LACE Working Group for Dynamics & Coupling: Research plan for the year 2007

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Introduction

Contrary to several previous working plans this one aims to mention just topics for which the manpower is known (or expected). The uncovered tasks are not listed here. Any possible candidates being interested to work on dynamics and coupling under the LACE coordination are kindly asked to contact the WG leader to discuss a relevant subject to be studied.

Traditionally the proposed plan is structured into three following sections:

- I. Non-hydrostatic dynamics
- II. Dynamics - more general topics
- III. Coupling

Each subject is labeled by the priority estimation with following meaning:

1 The subject has the highest priority. It is desirable to finish most of the work during a given year leaving no (fundamental) uncertainties for the future.

2 The subject has either some potential to directly improve the operational model performance or it is very close to be finished. For the long term research it represents subject which should be sooner or later done in any way.

3 The subject is currently relying to another related research. In this category are also subjects for which it is not clear whether their implementation would bring direct improvement of the model performance (at least when considering also the requested code implications and CPU cost).

Note that the priority number for a given topic is subject of the temporal model know-how. It can be easily modified once new circumstances would imply it.

1 Non-hydrostatic dynamics

- **Vertical finite element discretization scheme**

  Description and objectives: In order to further increase accuracy of the NH dynamic, the vertical representation can be discretized by the vertical finite element scheme (VFE) instead of the finite differences. The VFE scheme is already available for the hydrostatic code (as the operational scheme of IFS) so the aim is to extend it to the NH dynamics. This work is also very important for the others using (or potentially using) the ALADIN-NH code: HIRLAM and ECMWF. As one of the author of the hydrostatic VFE scheme of IFS (M. Hortal) works for HIRLAM now, an increasing joint cooperation between HIRLAM and ALADIN is expected on this subject.

  The current version of the ALADIN-NH VFE implemented offers stable and accurate solution for the integral and the Laplacian terms. In order to achieve code efficiency the Helmholtz equation becomes the two equations system. However the current solutions suffers by the X-term discretization being source of noise for VFE. Further work should be focused to remove this problem.

  Priority: 1

  Contributors: EM, JV

  Means: 7.5 months (2 months of LACE support)

2 Dynamics - other topics

- **SLHD above mountain regions**

  Description and objectives: SLHD is triggered by horizontal deformation of the model flow. This field is computed along quasi-horizontal vertical layers. It is evident that above mountains the "horizontal" deformation is influenced also by its vertical component (dominating in terms of absolute value). Like that the diffusion performed by SLHD is enhanced for such areas. This effect has been proven as detrimental for the prediction of the small rainfall rates in high resolution models.

  It is desirable to compute the deformation field in a more sophisticated way, excluding the vertical component from it. This can be reached by combination of the deformation with the geopotential field for example.

  Priority: 1

  Contributors: AS(?), MT(?), PS(?) and FV

  Means: 1.5 month

- **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

  Contributors: MJ

  Means: 1.5 month

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

  Description and objectives: As known the use of the SLHD scheme consequences by worsening of the model conservative properties. During his 2006 research JM showed that there is a way to withdraw this situation. He proposed to use the generic two-parametric interpolation allowing to keep acceptable accuracy while changing its damping properties with respect of the small scale. The tests he did in academic environment and 2D simulation were promising.

  Logically this work worth to be continued by full 3D simulation with intensive tests.

  Priority: 2

  Contributors: JM, FV

  Means: 4 months (2 months of LACE support)

- **Physics / dynamics coupling**

  Description and objectives: A continuation of the work started by the late 2006 of the physics coupling to the model dynamics is expected. The current treatment of physics offers stable solution but with the only 1^{st} order of accuracy. As found from stability analysis such treatment consequences by climatic drift corrupting the steady solution. The first outcome from the ongoing research is the averaging of diabatic tendencies along the semi-Lagrangian trajectory. This looks very promising at the moment. Some further investigation of numerous solutions for the Phys/Dyn coupling is desirable.

  Priority: 2

  Contributors: MT

  Means: 2 months (1 month of LACE support)

- **TL/AD of the semi-Lagrangian scheme**

  Description and objectives: The TL/AD code of ALADIN semi-Lagrangian scheme is available. The TL part is already in the public source. The AD still requires to be phased at the level of CY32T2. Some minor optimization (mainly for the code parallelism) was also performed during early 2007.

  Priority: 2

  Contributors: FV

  Means: 1 month

- **TL/AD of the SLHD**

  Description and objectives: Hoping to have first working version of ALADIN 4DVAR system it is just natural to made the TL/AD code consistent with the non-linear model. Moreover the role of diabatic processes, especially turbulent transport should be preferably represented by the TL/AD code.

  As already shown for the non-linear model the horizontal role of turbulence cannot be neglected especially when aiming to assimilate data from very high resolution. As the variational code of the 3D turbulence scheme with high order of accuracy seems to be really a far future, alternative solutions has to be investigated. Among them a non-linear 3D diffusion of the 1^{st} order accuracy seems to be a viable alternative. From this perspective to introduce SLHD seems to be a natural extension for the current TL/AD models.

  Priority: 2

  Contributors: FV, AT

  Means: 3.5 months

- **Thermodynamics consistency in the model equations**

  Description and objectives: Having now the new multi-phasic equations the model code has to be rechecked for being consistent with the new equation system. For example it is not certain whether the code is maintained consistently with respect to δm variable or the `LCONDWT` key. The proper computation of R and c_p should be also re-verified.

  The next step would be to verify the code bellow the `LSPRT` allowing to use moisture as the purely gridpoint variable.

  Finally the exact treatment of diabatic forcing (for the NH dynamics) can be reopened when the previous is found sufficiently coded.

  Priority: 2

  Contributors: PS

  Means: 2 months

3 Coupling

- **Boyd's method in SL space**

  Description and objectives: Having the environment to diagnose influence of the lateral boundary coupling to the model results various approaches then can be tested in the framework of the full model.

  One idea is to use semi-Lagrangian trajectories to emulate the transparent boundary condition. The expected noise generated between the inner model and leading model areas can be than further damped by an enhanced SLHD.

  Another necessity to improve model coupling is to replace the current spline bi-periodic extension by something more consistent with the inner model information. There are several approaches for it like one proposed by Boyd (2005) or so called perfectly matching layer approach. The aim should be to select the appropriate one and successfully implement it into the model.

  Priority: 3

  Contributors: FV, JM

  Means: 2 months

- **Spectral coupling**

  Description and objectives: The spectral coupling offers a nice alternative to the standard lateral boundary one. While the latter uses the information just from the relatively narrow area near the model boundaries, the former one keeps information from the whole domain.

  Obtaining positive results with this interesting way of LBC treatment, the work on this subject should progress toward the real operational exploitation. Knowing there is a perspective to compute the warning index by the ARPEGE, the spectral coupling technique has a potential to improve the quality of forecast especially for the severe weather situations. Such situations are known as having tendency to be missed by standard coupling technique with insufficient coupling frequency.

  Priority: 3

  Contributors: RR(?)

  Means: 2 months