small scale feature will not be missed in the initial state due to discarding the relevant piece of data for being too far from guess which happens when the small scale meteorological feature is forecast in the wrong position, either in space or in time, not to mention in intensity.

The planned developments in the fields of physics and dynamics may potentially create situations with numerically complex unphysical behaviours. Finding practical and acceptable solutions for such problems requires the testing capacity and the workforce likely to be missing after the initial scientific contribution and development.

Several years ago, research and development in numerics for dynamics and physics has been greatly improved with a positive feed-back between better theoretical understanding of the behaviour of the used numerical schemes and the numerical experimentation framework. Unfortunately, this research process did not continue with the same pace and productivity due to allocation of human resources on other tasks, mostly of local importance. This has not completely prevented the emergence of new ideas in the field, but it removed the manpower with capability of implementing and testing them.

Although the work on numerical efficiency issues might seem purely technical, its progress so far seems to prove otherwise. The complex problem of the anti-fibrillation procedure has yielded a practical and useful solution. The numerical coupling of surface to the upper atmosphere and the coupling of physics to the dynamics on different points on the trajectory both in space and time are other subject where not only technical and code developments are expected, but also a scientific contribution in a form of published papers that are most valued forms of proving the scientific content of any development when going to the scientific community.

The above-mentioned pace-slowing might have some unfortunate consequences since it should be crucial to ensure that the improvement in the objective scores or predicted precipitation maxima is coming from the parameterized process and not its numerical and unphysical properties.

We need tools that would allow distinguishing which part of the result is the product of parameterized or dynamical process and which part of the forecast is a consequence of numerical noise coming from inappropriate coupling of the physical process to the dynamical one, of model spin-up or of the numerical scheme used to solve a particular problem.

Significant changes in horizontal and vertical model resolution and model time-step and the level of sophistication in the parameterization of the physical process might yield different numerical method as the most efficient on to solve the particular problem.

The management of all the possible options in the AAAH system, especially when coupling of a particular physical parameterization package to the dynamical core is considered, should be joint responsibility of all the interested parties and require special attention and careful coordination of the efforts. The most general, flexible and modular framework of the solution would be beneficial for solving the above challenges.

Third Sub-item of Section III: 'LBC + Coupling' and Miscellaneous

Alternative formulation of the LBC and associated scientific issues; a prerequisite

It becomes more and more necessary to implement the approach of Boyd (2005) in ALADIN. One believes that this has to move to highest priority in ALADIN. It will allow all future research on LBC's to take this as the established solution. This will eliminate any concerns about suspicious accuracy related to the existing spline interpolation, allowing to focus on the more relevant open issues described below.

Boundary strategy for large area models (hydrostatic)

The standard lateral boundary treatment uses the fields from a global model to update the boundaries, allied with a zone adjacent to the boundary in which the guest fields are relaxed toward the host global fields. This is a source of error for two reasons: (a) all the fields are imposed (over-specification) and (b) the fields are only updated every 3 (sometimes 6) hours.

These errors can propagate from the boundary into the forecast area at essentially two speeds: (i) 'slow' (advective-Rossby waves) and (ii) 'fast' (gravity-inertia waves). The 'slow errors' are taken care of by situating the lateral boundaries far enough away from the region of interest so that they cannot travel there during the duration of the forecast. The 'fast errors' are eliminated by having a damping zone adjacent to the boundary. In that zone the damping mechanism is tuned to eliminate these boundary generated gravity inertia waves.

The strategy can be summarized as follows: treat the boundary in a crude manner, but make sure this crudeness does not compromise forecast accuracy in the region of interest; let us call it 'over-specify and relax'.

Boundary strategy for small area models (non-hydrostatic)

What should be the boundary strategy for an operational non-hydrostatic model? The above implementation of the 'over-specify and relax' philosophy becomes difficult to justify for non-hydrostatic models. Firstly, the limitations of computer power mean that it is not possible to move the boundaries far enough away to prevent advective errors from contaminating the forecast when rapidly moving depressions are crossing the boundary early in the forecast. Secondly, by definition, gravity waves must now be important. (if not, why go non-hydrostatic?). Therefore, having a boundary damping zone becomes problematic (how does one distinguish boundary generated 'noise' from meteorologically significant gravity wave activity?). Thus, both the 'slow' waves and the 'fast' waves can now contaminate the forecast.

What should be done? At this time there is no option but to continue in the short-range with the 'over-specify and relax' strategy.

Improvements which can be implemented in the immediate future

Within the context of the 'over-specify and relax' philosophy there are a number of improvements which can be attempted. A significant improvement is the following. The frequency of the boundary update is an obvious flaw, particularly in the case of nested systems with small innermost integration areas. For maximum accuracy the boundary should be updated every time step of the host model. In a nested environment this is perfectly feasible in principle: run the host model for one time step δt_h, at the end of which dump a boundary file for the guest model; stop the host model and run the guest model for n time steps, where $n.\delta t_g = \delta t_h$, using the boundary files dumped by the host model; continue, overwriting the boundary files. The expectation is that the advective waves would now be treated accurately enough to alleviate the need to keep the boundary in the far distance. Additional improvements can be made. Use the host model orography in the relaxation zone. Use weak boundary coupling in the lowest model layers. Tune the relaxation coefficients for fine grids and frequent boundary updates. One now needs to damp 'acoustic' as well as 'gravity' waves. When interpolating the boundary fields to the guest model use a method which produces well-balanced fields. Of course, none of these improvements solves the problem of distinguishing 'physical' gravity waves from those generated by the over-specification of the boundary fields.

Improvements which can be implemented in the more distant future

Is there a superior boundary strategy which addresses this issue? In principle, yes, there is a well defined method of treating the boundary accurately based on the ideas of Engquist and Majda, which McDonald, Termonia, and Voitus have been examining. This has been shown to work very well for linear systems for grid point models, and for one dimensional spectral models.

Essential tool for testing boundary strategies

In HIRLAM there exists no rigorous means of testing the impact of changes to the boundary coupling within the HIRLAM framework. Such a procedure does exist. It was described by Baumhefner and Perkey (1982). Let us call it the 'perfect forecast' method. The simplest way to set it up is as follows. First, run a (say 48h) forecast over the host area using a fine mesh. This furnishes the 'perfect forecast'. Second, repeat this forecast over the host area using a coarse mesh. This furnishes the 'coarse host forecast'. Store all of the prognostic fields at every time step for both these runs. One can now nest a guest area within the host area and test different boundary coupling strategies with rigor, since one has a perfect forecast with which to compare the guest area forecasts. Incidentally, running the guest forecast fine mesh forecast with a boundary update every time step provides us with a definitive test of the coding of the boundary coupling: if the forecast is not identical to the perfect forecast the code is erroneous. See McDonald (1998) for further discussion of what tests should be performed. Probably the best way to set this up is to run the host and guest forecasts simultaneously, as was described above.

Strategy for continued research in transparent boundary conditions in spectral models

1) <u>Strategy</u>

The aim is to investigate the possibilities of developing well-posed LBC's in a spectral model, specifically for the ALADIN dynamics.

Formulating well-posed LBC's is a tedious problem, since one essentially needs mathematically rigorous formulations as well as numerical stability. This makes the problem much more difficult than physics parameterization and dynamics. Indeed, in the latter the equations are essentially provided by nature while the remaining task is to control the unstable modes. Any well-posed LBC formulation is artificial by its very nature and there is no guideline from nature as to how to treat them. This leaves a wide range of formulations with no guarantee that one of them will work sufficiently well.

The problem is even more tedious for spectral models since in spectral space it is practically impossible to adapt fields locally, in particular at the lateral boundaries.

Research in LBC's is thus filled with pitfalls. Many of them have already been identified by work carried out in the HIRLAM community by McDonald (2000, 2002, 2003, 2005 and 2006). Therefore his work serves as the benchmark for potential future ideas on spectral well-posed LBC's.

Two general approaches have now been proposed for solving the 'spectral problem': the so-called extrinsic LBC's (Termonia and Voitus, manuscript) and iterative LBC's (Voitus, Termonia and Bénard, in preparation).

The 'Perfectly Matched Layer' (PML) approach has been demonstrated to be reliable in the sub-gravity case (i.e. when the gravity wave speed is greater than the wind speed velocity). However, in most geophysical applications the supergravity waves provide most of the contribution of the internal gravity waves. This makes PML presently a less attractive candidate for immediate investigation. Nevertheless, one should stay open-minded about it, i.e. monitor the literature, but not immediately focus HIRLAM/ALADIN research on it.

2) Known pitfalls

A brief list of the pitfalls identified by McDonald are:

- The problem that one calls "drift" in higher-order LBC conditions. It is expected to show up, independently of the dimensions of the system and of the type equations one is dealing with.
- The "corner problem": imposing LBC in the corners of a 2D horizontal domain causes problems. This confirms the need for 1D tests to separate this issue from the others. This corner problem will also be present in the spectral model.
- The problem of the trajectory truncation in semi-Lagrangian schemes. The upshot of the past research is that the so-called time interpolation is the best stable candidate for solving this. However, in its present state in the spectral-model setup, this time interpolation is computed with an iterative procedure which needs many iterations.
- Tests in a realistic setup (with real data) of McDonald (2003) without initialization made the LBC's inaccurate. This is very worrying, since it suggests that there exists a critical level of spurious gravity waves that can not be supported by the LBC formulation.

In the full 3D model it is difficult to properly diagnose these issues separately. Therefore the proper approach to make progress in this domain is to progressively proceed from simple models, via more sophisticated ones to the full model.

Some issues specific to the realistic equations are:

- The hydrostatic primitive equations – The hydrostatic equations are not mathematically well-posed. There is an incompatibility between integrating the hydrostatic equation vertically and handling the LBC's properly. – Problem of the "anomalous" mode associated with the Lorenz grid. Is their a more elegant solution than 'tweaked Lorenz grid' of McDonald (2006)?
- Euler NH – Presently it is not yet clear how to formulate the LBC's. Identifying the different waves (acoustic and gravity) leads to expressions in mode space which can not be straightforwardly transformed into a spatial constraint formulated in terms of differential operators, unless one uses approximations. It may not be possible to find approximations valid for the both gravity waves and acoustic waves simultaneously (see concluding remark at the end of the discussion on LBCs).

3) Extrinsic LBC's

The question posed by Termonia and Voitus (2007) is whether the lateral boundary conditions can be generated by means of a numerical scheme that is strictly distinct from the one that is used for the dynamics (SI SL). This is called an extrinsic scheme. There is now evidence in the 1D case that this is true. The 1D tests have even shown that the extrinsic scheme has the additional 'free benefit' of solving the Semi-Lagrangian trajectory truncation problem.

The primary aim is to carry this through to more realistic equations and higher dimension. If the validity of this concept is confirmed this may turn out to be useful for various reasons. The most conspicuous reason is that one could use an Eulerian scheme at the boundaries, which would eliminate the trajectories altogether.

The disadvantage is that one is here on scientifically unexplored territory. Additionally this approach touches the geometrical structure of the model. So one will be forced to revisit the model data flow at some stage.

A possibility that should be explored is to write an extrinsic scheme in the basis of the characteristic values, (Shoucri, 2004) which has some potential of providing enhanced stability.

4) Iterative spectral LBC's

Here one builds on existing knowledge to get better stability by iterating the dynamics with corrections at the lateral boundaries. The disadvantage is that LBC's will be tightly intertwined in the dynamics, so future developments in dynamics will influence the treatment of the LBC's and vice versa.

Currently, the Achilles heel of this approach is in the convergence of the iterations. Four iterations were necessary in the 1D tests to get acceptable results, which is discouraging. However, there are still un-investigated choices that might accelerate convergence. This will be the primary subject of some further study.

5) Model progression

Obviously, in full the 3D model, there are too many things that may go wrong at the same time. The only way is to solve the problems by progressively going from simple to more sophisticated models. One proposes the following model progression:

- 1D SW with Coriolis;
- 2D SW x – y;
- 2 layer model;
- 2D HPE x - σ;
- 3D.

The 1D and 2D linear models have analytical solutions. However, in each case a non-linear version of these laboratory models will be investigated. Clearly, for the non-linear tests a 'perfect forecast' setup will have to first be developed. It should be noted that a 'perfect forecast' setup exist for the full 3D ALADIN model (work of Masek and Vana).

The search for a more elegant solution than the "tweaked Lorenz" of McDonald (2006b) should be done in the 2D x - σ model.

Tests in the shallow-water models should start with zero-th order transparent LBC's and once these work they should be replaced by first-order ones to test the problem of the drift.

In this model progression it will be checked whether the proposed solutions are consistent with the existing 3D ALADIN dynamics.

For the extrinsic LBC approach this leads to the following road map:

1. Tests in the 1D linear shallow-water model with different extrinsic schemes; tests with bell-shaped feature entering the domain and radiation and adjustment test. This has been done (Termonia and Voitus).
2. The problem of the inaccuracy coming from the different nature of the spectral and the grid point space (specifically, the so-called Q operator in Termonia and Voitus) should be studied. For this ALADIN should first, or in parallel, switch to the approach proposed by Boyd (2005).

3. The problem is now that sub-stepping still has some CFL condition. So the next step is to test whether this approach of the base characteristic approach (Shoucri, 2004) allows getting a solution which is sufficiently practically unconditionally stable, provided one makes a small number of substeps. The same tests in the linear 1D shallow-water model as in point 1 will be used as benchmark.
4. Instead of first testing the non-linear 1D shallow-water model, the next step is to go the 2D linearised shallow water to see (i) whether extra complications will arise due to the organization of the extrinsic buffer near the boundary, (ii) to check the solution of Shoucri of time splitting to handle the characteristics in 2D, and (iii) to check the corner problem. The precise sequence of the subsequent research will from then on depend on the success/failure to solve the above issues.

For the iterative approach,

- The first tests are carried out in the 1D shallow-water model. The main goal is to study alternatives to accelerate the convergence of (i) the iteration in the 1D linear shallow-water model and (ii) the convergence of the solver of the trajectory time interpolation.
- Next, one will first go to the non linear version of the 1D shallow-water model in order to study the inclusion of the non-linear terms in the modified equation within the iterations. Convergence is the main issue here. It will then be decided from the outcome of these tests how to proceed to the more sophisticated models.

Diagnostics

Currently, the following diagnostics have been used RMS errors of the forecast fields, mean average divergence and mass budgets. For the non linear model the only known option is probably to carry out 'perfect forecast' tests. All aspects of LBC's should preferably be tested distinctly. For instance, outgoing modes should be tested in radiation experiments to check transparency. Subsequently, one should inject incoming modes to tests whether the meteorological features enter the domain correctly. Both aspects should systematically be tested, preferably separately.

Alternative formulation of the LBC and associated scientific issues; a conditional wrapping-up

In one way to look at the coupling problem now, the key question is whether one may find a well-posed formulation of the LBC's for the Euler equations. There is no reason to assume at present that this is possible. If we don't succeed in this all the rest does not make much sense. The problem with well-posed LBC's is that physically gravity waves and acoustic waves are actually a low $k^2 N^2/c_s^2$ limit manifestation of the solution of a dispersion relation that satisfies a quartic equation. The solution of this equation cannot be written in a local form, i.e. containing derivatives and hence it is impossible to formulate local LBC's. One option could be to approximate this equation by an expansion in small number, which should be typically buoyancy over speed of sound, and use a truncated version the higher-order derivative operators found in this way. Such a formulation should be tested in the Euler model, before attacking the more specific issues related to LBC's and testing them in both approaches of extrinsic LBC's and iterative procedures. This basic scientific question has indeed to be clarified.

Scale selective DFI and MCUF

It has been shown that DFI can filter some part of the meteorologically relevant modes when the propagation velocity of the large-scale flow becomes large enough (Termonia, 2008). This effect is essentially a Doppler effect. Consequently, its effect is more pronounced for the smaller scales, so one can expect this to become a bigger problem when increasing the resolution. The effect already manifests itself in the case of the Lothar forecast by ALADIN coupled to ARPEGE, but it may become worse for models running at kilometer scale coupled to a 10-km resolution. It may even be felt in other feature then the wave of an extreme storm.

Currently it has been shown that a DFI where the amount of filtering depends on the scales, i.e. the large scales are filtered more than the small scales, can cure the problem of the Lothar storm. This implementation has been possible or at least extremely easy to perform in a spectral model.

The work in Termonia (2004) allows to monitor the passage of fast propagating storms. This would allow to implement a coupling strategy with a procedure to blend a storm in the forecast in case of information loss at the lateral boundaries. The used DFI in that case must be scale selective and the wave-number dependence of the filter window can be adapted to the amount of detected information loss.

The work to concretise these ideas consists of two parts:

1. Phasing of SSDFI: an implementation of this exists in cycle 29 at the RMI. This should be phased. Note that it is possible to see SSDFI as a generalization of DFI, i.e. one might envisage a filter where the usual DFI is a special namelist-case of the generalized class.
2. Alternative coupling strategies: this consists in finding the optimal choice of using the MCUF field, blending and SSDI.
3. Quantifying the Doppler effect of the rotational flow. The interesting scientific question here is whether this Doppler effect is also felt in other meteorological features, at the very small scales, e.g. squall lines, very sharp fronts,… One could try and generalize the approach for the space-time spectral decomposition used in Termonia (2008) and also extend it with wavelets.

It should be briefly noted here that work on the DFI 'tool' must regain some lost priority, not only for the above topic but also for items specifically linked with the transition of physics to kilometric scales (grid-point variables' DFI, need to disentangle R and T for a DFI application when RT is the spectral variable of the model; DFI for additional prognostic variables in the NH case, …).

Time-step organization and the existence of compensating physics-dynamics coupling errors

The time-step organization of ARPEGE/ALADIN is not the best one from the point of view of numerical accuracy. The fact that it works well is currently believed to be due to historical tunings of the physics, inaccuracies with respect to nature having always been accommodated unconsciously within the boundaries of the unknowns of the physics parameterization. In some sense one believes this is a subtle form of compensating errors, but one which is very difficult to diagnose. The way to diagnose it would be either to change the time-step organization with the same physics or to use the same time-step organization with a modified physics. The latter is already the case in AROME and HIRLAM, if one can indeed one day call those, all other things equal within the current interface.

Anyhow the present strategy has worked fine in the past. Nevertheless, with the existence of the different physics packages with the ALADIN-AROME-HIRLAM community, it may pay off to reformulate the physics-dynamics coupling in a more clean way, i.e. more clean in the sense that if the parameterization were correct (which it never is) this would lead to more accurate results.

IV) Link with applications

NB: only three items will be considered here. There are indeed many more items at the 'edge' of the ALADIN Programme that may in principle belong to this Section, but it was felt that some ab-initio structuring should first be noticeable before the Programme supervision and management takes over part of the umbrella action. In other words, if some ALADIN meteorological services notice both a need and a potential for harmonisation it is up to them to undertake the first step leading to awareness of the concerned issue at the consortium level.

First Sub-item of Section IV: Link with Academia

This item is quite novel in the ALADIN framework (or rather the HARMONIE one, owing to its elaboration directly in this joint perspective with HIRLAM). The 'project' got the acronym CHAPEAU, *Common HIRLAM ALADIN Package for Education and Academic Use.* Since quite a lot of work is involved and only limited manpower is available, it is important to streamline current and planned efforts. The aim of the first discussions undertaken was to get insight into the experiences, wishes, ideas and expectations of the various parties involved, in order to find common ground for a quite long term joint effort. The following preliminary orientations were proposed.

Different kinds of use should be distinguished:

- Use at a higher level, e.g. to show how a model works, requires a model that can be run by others with provided or own data, and a possibility to choose among main options. For educational use the possibility of modifying input fields, in particular orographic fields, in a transparent way is of importance. This model might also be used as atmospheric driver for other models (chemical transport, hydrology, ocean).
- For more extensive research on NWP modelling we need to make available a more open model environment in which research can be carried out, e.g. research on different physical parameterisation schemes.
- A third kind of use could be upstream research in which results from academic research can be incorporated in the development.

The different ways of delivery could be implemented in this order. Making available a higher level model helps promoting the model at universities and probably leads to the request for more open model environment. If step 3 is reached the NWP community directly benefits from academic research. More generally, it was commonly felt that some research topics often arise that cannot be investigated by ALADIN/HIRLAM personnel. These topics could be very suitable and interesting for academic research at different levels (masters, PhD) and within each of the above-mentioned steps. The consortia could benefit a lot from the results. It should however be clear that each step also poses different requirements on involvement of ALADIN/HIRLAM personnel.

Conditions for use by/ involvement of Academia:

- Easy access and installation on different platforms
- Relatively easy to run a standard version of the model, e.g. by providing unix scripts with predefined settings and namelists, with guided choices for the most important options. (comparable with MM5/WRF). No fancy graphical or fully automated interface is needed.
- Input data has to be provided. The policy on some input data restricts the use at universities. Another solution may be to provide conversion tools so that freely available input data can be used.
- Post-processing and visualization of input- and output fields is important. This may require input/output data to be produced in formats recognized by open-source visualization tools.
- Good accessible/findable documentation, (linked to the code if needed)
- Easy accessible support. A suggestion to do this is to organize supervision by someone at the university who knows the ALADIN/HIRLAM community and model.
- The software/system that is delivered has to be free for academic use. For the IFS-born part of the software, a relevant document is the ALADIN-related software agreement between ECMWF and Météo-France and especially its Appendix listing the ECMWF protected parts.
- When the model environment is used for NWP research by universities the code has to be linked to the scientific documentation more closely than is the case for the operational software. A suggestion is to write a variant of parts of the source code to accommodate for this in the academic model environment. Automatic code generation tools might be useful for this.
- We aim at a single CPU code for university research, a multi-processors configuration will not be supported.
- Implementation of the single column version at a university may be a sensible first step.

In short, the initial (and practical) underlying aim is to have a tool that will be used to train future students in modelling itself, rather then letting them use the model as a black box, but having a code that can be used in a LaTeX-formula type of coding style and without the complexity of parallel computing implementation.

Basic positioning of the action:

The basis of MM5/WRF (often proposed as example for what CHAPEAU should aim at) is a cooperative development between universities and meteorological services of a mesoscale model for research and forecasting, whereas HARMONIE has been developed by meteorological services with a strong emphasis on operations. Reverse engineering of HARMONIE to conform up to the point of making it fit an MM5/WRF template may be a costly option. A different form of cooperative development may be more suitable in the

European context. Such cooperation could be based on contracted projects, where universities provide research capacity and met services provide support in the form of code expertise, implementation support and possibly access to computing facilities. Contractual agreements may solve restrictions that are currently placed on parts of the code and system.

In the longer term and referring again to MM5/WRF which has been able to gather a large community of users, one should not forget that testing new instruments, cooperating on NWP-based nowcasting with a better use of radar data are domains where collaboration with Academia could be rewarding, especially since NMS are the best (and perhaps only) institutes able to offer an operational environment (e.g. collection of all available observation data for instance) for academic partners to test their ideas. This could be a quite attractive way to make HARMONIE much more known and reputed.

Second Sub-item of Section IV: LAM-Climate

Limited area model ALADIN is currently used for climate research purposes at CNRM, CHMI, HMS and NIMH with scientist from other countries also participating on the research and development (Romania, Morocco, Canada). There are two versions of model currently in use: firstly it is ALADIN-CLIMATE V4 as developed at CNRM/GMGEC in close relation to ARPEGE-CLIMATE (and thus sharing for example the same set of physical parameterizations) and secondly it is ALADIN-CLIMATE/CZ directly derived from NWP version of the model as used at CHMI in the years 2003-2004 (pre-ALARO stage). French version of the model is based on cycle 24 whilst the Czech one is derived from cycle 28.

French ALADIN-CLIMATE V4 is operated also at Hungarian and Bulgarian meteorological services and at OURANOS consortium in Canada as well. In addition scientist from Romanian meteorological service participated on development of the model (e.g. introduction of spectral coupling into the CNRM version). Up to now, Czech version of the model is used only at CHMI.

The model in both of its mutations has been successfully used in frame of several national and international projects (e.g. EC FP6 ENSEMBLES, CECILIA) allowing for its direct comparison with regional climate models operated by other climate research centres. Its output has been utilized for a wide range of impact studies including agro-meteorology, forestry and hydrology.

Generally, to stress its difference to NWP versions the development of climate versions follows the progress of NWP but usually with some time delay (2 to 6 years given present model complexity) in implementation of new features. This is given by the different needs of climate research community (including impact researchers) resulting in the necessity to keep model stable for long time studies and research projects in order to secure the comparability of obtained results. Another reason is the focus on more theoretical aspects of models performance and properties in order to better understand it for which studies with somewhat coarser resolution and simplified physics are sufficient. Finally we should mention that implementation of new features is time demanding process as the careful and prolonged testing is often necessary before their final inclusion. This is due to the necessity to secure a safe and stable performance for long model integrations as some erroneous and undesirable behaviour of tested features could become evident only after long-time tests. Identification and understanding of such features and better understanding of model behaviour in general when integrated over long-time periods could also additionally provide a feedback for the community of NWP modellers allowing them to select and implement more realistic solutions for weather forecasting.

The planning for the future development of the model will be based on needs of the scientific community, available resources for climate modelling in participating countries and institutions and general development on the field of numerical (climate) modelling. We could expect that in the period of the forthcoming 4 years ALADIN will be developed into full-fledged regional climate model. To reach this goal the following objectives have been identified as the research goals to be dealt with in the time frame of the 4-year plan:

- Development of model pre-processor allowing for the use of initial/lateral boundary condition originating from other global climate models to ARPEGE-CLIMATE (HadCM, ECHAM). This should stimulate the use of ALADIN in “ensemble” style of studies where the focus is being laid upon various combinations between single global and regional models.
- Improvement of coupling technique based on comparison of “traditional” grid-point based coupling and spectral coupling. More studies focused on spectral coupling and its properties should be performed. The better of both methods should be introduced as the standard and primary choice.
- Ocean-atmosphere coupling should be introduced and could become possibly standard in case of experiments including large areas of sea surface. Regional version of ocean model NEMO is currently studied and tested for this purpose.
- Studies of model behaviour on high-resolution scales should be conducted. Outputs available from contemporary projects (FP6 CECILIA) could be partly used in this research aim. This aspect is crucial for the future development in the community and thus should be performed in coordination with other research teams (preferably in frame of wider international projects).

Practical implementation of abovementioned goals will be made in close cooperation between involved ALADIN partners with “centre of gravity” located at CNRM/GMGEC and as explained it will be dependent on the development on international scene and on the priorities and possibilities within national communities of ALADIN consortium members. It is expected that development at CNRM/GMGEC will continue in current frame of complementary ARPEGE/ALADIN system focusing on issues like coupling between regional climate and ocean models and experimenting with spectral coupling and its impact on modelled fields. At CHMI the development based on available “ALARO” code will continue with stress laid upon studies dealing with practical aspects of modelling in high resolution (particularly over Central Europe).

The combined effort of national ALADIN-CLIMATE research teams should lead to continuous expansion of the model into other countries and its better establishment in the global climate research community.

Third Sub-item of Section IV: Nowcasting

Introduction

The INCA analysis and nowcasting system (Haiden et al., 2007) is used operationally as a basis for very-short-range meteorological information and warning services and provides input for downstream applications such as flood prediction models (Komma et al., 2007). The system has been designed particularly for applicability in complex terrain. Operational verification confirms the added value of the INCA nowcast compared to NWP direct model output but also indicates several aspects of the current version of the system which could be improved. In order to be able to apply INCA to a large domain encompassing Central and Eastern Europe, the following developments are considered necessary.

Action 1: Precipitation analysis and nowcasting

Cross-validation of precipitation analyses shows that during convective episodes, when the rainfall patterns are dominated by localized cells, the quality of the combined raingauge/radar analysis of INCA is significantly better than simply using raingauge interpolation. However, in cases of widespread precipitation the improvement is less pronounced. The current seasonally-dependent pre-scaling of the radar field will be replaced by a situation-dependent pre-scaling using a distinction between convective and non-convective derived from 3-D radar data. While the method will be unified, the actual computation of pre-scaling factors needs to be derived individually by each partner country for their radar characteristics. In order to further improve the INCA precipitation analysis, a more complex merging algorithm of radar, satellite, and ground measurements will be developed. Satellite information will be used to further reduce the occurrence of spurious patterns in the radar field.

The current precipitation nowcasting scheme is unable to predict the evolution of convective cells, characterized by the processes of initiation, intensification, and weakening. Based on an existing prototype algorithm (Steinheimer and Haiden, 2007), an operational cell-evolution scheme will be developed. The method is using convective analysis fields such as CAPE, mass-convergence, or trigger temperature deficit to predict the probable further evolution of convective cells. Here, additional satellite-derived information (instability indices) from the MSG system will be used. In cloud-free areas, use of satellite data for actualisation of INCA temperature and moisture profiles will help to better estimate rapidly changing convective instability conditions. In addition, the cell-evolution scheme itself needs to be developed further. Specifically it should use all available remote sensing information relevant for convection, such as cell-specific intensification/weakening tendencies derived from consecutive infrared images, or lightning detection data. It should also be tested whether an update frequency higher than the 15 min interval currently used in INCA would be beneficial for convective nowcasting, especially with regard to localized flash flood warning and prediction.

Action 2: Temperature analysis and nowcasting

Under stable conditions, in particular during inversion situations, the INCA temperature analysis contains significant uncertainties, mostly because the vertical structure and top of the stable layer or inversion is not known. The altitudinal coverage by surface stations is insufficient to resolve the actual temperature profile in a valley. Moreover, ALADIN providing the first guess for INCA does not usually predict the correct depth of the cold near-surface air in mountainous terrain because it does not resolve the detailed topography. The current assumption of a prescribed, fixed inversion depth will be replaced by an estimation based on satellite data. Data from the MSG set of products as well as from the polar orbiting METOP system will be used as additional sources of information for the temperature analysis.

The high-resolution METOP surface temperature data, although available only once per day, could be used to better locate the height of inversions in mountainous areas.

Action 3: Cloud analysis and nowcasting

Many downstream applications (e.g. aviation forecasts in mountainous terrain, forecasts for winter road maintenance, or forecasts for mountain resorts) require more than just total cloudiness. For such users the height of the cloud base and associated visibility conditions are important parameters. In cases of low stratus, cloud top height is important as well. The current INCA cloudiness cannot provide this information. The objective of developments in the cloud analysis is to move from a 2-D analysis to a 3-D analysis. Cloud top height will be assessed by use of satellite information in combination with the 3-D humidity field. Cloud base will be estimated from near-surface dewpoint deficit as derived from the temperature and humidity analysis and the degree of mixing, judged by wind speed and stratification. During daytime, use of the MSG visible image will lead to a more highly resolved and better structured cloud analysis, especially in the case of cumulus cloudiness and low stratus. In an improved version of the cloud advection algorithm there will be the possibility of at least two cloud levels with corresponding different cloud motion vectors. This allows the INCA nowcast to predict that upper-level cloudiness moves over a stationary low-level cloud field.

Action 4: Pressure analysis and nowcasting

The current version of the INCA wind analysis does not take into account the pressure field. The wind field is derived kinematically by applying a sequential relaxation algorithm to the divergence field. It is however desirable to include pressure and exploit pressure/wind relationships to obtain a dynamically consistent wind analysis. In order to perform proper dynamical wind nowcasting (not just a local error-persistence nowcast as in the currently operational INCA version), information about the pressure field and its spatial and temporal changes is needed (cf. W10). Unless reference to the pressure-field is included in the system, it will be unable to nowcast the movement of fronts, convergence lines, or squall lines, or any kinds of thermally driven flows (valley winds, lake breezes). A three-dimensional pressure analysis shall be implemented in INCA. Existing methods of quality control of pressure observations for use in analysis over complex terrain (Steinacker et al., 1997; Steinacker et al., 2005) will be adapted into the INCA system. Starting from the NWP pressure forecast as a first guess, corrections will be made based on surface station observations, with the additional constraint that the three-dimensional INCA temperature analysis be hydrostatically consistent with the pressure field. From the nowcast of the three-dimensional temperature field, a nowcast of the three-dimensional pressure field will be derived hydrostatically. The aim of the work is to have an operational pressure nowcast (merging after a certain forecast time into the NWP pressure forecast) on which the wind nowcast can be based.

Action 5: Wind analysis and nowcasting

The operational INCA wind analysis is based on a sequential relaxation method. It provides a downscaled wind-field that is mass-consistent with respect to the high-resolution INCA topography and reproduces within grid resolution the observed wind vector at the surface stations. Currently there is no correction applied to the wind observation before it is used in the analysis. This leads to spurious effects and overestimation of wind speed near mountain stations. Another problem is that the differences between observations and first guess are interpolated isotropically. This generally leads to an underestimation of wind speed in the valley atmosphere, especially in valleys where there are no surface stations. Based on the method proposed by Rooy and Kok (2004) the difference between first guess and observations will be decomposed into a representation mismatch and a larger-scale model error. The anisotropy of the terrain will be taken into account in the interpolation of the observation correction by using weights which depend not only on distance but also on valley orientation.

Even though on average the INCA wind nowcast within the first 4 hours has higher skill than the NWP wind forecast, there is a problem with the prediction of strongly dynamic phenomena like fronts, squall lines or convergence lines if they are not already captured well by the NWP model. Also, thermally-driven flows can be predicted only to the extent at which they are present in the NWP forecast. It will be evaluated what proportion of the initial wind analysis error originates from the coarse initial data obtained by a NWP model on ~10 km resolution. Experiments will be made with the INCA wind analysis starting from an already dynamically adapted wind field at a resolution of the order of 2 km. The wind field at this resolution already represents most of the terrain influences (channelling, dynamically driven downslope winds) quite well, and the amount of necessary subsequent relaxation performed by INCA would be smaller.

Action 6: Wind gust analysis and nowcasting

There exists a 24-hr wind gust analysis which is issued once per day. Currently there is no 1-hr real-time wind gust analysis or nowcast in INCA. For many cases a rough estimation of gust speeds based on a gust factor (typically 1.6-1.8) applied to the mean wind is sufficient. However, especially in situations where convective downdrafts are causing high wind speeds, a better gust prediction is necessary. Otherwise maximum speeds may be strongly underestimated. Based on the concept of convective 'downburst potential' (Atkins and Wakimoto, 1991) an algorithm for the nowcasting of strong gusts due to thunderstorm activity will be implemented in INCA. The input parameters are precipitation intensity and temperature and humidity profiles in the boundary layer. The algorithm will be tested and calibrated on individual cases and validated against surface observations of wind speed during convective events.

V) Physical parameterisation – upper air aspects

Introduction

The current ARPEGE, ALADIN, ALARO and AROME physical packages were designed according to the scale (model mesh size) on which the model would run. This way of thinking made the packages diverge and the associated Physics-Dynamics Interfaces (PDI) of the AROME and ALADIN/ARPEGE/ALARO frameworks became incompatible with each other. For the period of application of the present plan it was decided, as outcome of the "Convergence dyas", that this scale dependent characteristic should fade out, this implying some steps to be taken in order to re-converge the different physics configurations and, when appropriate, their PDIs. The resulting actions of the "Convergence days" can be grouped into two. On the one hand we have actions which are rather straightforward and standalone: diagnostics and physics-dynamics interfacing. On the other hand there are two actions which are more interconnected with the rest: microphysics and use of 3MT in the ARPEGE framework.

Various recent tests made in the HARMONIE framework showed that also from a pure scientific point of view, microphysics and 'deep convection', which can be called 'moist physics' without too much generalisation, have become a troublesome part of the ALADIN-ALARO-AROME-HARMONIE framework, when used at the kilometric-type resolutions. Additional actions will thus have to be initiated and performed (in line with 'convergence-related' actions of course). A separate part of this "Upper air physics section" will therefore be devoted to specific actions in that field.

Besides this, and in more general terms, the evolution of the ARPEGE physics will have in the beginning of the four year period a direct influence on the evolution of the ALADIN physics. The search for more modularity and flexibility however will make it difficult to predict the future impact of the ARPEGE physics on the various versions of physics developed in the ALADIN consortium. The global ARPEGE system itself will be tested at the fairly high-resolution mesoscale (resolution down to about 7 km). Thus, in the following we will group the ARPEGE physics under the ALADIN physics (since the use of what is now ALADIN will remain also at larger scale, e.g. NORAF and GLAM-EPS).

The externalised surface scheme SURFEX will become the standard for R&D and operational applications.

"Convergence issues"

On the one side, the convergence process will concern the ARPEGE NWP/Climate duo (with issues like TKE CBR, sub-grid humidity representation, shallow convection, precipitation, ...). On the other side, the convergence will concern the AROME/ALARO duo: several actions will need to be concretised in order to make the different physical packages re-converge, in the spirit of what has been decided during the "convergence days" (Sept. 2008). These actions mainly concern the microphysics (ALARO vs. AROME) and 3MT.

Microphysics

- <u>ALARO</u>: Finalize the microphysics switches in APLMPHYS for ARPEGE-linked existing options. Include graupel as a prognostic quantity in APLMPHYS (but keeping the diagnostic treatment under a switch). Allow calls to the externalised ICE3 processes from inside ACACON, ACCOLL and ACEVMEL. One should also search for consistent alternatives for the current probability expressions used in statistical sedimentation scheme and even extend the code towards a two-moment precipitation scheme. Alternative ways to compute the final precipitation fluxes should also be studied. A new data flow should enable the use of the new prognostic species and guarantee compatibility with AROME.
- <u>AROME</u>: Externalisation of the ICE3 processes (with reproducibility).

3*MT*

5. ALADIN: Evaluation of the current version of 3MT representing deep convection for a wide range of horizontal resolutions (between 3 and 300 km mesh-sizes say). Aquaplanet tests can be useful. Implement an adequate use of Smith-type cloud fraction in 3MT. Test the impact of the microphysical schemes APLMPHYS vs. ACPLUIZ in 3MT. There is also a need to extend 3MT with a sub-grid non-precipitating convection scheme. A first step is the association of 3MT with the currently used non-precipitating scheme in ARPEGE: KFB. A second step would be to test EDKF in ARPEGE with the Bougeault deep convection scheme and if successful in combination with 3MT. The final step would be to develop a shallow convection scheme which has as objective to allow a continuous transition from shallow non-precipitating to deep precipitating convection.
6. ALARO: Exploring the qualitative and even quantitative aspects of the auto-extinction behaviour of convection within 3MT at higher resolution than the operational ones of ALARO-0. Developing a prognostic version for entrainment. Improving the adjustment. Extending 3MT towards shallow convection [may not happen along the same lines as in the above bullet].
7. AROME: The possible (and not yet decided) implementation of 3MT in the AROME framework depends on some concretisations of the convergence effort as well as on some common research on 'bridging' topics like microphysics, moist thermodynamic adjustment and the extension towards shallow convection.

Physics-dynamics interfacing (and thus implicitly diagnostics)

Extract from the ALADIN Strategic document, 2008-2017:

"*In the timeframe 2008-2012 one will aim at using as basis the Euler equations for shallow atmosphere (...) together with energy-conserving barycentric equations for the thermodynamics".*

The above aim for the thermodynamic equations is already implemented in the ALARO framework and remains to be implemented in the ALADIN (just completion) and AROME configurations. At "Convergence days" it was agreed that all configurations inside the ALADIN world should try to share a common PDI based for its equations on the principle above. The design of such an interface is not relevant for this section of the plan but it will of course have an impact on the physical parameterisations (e.g. the various microphysical ones) and interfaces (APLPAR and APL_AROME). Some specific medium- long-term actions are thus mentioned in the lists of issues below.

- cleaning of APLPAR and APL_AROME and if possible use FORTRAN features to reduce the number of arguments in the data flow
- extend the data flow in ALADIN/ALARO for new water species
- study the treatment of falling cloud species in the ALADIN/ALARO frameworks
- search for a common physics-dynamics interface (shared by ALADIN, ALARO and AROME) in the spirit of MAPFI

Moist physics

First of all, in order to tackle the various issues related to the moist physics it has become clear that one should:

- mobilize more manpower (there is a clear shortage of people aware of the various aspects of microphysics and deep convection)
- search for solutions suitable for and with the knowledge of both the ALADIN and HIRLAM worlds and this for both the short and long term (i.e. avoid another divergence of solutions)

Second, it is our aim that at the end of the four year period of this plan one should have (a) moist physics package(s) with the following characteristics:

- it operates at all operationally possible scales, from AROME to ARPEGE (this requires some flexibility to handle the different time step lengths)
- the deep convection part produces similar precipitation amounts and patterns for different resolutions (resolution independent)
- (extended) geometrical considerations for the deep convection part

Deep convection validation exercises using AROME, ALARO and HARMONIE however showed that the proposed actions of the "Convergence days" will not be sufficient and more efforts will have to be made. The following additional issues seem rather imperative to achieve the above aims:

a) Study the new strategy proposed by Luc Gerard to make 3MT really scale independent (use the time tendency of the updraft area fraction)
b) Study the idea for a "natural transition" from shallow to deep convection (e.g. associate 3MT with KFB or EDKF)
c) Control the (too) high sensitivity of lateral mixing of water species.
d) Revisit the cloud and precipitation geometrical considerations.
e) Reduce the outflow problems using issues 1 or 2, 3 and 4 above.
f) Correctly account for the mass and energy transfers by phase changes and precipitation leaving the atmosphere.

Other or specific ALADIN issues

- Turbulence/shallow convection: Validation and improvement of the CBR-turbulence scheme and the EDKF shallow convection scheme (same ones as in AROME). The links between the two schemes will be improved [see also AROME issues].
- Microphysics and clouds: Validation of clouds using satellite observations from CALIPSO and CLOUDSAT. Improving the ice microphysics.
- Radiation: Evaluation of the new shortwave radiation scheme (RRTM) and of the Monte-Carlo Independent Column Approximation (McICA) used in IFS. Improvement of ozone and aerosols: use of finer climatologies or link with MOCAGE model.
- Research will also be done on some specific demands of the users, e.g. sand and dust modelling for NORAF (starting in 2008).

Other or specific ALARO issues

All future developments remain in the spirit of modularity and flexibility with respect to other frameworks (ALADIN, AROME and HIRLAM).

- Gravity wave drag: the gwd-scheme is needed for mesh sizes above 2.5 km. In the current scheme, one should revisit the resonance issue. In the first half of 2008, a multi-directional version of the scheme will be further enhanced and validated.
- Deep convection - 3MT: 3MT is ready for operational use at the 10 km scale. In 2008 some ongoing validation of the multi-scale property is planned so that 3MT can also be activated operationally with 5 km mesh sizes.
- Radiation: The modularisation of the ALARO-0 radiation scheme is an ongoing action in 2008. Other topics which will be addressed are:
  - find more accurate fits of gas transmission functions using the RRTM database
  - optimisation of the modularised ACRANEB code
  - integration of climatology for aerosol's distribution in the scheme
  - implementation of relatively cheap clear-sky fluxes computation for an intermittent radiative scheme
- Turbulence - pTKE: The present turbulent scheme (pTKE) can be extended to a full TKE formalism (the analytical exercise was already done). Implementation and validation is still needed. HIRLAM shows interest to cooperate on this topic, probably around the QNSE ideas.

Other or specific AROME issues

Meso-NH will continue to help AROME developments by being a useful test-bed for kilometric-scale physics, and also for finer resolution studies (LES). For the relevant parts of the physics code package, the compatibility (and whenever possible identity) between Meso-NH's MASDEV library and AROME's CYxxTy will be maintained.

- Clouds and microphysics:
  - experimental (LES) study of the entrainment process inside the cloud
  - improvements in the explicit representation of microphysical processes (in comparison with 2-moment and bin schemes)
  - for the sub-grid condensed water species, study the impact of heterogeneous mixing of aerosols and cloud nuclei on the creation of precipitations (drizzle) and interaction with the radiative transfer
  - introduction of sub-grid microphysical effects
  - evaluation and improvement of the key parameters for the auto-conversion of cold clouds (containing ice), by comparison of model outputs with observations of high-level clouds
- Fog:
  -evaluation of the potential of Arome outputs for the forecast of fog (occurrence, localisation, structure). Link with the assimilation of fog and low-level clouds in Arome
- Turbulence and PBL clouds:
  - Further improvements of EDKF: switch and test the scheme in ARPEGE/ALADIN/AROME/Méso-NH and ARPEGE-Climate; careful study of the interactions between cloud/turbulence/radiation. The links between CBR and EDKF will be improved (such as triggering, TKE production, mixing length, ...)
  - Study of the interactions between turbulence/Sc representation and entrainment at the top of the cloudy PBL (via LES simulations)
- Turbulence from micro-to-kilometric scales:

- Study of the properties of lateral entrainment in Cb clouds: possible proposal of a parameterisation of lateral «cross-cloud» gradients and horizontal fluxes for Méso-NH; the adaptation for AROME will be investigated but might remain out of the scope of the 4 year period
- Study of the transition of turbulence from the very high resolution 3D turbulence to the kilometric-scale 1D turbulence. LES simulations at about 100 m resolutions will be carried out, and the continuous transition of the properties of turbulence as one goes to coarser grids (up to about 1 km) will be investigated for various PBL types
- Turbulence in mountainous areas: effects of slopes, orographic drag, differential heating, mountain breezes and strong inversions, valley/ridge contrasts

VI) Predictability and EPS

Introduction

The ensemble method provides useful information on the predictability of the atmospheric state and also on the probability of the occurrence of different weather events. Despite its obvious benefits it was used only on global scales and in the medium-range for a long time. In the last couple of years intensive research started in order to apply the ensemble technique in short-range mesoscale forecasting as well. Most of the studies show the benefits of limited area ensemble forecasting, but it is not yet clear which is the best method for the short-range mesoscale applications.

The main goal of the ALADIN consortium in the 2009-2012 period - as far as probabilistic forecasting is concerned - is the development and operational use (possibly in a distributed way) of a short-range limited area ensemble prediction system. To achieve these goals efficient coordination and task sharing will be key ingredients.

It is expected that the ensemble prediction system is able to add useful information to the existing deterministic forecasts, which means that at least the ensemble mean is more reliable than the control forecast. On the other hand it provides information about the predictability of the atmosphere, probabilities can be assigned to each forecast weather event.

Practical realization

The operational targets have two different components for the 2009-2012 period. One is the contribution of the ALADIN consortium to the HIRLAM-ALADIN project called GLAMEPS. This contribution will be in the first stage the simple downscaling of ECMWF EPS (only an arbitrarily chosen subset of the 51 members, because of the high computational costs) with a horizontal resolution around 20 km on a relatively large domain covering Europe (which is a result of a compromise between the participating HIRLAM and ALADIN countries). Similarly, a targeted EPS system (TEPS) currently under development by the Hirlam community, will soon be used to provide boundary conditions for further members for the GLAMEPS ensemble.

The other component is the development and operational use of a truly ALADIN specific system with a better horizontal resolution (~10 km) to be used at any ALADIN country, possibly in a distributed way.

Main development areas

g) ECMWF downscaling

Downscaling of ECMWF EPS members should be investigated in detail during the 2009-2012 period. First tests have already been made in several ALADIN countries and the LAEF system (by ZAMG) is running every day downscaling several (but not all) members of the ECMWF EPS system. It should be noted here that LAEF combines a rather simplistic view of the way to choose the 'chosen' realisation to downscale with a sophisticated package both to ensure the bridge between ECMWF and ALADIN specificities (e.g. surface schemes) and to foster dispersion at LAM scale via tools like blending-breeding and full multi-physics. As such, the approach appears nearly opposite to the one of GLAMEPS (see below). But one of the aims of the work linked with the present plan should be to rather consider this situation as one of complementarity and of potential of positive cross-influence.

Two different approaches are possible for the downscaling of ECMWF EPS. The first is the simple downscaling of the ECMWF EPS members (or a subset). Second possibility is the generation of a super-ensemble from more ECMWF EPS runs, clustering of this super-ensemble, selection of representative members and finally using these representative members as initial and lateral boundary conditions for the limited area system (this is the method used in case of COSMO-LEPS). Tests have been made for both, but they should be further investigated in detail.

In case of downscaling ECMWF EPS members the problem with surface fields has to be further investigated. The problem comes from the fact that the ECMWF model uses a different soil scheme than ARPEGE/ALADIN therefore it is not straightforward to initialize the ISBA fields (soil temperature and humidity) from the ECMWF analysis. In configuration 901 something is done about this, but from the results it seems that it is not satisfactory. The simplest solution found so far is to use the ARPEGE surface fields instead of the ECMWF ones in the initial condition of the ALADIN runs. The drawback of this solution is that in this case ALADIN EPS runs depend not only on the availability of ECMWF EPS forecasts, but also on the availability of the ARPEGE analysis. LAEF uses a time-lagged technique with rerun of cycling forecasts to solve both consistency and surface fields' dispersion; the longer-term potential of this method with respect to the other ones should be assessed.

A second technical hurdle for the downscaling of (T)EPS data is the current dependence (via the 901 configuration) on global datasets. While EPS runs are indeed archived for the globe, other ensemble forecasts such as TEPS (targeted EPS) may sometimes be stored only partially. While temporary solutions exist, there is not yet a fully satisfactory way of extracting ALADIN initial/boundary conditions from limited area datasets.

These issues, however, might more appropriately be addressed in the framework of the SRNWP interoperability program.

h) ARPEGE – ALADIN specific developments

Progress in this field is highly depending on the available manpower. However, the following areas would be worthwhile to investigate:

- **Simple downscaling of the PEARP members** (with high priority): Experiments are going on with the downscaling of the PEARP system in several ALADIN countries. This work should be continued in the future.
- **Computation of ALADIN native singular vectors to generate the initial condition perturbations** (with high priority): Work with ALADIN native singular vectors have started already. So far the experiments were restricted to compute and analyze the singular vectors. The aim for the 2009-2012 period is to investigate the possibility of generating the initial condition perturbations by using ALADIN singular vectors. It is expected that using ALADIN SVs to generate the initial condition perturbations will improve the forecasts with respect to the case when initial conditions are coming directly from the any coupling system.
- **Perturbation of the initial conditions by using ETKF** (with rather high priority): Development of ETKF to be used both for data assimilation and LAMEPS purposes.
- **Multi physics** (with somewhat lower priority): Development and testing of the multi physics approach, i.e. using different physical parameterization packages for the different members of the ensemble.
- **Stochastic physics** (with somewhat lower priority): Development and testing of stochastic physics methods. Stochastic physics is used successfully in the ECMWF ensemble prediction system to deal with errors caused by simplified physical parameterizations. So far a scheme is used where, for each ensemble member, the tendencies of parameterized physical processes are perturbed. HIRLAM proposes to rather perturb the physics critical tuning constant (rather then the output of physical computations) and this should be jointly assessed within HARMONIE.

i) Related developments

Probabilistic forecasts require special ways of visualization and verification, which cannot be solved by using the existing tools designed for deterministic runs. Therefore effort should be invested into the development of appropriate visualization and verification software packages. These should be based only on such tools which are available for all ALADIN members.

Ensemble forecasts, like the deterministic ones can have systematic model errors (bias), therefore calibration might be necessary. In the special case when not all ensemble members are generated by using the same technique, or by using the same model, there might appear big differences between the reliability of the different members. In this case calibration is again a crucial requirement. Accordingly some software needs to be developed and made available to be used by all ALADIN members who wish to run an ensemble system. This should also be based on tools available for all ALADIN members.

Concerning the calibration, there are also outstanding scientific issues, such as the case when ensemble members are chosen variably from different sources.

International links

The majority of the ALADIN countries participate in the SRNWP-PEPS project coordinated by DWD. This is a poor man ensemble prediction system, which does not require the run of several ensemble members from the participating countries. Only the deterministic runs are collected and used for the generation of probabilistic products. However, participation in this project can help to gain some experience with the multi-model method.

Another important international project is GLAMEPS. As mentioned in the strategic document, in the short term our forces should focus on the success of this project. The contribution of the ALADIN consortium to GLAMEPS will be - in the first stage - the simple downscaling of ECMWF EPS and targeted EPS with a horizontal resolution around 20 km on a relatively large domain covering Europe (the common domain to be used in GLAMEPS).

The GLAMEPS system will be the ALADIN-HIRLAM contribution to a (proposed) pan-European ensemble system called EurEPS. The EurEPS project can be understood as an extension of GLAMEPS towards a pan-European cooperation which will include the other LAM consortia (COSMO, Met Office) as well. EurEPS in turn could be the European component of the world wide TIGGE-LAM (which is being realized inside the THORPEX project).

Outlook

It is expected that in the 2009-2012 period the implementation of ensemble forecasting systems becomes possible in several ALADIN countries. As a first step the applied method could be the downscaling of global EPS systems (PEARP, ECMWF EPS, TEPS) or the use of ALADIN singular vectors or an extension of the rather heuristic but efficient techniques used in LAEF. Experiments are planned with other techniques such as ETKF, finely tuned multi physics, stochastic physics. Through our participation in GLAMEPS (and also in SRNWP-PEPS) experience can also be gained regarding the multi-model method. In the 2013-2017 period – as mentioned in the strategic document – efforts should be made to develop a multi-model probabilistic forecasting system together with the other consortia.

VII) Surface and soil processes – for Model and Data Assimilation

Introduction

The main objective in this area is to provide the best possible description of exchanges of heat, water and momentum between the Earth's surface and the lower atmosphere in the ALADIN NWP model. Given the wide range of temporal scales associated with the various surface types of interest (e.g. several weeks for the root zone soil moisture to few hours for the vegetation temperature) and the forecast range of ALADIN (1-2 days), a distinction can be made between variables that need to be accurately initialised (or analysed) and variables that require an accurate modelling description. This explains why the proposed developments for the next coming 4-year period are split between modelling and data assimilation activities.

The period 2008-2011 will be characterized by three important evolutions that will impact the activities on surface processes:

- At the beginning of the period, the coupling of ALADIN with the externalized surface module SURFEX will reach a pre-operational phase and will then become operational in all NMSs.

- There will be an increasing collaboration with the HIRLAM consortium that will help the ALADIN consortium to improve more rapidly on some components of the surface modelling/analysis systems (e.g. snow)
- At the end of the period, higher horizontal resolution versions of ALADIN will become available, and will require to start paying attention on surface types that are currently ignored (e.g. lake, towns)

However, when considering the foreseen action as a whole, putting together considerations about scale-independent applications, complexification of the atmosphere-surface interactions, observation operators, variational data assimilation, etc. should require increasing coordination between the various actors. But this coordination will have to rely on some progressively increasing rationalisation of the software. Some steps in this direction have already been taken but they remain rather limited and will have to grow in scope as the actions listed below intrinsically progress.

Modelling activities

The main task to be completed in 2008-2009 is the coupling of the externalized module SURFEX to the atmospheric NWP model ALADIN. This activity has significantly progressed during the last two years. In particular, the SURFEX workshop held in December 2006 (Toulouse, France) has helped to define priorities, critical issues and collaborations with HIRLAM. The chosen strategy has been to propose a first ALADIN-SURFEX coupling including only technical aspects (i.e. a version of the land surface scheme ISBA within SURFEX as close as possible to the one currently used in ALADIN and ARPEGE NWP models). This consistency means that the improved physiographic surface databases available within SURFEX (ECOCLIMAP for land covers and FAO for soil types) will not been used in the first implementation. This strategy will allow an easier identification of differences due to the technical implementation from those related to different physical descriptions.

The current version of SURFEX (version 3 available since February 2008) includes the necessary modifications to reproduce the behaviour of the ALADIN version of ISBA (in particular the ALADIN/ARPEGE formulation of surface turbulent transfer coefficients) and to use climatological databases generated from the ARPEGE/IFS configuration E923. A number of activities are planned in 2008 for validating and optimizing the different tasks required for the production of climatological fields over the various geographical ALADIN domains. A number of remaining differences between the SURFEX and ALADIN versions of ISBA will also be examined (such as the dependency of latent heat with temperature and heat capacity with humidity). In collaboration with HIRLAM, studies for an improved consistency in the description of momentum transfers for both turbulence and gravity wave drag will be undertaken. In the present coupling, the ALADIN orography (that includes a spectral treatment with an envelope orography) replaces the one computed in SURFEX (since it is only generated from a grid point treatment). The treatment of sub-grid scale orography parameters currently done independently (and differently) in SURFEX and ALADIN will be harmonized.

Presently, the externalized module SURFEX is coupled to atmospheric models having short time steps (AROME, Meso-NH). The coupling with ALADIN and ARPEGE has obliged to consider the implicit coupling strategy proposed by Best et al. (2004). Some numerical problems still remain and need to be examined more precisely. In particular, it is envisaged to include an "antifibrillation" algorithm to reduce the temporal noise on surface temperature.

During the first half of the period, the SURFEX module will be improved on three aspects through a collaboration with HIRLAM: a more realistic description of the snow-forest interactions by having two separate energy budgets (one for the upper vegetation canopy and one for the underlying snow pack), a prediction of lake surface temperatures described by the simple Flake model, and a modelling of snow over ice extensions.

During the second half of the period, new capabilities offered by SURFEX in terms of surface modelling and specification of physiographic databases will be evaluated and implemented operationally if forecast results (mostly in terms of near surface parameters) are satisfactory. More precisely, the three-layer (already used in the atmospheric model AROME and in the hydrological model SIM) and the multi-layer (that should improve the soil water freezing/thawing description) versions of ISBA will be evaluated in a NWP context. The new parameterization ECUME of oceanic fluxes (Lebeaupin, 2007) calibrated against field campaign datasets and already used in AROME will be evaluated in ALADIN. The improvements to the description of land surface cover types provided by the ECOCLIMAP data base will be considered for NWP applications in combination with near-real time satellite products (particularly for surface albedo and leaf area index) as detailed in the next section. The effect of urban and lake surfaces on short-range forecasts will be examined when versions of ALADIN at grey zone resolution (about 5 km) are tested.

Data assimilation activities

It has been decided to develop a new land data assimilation system within SURFEX "offline" based on a simplified Extended Kalman Filter. With such system, it will be easier to assimilate new surface observation types and to initialise new prognostic variables available in recent versions of the ISBA scheme. Indeed, the current "optimal interpolation" (OI) soil analysis derived from ARPEGE and used by various ALADIN partners only relies on screen-level temperature and relative humidity observations and is very much tied to the two-layer version of ISBA through an empirical calibration of optimal interpolation coefficients (Giard and Bazile, 2000).

The new soil assimilation system is designed independently from a given land surface scheme. The underlying idea, already used operationally at DWD (Hess, 2001) and previously evaluated in ALADIN (Balsamo et al., 2004), is to compute the Jacobians of the observation operator in finite differences (no need for a land surface scheme adjoint) by splitting the control variable in a set of independent columns (thereby reducing to an affordable level the amount of required perturbed runs). Indeed, it is important to prepare the use of satellite data that are already available to the NWP community such as surface soil moisture contents from ASCAT and ERS scatterometers and that will be produced from soil moisture dedicated missions (ESA/SMOS in 2009 and NASA/SMAP in 2011). A first prototype is already available in SURFEX for the assimilation of screen-level observations (more precisely screen-level analysis increments) and its capability to ingest satellite derived surface soil moisture contents will be evaluated in 2008.

Similarly to what has been proposed for the coupling of SURFEX with the ALADIN NWP model, a two-step approach for the externalization of the soil analysis has been adopted. The current OI soil analysis has been recently externalized (end 2007) from the upper air optimal interpolation system CANARI for its inclusion within SURFEX. This strategy will allow to clearly separate technical from scientific issues.

In 2008, the OI soil analysis available in CANARI will be implemented operationally by a number of ALADIN partners. This is an important preliminary step since it requires to set-up a 2D spatial interpolation of screen-level observations over limited area domains. Such 2D spatialisation is necessary for both the current soil analysis and the new externalized system. This activity has started in 2008 in collaboration with HIRLAM since it has (*almost*) been agreed that the HIRLAM consortium will use the CANARI 2D optimum interpolation as a common HIRLAM/ALADIN tool for surface analyses. Features present in the HIRLAM 2D spatialisation module (SPAN) that are not available in CANARI will be included in the ALADIN optimum interpolation scheme during the first half of the period. More precisely, it will concern the vertical interpolation procedure at observation level and the development of a snow depth analysis in CANARI (which is more an activation since such analysis already exists in CANARI).

The definition of the vertical interpolation operator at screen-level is particularly important since it is required for soil analysis but also for atmospheric analyses (and the two should better be consistent), and model forecast verifications. It has been recognized that the observation operator for the vertical interpolation should take place in SURFEX and be consistently passed to the upper air and/or screen-level atmospheric analyses when needed. Validation studies will take place in 2008-2009 to compare the various vertical interpolation schemes available within SURFEX and in SPAN. They differ by the fact that they are either prognostic or diagnostic and by the definition of aggregated surface properties (model variables, exchange coefficients or turbulent fluxes). A strategy for the estimation of linearised versions (Jacobians) will have to be defined, also as consistently as feasible.

The snow depth analysis will first make use of SYNOP observations (current HIRLAM configuration) and move progressively towards the use of satellite products from the EUMETSAT LandSAF in terms of snow cover (that are available in near-real time and have reached a level of quality compatible with NWP requirements). Methodologies developed at UKMO and ECMWF for the inclusion of fractional snow cover information in the snow depth analysis will be examined.

At the end of the period, a new 2D spatial interpolation tool based on wavelet approach (relaxing the homogeneity and isotropy hypotheses of the structure functions) developed by the HIRLAM consortium will be evaluated against the “optimal interpolation” tool (for screen-level parameters, SST, snow depth analyses), and used as soon as possible.

Expected improvements to the physiographic data bases in terms of vegetation properties when using the ECOCLIMAP product (Masson et al., 2003) will be combined as soon as possible with satellite products that provide real time information on the land surface phenology. Indeed, it is important to recall that, even though ECOCLIMAP provides an improved surface type cover classification (based on time series of NDVI), the actual properties needed as inputs to the land surface scheme (albedo, LAI, minimum stomatal resistance, roughness length) are still arbitrarily specified through correspondence tables. Satellite derived products have greatly improved during the last ten years both in terms of retrieval quality, spatial and temporal resolutions and near-real time availability. The current quality and availability of EUMETSAT LandSAF products in terms of surface albedo and

LAI make them suitable for NWP applications. A simple Kalman filter approach has been developed at Météo-France in order to optimally combine LandSAF and ECOCLIMAP surface albedos (but still relying on ECOCLIMAP vegetation fraction in each model grid box). This methodology will be evaluated by ALADIN partners in 2008-2009. In particular, practical aspects for implementing an operational suite that requires downloading LandSAF products in real time (either through ftp or EUMETCAST) will be examined. The use of LandSAF products of LAI and fractional cover is foreseen at the end of the period.

Regarding sea surface temperature (SST) and sea-ice concentration (SIC) (thickness, temperature) analyses, the CANARI interpolation tool has recently been adapted to produce such analyses over limited area domains. During the period, progress in this domain will be rather limited. It is not envisaged to develop dedicated limited area analyses of SST and SIC in the ALADIN consortium. The strategy of interpolating global analyses over ALADIN domains will remain. However, global analyses at higher spatial and temporal resolutions (MERSEA product developed by CMS/Lannion and IFREMER) will be used in the CANARI SST analysis. Since the HIRLAM consortium is engaged in the EUMETSAT OSI-SAF, it will be possible to use within CANARI improved products (analyses) when their developments are mature for operational applications.

In 2009 the use of the externalized soil analysis based on OI should become operational in most ALADIN centres, in order to prepare the move in 2010 towards the EKF system. During the second half of the period, the use of ASCAT satellite products within the soil analysis should be evaluated and proposed for operational implementation if results are satisfactory.

Another advantage of an externalized land data assimilation system lies in the possibility of forcing the lowest atmospheric level with improved radiative and/or precipitation fluxes where available. Such additional (and useful) information was not included in global soil analysis systems due to the availability of such data only over limited areas. On the other hand, several regional analysis systems are running land surface schemes in forced mode without actual data assimilation (e.g. NLDAS over the US or MOSES over the UK). The combined use of LandSAF downward radiative fluxes and precipitation analyses (derived from spatialisation of raingauges or radar products) as improved forcings to the externalized land data assimilation system together with observations (soil moisture, two-meter parameters) that may contain similar information will have to be carefully studied. A joint action shall be undertaken between ALADIN and HIRLAM to obtain required data sources not available through standard communication networks (GTS, EUMETCAST).

A methodology for the analysis of lake temperature will be defined in the second half of the period. Collaborations through SRNWP will be fostered in this area, in particular regarding the collection of ancillary lake datasets over Europe.

VIII)System aspects

First Sub-item of Section VIII: Networking, Maintenance and Operational switches

Networking

The distribution of research, development, maintenance and operational activities of the ALADIN consortium will continue in the next period. More specialized expert teams will emerge especially if local collaboration with national academic institutions is successful. The maintenance process will be further distributed, especially on externalized packages. More models (ALADIN/ALARO/AROME) will be operated by Partners having different options and tunings of the implementation. All those factors will further increase demand for efficient communication and information sharing.
The traditional information exchange means like e-mail lists, documentation repository, the web site and the Newsletter will keep playing their indispensable role in the community life. However, as documentation is traditionally a weak point of ALADIN (and documentation *maintenance* in particular) new communication means on one hand being more flexible than a static web and on the other hand allowing better backtracking than a sole e-mail exchange should be explored.

- A well moderated computer forum can offer discussion board for example for working groups or as a melting pot for maturing Frequently Asked Question files. Usage of a forum asks for new habits (one will have to actively check the site if there is a new contribution, unless the forum can be consulted as a mailing list distribution) but it offers a new service of keeping of the discussion on one place for later reference and search. Pilot studies can be conducted on the following topics :

Support for porting new versions of the code
Support of an ALADIN research version for Academia.
LTM discussion and test reporting linked to coordinated operational switches

-The existing ALADIN documentation web site is a very good first step but it should be extended towards a more open wiki-like system. Wiki offers an opportunity to solve the long-lasting lack of concise and up-to-date user guide.

Since such web tools have never been used by whole ALADIN community, RC/LACE and HIRLAM experience in these matters should be considered. It should be mentionned that training on new webtools is time consuming, too.
Ideally, the forum and/or wiki site and the official ALADIN website should be built in a complex portal, remaining at the same time consistent with HIRLAM web tools. It is proposed to set up a working group composed of ALADIN ST, relevant CSSI members, representative of RC LACE (which operates a portal site) and representative of HIRLAM (which run a wiki system).

Around maintenance prevention

Because of the policy sides which the problems of maintenance have, it is difficult to write down a reliable workplan for the next years. What is sure is that the growing of the constraints is inviting us to explore new maintenance procedures and to use (or if not possible: to develop) advanced technical tools. Therefore the text below is rather an enumeration of propositions - that have not always been proven feasible so far - which cover mixed aspects: automatisation, documentation, communication and normalisations.

- Whenever possible, automatised procedures should be used to improve the security of code phasing. Among automatic tools to improve and to conform the submission of codes modsets, we could setup a normalized and automatic source-code contribution form. When processed automatically, such electronic forms could feed the source-code database as well as the documentation (memorenda)

- Documentations should be systematically delivered at the closure of each phasing exercise. Aditionally to source code or namelists evolutions memorenda, it would be helpful to update a "history" of the problems encountered along the evolution of the software: not only bugs, but also communications miss, etc ... Just having such an account of continuing maintenance issues should have a pedagogical virtue.

- Training course on maintenance and the software architecture should be organised on a regular basis. There should be a renewing of the teachers to enforce the maintenance knowledge to spread among the newcomers. During such training course we should also propagate our knowledge about portability and optimisations aspects.

- The source code rationalisations should be emphasised in the maintenance work.
The Coding Standards recommendations should continue to be monitored on a regular basis, and effort should continue to reduce the amount of norms violations. The Coding Standards themselves should be revisited in order to fit a more object-oriented approach in the code conception and coding style.
The source code modularisation should increase taking into account projects under discussion in the whole of the ARPEGE/IFS/LAM community (e.g. toward an Object Oriented spirit following the so-called "OO" project at ECMWF). Externalisation of large pieces of code should continue as well, as it participates to the "OO" approach in a clearer partition of the code.
For each new cycle, several computer architectures and compilers should be tested on basic model runs : this is an efficient bug-killing activity and it early prevents from portability failures.

- Computational performances should be monitored, as a final step during phasing exercises with the help of automatic tools. Normalized tables or figures should be produced in order to monitor computational cost with respect to the scientific innovations. The same information would be re-usable to control the computational efficiency from one platform to another and could contribute to the ITTs of all the partners.

- The HARMONIE source code repository (SCR) on-line tools will be evaluated by ALADIN to get familiar with them and to get involved in their evolution. Progressively, test actions on these tools will be proposed to HIRLAM considering both scientific and technical aspects.

The future of the compilation system

During the next 4 years the main build system in use for ALADIN (and by extension: ODB, AROME ...) should remain the same procedure as the one used nowadays (gmkpack).

Today the advantages of this tool are double:
- its own needs for maintenance and developments have remained relatively reasonable so far, compared to the size and variety of the source-codes, and the number of developers (it is estimated 2 person x months per year plus less than 1 person x week per year and per country), and its flexibility has been proven sufficient.
- in spite of its non-standard way of working, it satisfies the majority of the users thanks to its user-oriented interface and its portability to various platforms, which limits the maintenance

effort as soon as new source-code release should be installed all over the computers of the consortia.

However, and concerning the maintenance especially, the source-code administrators and the experts are aware of its weaknesses, like its limited ability to "ingest" external source codes coming with their own making rules, or to update itself when the rules for making an executable change in a new release. In the scope of increasing cooperation with Academia and the general tendency to externalize the source-code (for the sake of its maintenance, fighting against increasing complexity), the cost of the maintenance of the build system is quite likely to rise. Unfortunately it is difficult to find developers motivated in such a topic.
It is noticeable that having problems with the build system is not a specificity of the ALADIN consortia : today ECMWF is looking at improving its build system ; the comprehensive build system of the UKMO (FCM) is warranted only for the UKMO source-codes, and needs as well that the source-codes follow specific rules.

Nevertheless, two milestones can change the situation:
1) if ECMWF adopts a new build system, we would evaluate it for our own needs. Maintenance should be easier if ALADIN and ECMWF could share the same build system; however:
- The fact that, for ALADIN, the installations are disseminated in many countries (with various platforms and size of teams) makes the maintenance more complex than at ECMWF.
- Beside the shared source-code between IFS/ARPEGE and ALADIN, more source-code libraries (SURFEX for instance) have to be maintained.
- A modern build system cannot be disconnected from a source-code management software. Such a software needs supplementary knowledge and maintenance, and the choice of the software depends of the price to pay and the complexity of the phasing exercises to handle.
In conclusion, sharing a new build system with ECMWF could also be more maintenance-demanding for the partners. An audacious solution would be to convince ECMWF to adopt our own build system.
2) When HIRLAM has fully turned to ALADIN, we shall have a stronger workforce to develop and maintain a comprehensive build system (not necessarily starting from scratch), able both to handle various codes and to install itself in small or big centres.
Therefore we must pay attention to existing alternative software pieces.
Meanwhile gmkpack will have to be maintained and developed toward:
- less maintenance: progressively, what is source-code-specific will be externalized and available as plug-ins.
- easier installation: Academia should be able to install the source code with a minimal support from the meteorological services. Therefore the installation procedure from bottom to top will be made more automatic, and a comprehensive tutorial will be finalized.
- promotion : it should also become a possible alternative for an ECMWF solution.

ALADIN, ARPEGE and operational switches

ALADIN-France for the time-being, or later something that would play the same role, will continue to be considered as the LAM declination of the ARPEGE latest choices, and hence as the ‘reference’ configuration for bridging the work between global (IFS/ARPEGE) aspects on one side and LAM aspects on the other side.
The particular role played by the phasing actions in Toulouse will be preserved to anticipate and early harmonise LAM developments with any constraint coming from the algorithmic specificities of the IFS/ARPEGE backbone

The well-established coordination of ALADIN and ARPEGE operational switches will be maintained and further improved. The following major sources of coordinated switches are anticipated for next 4 years:

- Following resolution increase of ARPEGE by a corresponding grid change in ALADIN coupling transmission files. The responsibility for coupling domain set-up will be delegated to their users which will increase flexibility to change domains parameters whenever a Partner or their group will need it. This will also include evolving needs of Partners' operational applications on new coupling fields (e.g. hydrometeors) in (currently unlikely) case their coupling is found beneficial for coupled model.
- The changes of format of coupling files. This includes changes like internal compression of fields or using frames instead of full spectral fields. The development of new coupling methods can also bring new demands for coupling fields' composition and consequent coordinated operational implementation.
- The changes in surface scheme. The migration from ISBA to SURFEX in ARPEGE might call for a coordinated operational change of all ALADIN coupling files due to the changes in the climate databases used by SURFEX.

Second Sub-item of Section VIII: Coordinations and links with phasing

An initiative for annual HARMONIE coordination meeting will be proposed. This kind of meeting would serve as a coordination mechanism for the cycles more in the spirit of the current IFS/ARPEGE coordination meetings. The main aims of such action would rather be 'HARMONIE towards IFS' and 'needed back-phasing for truly common scientific efforts'. Such meeting could be probably organized in piggy-back with some HIRLAM management group meeting or via teleconferencing. The exact means of organization must still be discussed on both sides.

ALADIN will deliver 'official export versions' less frequently but with higher "Quality Assurance" at the level of meteorological results and directly related technical aspects (portability, bug-fixes, computational performance). The achievement of a sufficient "QA" level for a release identified as such will require that ALADIN people quickly return to it for consolidation (code modifications as well as namelists for quasi-operational usage).

The establishment of "QA" versions will involve decentralized, coordinated actions and staff work in ALADIN and HIRLAM, increasing the habits for common work and "language". In this spirit, HIRLAM and ALADIN management should jointly find a common solution for ALADIN people to perform some work in the HARMONIE system remotely, outside Toulouse, (together with HIRLAM's 'system experts') in order to increase the level of "QA" in some chosen releases. The exact scope and detailed aspects have to be checked, and where help from ALADIN side would be required, shall be discussed at the proposed HARMONIE coordination meetings.

Beside the ARPEGE/IFS common cycles, HARMONIE R&D reference cycles will need to be carefully synchronised between ALADIN and HIRLAM, as it is now between IFS and ARPEGE/ALADIN. As one should avoid the risk of HIRLAM contributions being temporarily frozen for entering only the releases targeted for joint "QA" efforts, as well as HIRLAM-sided branches of code unable to re-enter the main trunk because of IFS/ARPEGE "in between" backbone constraints, the HARMONIE coordination meetings should and will review such aspects as status of cycles, progress and plans and preparation of the next release (which cycle with respect to ARPEGE/IFS, which content, analysis of possible conflicts and list of actions).

Third Sub-item of Section VIII: SRNWP interoperability Project

Interoperability Project (IOP) will be the first practical activity financed by C-SRNWP Programme aiming at improvement of conditions for NWP data exchange and sharing between European models and consortia. IOP will not only facilitate the data exchange but it will prepare important component of the environment for future European trans-consortia projects like Verification Project or EurEPS. IOP will mainly focus on definition and implementation of a unified exchange data format and physical meaning, with the emphasis on NWP model gridded data outputs and inputs and in lesser extent on the observations data.
ALADIN consortium will take part in IOP in a concerted action with RC LACE. IOP being coordinated by UK MetOffice essentially assumes active participation of all European NWP consortia in both finding the right definition of the interoperable data format and content and in development of adaptor software for conversion from every model internal data formats. This will also offer an opportunity for ALADIN Consortium for improvement and consolidation of some post-processing tools and potential enhancement of product exchange between Partners.
In the scope of the SRNWP interoperability project, ALADIN and LACE consortia should make themselves ready together in 2009-2010 for the minimum deliverables (D1 to D4).
Two approaches are possible:
- either go straightforward and fast towards the (minimal) objectives,
- or include the tasks in a more general framework to improve the flexibility (at users interface) and try to limit the price of the maintenance of the software pieces.

Depending on the manpower needed after the specifications of the Interoperability standard format and adaptator software have been agreed, either the second approach will be adopted, or the first one will be adopted, keeping an eye onto the second.

D1,D2 (set-up of interoperability standard output format)
Involvement of experts in dynamics, physics and soil and surface processes will be necessary to specify horizontal and vertical representations of the model data as well as the list of soil and surface and upper-air parameters for the interoperability standard format. A special decision will have to be made regarding the surface and soil variables depending on the progress of the migration from ISBA to SURFEX scheme at the Partners. Moreover, data assimilation experts will also participate in IOP review of standards and practices in coding observations.
ALADIN consortium will take turn in the maintenance of the agreed standards documentation.

D3 (specifications of the adaptator software, and its maintenance aspect)
Involved experts will review and agree on methods how to create fields with the physical meaning imposed by the Interoperability format, in terms of interpolation methods, grid definitions, staggering, space representation etc. The Interoperability Project has decided to leave the implementation of conversion to each Consortium. This decision should enable the ALADIN Consortium to keep with the methods used in the ALADIN model to allow code

design compliant with requirements of portability, flexibility, computational efficiency and readability of the software for this piece of work.
ALADIN consortium can offer its know-how on procedures for maintenance and coding standards (the legacy of ARPEGE/IFS and now also recommended in HIRLAM).

D4 (adaptator toward interoperability format)
Since the Interoperability Project has decided that each Consortium would provide their datasets in the native grids (horizontal and vertical), the adaptor from ALADIN internal "FA" format to interoperability format will consist of the following two steps:

- The ALADIN FullPos configuration, possibly enhanced to address the interoperability requirements on the variables. Should the interoperability format require specific soil parameters the issue will have to be addressed depending on the state of migration from ISBA to SURFEX.
- The convertor form ALADIN "FA" format into the Interoperability format (GRIB-2). One path to pursue would be to start from existing convertors "FA"-to-GRIB-1 and adapt it to GRIB-2. This solution should be considered in case of lack of time and/or manpower. But more ambitious solutions should be evaluated as well :
  i) <u>An external multi-format converter</u> (interpolation-free), preparing a possible switch from GRIB-2 to another format like NETCDF.
  ii) <u>Pluging-in of the adaptator software inside FullPos</u>. In the long term this approach looks like the most promising one but it needs a strategic agreement.

D5-D6 (Enhancements of existing tools to enable one model to process data from other ones)
The configuration ALADIN E901 converting GRIB-1 files to ALADIN FA files developed in 1995 for COMPARE exercise will be first rehabilitated and its documentation updated, then enhanced to support GRIB-2 files in input. Next, we shall study methods to process input data from the other SRNWP models. This may be achieved by pluging inside this configuration external tools provided by other consortia.
Having other SRNWP models outputs directly readable either by ARPEGE or ALADIN looks out of scope in a four-year plan.
Toolbox like EGGX to handle the Aladin geometry, together with a documentation, will be made available to other SRNWP consortia.

In a broader context and beyond IOP scope ALADIN Partners should contribute to the maintenance of the ARPEGE 901 configuration, in particular to reflex changes in ARPEGE/ALADIN surface scheme (ISBA to SURFEX) and to respond to future changes in the IFS surface scheme. The 901 configuration is essential for various ECMWF Reanalysis ALADIN downscaling studies which will stay interesting for Partners given the ambitious plans of ECMWF in future reanalysis projects.

<u>Synthesis</u>: The volume of effort needed to realise all aspects of the 4-year plan (and its itemisation along the various issues) is not yet present in this 'first-year + HIRLAM-linked-upgrades version'. It is however thought, like when such an exercise was undertaken (too early as it turned out) at the end of 2006 on the basis of a 1-year planning) that the total of available manpower is sufficient on average but that redistribution from over-staffed topics towards under-staffed ones will be one of the main tasks of the management, something of course easier to realise on a time scale of four years.

The method for reaching (progressively) this goal will rely on the following ideas:

- the main sorting-out tool should be a study of the various demands put on the LAM NWP community by its users and hierarchies;
- the manpower priorities for critical actions (and the related recognised existing sub-optimal uses) should be clearly expressed (this started already in 2008 on a 'trial and error' basis);
- like it was always the case in the ALADIN 'culture', the manpower offer by spotting opportunities at the Consortium level shall take preference, especially for topics requiring specific skills, on the offer on the sole basis of individual teams' local plans;
- yearly work-plans will be the occasion to make these special kinds of offer and demand meet more and more in order to optimise the manpower use.

The other important task for the CSSI and for the Programme Management will be to seek more and more harmonisation with the HIRLAM plans as well as with the internal ones of the Partners, especially in the case of Météo-France and of the RC-LACE Consortium. This first updated version of 2009 indeed takes into account as much as possible the comments made by the HIRLAM Management Group about the 2008 version, in the two most contentious areas, i.e. 'upper air physics' and 'system'.

Concerning the latter point, the following web-links allow interested readers to check the consistency (for common parts) and/or the complementarity (for other parts) of the above plan with the various interlinked official planning documents:

- for Météo-France: ????
- for RC-LACE: ????
- for HIRLAM: http://www.hirlam.org/documents/HIRLAM_A_sciplan_2007_20070125.doc