Proposals on “surface” issues for the ALADIN 2005-2008 R&D plan

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Introduction

The description of exchanges between surface and the atmosphere, and the consistent initialization of surface characteristics, is one of the domain where the interactions between all aspects of NWP have been the earliest, and the strongest up to now. Such an integrated approach is hence preserved in the present document, all the more since this feature is now enhanced by the already started externalization of the corresponding source code (in a library called SURFEX). The use of this module (but not the options chosen) is assumed to be independent from the upperair physics used, hence from the horizontal scales considered.

Coupling SURFEX to ARPEGE/ALADIN/AROME

ARPEGE/ALADIN/SURFEX : introduction

This action was launched mid January 2005. It is intended as the contribution to the so-called "jump to ALARO" for surface, imposed by the choice of externalization done for AROME and the need for common interfaces for all models. At first, mainly technical changes will be considered, with the following framework :

- models and scales : operational and climate ones, ARPEGE and ALADIN/ALARO,
- configurations : all (dynamical adaptation, data assimilation, changes of geometry, etc.),
- "atmospheric" physics : validations with the present ones and short-term changes (in 2005),
- as few changes as possible to the operational backgrounds,
- simultaneous jump for all operational suites in 2006 (as far as possible).

ARPEGE/ALADIN/SURFEX : short-term plans

1. *Changes in SURFEX*

The following points have already been identified, but some more may be required and there will be feedbacks from parts 2-3 :

- management of new grids (geometries),
- allowing the use of other databases than ECOCLIMAP via the reading of model fields in "historical" files rather than their systematic re-computation, on-demand time update of physiography,
- improvement of I/Os : allowing other file formats (first FA/LFI), optimizations,
- optimizations : slicing in "NPROMA-type" packets, checking the compatibility with further ones such as OpenMP,
- improved exchanges of information with the other models : both providing information on surface description to upperair for observation operators, Full-Pos, etc., and adding some more if required for the coupling of physics,
- improved consistency with the upperair model (ISBA settings – including the introduction of the "Bazile" snow scheme-, thermodynamics, computation of screen-level fields, ...).

2. Validation of implicit coupling between upperair and surface physics (configuration 001)

Through at least the following steps :
- validation of explicit coupling with ARPEGE/ALADIN physics in a 1D framework,
- validation, and refinements if required, of implicit coupling with ARPEGE/ALADIN physics in a 1D framework,
- evaluation of the impact of the present hypotheses (e.g. on the choice of variables, the treatment of thermodynamics, the management of wind, the list of required informations, ...) in a 3D test-bed based on ALADIN and simulating the coupling,
- implementation of the most critical modifications,
- 3D validations,
- refinements considering the points temporarily left aside.

3. Coupling to other configurations

First checking which are the missing informations from and to the surface module in the present framework. At least all the presently used surface characteristics as a first guess (still keeping in mind that only the code changes, not the surface scheme in this first step). However one may/should try to reduce the number of required fields. The following directions of work have already been identified :
- simplification of "ACHMT et al.", to avoid computations that are relevant to SURFEX and the need for "constant" surface fields,
- implementation of a cheap dynamical O.I for soil/surface temperature and mean soil moisture, so as to both get rid of the explicit dependency of coefficients on surface characteristics and anticipate changes in the scheme,
- evaluation of the impact of a direct interpolation instead of a computation of screen-level fields for the corresponding observation operators.

4. Intensive validations

Of course ...

AROME

An interface between Meso-NH physics and SURFEX is already available within the prototype, choices more or less done, and small time-steps are used, so that work on these issues is not felt as critical as at larger scales for the coming two years. The coupling of data assimilation configurations with SURFEX, not so much investigated so far within AROME, may be derived from the developments performed for ARPEGE/ALADIN.

Improvement of surface analyses

SST and sea-ice

For the while, SST analysis is performed every six hours in ARPEGE only, using surface observations (BUOYs, SHIPs) with the NESDIS SST analysis as a relaxation. Improvements may be expected from a higher resolution analysis, in ALADIN, using new data such as those from geostationary satellites, providing high temporal and spatial SST observations over cloud free areas, used directly and via more advanced "ocean and sea-ice" SAF products (e.g. data at 0.1° resolution with quality flags over European seas and the Atlantic ocean, derived from Meteosat-8 and GOES-East). Structure functions are also to be considered, so as to better take into account the coastal contrasts.

Snow cover

There is a lot of work here, for there is nothing in operations, while an error on snow water equivalent may persist during several days with a negative impact on the forecast of 2m temperature. At least starting by a better initialization within Full-Pos, a relatively easy first cure.

There is an O.I. scheme coded in ARPEGE/ALADIN, however it has shown its limits and observation operators have not yet been updated to use the available model information on density. Besides HIRLAM has developed an advanced snow analysis (and already provided the code to other users), which appears as a valuable alternative, especially in the framework of a close collaboration. As for SST, the use of SAF products is to be considered.

Soil moisture and temperature

Several directions of research, on top those described in the second (just before) and fourth (just after) parts :

- evaluation of statistical O.I. versus more or less refined versions of dynamical O.I versus more advanced (and expensive) schemes such as 2D-Var;

- evaluation of the impact of the use of analysis increments at the lowest model level, or with new observation operators, as input to soil/surface corrections;

- comparaison with off-line initialization (whenever available);

- using new observations : precipitations, satellite observations (infrared surface temperature from METEOSAT-8, microwave surface temperature from SMOS and scatterometer from METOP), ...

Implementation of advanced features in the NWP framework

Hereafter are more sophisticated surface schemes already available in SURFEX and a tentative evaluation of the tasks required for using them operationally. Of course both the relevance and the operability of each option are strongly dependent on the considered space (horizontal and vertical resolutions) and time (time-step and forecast range) scales.

Three-layers scheme, improved descriptions of run-off and drainage

A priori, mainly validation should be needed.

ISBA-DF

It is based on a diffusive approach, with a tunable number of layers and 3 variables for each : temperature, liquid water, frozen water. An optimization of the number of layers will be required for each type of application. Most of the work required is expected on the definition of a consistent initialization, both on the vertical and between variables, considering dynamical adaptation (changes of geometry) as well as data assimilation. For the latter, strategies will have to be reconsidered, at least for cost reasons : simultaneous analyses versus redistribution of corrections versus ?

Tiling

A two-level tiling system is available in SURFEX : 4 "tiles" or surface types (sea, lakes, town, vegetation), and from 1 to 12 "patches" for the description of the vegetated fraction. An adaptation of the formulation of implicit coupling, not considering several surface temperatures up to now, will be necessary. Otherwise very short time-steps are required which is not consistent with the target horizontal scales for tiling. There will be of course many initialization problems, for changes of geometry and data assimilation, and post-processing or verification ones too.

Advanced snow scheme

It is based on Boone and Etchevers, 2000. It includes 3 layers in the snow pack and describes the evolution of albedo, density and liquid water. Since two energy budgets are considered here, an adaptation of implicit coupling is required. And the implementation of a more sophisticated snow scheme is meaningful only with a simultaneous improvement of snow cover analysis.

TEB

This scheme provides a very detailed description of the urban environment and its radiative impact. However implicit coupling difficult to consider here, because of the "canyon" approach. Hence only applications with short time-steps may be expected.

ISBA-AGS

This is the "interactive vegetation" scheme, including the description of photosynthesis and CO2 exchanges. It is just mentioned here, since of interest mainly for climate simulations

Databases for the description of surface characteristics

Orography

The present global "Manu" files, based on GTOPT030 data, will soon be of to low resolution (2'30) for research then operational applications. Similar databases at higher resolution, but with as counterpart a poorer description of subgrid-scale features, may be built from GTOPT030 (initial resolution id 0'30). Another solution is to build higher resolution databases covering (parts of) Europe and Northern Africa, using all locally available data. It may be performed as individual (national) or, better, common actions within the existing SRNWP framework.

ECOCLIMAP-1

The ECOCLIMAP database provides informations at a resolution of 1 km for a wide range of surface characteristics on the entire globe. However, the present, recently updated, version won't be considered in the first implementation of SURFEX, for further and independent validations are still required. Using ECOCLIMAP, in an increasing number of applications (i.e. considering the specific needs of observation operators for satellite data), is hence among the first next steps.

ECOCLIMAP-2

Further improvements of ECOCLIMAP are already scheduled, relying on new informations (Global Land Cover and Corine Land Cover 2000, VEGETATION satellite data) and new algorithms.

Improvement of surface schemes

Beside the changes required to be able to use the present SURFEX options in a NWP framework, the following desirable refinements have already been identified :

- improved description(s) of air-sea exchanges (e.g. coupling with a 1d model of oceanic mixing layer),
- description of lakes (including freezing),
- improved description of sea-ice,
- separate energy budget for vegetation (i.e. different temperatures for canopy and bare ground).

But a longer list may be considered : contributions are welcome !

Coupling to hydrological models

Further and more coordinated actions would be welcome. But that's beyond the scope of this research plan.

Which collaboration with HIRLAM partners ?

Cooperation between ALADIN and HIRLAM scientists on such issues is now more than 10 years old. HIRLAM has developed its own surface schemes, but starting from the same basis, ISBA, as for ARPEGE/ALADIN and SURFEX.

The requirement to be able to use within the same software all upperair physics with all surface ones, with a physical meaningful coupling of course, implies the following (at least) :

- an "externalization" of HIRLAM surface schemes (rather than their coding in SURFEX),
- a close cooperation at each step (when moving to increased complexity) of the definition of the interfaces (the exchanges of informations, considering all configurations), from equations to the list of fields,
- capitalizing on experience from each side.

A close cooperation will be welcome in the domain of the analyses of screen-level and surface fields, where the HIRLAM model present many far more advanced features than the ALADIN (and AROME) one.

Of course, building new databases for the description of surface should involve as many countries as possible.

To end with, let's recall that HIRLAM is responsible for surface issues at the SRNWP level !