wWorking Area Dynamics & Coupling

Progress Report

Prepared by:	Area Leader Petra Smolíková
Period:	2021
Date:	2/3/2022

Progress summary

This report summarizes the work done in the Area of Dynamics & Coupling of the RC LACE during the year 2021 with the emphasis on last four months. Some previous results are described in more details in the report on the Area of Dynamics & Coupling from September 2021. Due to the epidemiologic situation in all the Europe the working conditions were limited, and only two research stays were executed. On top of that, valuable work was done locally.

1. Scientific and technical main activities and achievements

Task 1. Vertical discretization

Subject:1.1 Design of vertical finite elements scheme for NH version of the model

Description and objectives: The main objective of this task remains the same for years - to have a stable and robust vertical finite elements (VFE) discretization to be used in high resolution real simulations with orography with the expected benefit being the enhanced accuracy for the same vertical resolution when comparing with vertical finite difference (VFD) method. We want to stick as much as possible to the existing choices in the design of dynamical kernel (SI time scheme, mass based vertical coordinate) and to stay close to the design of VFE in hydrostatic model version (according to Untch and Hortal). The compatibility of the newly proposed vertical velocity variable with VFE will be studied and code will be modified to allow the usage of both.

Status: **The topic is PENDING.**

Contributors: none

Executed efforts: none

Subject: 1.2 Modularization of vertical discretization

Description and objectives: The influence of a vertical discretization on stability and accuracy of the model integration is still not well understood. This task incorporates two parts, one technical – to modularize the vertical discretization from other parts of the dynamics; and second scientific, to understand better the influence of vertical levels definition on the behaviour of the model. It is a known fact that SL interpolations are less accurate when applied in terrain following vertical coordinates then in smooth pressure levels (Park et al., 2019). The usage of hybrid levels up to the stratosphere is a common practise in our community. However,

it can be a source of noise in the upper model levels. This undesirable phenomenon can be simply pacified by using pressure levels already from the middle troposphere and higher. Such a choice could have a positive influence on the quality of the upper level turbulence (CAT) prediction and it could possibly avoid the generation of vertical chimneys in the vertical velocity field observed often over an orography. This could have as well a positive impact on precipitation field which may become smoother. Hence, we propose to investigate the influence of "hybridism" on the quality of the model prediction and to try to find an optimal choice for vertical coordinate setting.

[S.-H. Park, J. B. Klemp, and J.-H. Kim, *Hybrid mass coordinate in WRF-ARW and its impact on upper-level turbulence forecasting*, MWR, in press, 2019]

The topic is PENDING.

Contributors: none

Executed efforts: none

Task 2. Horizontal diffusion

Subject: 2.1 Tuning and redesign of the horizontal diffusion depending on the scale

Description and objectives: A numerical diffusion has a significant role among the other mixing parameterizations since it must be present from planetary to viscous scales, mimicking the continuation of the energy cascade at the end of model spectrum and simulating residual processes which are not well captured by other parameterizations, as well as acting to filter-out unwanted discretization noise. The SLHD (semi-Lagrangian horizontal diffusion) is a flexible tool to represent the numerical diffusion in the model which was proven to be well working throughout a wide range of resolutions. Nevertheless, this tool has an enormous number of tuneable parameters and includes not only flow dependent grid-point diffusion, but a supporting spectral diffusion as well. The behaviour of the whole scheme in high resolutions appears to be not understood well. The topic covers the proposal of an experimental setup enabling to test schemes in multiscale environment, developing tools to diagnose energy and entropy in the model system and SLHD tuning to get a consistent and scale invariant parameterization of mixing processes. The work started in the last year with the sensitivity study in the cascade of resolutions (4km, 2km, 1km). Moreover, the domain covering roughly the same territory with the horizontal resolution of 500m was prepared to complement the existing experimental environment. The original method was designed to determine the resolved TKE. We continue in the work.

Status: The research stay of Mario Hrastinski at CHMI was postponed to April - May 2022 since Mario was working hard during 2021 to finish his PhD thesis with different subject.

Executed efforts: none

Documentation: none

Task 3. Time scheme

Subject: 3.1 Generalization of the semi-implicit reference state to include vertical profile of background variables and horizontal features as orography

Description and objectives: One of the possible ways to attack this subject is a direct inclusion of the tangent-linear approximated model in the semi-implicit time scheme. The stabilising effect of such method was identified at ECMWF for the hydrostatic IFS by Filip Váňa, and the potential of the new design of SI scheme has been exploited in low spatial resolution (corresponding to usual values in global applications). The most interesting point is the incorporation of orography and real vertical profiles into the linear model, while in the existing reference state for linearization no orography and only constant vertical profiles are present. The consequence of this new design of SI scheme would be no need of the spectral space representation of model variables and of transformations between spectral and grid-point spaces once the horizontal derivatives are calculated in a local way (for example through finite differences). The crucial point is here the iterative method used to solve the Helmholtz problem and its convergence behaviour in higher spatial resolutions (with steeper slopes). There are other less ambitious ways how the vertical profile of the reference state could be incorporated in the semi-implicit scheme which may be also investigated.

Status: **The topic is PENDING.**

Executed efforts: none

Documentation: none

Subject: 3.2 The trajectory search in the SL advection scheme

The topic is CLOSED.

Subject: 3.3 Dynamic definition of the iterative time scheme

Description and objectives: Tests in higher horizontal resolutions then those used currently in operational applications (being close or less than 1km) reveal that in most of the cases the

SETTLS time scheme is enough to deliver stable solution while there appear some cases when at least one iteration of the iterative centred implicit scheme is needed. When going to higher resolutions it may happen that even one additional iteration (corrector) is not enough as reported by Karim Yessad. The idea of this topic is to determine a condition which will evaluate the stability of the integration and in case there is an indication of poor stability the iteration will be started. Ones such condition defined, the time scheme would become more efficient and the computer time will be invested only when needed. Iterative time stepping procedure could be used as well regularly every Nth time step (N>1) to better balance the cost/stability properties of the whole scheme. Implementation of such choice would require careful allocation of corresponding buffers and thorough handling of the data flow between consequent time steps treated in a different way.

Status: Due to the covid situation and recommendations of the relevant authorities concerning travelling, the research stay of Alexandra Craciun at CHMI was cancelled for 2021. We hope to see her in Prague in 2022.

Executed efforts: none

Documentation: none

Subject: 3.4 Terms redistribution through new vertical motion variables

Description and objectives: Motivated by the work of Fabrice Voitus which was presented at the ALADIN Workshop in Toulouse in April 2018 we started this new subject. The aim is to reformulate the nonhydrostatic nonlinear model to obtain simple bottom boundary condition which is easily fulfilled. This aim may be reached only for restricted choices done in the dynamics of the ALADIN system. In particular, only the case when vertical velocity variable is used in the nonlinear nonhydrostatic model in the two-time level SI SL scheme. The bottom boundary condition was proven to be very important for the stability and accuracy of the whole discretization of the system of prognostic equations. Several new formulations of vertical velocity were already proposed in 2018 and implemented in the model code. Parallelly, new vertical motion variable was implemented in Toulouse by F.Voitus. Its usage with VFE discretization will be studied and code will be modified.

Status: The topic is PENDING.

Executed efforts: none

Documentation: none

Task 4. Evaluation of the model dynamical core in very high resolutions

Subject: 4.1 Tuning of dynamical adaptation of the wind field at different resolutions

Description and objectives: The quality of the wind field forecast may be improved in case of strong wind and rugged terrain through a dynamical adaptation to high resolution topography by running short range forecast of the ALADIN system in higher than standard operational resolution. Wind field from the dynamical adaptation may be used as well to evaluate local wind climatology. This strategy was applied on Croatian domain to better capture the local wind "bura" being developed due to large gradients of pressure over the coastal mountains having large spatial variability and local terrain dependence. The influence of non-hydrostatic dynamics setting in several high-resolution experiments (500m, 250m) will be studied.

The work is connected to physics, since the influence of parameters of the turbulence scheme is being questioned as well.

Status: **The topic is PENDING.** Its realization is connected to the procurement of the new HPC in Croatia, since new application being run in higher horizontal resolution on the new HPC is foreseen to create the LBC files needed for the dynamical adaptation.

Executed efforts: none

Documentation: none.

Subject: 4.2 Upper boundary condition

Description and objectives: There are some indications that upper boundary may cause a problem in higher resolutions. There could be a big jump in vertical levels needed which may destabilize the whole model as it was observed for finite elements used in the vertical discretization of ALADIN-NH.

In general, on the top boundary there is no material surface contrary to the bottom boundary and vertically unbounded atmosphere may be undesirable in some applications. In practice, velocity normal to the upper boundary is set to zero causing wave reflection similar to lateral boundaries. Free-slip conditions are used for other variables. This means that the vertical derivatives of these variables are equal to zero and there is no mass and heat transfer across the boundary. Radiation boundary condition can be imposed by diagnostic relationship between pressure and vertical velocity at the top (Klemp, Durran 1983; Bougeault 1983). However, it is formulated in terms of vertical wavenumbers and frequencies and is difficult to be implemented. To overcome this problem an explicit absorbing layer is applied for example in SLHD (semi-Lagrangian horizontal diffusion) where spectral diffusion works only when

approaching to the top, and an implicit absorbing layer is applied through the coarsening of the vertical resolution when approaching to the top. It should be investigated if there are some new or enhanced problems at the model top in horizontally or vertically higher resolutions and solutions could be proposed if needed.

Status: **The topic is PENDING.**

Executed efforts: none

Documentation: none

Subject: **4.3 Experiments in very high resolution**

Description and objectives: As reported by Fabrice Voitus (Météo France) the numerical stability of the ALADIN nonhydrostatic dynamical core is endangered as soon as the horizontal resolution of 350m is approached above steep orography. To be able to test this statement and to analyse the model dynamical core behaviour we must start experiments in these very high resolutions. For these goals the climate files must be prepared from a fine database.

Status: With the foreseen project DESTIN-E where several RC LACE countries will be involved, experiments in even higher resolution of 100m are expected to be prepared as well as more convenient set ups around 500m of horizontal resolution. The new options in dynamics will be tested in these scales expecting better stability results to be achieved. Some experiments have already started with a domain over Alps in 150m horizontal resolution prepared by Météo-France. The aim is to enhance the stability of the proposed time scheme which is seen as insufficient. Moreover, a setup for an experimental domain over Central Europe covering the Alps was prepared with the following parameters: horizontal resolution of 456m, 4800x3240 grid points, 87 vertical levels. With these parameters, PGD tool and e923 configuration need modifications for parallelisation and further changes which were prepared by Météo France. The problem needs more investigation and a transfer of expertise. Fortunately, these processes will be needed in the DESTIN-E LAM project and thus will receive the needed attention. Once the e923 configuration is able to handle the target domain, it will be necessary to make PGD tool working with it, since GMTED2010 orographic fields enter e923 via PGD file.

It seems that experiments on comparably large LAM domain were not run in the whole ACCORD consortium so far. In order to start experiments paving the way to NWP on hectometric resolutions, technical knowledge must be built first, including modifications of the model code and tools necessary for climate files generation, and for handling of huge FA files. Hence, the preparation of such experiments demands more workforce than is usual for increasing the model resolution.

The topic is ONGOING.

Contributors: Ján Mašek (CHMI)

Executed efforts: 1 PM of local work

Documentation: none

Task 5. Optimization of the model code to better balance computer resources/results achieved

Subject: 5.1 Single precision

Description and objectives: We propose to investigate the impact of limiting the precision of real-numbers used in the model code to only 32 bits (single precision) in most of the calculations instead of commonly used 64 bits (double precision). The results from annual integration of IFS and from medium range ensemble forecasts indicate no noticeable reduction in accuracy and an average gain in computational efficiency by approximatively 40%. We would like to carefully check the limited area model dedicated part of the code to obtain similar results in CPU reduction while keeping reasonable accuracy level. The envisaged code changes would be rather technical including replacement of hard coded thresholds with intrinsic precision functions, avoiding divisions by floating point numbers that may become zero etc.

Status: The topic is PENDING.

Executed efforts: none

Documentation: none

Task 6. Basic equations

Subject: 6.1 Reformulation of the NH system as a departure from HPE

Description and objectives: Currently hydrostatic (HY) and fully compressible nonhydrostatic (NH) system of equations and its numerical integration form two dynamical cores which are separated in a substantial part of the model code. Recently Voitus showed that unification in the spectral Helmholtz equation solver is possible through elimination of all variables except horizontal divergence in both these worlds. The aim of the topic is to reformulate the compressible nonhydrostatic system of equations as a departure from the hydrostatic system which may be controlled through a new parameter ε (ε = 1 NH core, ε = 0 HY core). Then all computations of the dynamical core can be treated in a unified code. Moreover, this parameter

ε can be vertically dependent. It would allow to suppress nonhydrostatism close to the model top where the vertical resolution is too coarse to properly sample NH processes.

Status: A set of control parameters was introduced in the full Euler system of equations that master separately each nonhydrostatic term. If all the parameters are set to 0, the system collapses to the hydrostatic primitive equations, while setting all parameters to 1 gives Euler equations. These control parameters may be defined independently in the linear model and in the full model used in the SI non-iterative or iterative time schemes. Full stability analysis of the SHB type was prepared which showed the regions of stability for distinct choices of control parameters. The analysis indicates which values of control parameters may possibly have the stabilization effect on the integration scheme. One may conclude that values slightly higher than 1 used in the linear model are beneficial for the stability while values smaller than 1 are destructive. On the other hand, if applied in the linear and in the full model we find the opposite behaviour. The results differ depending on the time scheme used.

After idealized experiments run in the vertical slice 2D model version, real simulations were run for two datasets. The first corresponding to the Czech operational setting and the Czech operational domain in 2.325km, dynamical adaptation for a case of strong wind over Krušné Hory from 12 February 2019 00 UTC integrated for 24 hours. There is a very good correspondence between results of the stability analysis and model behaviour found in the real simulation. Hence, we are able to enhance stability of the model time scheme through the change of the control parameters. The time scheme used in this case is two-time-level non-iterative SI extrapolating along the SL trajectory (SETTLS). The obtained results were qualitatively compared with a given reference. We may say that the basic NH features are captured by the model with reasonable values of control parameters, for values differing significantly from 1, a deterioration of results is observed.

The second simulation was run for the Occitania domain in 375m horizontal resolution resolving deep convection and with corresponding ALARO physics. In this case the modification of control parameters in the linear model only was not enough to ensure stability and we had to modify the control parameters in both, the linear and the full model. The time scheme used in this case is the iterative centred implicit two-time-level scheme with one iteration (PC). More details may be found in the previous report on Dynamics & Coupling Area progress from September 2022. We prepare a paper for a peer reviewed journal.

The topic is ONGOING.

Contributors: Jozef Vivoda (SHMI), Petra Smolíková (CHMI)

Executed efforts: 8 PM of local work

Documentation: a manuscript of the paper in a peer reviewed journal, in preparation

Task 7. Coupling strategy

Subject: 7.1 The impact of higher coupling frequency

Description and objectives: The impact of higher coupling frequency was already investigated in the past and revealed an interesting option which may help to capture meteorological features which would be omitted with lower coupling frequency. Moreover, the LBC files started to be operationally available for the LACE domain in 1h frequency recently. We would like to assess the impact of the increased frequency of coupling on real cases in the context of our current operational resolutions. The operational usage of 1h coupling frequency is limited by the available transfer speed of LBC files to the partner countries.

Status: **The topic is PENDING.**

Proposed contributors: Mario Hrastinski, Iva Dominovic (DHMZ)

Executed efforts: postponed to 2022, Iva Dominovic left the NWP team, replaced by Ana Sljivic

Documentation: none

Subject: 7.2 Frame approach in the LBC files

Description and objectives: 1 hour coupling frequency is believed to be an interesting option, but the current LBC files prepared from ARPEGE for the LACE domain are "huge" while our HPCs are "fast". It follows that we are not able to get the LBC files quickly enough to use them operationally in high frequency (1h). We might think about frames implementation in FA format and about connected problems (LBC transformed to grid point space, the central part removed and just the frame distributed, central values smoothly completed, the whole field biperiodized and transformed to the spectral space). Such procedure must keep the values in the coupling zone reasonably precise. We would like to start to design such frames and to test them. These activities must be strongly coordinated with our partners, mainly Météo France, as the producer of LBC files.

Status: To get the information from driving global or limited area model, LBCs are used only in an outside frame of a domain (extension and intermediate zone). The width of these zones is only in tens of grid-points. In the rest part of the domain (central zone) LBCs are not used directly. The idea is to check how removing the values in the central zone of LBCs will affect the model performance. We have used the modification made in MF introducing the possibility to read grid-point represented model variables. There is a possibility as well to create artificial values in the central zone with the offline fullpos. However, this code is not used operatively and does not work properly in recent model versions. Hence, to replace the values in the

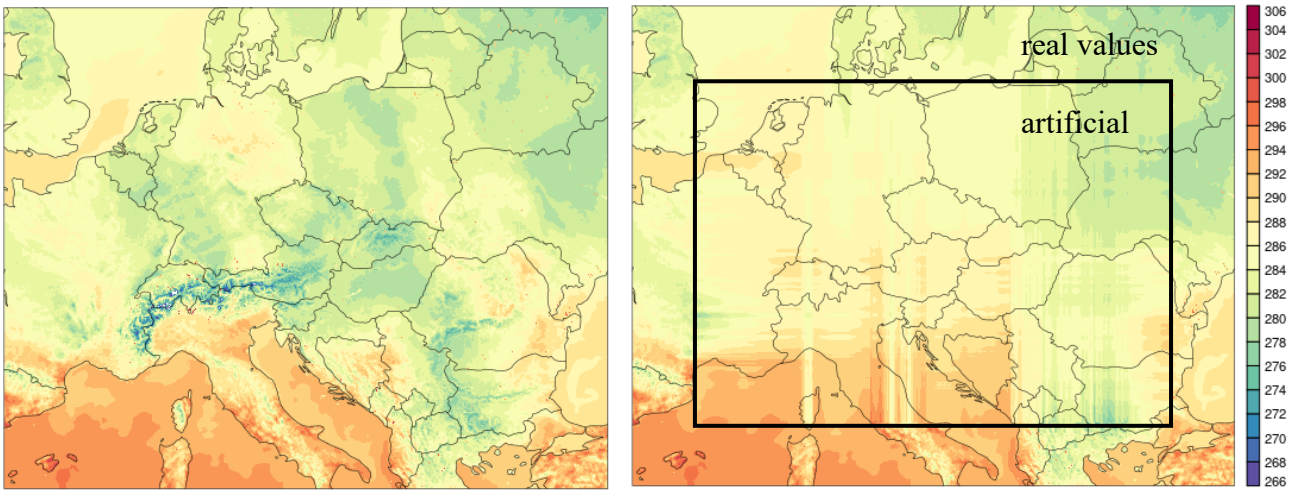

Figure 1: Comparison of surface temperature in full (left) and reconstructed framed LBC file (right).

central zone with artificial values we used a Fortran based external tool. It turned out that simple replacing a defined rectangular with zero or with an average value of a field does not work. Hence, we replaced the inner part of the field with an inverse distance-weighted interpolated values from its edges (Fig. 2). Some modifications of the size of the hole were tested by changing a parameter ICPLSIZE (where ICPLSIZE=0 means the biggest hole possible). Only upper air fields were hollowed since they are the subject of coupling. The other fields which are needed for physics, surface scheme or other purposes as orography, roughness etc. are kept unchanged.

Such modified LBC files were used to run experiments in a serie of 14 successive days in November 2021. We calculated the usual objective scores (RMSE, STDEV, BIAS) for model variables and other characteristics. The degradation of results with framed LBC files was not observed as illustrated in Figure 1.

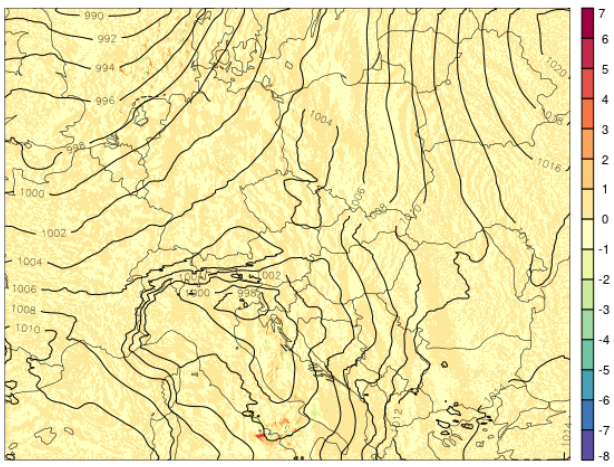

Figure 2: Difference of meridional wind component between forecast made from framed LBCs and the reference. The isolines show MSLP (hPa).

In addition to mean value of accuracy metrics, we "visually" checked four parameters (temperature, wind components and precipitation) at several model levels. An example is shown in Fig.2. Some differences occur mainly within the front zones that are near centres of lows (e.g. in central Italy and at the North Sea); however, they are local in space and thus do not affect the overall accuracy of the forecast measured by the verification scores.

Hence, the conclusion is that the framed LBC files may serve well as the boundary conditions for our applications. What is similarly important is whether there is a possibility to decrease the file size when framed grid-point values of model variables were transferred in LBCs instead of spectral representation. Here, it shows that there are more drawbacks then benefits. The idea is to prepare framed LBC files in the final resolution, but then the size of the framed grid-point field may easily exceed the size of saved spectral coefficients in case of spectral representation. We have calculated the file size estimate in the example of Czech operations and find out that the benefit is not big enough. See Figure 3 for the illustration of the number of saved reals in variously represented fields. We consider the coarse resolution domain (for LBCs) to have x grid-points in both horizontal directions and the high resolution domain (for the LAM model forecast) to have 4x grid-points in both horizontal directions, for simplicity.

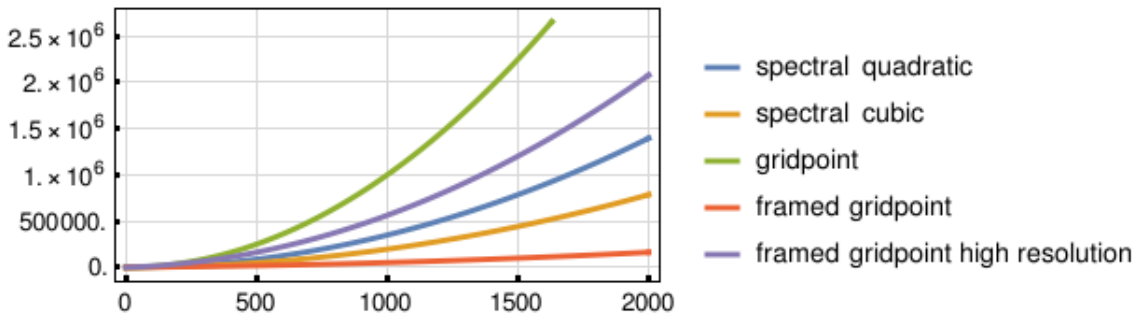

Figure 3: The number of reals saved in various field representations for a square domain with x grid points in one horizontal direction; x is on the x-axis. HR domain is 4 times wider than the original domain.

To get better compression of data, the framing must be done on the coarse resolution LBC files and the interpolation to the target grid afterwards. But this approach was not tested yet.

The topic is ONGOING.

Contributors: Gabriel Stachura, Petra Smolíková

Executed efforts: research stay of Gabriel Stachura in Prague - 1PM (Nov 2021), 1PM of local work

Documentation: report on the LACE web pages

Subject: 7.3 The impact of higher truncation in LBC files

Description and objectives: Another way how to decrease the size of LBC files while hoping in keeping the quality of the final forecast is to increase truncation of spectral fields in LBC files (quadratic, cubic etc.). This will be tested.

Status: Even if the truncation used in global model ARPEGE is linear and the horizontal resolution variable (stretched grid with approximately 5km horizontal resolution over Europe), the LBC files on the telekom domain produced in Météo France have quadratic truncation and regular distance in the grid-point space of 8km. Thus, a significant reduction of the size of the transferred information is already done. The goal of the work was to decide whether even higher truncation in the spectral space of LBC files can keep valuable information without having a detrimental effect on the final LAM forecast.

Naturally, we tested first the cubic truncation. The truncation is made consistently for upper air fields and the surface geopotential. We prepared the files in two steps. First, we prepared the cubic truncated LBC files in the original geometry and in the second step we interpolated to the final horizontal resolution (2.325km) and final vertical levels distribution (87 levels) using e927 configuration. We used different clim files for these two steps.

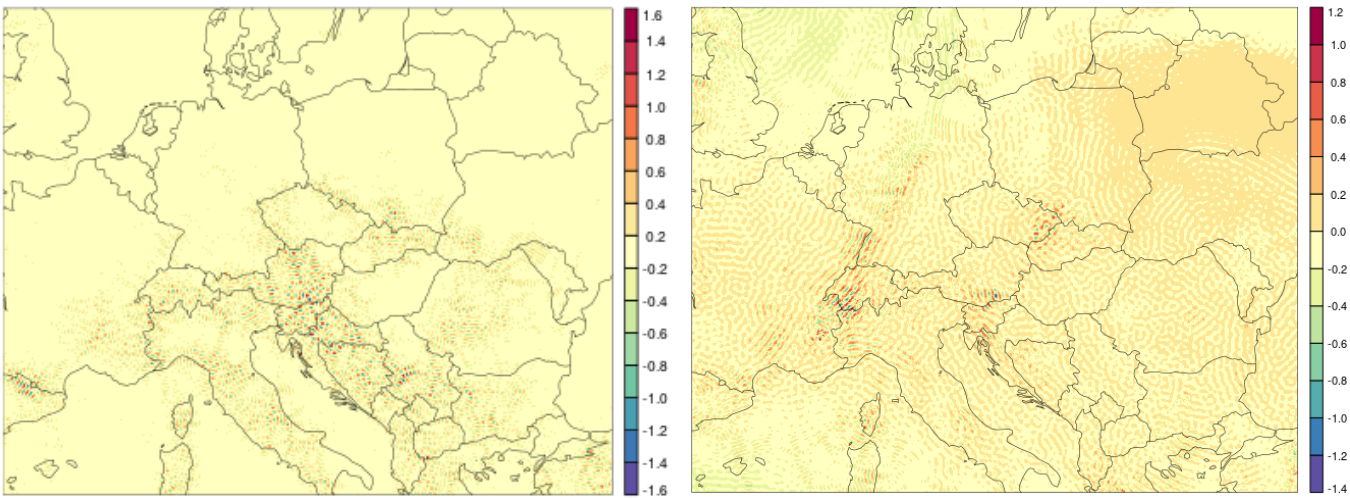

Figure 4: The difference of temperature at lowest model level and zonal component of wind at 40th vertical level between target LBC files created from cubically truncated files and the reference generated from quadratically truncated LBC files.

We can see that in case of temperature at lowest model level (Fig. 4, left), deviations relate to mountains and highlands. On higher levels, deviations tend to have lesser spatial extent. The magnitude of the deviations is generally acceptable (hardly exceeding +-1).

Then we prepared a serie of experiments for 14 successive days in November 2021. We run once a day forecast from 0 UTC for 24 hours in a dynamical adaptation. The forecast from cubic LBCs has generally similar accuracy to the reference one. Some systematic bias is seen in case of geopotential and wind speed; however, its magnitude is small. What is probably more concerning is the fact that geopotential bias is the most distinct at higher levels of the atmosphere as we see in Fig. 5. The bias is mostly positive and reaches up to 10 m2/s2, which is around 1 m of geopotential height.

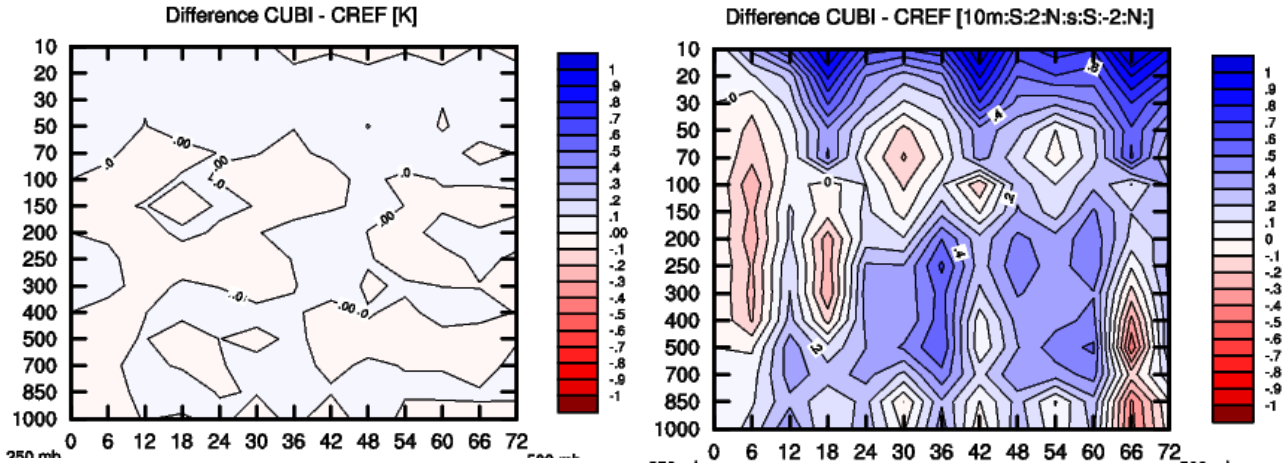

Figure 5: Temporal evolution of difference of RMSE between the experiment with cubic LBCs and the reference forecast for air temperature (left) and geopotential (right) at different pressure levels (vertical axis).

The produced forecasts were also checked octometrically in order to spot some potential outstanding values occurring on small area and therefore not influencing the average domain statistics. Main differences are related to front zones near low-pressure areas. Temperature deviations mostly stay within +-1 degree.

The topic is ONGOING.

Contributors: Gabriel Stachura, Petra Smolíková

Executed efforts: 1 PM of local work

Documentation: report on the LACE web pages

2. Documents and publications

One paper is being prepared for a peer reviewed journal:

Jozef Vivoda and Petra Smolíková, *Stability properties of the constant coefficient semi-implicit schemes solving equation system with controlled nonhydrostatism,* in preparation.

One report is being published on the RC LACE web pages:

Gabriel Stachura, *Frame approach in coupling*, 13pp.

Activities of management, coordination and communication

1) **36th LSC Meeting**, virtual, 23-24 March 2021
2) **Machine learning for numerical weather predictions and climate services,** ECMWF, virtual, 14-16 April 2021
3) **First ACCORD All Staff Workshop 2021**, virtual, 12-16 April 2021 – presentation of Petra Smolíková "Generalization of the linear model used in the SI and ICI time schemes"
4) **37th LSC Meeting**, virtual, 20-21 September 2021
5) **43rd EWGLAM and 28th SRNWP joined meetings**, 27 Sept - 1 Oct 2021, virtual – presentation of Petra Smolíková "RC LACE advances in dynamics"

LACE supported stays

Two research stays were cancelled due to the covid-19 restrictions, we expect their realization in 2022:

1) Tuning and redesign of the horizontal diffusion depending on the scale – Mario Hrastinski (DHMZ), 1 PM in Prague
2) Dynamic definition of the iterative time schemes - Alexandra Craciun (ANM), 1 PM in Prague

Two research stays were done:

1) Reformulation of the NH system as a departure from HPE - Jozef Vivoda (SHMI), 0.25 PM in Prague
2) Frame approach in the LBC files – Gabriel Stachura (IMGW), 1 PM in Prague

Summary of resources/means

The efforts invested in the area of Dynamics & Coupling in 2021 were limited, partially due to restrictions connected to the epidemy of covid-19, partially for unavailability of needed workforce due to other reasons. We were able to commit one half of the work we planned for the whole year. Two research stays were executed in the length of 1.25PM.

Task	Subject		Resources		
			Planned	Executed	Stays Plan/Exec
1. Vertical discretization	1.1	Design of VFE in NH model	2	0	-
	1.2	Modularization of vertical discretization	2	0	-
2. Horizontal diffusion	2.1	Tuning and redesign of the horizontal diffusion depending on	2	0	1/0
3. Time scheme	3.1	Generalization of the semi-implicit reference state	2	0	-
	3.2	The trajectory search in the SL advection scheme	0	0	-
	3.3	Dynamic definition of the iterative time schemes	3	0	1/0
	3.4	Terms redistribution through new vertical motion variables	2	0	-
4. Evaluation of the dynamical core in very high resolutions	4.1	Tuning of dynamical adaptation of the wind field at different	0	0	-
	4.2	Upper boundary condition	2	0	-
	4.3	Experiments in very high resolution	2	1	-

5. Optimization of the model	5.1	Single precision	1	0	-
6. Basic equations	6.1	Reformulation of the NH system as a departure from HPE	2	8	2/0.25
7. Coupling strategy	7.1	The impact of higher coupling frequency	2	0	-
	7.2	Frame approach in the LBC files	1	2	0.5/1
	7.3	The impact of higher truncation in LBC files	1	1	-
Total manpower			**24**	**12**	**4.5/1.25**