Working Area Dynamics & Coupling

Progress Report

Prepared by:	Area Leader Petra Smolíková
Period:	January - June 2025
Date:	04/09/2025

Progress summary

This report summarizes the work done in the Area of Dynamics & Coupling of the RC LACE from January to June 2025. One research stay was executed in this period. Other work was done locally. The work done was registered in the work packages DY1, HR, COM2.1 and MQA3 of the ACCORD registered workforce summary for the first two quarters of 2025 and partially also in the project DEODE_330.

We keep track of closed topics and subjects in the numbering and number the new topics and subjects with consecutive numbers. The closed topics and subjects are not listed any more in the report and thus the numbering may jump up several numbers.

1. Scientific and technical main activities and achievements

Task 1. Vertical discretization

Subject: 1.3 Ways how to decrease the first model layer height

Description and objectives: A necessary condition for the possibility to increase the density of model layers close to the surface is a lower placement of the first model layer. This placement has consequences in the turbulence scheme and must be done properly.

Status: No progress was made. A research stay and local work is planned for the second part of 2025.

Subject: 1.4 Study the effects of increased vertical resolution

Description and objectives: When going to very high (hectometric) horizontal resolutions we face the necessity to increase the vertical resolution to avoid a situation when the horizontal resolution would beat the vertical one and the model grid box will transform from a horizontal slice to a narrow vertical column. We will investigate how to benefit from this necessary change.

Status: No progress was made. The work depends on the outcome of Subj.1.3.

Executed efforts in Task 1: None

Task 2. Horizontal diffusion

Subject: 2.2 Evaluation of resolved and total TKE in the cascade of resolutions

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. Traditionally, the vertical part is treated in a parametrization scheme, while the horizontal part is being calculated by model dynamics. We expect that when going to higher horizontal resolutions the resolved part will increase and the sub-grid part decrease. This behaviour must be controlled, and the separated parts evaluated to ensure the correct behaviour of the whole process in all scales. An original method to determine the resolved TKE was already designed. The work will continue.

Status: No progress was made, since no workforce is available.

Subject: 2.3 Scale adaptation of horizontal and vertical turbulence

Description and objectives: After assessing the resolved and total TKE in all scales, adaptations of the horizontal turbulence (SLHD, spectral) and vertical turbulence (TOUCANS) must be proposed to ensure the correct behaviour of the whole diffusion process.

Status: No progress was made, since no workforce is available.

Subject: 2.4 Horizontal features of the turbulence scheme TOUCANS

Description and objectives: The necessity of including the 3D processes like horizontal wind shear and advection to improve the representation of turbulence kinetic energy (TKE) and of turbulence total energy (TTE) in runs with kilometric horizontal resolution was recognized. The implementation of horizontal features into the turbulence scheme TOUCANS was already started. In the proposed solution horizontal shear effects were parametrized using three different approaches and were included in the prognostic equations for TKE and TTE. The work will continue.

Status: No progress was made, since no workforce is available.

Executed efforts in Task 2: None.

Task 3. Time scheme

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: No progress was made. The work was planned for the second half of 2025.

Subject: 3.5 Orographic terms in the linear part of the ICI time scheme

Description and objectives: Steep slopes of orography seem to play crucial role in the stability of the ICI time scheme with constant coefficients which is used in ALADIN/AROME/ALARO models. Linear model in the current approach does not include orographic terms at all. Following proposal of Fabrice Voitus (Météo France) and Jozef Vivoda (ECMWF), a new vertical Laplacian operator was proposed containing linearized second order terms associated with the horizontal gradient of orography. This method will be further developed, tested and evaluated.

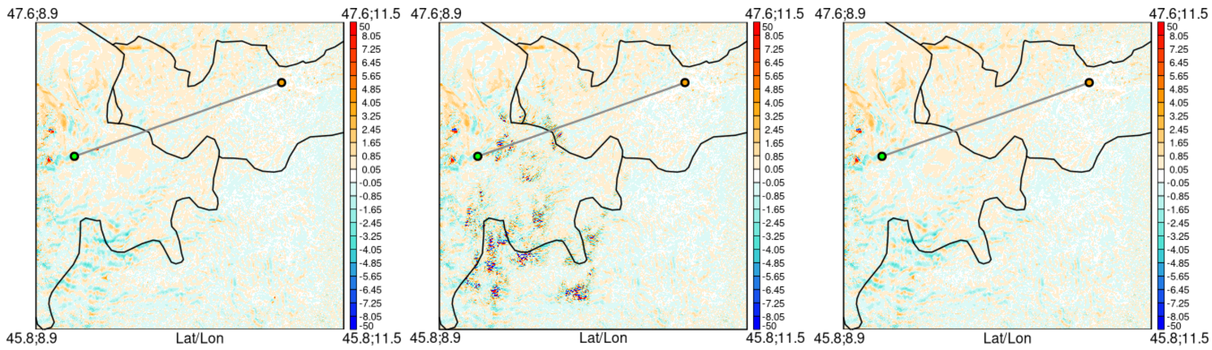

Figure 1: Vertical velocity field at 1km altitude for (SITRA,ND4SYS,MAX_SISLP) equal to: (50K,2,0) in the left, (50K,0,2.34) in the middle, (100K,0,2.34) in the right.

Status: The code modification prepared previously was phased to CY48T3 and CY49T2. On top of that in recent cycles and CY50T1 a modset prepared by Fabrice Voitus (Météo France) is available under the key NOPT_SISLP bigger than 1. With NOPT_SISLP=1 the reference slope is fixed and may be chosen through the namelist value and with NOPT_SISLP=2 an automatic choice aiming for the highest slope detected in the domain is done. We tested these options for the case of 19 August 2022 0UTC + 24 hours, over the Alpian domain in 200 m horizontal resolution., the value 2.34 corresponds to the highest slope in our domain. The correct combination of MAX_SISLP and SITRA leads to noise elimination in the vertical velocity field; see Figure 1 for details.

Moreover, the documentation for this option was prepared, see its first version on the LACE web pages.

Contributors of Task 3: Nika Kastelec (Sl), Petra Smolíková (Cz)

Executed efforts in Task 3: 1 PM a research stay of Nika at CHMI, 1.75 PM of local work registered to DY1 work package of the ACCORD workforce summary.

Documentation: the report from the stay and the new code design documentation available on the LACE web pages

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

Subject: 4.4 Exploring capability of existing dynamics choices in VHR experiments

Description and objectives: The setting of dynamical parameters, truncation of spectral fields etc. may help to run successfully in VHR. Choices already prepared in the model code must be explored and tested.

Status: Several case studies of severe storms and flow over the orography (Alps) were run in Slovakia in the frame of DE_330 project. Several settings of dynamics were tested, focussing on the time-step and the application of DFI but also on horizontal diffusion setting.

Tornadic supercell at Orosháza, Hungary, 17 May 2021

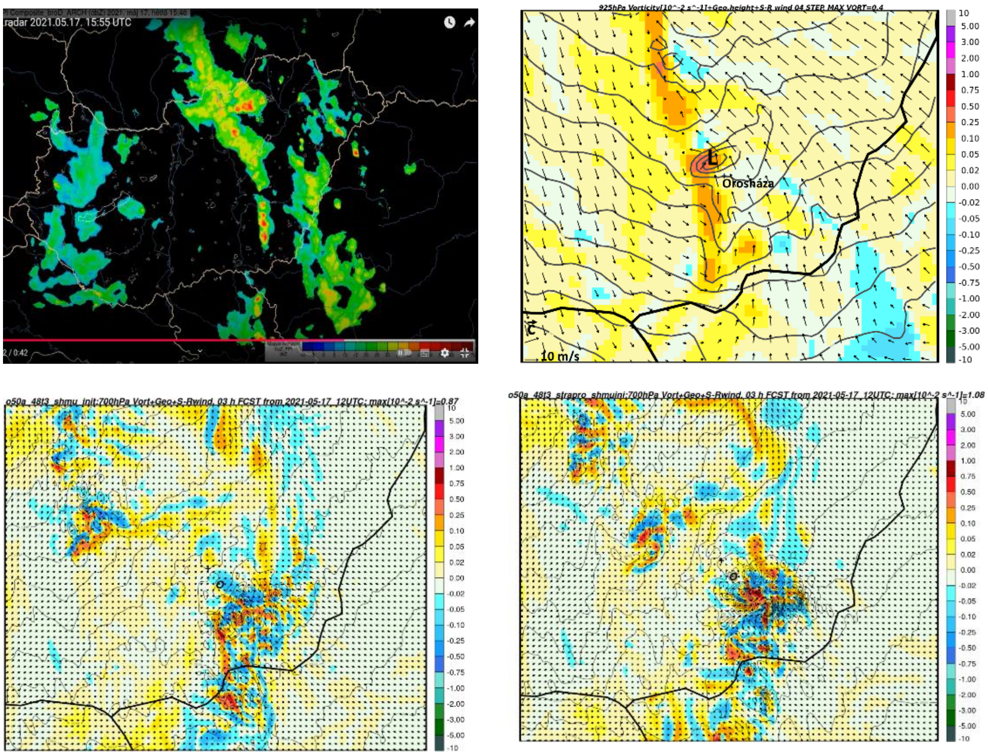

Figure 2: A) Mosaic radar reflectivity image of OMSZ, valid for 17 May 2021 16 UTC, showing a squall line over southeast Hungary with storm. Zoomed area with forecasted relative vorticity, geopotential and storm-relative wind at 15 UTC B) at 925 hPa, using ALARO 2km run. C) at 700 hPa, using ALARO 500m with parameterized convection (3MT), D) as in C but with explicit convection (3MT off).

The event was forecasted by operational configuration ALARO 2km. The simulated supercell was very close to the real storm position (see Figure 2 top row). Unfortunately, the storm was close to the edge of the ALARO 2km domain. The original forecast was provided as dynamic adaptation (ARPEGE LBCs), with 73 vertical levels and cycle CY43T2.

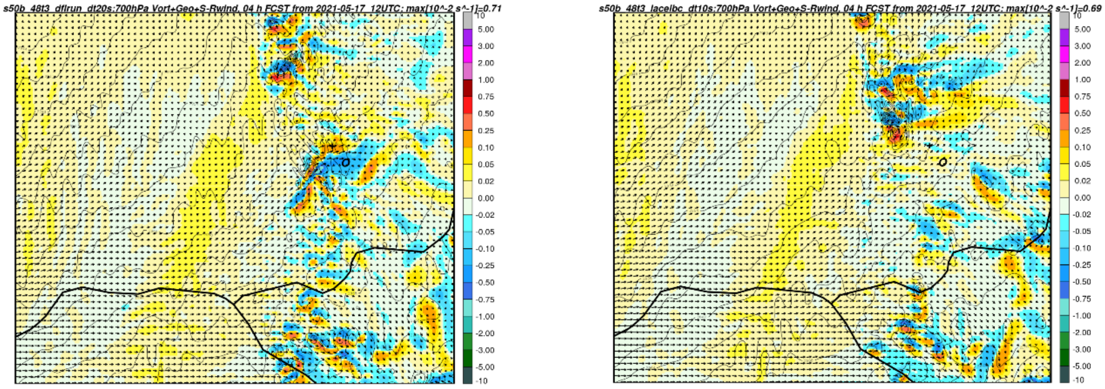

Figure 3: Left: 700 hPa relative vorticity, geopotential and storm-relative wind, valid for 17 May 2021 16 UTC for the experiment on 500m larger domain, ARPEGE LBC and 20s time-step. Right: the same but with 10s time-step and with DFI.

Recent tests (Figures 2 bottom row) were done on a 500m horizontal resolution domain, with LBC from an intermediate model run on 2.4 km resolution large domain (based on ARPEGE LBCs and SHMU initial conditions). Model cycle CY48T3, and 20s time-step were used. Both parameterized and explicit convection modes were tested. However, the forecast was not satisfactory, the propagation of the simulated storm was faster than observed, the vorticity field showed complicated multicellular structures, whereas the original, squall-line character of the event, was lost.

The experiments at 500m horizontal resolution were reproduced with larger domain (covering nearly the same region as ALARO 2km) and as a dynamic adaptation (direct coupling to ARPEGE LBCs). This experiment confirmed that the LBCs and initial conditions had a substantial impact on the right timing and structure of the simulated supercell (see Figure 3). It was experienced that shorter time-step (10s instead of the reference 20s) can improve the forecast of the storm, as the vortices and the circulation of wind were better expressed, and the result was qualitatively closer to the original ALARO 2km reference. However, the forecasts were still not entirely satisfactory, as the vortices are not as permanent as in the ALARO 2km and the fields of geopotential and vorticity exhibit a lot of noise (even if DFI is applied). Very similar behaviour is observed in other supercell situations (as 7 June 2025 in southwestern Slovakia, 6 July 2010 and 29 August 2010 over Northern Italy, etc.), which are not shown here. Though, the problem is probably related to several parts of modeling (mainly physical parameterization, dynamics and initialization procedure).

Moreover, at the resolution of 500 m there is a problem with deep convection parametrization while turning it off makes it even worse. The fields of several parameters (vorticity, etc.) are unrealistic, and the clouds in the model disappear too quickly compared to observations or forecasts from models with a 2 km horizontal grid. The geopotential fields are also very noisy, which may also be a consequence of numerical instability or insufficient horizontal diffusion. These aspects must be considered before high resolution runs become operational in any sense.

Besides VHR experiments, sensitivity tests on the 2km resolution domain were run with shorter time step (72s instead of operational 90s). The reason for that was a frequent “Semi-Lagrangian trajectory underground" warnings from the operational production. Though, the impact of shorter time-step was neutral both on scores and severe weather cases, shortening of the time-step did not substantially reduce the warnings – as these appear at the beginning of the DFI procedure. The reason can be rather in the inconsistency between the IC (A-LAEF) and LBC (ECMWF) – which must be further studied.

Subject: 4.5 Testing recently developed approaches in model dynamics

Description and objectives: The new vertical motion variable w5 was formulated and implemented by Fabrice Voitus. The "on demand" time scheme and the blended NH/HY dynamics were formulated and implemented in the frame of RC LACE. Could some of these techniques increase the numerical stability achieved in VHR experiments? On top of that, the scientific and technical (code describing) documentation describing these new features is needed and will be prepared.

Status: New dynamics options were implemented in the DEODE_330 workflow in CY48T3 and CY49T2. These changes include:

- Elimination of the linear system up to horizontal divergence (LSI_NHEE=T)
- New vertical divergence variable (NVDVAR=5)
- Consistent moisture inclusion in the definition of vertical motion (L_RDRY_VD=T, L_RDRY_NHX=T)
- Better bottom boundary condition for the vertical velocity variable (LBIGW=T)
- Diagnostic treatment of the orographic part of the vertical divergence variable (the X-term)
- Supressed transformation of the X-term to model spectra and back (LSPNHX=F)

The chosen testing environment was manifold:

1) The case of 19 August 2022 0UTC + 24 hours, over the Alpian domain in 200 m horizontal resolution

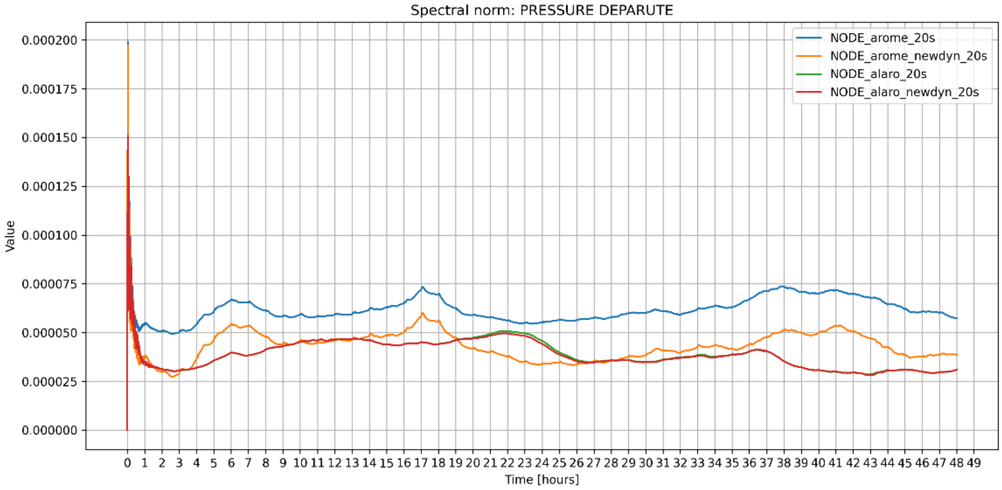

Figure 4: Time evolution of pressure departure spectral norms for ALARO and AROME CMC with old and new dynamics.

- In this resolution the benefit of new choices is most visible in the elimination of chimney patterns generated over steep slopes and elimination of noise detected in the time evolution of spectral norms of model variables.

2) Several cases over various domains in 500m horizontal resolution with three CMCs available in DEODE_330
    - The sanity checks revealed problems in AROME CMC connected to the usage of first order decentering with parameter VESL > 0. This must be further investigated. See Figure 4 for an illustration of results.
    - It was found that AROME CMC does not have a well-tuned spectral nudging and new tuning suggested by our French colleagues was applied; see Figure 5 for the consequences.

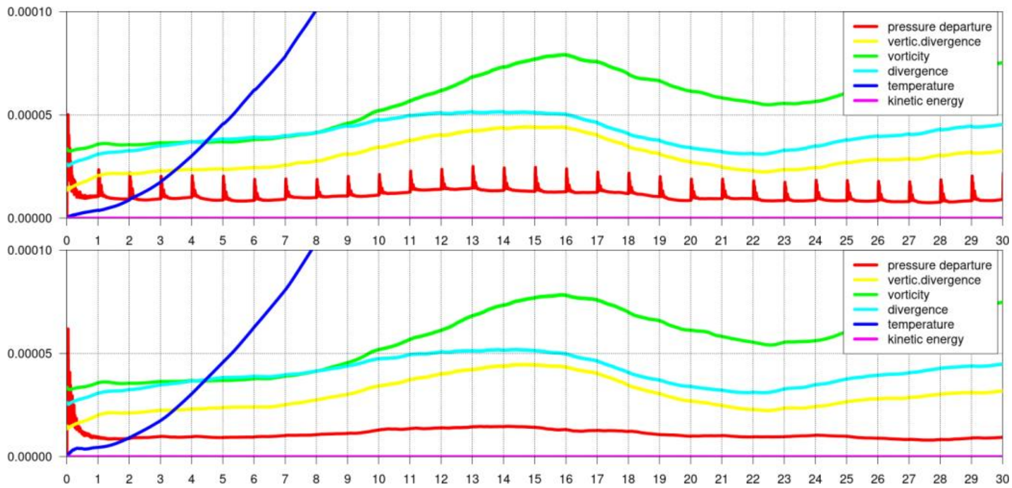

Figure 5: Time evolution of spectral norms of model variables with AROME CMC and the old (top) and the new (bottom) setting of spectral nudging.

3) Long term objective scores verifications (November 2024, one run per day starting at 0UTC, running for 48 hours) in 500m resolution over several domains chosen in DEODE_330
    - Standard objective scores do not show any problem with the new dynamics configuration, all runs are stable and RMSE, STDEV and BIAS are comparable with the runs with original code for all CMCs

Subject: 4.6 Horizontal diffusion setting in VHR experiments

Description and objectives: It was shown that the adaptivity of the spectral diffusion to the change in the horizontal resolution is not sufficient. A stronger spectral diffusion has to be applied at least on motion variables to get rid of the small-scale noise produced by the model. Tuning of SLHD is foreseen as well in VHR experiments.

Status: Tornadic supercell at Orosháza, Hungary, 17 May 2021

Further tests on 500m horizontal resolution were provided in Slovakia for this case, with different settings of horizontal diffusion. The testing environment was described in Subj.4.4. The cycle CY49T2 was used here. The setting denoted “spdif” in Smolíková, 2019 (when only spectral diffusion is applied, which is similar to AROME MF operational setting) was compared to “shdref” setting from Simon and Čatlošová, 2021 (SLHD set to default, RDAMPX=20.). The “spdif” run produced very noisy results, the “shdref” showed smoother results but no qualitative difference with respect to reference runs (see Figure 6).

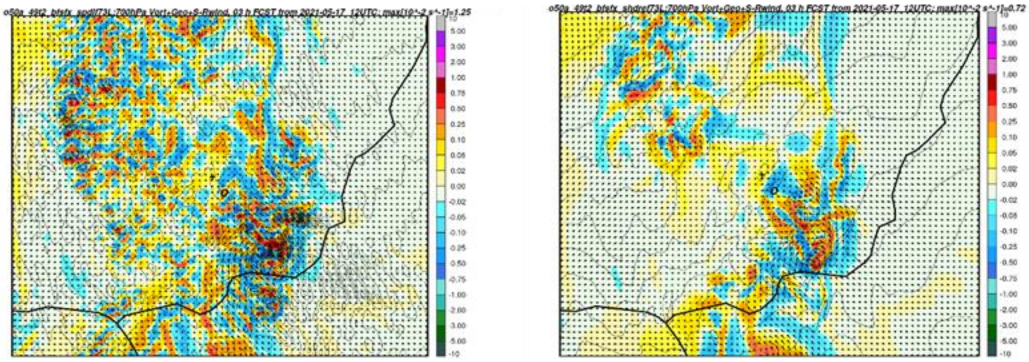

Figure 6: Left: 700 hPa relative vorticity, geopotential and storm-relative wind, valid for 17 May 2021 15 UTC for the “spdif” experiment with horizontal diffusion. Right: The same, but for the “shdref” setting. Compare to Figure 2 and 3.

Subject: 4.8 Model initialization for VHR experiments

Description and objectives: The balance in the initial fields is crucial for the stable integration of the model. Available processes as DFI may be involved. On top of that, based on ideas developed in Subject 6.1 the non-hydrostatic dynamics is being introduced as an increment of the hydrostatic one based on some control parameters. Hence, if these control parameters will evolve in time during the integration, the non-hydrostatic dynamics will be introduced smoothly, keeping the current atmosphere always in a balanced state without sudden jumps in the prognostic fields. This approach will be implemented, tested and evaluated.

Status: The blended approach described in Smolíková and Vivoda (2023) was implemented in the code. It allows for an intermediate state between hydrostatic primitive equations and fully elastic nonhydrostatic Euler equations system which is slowing down the fastest moving modes. Moreover, an update of SI reference state parameters is allowed at every time step. These two modifications together enabled to start from hydrostatic dynamics, the same as used in the driving model, and after some short time allowing to balance the initial state, the smooth transition to the nonhydrostatic dynamics

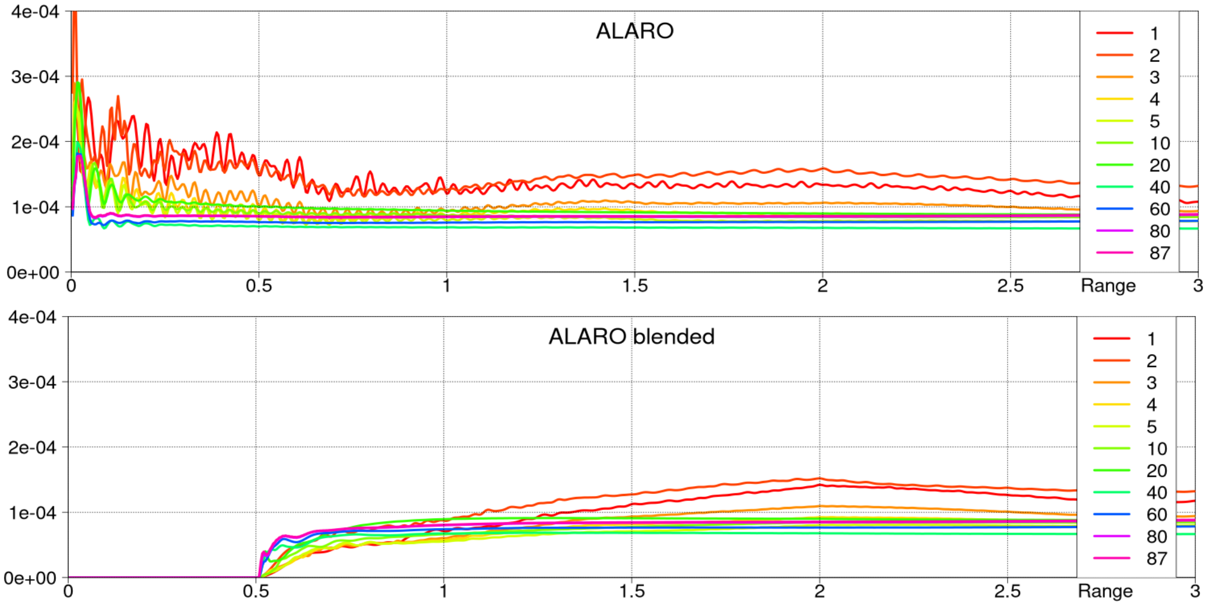

Figure 7: The time evolution of the domain averaged spectral norms of pressure departure at several vertical levels with ALARO model setup for the standard solution (top) and for blended approach (bottom), Forecast from 10 April 2025, 00 UTC, over Mediterranean domain in 500 m horizontal resolution, 87 vertical levels.

is applied using the blended approach with one main control parameter going from the value 0 to the value 1 in both, the linear model and the non-linear residual. After this transition phase, the fully elastic nonhydrostatic dynamics is used to deliver the forecast.

The chosen time window for the transition is 2 hours, with first 30 minutes of purely hydrostatic dynamics. The behaviour of the model corresponds to the expected behaviour, the pressure is changed from its initial hydrostatic value to the final nonhydrostatic one, and the transition is smooth, as seen on the time evolution of the domain averaged spectral norms of model variables, especially pressure departure. See Figure 7 for an illustration. The method gives satisfactory results, keeping in mind that only upper-air values of model variables are directly influenced with the surface values being still highly dominated by the imbalance between the driving model and the substantially different LAM solution.

In Figure 8 we show the time evolution of the mean absolute difference in the pressure departure field that arises when the blended approach is applied in comparison with the mean absolute difference that is given by the model set up. The difference in the latter case is much bigger and hardly decreases in time. For initialisation with the blended approach the NH solution is restored after 2 hours of integration.

Contributors of Task 4: André Simon (Sk), Nika Kastelec (Sl), Petra Smolíková (Cz)

Executed efforts in Task 4: 5.5 PM of local work

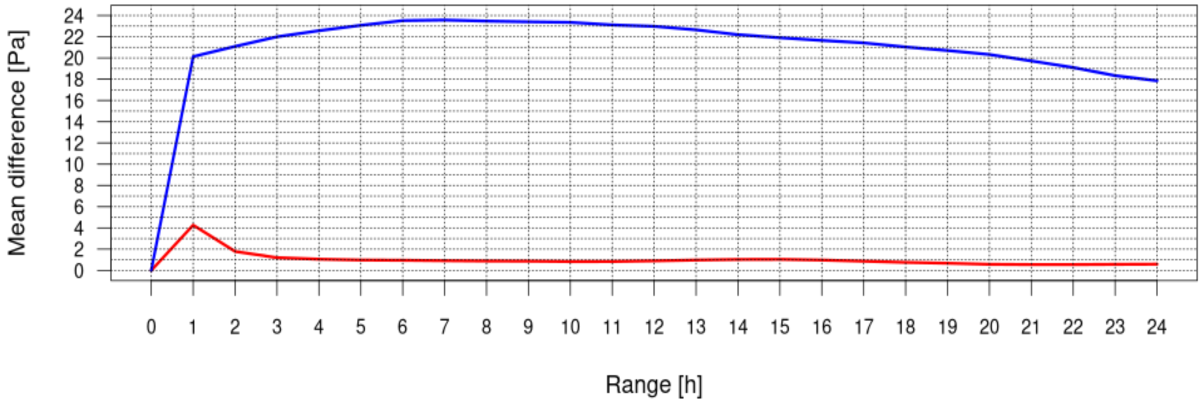

Figure 8: The time evolution of the mean absolute difference between experiments with the blended approach and with NH dynamics for ALARO model setup (red) compared to the same metrics for the difference between NH run with ALARO and AROME model setup (blue).

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

Subject: 5.1 Single precision

Description and objectives: Continuous process toward more and more CPU demanding model applications lead to the efforts to decrease number representation precision from so called "double" to "single" precision everywhere where the accuracy of calculations is not in danger. These goals were assessed at ECMWF and Météo France and a substantial part of model codes was adapted to them. 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 plan to carefully test all code branches of the dynamical core commonly used in our applications to identify potential risks of this approach. Then the physical parametrizations of the ALARO package will undergo the same procedure. The envisaged code changes are rather technical including replacement of hard coded thresholds with intrinsic precision functions, avoiding divisions by floating point numbers that may become zero etc.

Status: No progress was made. The research stay of Oldřich Španiel is planned for second half of 2025.

Subject: 5.2 The FFTW algorithm

Description and objectives: The FFT992 method is traditionally used in ACCORD system for transformation between the grid point and the spectral space. The FFTW ("Fastest Fourier Transform in the West") method is licensed by MIT to ECMWF from 2016 and sub-licenced to the ACCORD consortium, both valid until 2031. It was reported by Météo France, that the usage of FFTW may bring substantial CPU time savings (up to 5%). The performance of the transformation method is platform dependent. It follows that it is recommended to test FTTW for each forecast operations separately, on the targeted computer system.

Status: Testing for Hungarian operations

FFTW was tested in AROME/HU and AROME-RUC (cy46t1_bf07) using two different domains with spatial resolution of 2.5km and 1.3km, and two different time stepping procedures (SETTLS and PC). The runtimes of the forecast were compared for the 24-hours long run starting from 22 June 2024 0UTC, the case with considerable amount of precipitation appearing in the area of interest.

Table 1: Runtimes of the experiments with FFT992 and FFTW.

Experiment	2.5km, L60, SETTLS	2.5km, L60, PC	1.3km, L90, PC
FFT992	32 min 20 s	39 min 28 s	291 min 57 s
FFTW	32 min 10 s	39 min 16 s	279 min 53 s
Outcome	FFTW faster (~0.55%)	FFTW faster (~0.48%)	FFTW faster (~4.14%)

Based on these results, it was summarized that the FFTW method is up to 4% faster than the reference FFT992. On the other hand, for some cases tested previously the FFTW was the slower one, mainly at a shorter range with non-iterative time scheme (SETTLS). The FFTW works better at expensive runs (higher horizontal resolution, more grid-points, PC time scheme, shorter time step).

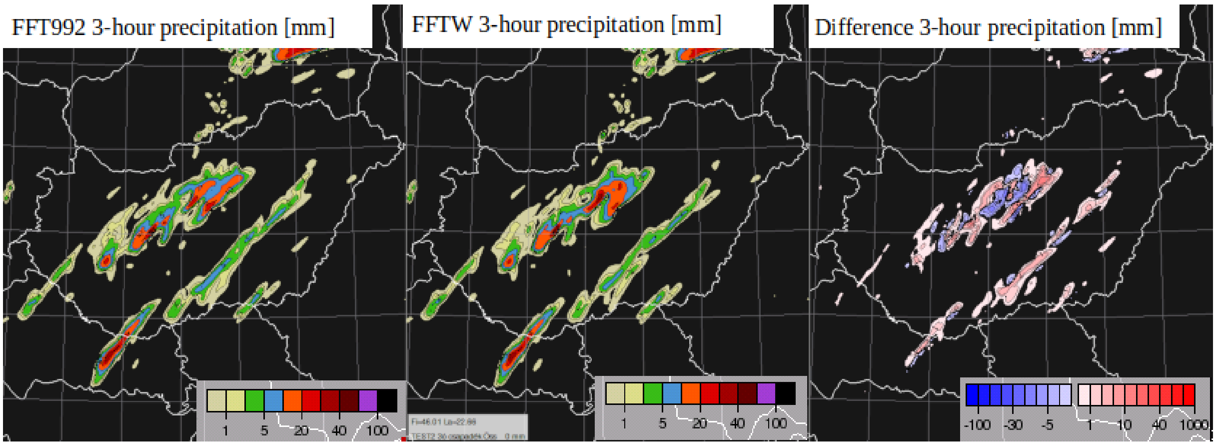

Figure 9: 3-hour precipitation amount [mm] valid for 23 June 2024 0 UTC based on the AROME forecasts initialized at 0 UTC on 22 June 2024 using FFT992 (left), FFTW (middle). Both experiments are at 2.5 km horizontal grid spacing, with 60 vertical levels and using predictor-corrector method in the time scheme. The right panel represents the difference between the results of the two experiments.

Figure 9 shows that resulted precipitation forecasts have some differences, especially in the location of the local maxima, however, the two fields may be considered meteorologically equivalent. Some localized differences were also seen in the temperature field at 850 hPa (Figure 10).

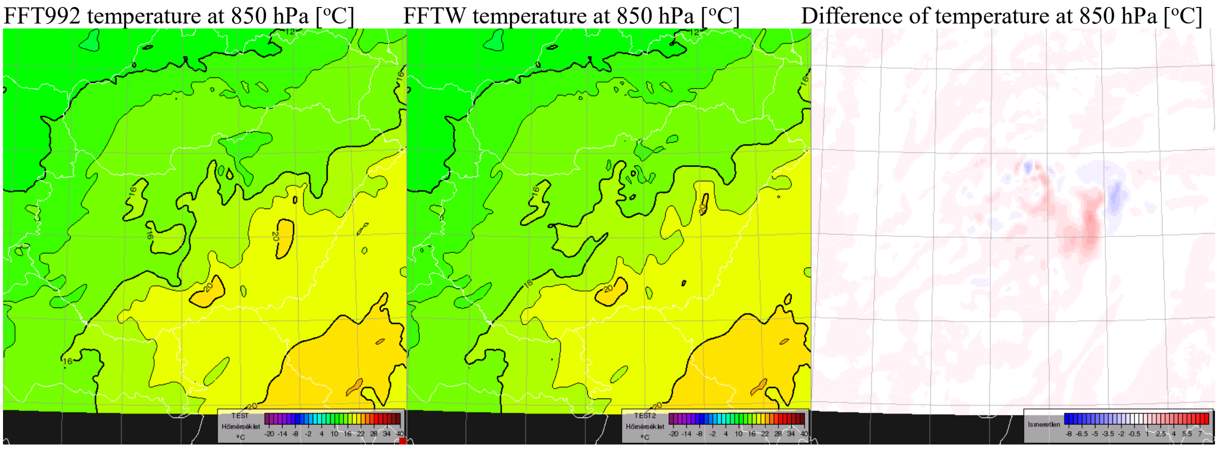

Figure 10: Temperature [°C] at 850 hPa level valid for 23 June 2024 0 UTC, based on the AROME forecasts initialized at 0 UTC on 22 June using FFT992 (left), FFTW (middle) at 2.5 km horizontal grid spacing, 60 vertical levels and using predictor-corrector method in the time scheme. The right panel represents the difference between the results of the two experiments.

<u>Testing for Czech operations</u>

In Prague, the FFTW functionality was tested with CY48T3 being prepared for new operations. The computational platform available here is NEC SX Tsubasa, a vector engine based computer. The performance with FFTW using the export version of the code equipped with specific modifications for

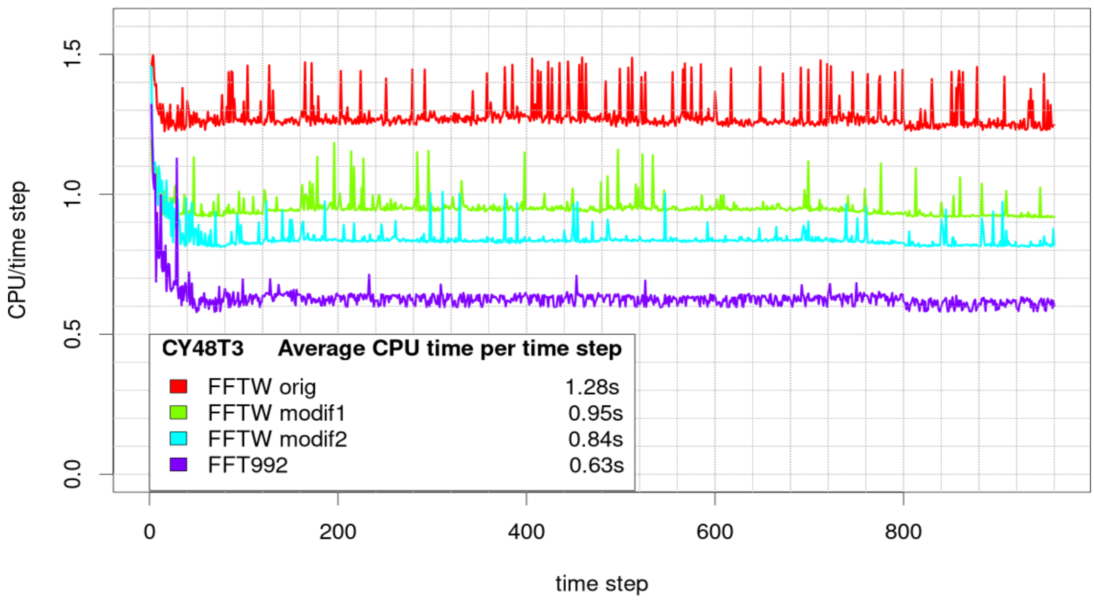

Figure 11: The CPU time needed for individual steps of the ALARO forecast, when FFTW or FFT992 methods are used for transformations.

the local application was approximately twice slower than the original version with FFT992. Then two modifications being suggested by Ryad El Khatib (Météo France) were introduced. The first one defines the key LALL_FFTW allowing for transformation of all fields in one batch, and the second switches the order of loops in the module tpm_fftw. Both modifications helped to improve the performance, but still the run with FFTW is 30% slower than the traditional transformation. See Figure 11 for details. We will continue our efforts.

Contributors of Task 5: David Lancz (Hu), Petra Smolíková (Cz)

Executed efforts in Task 5: 0. 5 PM of local work.

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 several control parameters (all= 1 NH core, all = 0 HY core). Then all computations of the dynamical core can be treated in a unified code. Moreover, these control parameters 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: The code modification for gradual transition from the HPE system to non-hydrostatic fully elastic (EE) system of equations was introduced by Fabrice Voitus in CY50T1. The whole code for HY-NH blended approach available under LNHHY key was cleaned up, simplified and debugged. Only one control parameter was kept under the name RNHHY_DELTA. The fixed value of this parameter available through the namelist was reintroduced. Thus, a cleaned fully functional version of the blended approach is available in CY50T1.

Subject: 6.2 Options for calculation of the X-term in vertical divergence variable

Description and objectives: The model variable for vertical motion in the linear part of the ICI time scheme may have several variants in the dynamical core of the ACCORD system. It was shown that the time scheme's numerical stability depends on its choice and that the most stable option is with modified vertical divergence including the so-called X-term depending on the model orography. On the other hand, in the non-linear part of the ICI time scheme, vertical velocity is used instead in all cases. It follows that a direct and reversed conversion between the two model variables must be applied in each time step. The X-term needed for this conversion may be either calculated from other variables or saved. In the latter case, it is necessary to treat X as a separate model variable which is being

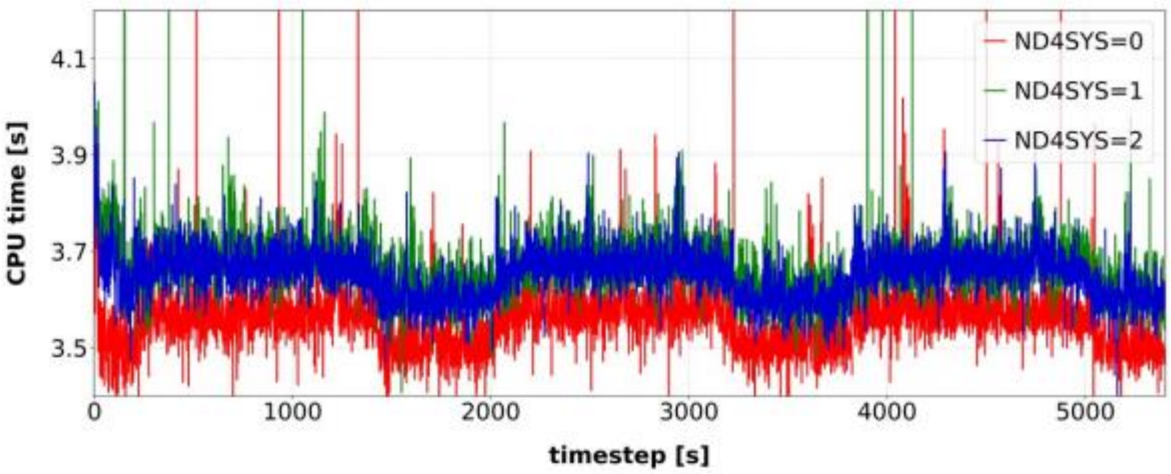

Figure 12: CPU time needed for individual time steps with different ND4SYS; ND4SYS=0 is combined with LSPNHX=F.

transformed between grid-point space and spectral space. Such transformation of an additional model variable is expensive but may have an important impact on the whole integration results. The transformation to spectral space guarantees some level of filtering and consistency of the calculations needed for the vertical motion variables conversion. We would like to investigate whether the current treatment of the X-term is the best choice in terms of accuracy and numerical stability of the time scheme, and what would be the influence of the recalculation of X in each place where it is needed without its transformation to spectral space.

Status: The code modification was originally proposed for CY46T1, recently it was phased to CY48T3, CY49T2 and CY50T1 and to the DEODE_330 corresponding code. It enables to calculate the X term whenever needed from model variables (if ND4SYS=0) and without the need to transform the X term to the spectral space and back (if LSPNHX=F). The testing of this code done in Prague is described in the report P. Smolíková with coauthors "New options ND4SYS=0 and LSPNHX=T implemented on top of Czech operational model version CY46t1as_op1", available on the LACE web pages. The CPU time saving coming from this modification was shown to be about 5-7% for the whole model forecast. On top of that, when the X term is calculated diagnostically and used for the transformation from vertical divergence variable to the vertical velocity variables directly without evaluation of the time evolution of X (under the key ND4SYS=0), the chimney patterns are removed from the vertical velocity field. Moreover, the time oscillations present in the solution are as well being removed. This was demonstrated by the time evolution of domain averaged spectral norms of vertical divergence and pressure departure.

Phasing to Croatian operations

The ND4SYS=0 code and the LSPNHX option was phased into local CY46T1 at DHMZ. This was followed by tests against ND4SYS=1 and ND4SYS=2 options on four cases in 1.3 km horizontal resolution, 87 vertical levels and quadratic grid: convection (2x), bora and Boris storm. Then the impact on the CPU

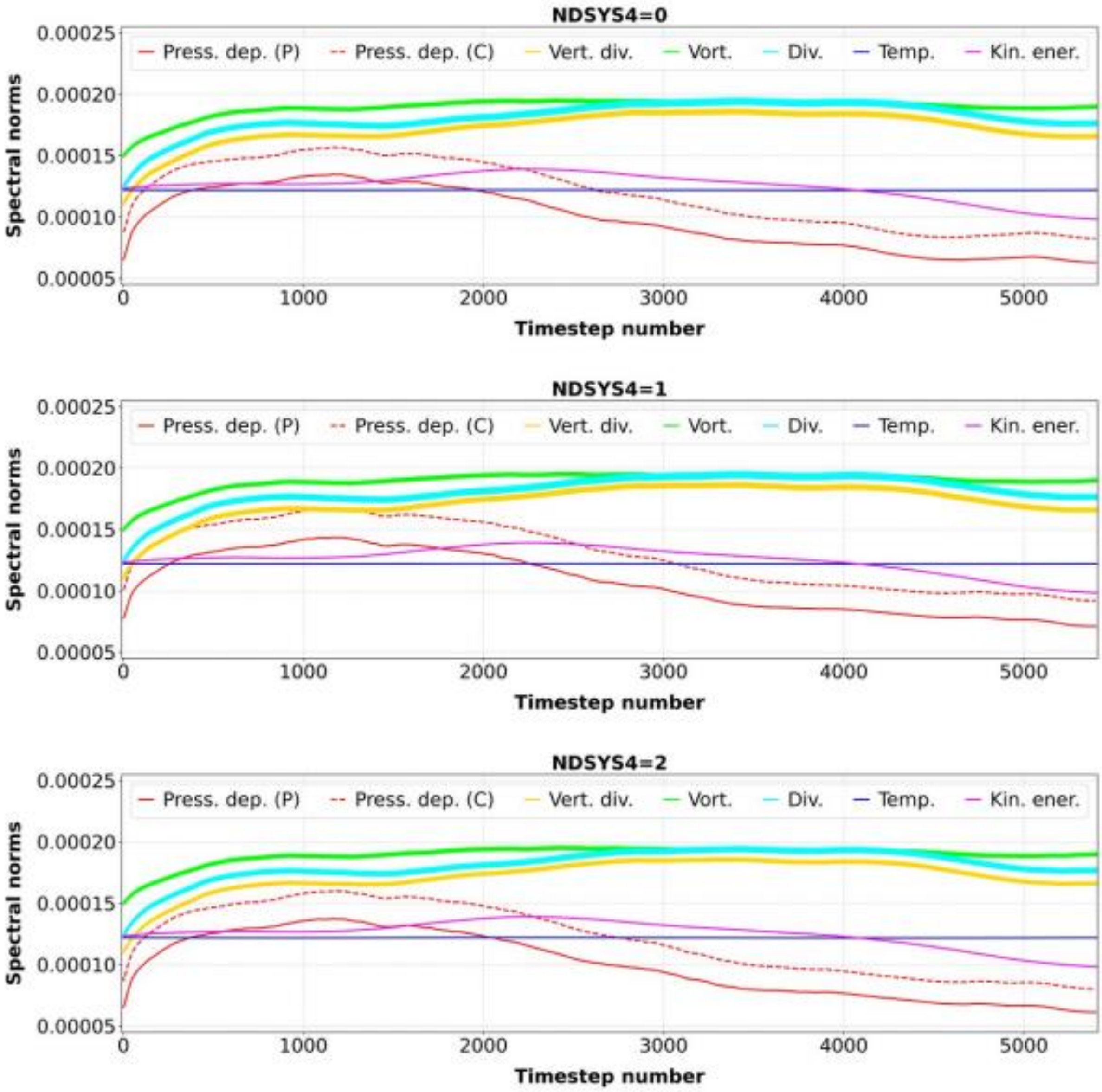

Figure 13: The time evolution of spectral norms for different ND4SYS options.

time needed, spectral norms of model variables, kinetic energy spectra, and on the chosen fields was analysed.

The CPU time saving with ND4SYS=0 is ~ 5% (see Figure 8), i.e., 2.5-3 minutes on the "real time" needed to complete the 24 hours forecast. In all four cases, the temporal evolution of norms was rather smooth, with barely noticeable differences between the options (see Figure 9). When the pressure departure norm was plotted separately for predictor and corrector steps, it was observed that the difference is largest for the ND4SYS=1 option and smallest for ND4SYS=2. The kinetic energy spectra were rather similar for most of the levels, except in the vicinity of level 10 (~ 17.5 km; see Figure 10). The differences in fields were rather small, except for the vertical velocity.

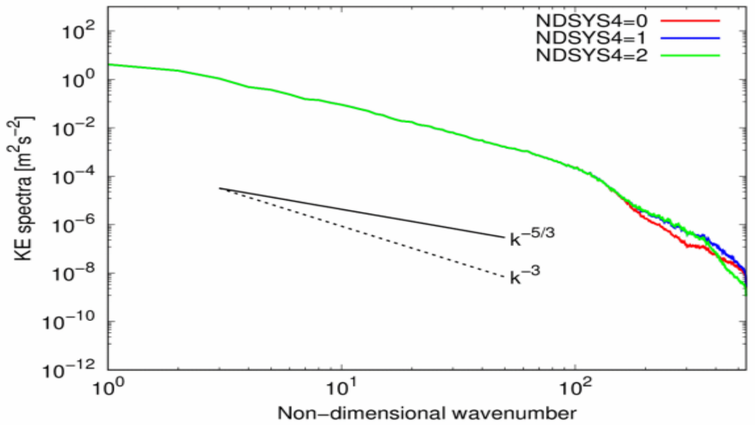

Figure 14: Kinetic energy spectra on 10th vertical model level for the case with three different values of ND4SYS.

Contributors of Task 6: Mario Hrastinski (Cr), Petra Smolíková (Cz)

Executed efforts in Task 6: 2.25 PM of local work

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: No progress was made.

Subject: 7.4 Preparation of new LBC files from IFS

Description and objectives: Preparation of new LBCs in higher horizontal and vertical resolution from the IFS files is planned for the new operations. Problems with the performance of the e903 procedure were detected and need to be solved.

Status: No progress was made.

Executed efforts in Task 7: None.

2. Documents and publications

One reports from the executed research stay is available on the RC LACE web pages:

- Nika Kastelec, *Overview of new dynamic options*, 9pp.

On top of that, the documentation of the recently developed dynamics options will appear on the LACE web pages:

- Petra Smolíková, *New options ND4SYS=0 and LSPNHX=T implemented on top of Czech operational model version CY46t1as_op1*, 4pp.
- Petra Smolíková and Nika Kastelec: *Proposal for the setting of new dynamic options for high resolution runs in DEODE*, 17pp.

3. Activities of management, coordination and communication

1. DEODE WP9/10 Working Week, 20 - 24 Jan 2025, presentation of Petra Smolíková: *Dynamics for DEODE LAM model higher numerical consistency, stability and accuracy*
2. 44th LSC, 6-7 Mar 2025, Krakow, Poland
3. ACCORD All Staff Workshop, 31 Mar – 4 Apr 2025, Zalakaros, Hungary, presentation of Petra Smolíková: *Dynamics for higher numerical consistency and stability*

4. LACE supported stays

One research stay was executed in the first half of 2025:

Nika Kastelec, *Orographic terms in the linear part of the ICI time scheme*, 1 PM in Prague

5. Summary of resources/means

The efforts invested in the area of Dynamics & Coupling of RC LACE in the first half of 2025 exactly covers one half of the efforts planned. Together 11 PM were reported in the area of Dynamics and Coupling. A lot of efforts was invested in the testing of available dynamics options, improvements in the ICI time scheme of the ACCORD system and in the testing of the newly designed features in the model dynamics. These efforts are needed to fulfil the goals of the project DEODE_330 and mirror the engagement of the RC LACE member states in this project. The coupling strategy does not seem to call for urgent adjustments and may be seen as satisfactory for the current model applications. One research stay was executed in the length of 1 PM, three others are planned for the second half of 2025. We contributed to the work packages DY1, HR, COM2.1 and MQA3 and some work was committed as connected to DEODE_330 to the ACCORD work force statistics.

Task	Resources			
	Total		Stays	
1. Vertical discretization	1	0	-	-
2. Horizontal diffusion	3	0	1	0
3. Time scheme	6	2.75	2	1
4. Evaluation of the dynamical core in VHR	6	5.5	-	-
5. Optimization of the model code	1	0.5	-	-
6. Basic equations	4	2.25	1	0
7. Coupling strategy	1	0	-	-
Total manpower	**22**	**11**	**4**	**1**