LACE Working Group for Dynamics & Coupling: Research plan for the year 2008

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Introduction

This plan gives an overview of the areas on the fields of dynamics and coupling which seem to be both of interest and possibility to be studied during 2008 within the organized RC LACE research. Although the listed subjects are mostly reflecting the available manpower, there are possibilities for inclusion of new manpower. Indeed, non reserved subjects difficult for newcomers and/or requiring longer time to deal with (like radiative upper boundary, higher order accuracy coupling physics to dynamics or transparent LBCs) are not included to the plan.

As the high resolution modelling plays increasing role in the dynamics research it has been decided to leave the traditional separation of dynamics to NH and the "other" one. It is evident that to run operational model based on NH dynamics is the target for all the LACE countries. Logically any research on dynamics related to the operational application should be primarily concern to the NH dynamics. Thanks to the tradition that the NH dynamics is implemented as an extension of the hydrostatic dynamics, there is a good hope that major part of the new features would be still available for the hydrostatic version of code as well. The proposed plan is then sectioned to just dynamics and coupling.

1 Dynamics

- **Further improvement of the NH dynamics**

  Description and objectives: The NH dynamics is constantly developed model feature since mid nineties. Although the code has been satisfactorily analyzed for stability or tested on various academic environments, its pure operational experience is still missing. The main focus for 2008 is than to study the added value of NH dynamics with respect to the operational ALADIN application.

  Ideally the parallel test is launched for hydrostatic and non-hydrostatic dynamics using the same geometry and physics. The observed differences should then serve as the input for further development of the NH dynamics. It is highly desirable that the outcome of this work at the end will be an operational application based on ALADIN NH code. Indeed to fully benefit from the NH dynamics, a sufficient resolution (vertical and horizontal) of the computational domain has to be defined. Thus this study rely on successful implementation of full ALARO physics (including 3MT recognizing convection as both sub-grid and resolved feature).

  The goals of this work are then following:

  - Compare the (full) model results obtained with hydrostatic and non-hydrostatic dynamics. Alternatively this can to be repeated for various resolutions.
  - In case the NH dynamics offers worse performance in terms of accuracy, level of numerical noise, computing efficiency and stability a targeted research should be applied to make the NH dynamics fully comparable to the hydrostatic one (indeed the NH code should never be of the same cost and stability as cheap as the hydrostatic one).
  - Once the two cores gives comparable results, prepare the operational ALADIN application for switch to the NH dynamics.

As the partners are also dealing with the NH code at the same time (Météo-France, ECMWF, Hirlam) any possible development of NH model should be coordinated among them. It is highly desirable, that the NH core is stabilized in the way that an effort to derive its TL/AD version can be invested.

Priority: 1

Contributors: RB, PS, JM, JV, FV, ??

Means: 6 months

- **Thermodynamics consistency in the model equation**

  Description and objectives: The ongoing work on consistent coupling of physics to fully elastic model should be finished.

  Priority: 2

  Contributors: PS

  Means: 0.5 month

- **Vertical finite element discretization scheme for NH**

  Description and objectives: In order to further increase accuracy of the NH dynamic and make it comparable with the hydrostatic one, it is desirable to adapt for the vertical discretization the vertical finite element scheme (VFE).

  The current research version of the ALADIN-NH VFE seems to have still some problems related to its formulation. Logically further work including deeper understanding of the current problems is desirable.

  Priority: 1

  Contributors: JV

  Means: 3 months

- **Improved SLHD triggering**

  Description and objectives: SLHD acting locally within one 3D stencil of the semi-Lagrangian interpolation seems to have some potential to be easily adapted for orographic regions. However its triggering function based on horizontal deformation is presently computed along the quasi-horizontal eta levels. This may introduce spurious circulation above a sloped terrain. The solution to prevent this is to compute the triggering function (based on horizontal deformation) along purely horizontal surfaces. The other issue linked to this non-linear diffusion scheme is to make its triggering dependent not only to the scalar quantity of flow deformation but also on divergence. This rather heuristic approach is widely used in fluid dynamics model for its ability to consistently damp the accumulated energy at the end of finitely truncated model spectra. This approach then can be used as an alternative to the current habit to damp strongly spectral divergence compared to the other fields. Last and not least, there is still hope to design an universal tuning offering for any scale comparable performance of the SLHD.

  Priority: 2

  Contributors: JM

  Means: 2 months (1 month on LACE support)

- **New interpolators for semi-Lagrangian advection**

  Description and objectives: It is of high interest to finish the ongoing work on the redesigned data-flow for the SL interpolation. A validation of numerous alternatives of the developed code and promotion of the changes to the TL/AD model is still to be done before the code is ready to enter the common source code.

The new design offers more freedom for the interpolator (accuracy and diffusivity including its selectivity) and more efficient computer performance in terms of CPU saving. It is especially beneficial for the SLHD data flow. With the new code this becomes just a special feature of standard interpolation differing by only interpolation weights computation. This unification of SL interpolation data flow gives an infinite freedom for interpolators in terms of their diffusivity and accuracy. Moreover it also allows simple way to have TL/AD version for any such interpolator including the SLHD.

Priority: 1

Contributors: FV, JM

Means: 3 months (0.5 month on LACE support)

- **TL/AD of SLHD**

  Description and objectives: Hoping to have soon new data flow for the SL advection, it becomes relatively feasible to project the SLHD scheme into the TL/AD model. The impact of the non-linear horizontal diffusion projected to the linear model will be then studied by simple sensitivity experiments.

  Priority: 2

  Contributors: FV, AT

  Means: 3 months

- **Design for 3D turbulence scheme**

  Description and objectives: Considering the increased interest to simulate meso-scale processes by the operational application it is right time to think about the design for a turbulence scheme taking into account also the horizontal mixing. The present code considers diabatic processes just along the vertical column. As the physics is implemented fully as the 1D feature any inclusion of 3D scheme requires some structural changes of the model data flow. It seems to be wise to couple any such 3D turbulent scheme to the model at level of semi-Lagrangian interpolation evaluation. There are at least following two reasons for it: First this is the only place in the present data flow working with full 3D stencil. Second the semi-Lagrangian interpolation itself is a source of diffusion. In case of 3D turbulence inclusion on the other place in the model, it can be difficult to separate the contribution of the random SL interpolation from the sophisticated turbulent scheme. Thanks to the SLHD scheme the damping abilities of the SL interpolation can be controlled in a profitable way. It seems to be natural to use the SLHD environment also for the full 3D turbulence.

  The aim of this work should be the study of the code with respect to possibility for 3D turbulence adaptation. The way how the block of 1D physical parameterization is coupled with the full 3D scheme and the way how the horizontal diffusion coefficients are evaluated are still open issues. Among those scientific aspect, the overall scheme cost is also an issue to be considered. It should be also clear to which extend it is possible to design accuracy of such scheme. At this stage a simple 1st order of closure aiming primarily the computational efficiency and numerical stability would be sufficient. If applicable a possible extension toward higher accuracy of any such scheme can be also estimated. Accordingly the precise analysis of data flow from dynamics and physics should be given to leave no open questions for the scheme implementation.

  Priority: 3

  Contributors: FV

  Means: 1 month

2 Coupling

- **Better LBC treatment**

  Description and objectives: Expecting some outcome from the work of F. Voitus and P. Termonia on externalization of the LBC treatments allowing its adaptations to the work of A. McDonald on transparent boundary condition, all activities on the LACE side has stopped.

  However, as the LBC is one of the factors of importance for LAM modelling, it is desirable to achieve some progress in this area. In case the practical implementation of the mentioned research is stacked by problems, LACE can assist to overcome them.

  Alternatively the experimentation with increased diffusion near the bounds or better double-periodicization procedure can be investigated.

  Priority: 2

  Contributors: ??

  Means: ??