LACE Working Group on Dynamics & Coupling

Summary of 2011 work

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Preface

With the end of the Project on NH dynamics the main focus in the LACE model research concentrates to the model physics development. This can be illustrated with the situation at CHMI (where the dynamics team covers almost entire LACE workforce for this area). There the three core people (out of four available for dynamics) were mostly devoted to model physics (convection and cloud scheme, radiation and turbulence) during the 2011. Like that the total contribution from CHMI to the model dynamics hardly exceeds 8 months compared to the originally planned 15 months. The total workforce dedicated to dynamics was reduced to 60% (real efforts of 10.5 months compared to estimated 17.5 months).

This situation just confirms that the operational dynamics offers accurate and robust performance, so there are no apparent or urgent problems to be solved there. Any research in dynamics is thus rather longer term issue focusing to the future operational configurations at higher resolutions (kilo-metric scale). This is naturally seen to be of lower importance for the Local Team Managers who seems to rather prioritize the development of physics for its potential to offer immediate benefit for the current operational implementations.

This outflow of the workforce from dynamics to the area of physics then illustrates among the flexibility of researchers the understaffed situation of the research within the LACE countries. This in connection to relatively long term character of any research in the area of model dynamics can create soon a potential problem when moving toward final scales.

Progress description

Still even with the mentioned drain of the people to other areas, bellow the description of progress is given for particular topics following the original plan for 2011.

1. **VFE NH**

   Description and objectives: The subject is very complex. It was agreed to put increased manpower to this subject in order to progress from the current stagnating situation. The target is still remaining the same: to achieve with minimal principal changes of the model dynamics the stable VFE discretization.
   During this year some minor progress was achieved, mainly related to the phasing the VFE development to the most recent model version (CY36T1). Some new approaches were tested (including the feasibility study to formulate model in covariant velocity components) but none of the tested option offered stable solution for VFE discretization so far. We failed to devote for this subject more than

one person, so in this respect there is no difference compared to the previous years.

Recognised workforce: J. Vivoda (Sk), F. Váňa (Cz) and J. Mašek (Cz) - 4 months (2 months with LACE support)

Real effort: J. Vivoda (Sk) (2.5 months on LACE support), F. Váňa (Cz) (1 week) and J. Mašek (Cz) (1 week)

2. **Non iterating version of advection of vertical velocity**

Description and objectives: The advection of vertical velocity (so called `LGWADV=.T.` option) is so far the most accurate alternative for the model NH dynamics. It was however believed to be only available for the ICI scheme.

During the work aiming to code the SETTLS technique for this option to profit from the simple (non iterative) SI time stepping, it was found that the relevant code already exists in the model. It was just not used, for the lower stability compared to the ICI scheme as tested for the IFS model. The IFS model is however differing from the Aladin time-step organization (mainly due to the physics called after explicit dynamics). So that it can't use the SI scheme already used in Arome. Not surprisingly then the desired SETTLS scheme with `LGWADV=.T.` offered stable and accurate performance for the Aladin, superior to any other existing alternatives of NH model. Still some weak instability has been detected associated with the SETTLS stabilization in academic tests. In the ongoing work the aim would be further understand and stabilize this feature.

Recognized workforce: F. Váňa (Cz) - 2 months

Real effort: F. Váňa (Cz) - 1.5 month

3. **Pressure gradient term and optimal treatment of model orography**

Description and objectives: An accurate discretization of the pressure gradient (PG) is the essential target for being able to correctly treat the model orography. This becomes increasingly important for high resolution simulations.

The study was aiming to analyze an error associated with the PG term. In addition to this, several approaches were investigated for their potential to further improve the present PG term evaluation. Although there is still some space to achieve an improvement of the existing PG term evaluation, it was concluded to at the moment rather activate the existing vertical element discretization technique already offering very good quality for this term for relatively low extra cost.

Recognized workforce: J. Mašek (Cz) - 2 months

Real effort: J. Mašek (Cz) - 1 month

4. **Preparation for higher resolution**

Description and objectives: By increasing a model resolution (horizontal and vertical) some "sleeping pathological syndromes" can be amplified to an extent when they cause a harm to the model forecast. The aim of this task then was to ensure that by increasing resolution from 8-10 km to the targeted resolution of around 4-5 km of horizontal mesh (with over 60 vertical levels) the model offers improved forecasting skills compared to those from the original resolution. Thanks to some extensive parallel tests at CHMI this has been ensured, especially by the new proposed tuning of horizontal diffusion, better vertical interpolation in higher troposphere and activating the vertical finite element discretization scheme. The next step would be naturally to ensure that similar changes holds also for

the further resolution increase to around 1-2 km of horizontal mesh.

Recognized workforce: J. Mašek (Cz) - 2 months, R. Brožková (Cz) - 1 month and F. Váňa (Cz) - 1 month

Real effort: J. Mašek (Cz) - 0.5 month, F. Váňa (Cz) - 0.25 month

5. **Multi-phase aspects**

Description and objectives: Revision of the physics-dynamics coupling in the sense it allows fully elastic coupling of diabatic tendencies in pressure based model coordinate. The proposed method should consistently treat the existing water phases in the model atmosphere.

Recognized workforce: R. Brožková (Cz) - 2 months

Real effort: nothing done for this year

6. **Second order accurate coupling of physics to dynamics**

Description and objectives: The present coupling of physics to dynamics offers very stable and robust solution. The price to pay for it is however its only first order accuracy in time. Using the SETTLS technique for the physical tendencies the present time-stepping should be relatively easily extensible to a second order accuracy coupling without a need to change timestep organization. The basic coding of this new higher accuracy scheme has been finished. However, the real case simulations with the settings used in the current operational version of the model Alaro for the Czech domain (4.7 km horizontal resolution, 87 vertical levels, 2tl SI-SL time scheme) showed poor stability of this configuration. If the SETTLS type coupling is applied on all the advected variables (but the moisture is enough to produce this phenomena) significant time oscillations appear in the field of temperature mostly near the ground, but not exclusively restricted to this area. If applied only on prognostic variables as the temperature and the wind components, the stability was recovered but the expected enhanced accuracy was not detected in a one month validation. We conclude from these tests that we shall stay with the current explicit technique of coupling the physics to dynamics and we resign for the time being on the second order in time accuracy.

Recognized workforce: P. Smolíková (Cz) - 2.5 months

Real effort: P. Smolíková (Cz) - 2 months

7. **3D turbulence scheme**

Description and objectives: The first version of a 2D extension of the turbulence scheme (so called 1D+2D turbulence) was made available in summer of 2010. It however still required an additional extension to comply with all the existing model options in the NH dynamics, to be validated and finally phased to the common source code at the level of CY37T1.

The basic coding has been finished in early 2011 and phased to CY37T1 where it was further modified to comply with the forthcoming OOPS (Object Oriented Prediction System) redesign of the model source. In parallel to extensive validation (and debugging) of the TOUCANS turbulence scheme (to which this extension is only complementary), the 1D+2D version was continuously maintained to be updated accordingly. The latest update made the scheme consistent with the TOMs (third order momentum terms) treatment for the temperature and scalar variables. This updated code has to be once again phased to the common source, either as a fix above the CY37T1 or to a higher model release, like CY38T1. In parallel a scientific validation of the new scheme can start.

Recognized workforce: F. Váňa (Cz) - 1 month

Real effort: F. Váňa - 1.5 month

8. **Optimal model setup of NPROMA**

Description and objectives: The present automatic setup for NPROMA parameter (the main model tunable to influence the platform dependent computing efficiency) was hard coded for the LAM model. So far this was only possible to bypass it by setting this parameter to a given value. As the optimal value of this parameter especially for vector machines (with values of NPROMA exceeding 2000-3000) using OpenMP parallelization is strongly domain and number of parallel threads dependent it was found desirable to let the model to compute the optimal value by itself. The new code fixing this long-lived bug has been coded, tested and phased to the CY37T1.

Recognized workforce: F. Váňa (Cz) - 0.5 month

Real effort: F. Váňa - 0.25 month

Summary of dedicated manpower

The total workforce dedicated to dynamics was reduced to 60% (real efforts of 10.5 months compared to estimated 17.5 months). To keep the planned level of the workforce, either some new people have to be attracted, for example from the universities, or people from non-LACE countries might be invited to work on the topics within the LACE supported stays. The LACE representatives are encouraged to attract new people, since otherwise it is very difficult to make progress within the provided manpower.

Task	Planned means (in months)	Executed means (in months)
VFE NH	4 (2 on LACE sup.)	3 (2.5 on LACE sup.)
LGWADW,SETTLS	2	1.5
PG term	2	1
Higher resolution	4	0.75
Multi-phase aspects	2	-
Coupling of physics to dynamics	2	2.5
3D turbulence	1	1.5
Optimal NPROMA	0.5	0.25
Total	17.5 (2 on LACE sup.)	10.5 (2.5 on LACE sup.)