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

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Introduction

This paper aims to give an impression about areas on the fields of dynamics and coupling which seem to be of interest and possibility to be studied during 2008 within the organized RC LACE research. At the moment there are however still some uncertainties related to the present research (in LACE or outside). Moreover the availabilities of researchers are also a bit obscured to the current knowledge. Thus this document should be rather considered as a definition of short terms interests than tight research plan for 2008.

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

- **Physics/Dynamics interface**

  Description and objectives: Putting more weights to the detailed description of the meso-scale atmospheric events, physics plays increasing role in the numerical model. As the accuracy of the parameterization schemes has significantly increased an effort should be spent also to the way how the physics is coupled with the model dynamics. Presently the phys/dyn coupling used in AAAA models is just of first order accuracy.

  There has been already quite some progress on this area. Martina was implementing and studying some possibilities leading to the 2^{nd} order accuracy interface since 2005. Moreover the detailed analysis for the AAAA model has been done in Belgium offering also solution for higher accurate phys/dyn interface. It is just logical that there is an interest to profit from those studies in order to implement them as an operational feature.

  Additionally the interface should be studied with respect to the ICI time-stepping. The iterative scheme allows to make a huge variety of choices. Ideally an algorithmically elegant and non-expensive solution offering accurate solution (i.e. not drifting the steady state) with sufficient stability should be achieved.

  As there was already some progress achieved in LACE and Belgium an coordinated action is highly desirable.

  Priority: 2

- **Further improvement of the NH dynamics**

  Description and objectives: It is known that the convective bubble test indicates some deterioration of performance with the d prognostic variables compared to the advection of w. This result from the very sensitive academic test has probably just small impact for the real atmospheric model performance.

It however indicates that there is still space to further improve the NH core. More serious seems to be instabilities recently detected in regions where the nonlinear model significantly differs from the reference profile of the SI background for simulations done with high vertical resolution. Recent evolution of the dynamics in Arome also indicates that the NH core should be finished in the way that there are no open questions left related to its various setting. Finally it is desirable that the NH core is stabilized in the way, that an effort to derive its TL/AD version can be invested.

Priority: 1

- **Vertical finite element discretization scheme**

  Description and objectives: In order to further increase accuracy of the NH dynamic, it is desirable to represent the vertical discretization by vertical finite element scheme (VFE) instead of finite differences. The VFE scheme is already available for the hydrostatic code (as the operational scheme of IFS) so the NH version can at least partially profit from this fact.

  The current version of the ALADIN-NH VFE implemented offers stable and accurate solution for the integral and the Laplacian terms. Its full implementation however suffers by noise. It is of great interest that the work is finished to offer expected increase of accuracy for the vertical discretization of the NH dynamics.

  Priority: 1

- **SLHD on steep slopes**

  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. In order to prevent this the horizontal deformation should be computed along purely horizontal surfaces.

  Estimated working time: 1.5 person/months

  Priority: 2

- **Radiative upper boundary condition**

  Description and objectives: It is clear that a sophisticated treatment of the boundary conditions is essential for the model accuracy and stability. While the bottom and lateral boundary conditions are subject of an intensive research the top condition is typically represented by increased horizontal diffusion acting as a damping sponge. With the increasing number of the upper air satellite data and the better vertical model discretization (like VFE), the importance of more precise top condition is rising.

  The so-called radiative boundary condition reflecting no vertically propagating wave downwards to the model atmosphere seems to be a clean and sophisticated solution for the model top.

  Following published ideas an analysis of the recursive filter based on the non-reflecting upper boundary condition (RUBC) for gravity and acoustic waves interaction with the semi-implicit temporal scheme was carried on. The main concern was to influence the phase speed of the waves caused by a SI scheme on the radiative performance of RUBC. It was suggested that RUBC should be kept in an explicit form in order to properly handle wave radiation. Next step should be the scheme implementation into the model and testing it in the framework of the 2D and 3D experiments.

  Priority: 3

- **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 SL interpolation in the way to commit it into 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. This is especially beneficial for the SLHD which would differ by only interpolation weights computation from the non-SLHD case in the new design. This unification of SLHD into the SL interpolation also allows simple way to have TL/AD version for this non-linear diffusion once the new data-flow is reflected by this kind of code.

Priority: 1

- **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 an design for a turbulence scheme taking into account also the horizontal mixing. It is evident that with the current design of the model parameterizing diabatic effects just along a vertical columns is insufficient for the scheme considering also horizontal direction. Logically some parts of the scheme have to be completed during the model dynamics evaluation outside the model physics. It has been demonstrated (for example by analysis of P. Bénard) that an ideal place for inclusion of scheme with 3D extend could be the interpolation stencil of the SL interpolators. Specially the design of the SLHD can be easily adapted to provide effects similar to 3D turbulence.

  The aim of this study should be to define guidelines for implementation of such scheme into the model. It should be 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: 2

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 crucial factors 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