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

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Introduction

This paper aims to give an impression about areas on the fields of dynamics and coupling which seems to be of interest and possibility to be studied during 2007 within the organized RC LACE research. Since most of the 2006 topics are still in progress (not finished for the moment), this plan should be considered as limited to the current knowledge. It can easily happen that any new outcome from the ongoing research might significantly influence the final 2007 plan. For the moment the availabilities of researchers are also a bit obscured. Hence a persistence with the 2006 is presumed for the year 2007 regarding the available manpower and LACE funds. Probably not all the subjects will be covered as it was also the case before. But at least the topics with the highest priority should be tackled by LACE scientists.

Traditionally the proposed plan is structured into three following sections:

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

1 Non-hydrostatic dynamics

- **Iterative schemes**

  Description and objectives: The stable iterative scheme (ICI scheme) is available in the model for the 2TL SL time-stepping and Eulerian advection. There are several possibilities to further generalize the ICI code (like extension to the 3TL SL advection) but none of them is currently of really high priority. Probably more important would be to review the physics coupling to the dynamics. 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.

  Estimated working time: 3 person/months

  Priority: 3

- **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.

  One of the suspicious places of the NH dynamics is the discretization of the so called Z-term. A specific study diagnosing other approaches for this term can give clear indication of the source of this limited model performance.

  Moreover there is also an interest of the ECMWF to profit from the ALADIN-NH code and to use if in the IFS as well. However the ECMWF people seems to be not convinced to the ALADIN-NH

choice of prognostic variables. Hence it seems to be important to solve "residual small problems" of the existing ALADIN-NH dynamics. Like that it will be clearly demonstrated that the chosen prognostic variables are comparable if not superior in terms of accuracy, stability and code efficiency over the other alternatives.

Estimated working time: 2 person/months

Priority: 1

- **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) is going to work for HIRLAM, 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. This solution should be preferably phased into the common source code as the basis for further full VFE scheme implementation.

  Estimated working time (of LACE people): 4 person/months

  Priority: 1

2 Dynamics - other topics

- **Towards the better approximation of the horizontal pressure gradient term**

  Description and objectives: It is known that especially in the presence of sharp orographic slopes the current treatment of the horizontal pressure gradient term has some limits. The topic has been already accepted by the HIRLAM scientist (U. Andrae) who will continue his work with help of R.Brožková.

  Estimated working time (of LACE people): 0.5 person/months

  Priority: 2

- **Horizontal diffusion schemes for the regions with orographic features**

  Description and objectives: There are currently two horizontal diffusion schemes available in the model. Both of them tends to have some problems close to the orographic features.

  The spectral diffusion acting along the sloped model levels is known for its destruction of valley inversions or creation of false advection from air mass being above other air mass with different characteristics. This known weakness is treated in case of temperature field by diffusing the difference between the temperature and the prescribed temperature of the standard atmosphere. Even such solution is not always sufficient. Moreover the other fields are not vertically corrected at all. A targeted study can diagnose the impact of spectral diffusion, eventually to propose some solution for the diffused amount.

  SLHD acting more locally within one 3D stencil of the semi-Lagrangian interpolation seems to have less problems with the false advection around sloped terrain. Its triggering function - the horizontal deformation function is however computed along model layers. It is evident that in mountains such function is consequently enhanced by the impact of the sloping surfaces. The diffusion performed by the SLHD is then randomly stronger for such areas. Again this effect should be studied more in detail. If found serious problems for the scheme performance a solution to solve it should be proposed.

  Estimated working time: 1.5 person/months

  Priority: 3

- **Solid top of the model atmosphere**

  Description and objectives: Various validation tests of model dynamics are performed in the framework of idealized atmosphere. Such experiments have typically solid atmospheric top defined at certain height. This options is not available in the ALADIN model. Numerous approximations if not even tricky solution (like vertical inversion of the atmosphere) have to be implemented in order to perform idealized tests. Logically the results of such tests then can't be always compared with the published reference results of the results of other models.

  The aim of proposed work should be to implement option in the model allowing to perform 2D and 3D tests with well defined solid model top.

  Estimated working time: 1 person/months

  Priority: 3

- **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.

  Estimated working time: 10 person/months

  Priority: 3

- **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 J. Mašek 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.

  Estimated working time: 2 person/months

  Priority: 2

- **Physics / dynamics coupling**

  Description and objectives: A work started by the late 2006 aims to increase the accuracy of the physics coupling to the model dynamics. 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. A way improving the physics coupling accuracy can be the averaging of diabatic tendencies along the semi-Lagrangian trajectory. The first approach is to follow the treatment used by the ECMWF which is already available in the code. In case it is found necessary such treatment can be further modified toward the operational extent with ALARO physics.

Estimated working time: 2 person/months

Priority: 2

- **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 one. 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. Since 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. As the SLHD offers the efficient way to simulate such approach for the non-linear model, it seems to be natural to extend it into the TL/AD models as well.

  Estimated working time: 5 person/months

  Priority: 2

3 Coupling

- **Better LBC treatment**

  Description and objectives: During his November stay at CHMI J. Mašek should prepare the 3D 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.

  Estimated working time: 2 person/months

  Priority: 1

- **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 is not progressing toward the real operational exploitation. It is felt as a pity knowing there is the perspective of having warning index implemented into the ARPEGE code. This combined with the spectral coupling would have 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.

  Estimated working time: 2 person/months

  Priority: 3