Working Area Physics

Work Plan Proposal

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1 Introduction

The current focus of research and developing activities inside LACE is to achieve a scale-independent ALARO physics package, which allows us to produce operational forecast at the resolution between 5 and 1 km mesh-size. The developments of physics schemes for high resolution gathered into ALARO-1 have been ongoing for more than 10 years. Most of individual schemes have reached the step of the individual tuning and validation; the tuning and further validation of the whole model where these modules interact together is going on. Several countries utilize AROME CMC, wherein their development activities are currently more focused on surface aspects.

The operational applications in LACE countries use (to be checked[1]):

- A baseline version of the ALARO-0 (available in December 2012, still used),
- the first version ALARO-1vA (available in December 2014)
- and also the newest second version ALARO-1vB (available February 2017).

The benefits of the high resolution with ALARO-1vB have been seen for quite some time and continue to grow with recent developments. Nowadays, they are mainly focused on adaptation for the (sub-)kilometre mesh size and optimization across several grey zones (e.g., deep convection, turbulence and gravity wave drag), as well as on coupling to the SURFEX model and exploiting its advanced options. Majority of related tasks are under Physics (PH) Work Packages (WPs) of the ACCORD RWP for 2024: PH1 (Turbulence & shallow convection), PH2 (Radiation), PH3 (Clouds-precipitation microphysics), PH4 (Common 1D MUSC framework for parametrization validation), PH5 (Model Output Postprocessing Parameters), PH6 (Study the cloud/aerosol/radiation (CAR) interactions), PH7 (On the interface between the surface and the atmosphere) and PH8 (On the interface of Physics with Dynamics (and time stepping)). There are also other WPs under “Surface analysis and modelling” with contribution from RC-LACE countries; SU3 (SURFEX: validation and development of existing components for NWP) and SU5 (Assess/improve quality of surface characterization) now included in this plan. Finally, there is also a dedicated package for the sub-km modelling, abbreviated as HR.

2 Goals

The highest priority within “Physics Area” is to optimize the performance of the LAM for resolutions in the 1 to 5 km range. Quality of simulations can be improved with better representation of clouds, as they are treated by a combination of different schemes (input to radiation, turbulence). With including of the refinements of the parametrization of the convective drafts it is expected to achieve seamless solutions across a wide range of horizontal resolutions, including the grey zone of moist deep convection, down to 1km.

1 This seems as outdated information.

Research will continue to enhance the description of physical processes also at sub-km resolutions (study of turbulence at grey zone, two-moment microphysics scheme). Experiments in very fine resolution (with ALARO and AROME) will indicate the problems which should be tackled. Additionally, enhanced description of atmosphere-surface link available in SURFEX should be implemented. Better description of the (stable) boundary layer behaviour, low cloudiness, daily cycle of precipitation and convection under unstable circumstances are among the most desired improvements.

3 Main R&D activities

Action/Subject: Turbulence & shallow convection (PH1)

Description and objectives:

A substantial part of the foreseen work on turbulence and convection is related to (very) high-resolution runs and the grey zone and intertwines with activities in the “Dynamics & coupling area”. However, at current mesh sizes of operational models, there is a need to: i) improve the mixing length computation (PH1.1), ii) work on debugging the TOMs solver (PH1.2) and iii) improve the performance within a very stable boundary layer (PH7).

Work (for the shorter term or a bit longer) on more pragmatic adaptation for the turbulence and shallow convection for running the CSC at 500m or less by modifying mixing length and a more scale aware mass flux for shallow convection. Note that a scale-aware convection scheme might already be beneficial at current operational resolutions (between approx. 500m and 2.5km)

About the path towards 3D effects in turbulence, hereafter we recall the outcomes of the side meeting discussion at the 2022 ASW:

* the short/mid-term plans seem clear: implement and validate quasi-3D formulations, study the Goger etal. approach (in mountaineous areas), study the Moeng etal. approach (for strong convection clouds)

* towards "full 3D turbulence"(longer term):

- focus on what observations can teach us and what other have already done, make bibliography survey on what other academics have done regarding scale analysis

- full 3D turbulence requires to compute the horizontal divergence of horizontal fluxes, and it is important to first understand which of these terms really matter (cf scale analysis outcome)

- from the code point of view, we probably have all the relevant infrastructure for 3D turbulence, or we know how to code what's missing

- addressing the 3D effects of turbulence with SLHD (PH1.3).

Proposed contributors, Estimated efforts: M. Hrastinski (Cr) 0.75 PM, R. Brožková (Cz) 1.0 PM, J. Mašek (Cz) 1.0 PM, P. Smerkol (Si) 4.0 PM; TOTAL: **6.75 PM**

Planned timeframe: whole year

Planned deliverable: code modification, documentation updates and stay reports

Description of activities: Developments of the TOUCANS turbulence scheme will continue with priorities in four directions: i) further evaluating and optimizing the performance of TKE-based mixing length formulation and its documentation (PH1.1), ii) revision of TOMs parameterization (PH1.2), iii) addressing the 3D turbulence effects (PH1.3) and scale-awareness of the scheme in whole (PH8.4), and iv) reformulating shallow convection cloudiness (needed in the radiation). Additionally, efforts will be made towards the single precision ALARO-1 (with TOUCANS), which is reported under the SY package of the ACCORD RWP 2025. Some related activities, e.g., preparation for a decrease in the height of the lowest model level and dealing with very stable boundary layer issues, are also planned within the PH7 package.

Action/Subject: Radiation (PH2)

Description and objectives:

The focus is put on interfacing of ACRANEB2 radiation scheme with near real time aerosols, plus externalization of cloud effective radii. These points are addressed within workpackage PH6. Apart from that, minor improvements of ACRANEB2 scheme are planned: interfacing and testing of single precision version in 3D model, inclusion of CFC-11 and CFC-12 in CO2+ composite, impact of clouds on the broadband surface albedo. Future revision of gaseous transmissions is possible. There is currently no idea how to accommodate 3D effects in ACRANEB2. GPU refactoring issues will be solved during preparation of APL_ALARO. Plugging of ecRad in APL_ALARO is also considered.

At the side meeting of the ASW2022 about 3D effects in physics, the following workplan had been outlined:

- evaluate a poor man's solution (TICA) for taking into account some 3D effects, however we could perhaps aim for a more ambitious and valuable plan (see next bullets)

- develop a coarse grid approach with SPARTACUS, the 3D solver that comes with ECRAD: (1) study the IFS code solution and draft specs for LAM; (2) implement the call to SPARTACUS in LAM; (3) use fine grid fields for cloud overlap, effective cloud edge length, cloud optical saturation

- first steps should be to form a task team to further discuss this work plan, evaluate the manpower needs for its realization and start assessing its possible staffing (it was noted that ACCORD might need an ECRAD expert of its own)

Proposed contributors, Estimated efforts: NODE; TOTAL: **0.0 PM**

Planned timeframe: whole year

Planned deliverable: code, report

Description of activities: There is no capacity/workforce for radiation-related activities in 2025. However, the topic planned to be covered later this year is the interoperability of ACRANEB2 and ecRad between CMCs in the scope of Sophia Schäfer's stay at CHMI. The possible/relevant topics to be addressed in future, e.g., introducing 3D effects and revising broadband gaseous transmissions (or a hybrid approach), are considered "not easy to win" or not that urgent.

Action/Subject: Clouds-precipitation microphysics (PH3)

Description and objectives:

The focus is on improvement of processes of autoconversion, collection, evaporation and melting in ALARO, all of them using prognostic graupel. Comparisons are made with solutions in other microphysics packages: ICE3, WSM6, Thomson, COSMO, UM. Impact of improvements in vertical geometry will be evaluated. Inclusion of n.r.t. aerosols in APLMPHYS is considered.

Proposed contributors, Estimated efforts: D. Němec (Cz) 10 PM and M. Tudor (Cr) 1.0 PM; TOTAL: **11.0 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing/validation, stay report

Description of activities: Along with the work on fulfilling the above objectives, David Němec will continue with the development of a two-moment scheme with aerosols in the ALARO framework, which is also the topic of his PhD.

Action/Subject: Common 1D MUSC framework for parametrization validation (PH4)

Description and objectives:

Maintain and regularly upgrade a "common MUSC" 1D testing environment for Arome-France and Harmonie-Arome, for the evaluation of physics parametrizations against Cloudnet and LES data and idealized experiments.

In 2018/2019 a new version of MUSC has been developed at Met Eireann, which is much more user friendly. However, no special reference cases are part of this system, so the old test cases have to be added (GABLS-1, GABLS4, ARM-Cu, ASTEX and a Cabauw fog case). Desired new cases include e.g. a case with light recipitation (RICO), dry convection, and an idealized case for mixed-phase clouds.

In 2021, a beta version of the common (between the 3 CSC) MUSC version based on cy46t1 have been created during the Working Week in 2021 and validated at least for some cases for the 3CSC without SURFEX, however some works needs to be done for ALARO and SURFEX. The visualization tool EMS developped by R. Roerhig is now available. A continuation effort shoud be done in 2023 to increase the number of available "ideal" cases in order to have a diversity of meteorological siutation to evaluate, compare all the parametrizations available accross the CSC and ARPEGE. Therefore a training and/or working days can be organized may be every two years or for a new MUSC version based on a new cycle.

Proposed contributors, Estimated efforts: M. Tudor (Cr) 0.5 PM; TOTAL: **0.5 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: The planned activities include establishing, maintaining and upgrading the “common MUSC” system and using it for possible testing of refactored code (APLPAR vs. APL_ALARO).

Action/Subject: Model Output Postprocessing Parameters (PH5)

Description and objectives:

There is an increasing need for new postprocessing parameters out of the NWP systems for many applications such as aeronautics, green energy sector, automatic forecasting and for various end-users. This need is reflected in the ongoing work of many NMSs in ACCORD.

In this WP, we address the work on the model output, as produced mostly from the executables available from compilation (ie MASTERODB). The activities on postprocessing are coordinated within this package in order to avoid possible duplication of work. In 2021, an inquiry was launched in order to update the list of diagnostic and output fields planned or under consideration by the local teams. The goal then also was to understand whether these model outputs could/should be considered for computation during the model runtime (if they require specific model fields) or whether they could/should be part of an offline, downstream post-processing. Only the first case clearly belongs to the ACCORD RWP matters (common codes).

As an outcome of the 2021 inquiry (aka PH5-questionnaire), the model output fields have been grouped into four categories for which we intend, at ACCORD level, to build more synergy across teams. Various needs for postprocessing fields (for traffic, energy or tourist/sport sectors) can be assigned to a task depending on the category of the required output. The intention is to organize dedicated meetings per category, so that the teams involved in each can exchange about their plans, and transversal collaboration per thematic can be encouraged. Another aim of the WP PH5 is to coordinate the work done on the implementation of the selected parameters into the common code for all three CSCs, and to implement, tune and validate these parameters. The new postprocessing parameters need to be validated (related to MQA) and for that new data types might be needed (DA3-DA4). Specific postprocessing related to ensemble forecasts is addressed in EPS packages, the same for DA etc.

Proposed contributors, Estimated efforts: A. Simon (Sk) 4.0 PM and M. Tudor (Cr) 1.0 PM; TOTAL: **5.0 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: Foreseen activities include passing the prognostic graupel information into the parameterization of accreted precipitation (wet snow and ice) within the CY49, as well as the computation of vertically integrated liquid (from radar reflectivity or model microphysics). The latter should be important for comparison of predicted thunderstorms with radar measurements, adjustment of graupel and hail schemes, etc. Additionally, some time will me devoted to editing the WP, organizing the workflow and preparing documentation.

Action/Subject: Study the cloud/aerosol/radiation (CAR) interactions (PH6)

Description and objectives:

Build a unified framework to treat cloud/aerosol/radiation (CAR) interactions from external aerosol concentration sources and optical properties to the radiation and cloud microphysics parametrizations available in ACCORD system.

Basic decision is to use CAMS n.r.t. aerosol mass mixing ratios (MMRs), and to provide infrastructure enabling its exploitation in all ACCORD CMCs. The design should be general enough in order to make possible future use of alternative aerosol data (e.g. from MOCAGE). Usage of CAMS aerosol MMRs via traditional monthly climate files will be ensured, as well as backward compatibility using aerosol optical depth (AOD550) climatology as input. PH6 aims at: 1) Preparation and transfer of aerosol input to the forecast model 2) Ensuring consistent code structures, interfaces and namelist definitions in the forecast model, available for specific radiation and cloud microphysics parametrizations 3) Providing utilities for use in data transfer, namelist generation and testing.

Proposed contributors, Estimated efforts R. Brožková (Cz) 1.0 PM (Cz), J. Mašek 1.0 PM (Cz) and P. Sekula (Pl) 4.0 PM; TOTAL: **6.0 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: The activities include i) the code phasing of necessary developments to higher cycles and ii) validation and tuning to prepare CAMS-based aerosols for future operational use in the radiation scheme.

Action/Subject: Interface issues between the surface and the atmosphere (PH7)

Description and objectives:

This WP deals with interaction issues between the surface and the atmosphere and focuses especially on a few topics including stable boundary layers, ALARO-SURFEX coupling, the role of the lowest model level and surface properties, currently TEB, included in the atmospheric parameterizations.

The stable boundary layer and our inability to properly model it, with consequences for near-surface essential variables like e.g. T2m, has been a long standing problem. This subject was brought up in a side meeting of the 2022 All Staff Workshop and a summary of the discussion and suggested ways forward is given via this link. In this WP we will first look into the items additional term to scalar-flux formulations and learn from relevant observations via our academic contacts.

The coupling of ALARO to SURFEX includes a number of issues, some are directly SURFEX related and will be covered by tasks in SU3 and SU6 while some are dedicated to the interface between ALARO and SURFEX codes and will be covered by tasks in this WP.

With an increasing number of atmospheric vertical levels we tend to push the lowest model level closer to the surface. For stable boundary layers (BLs) this is often beneficial since they are characterised by thin BLs, however, for neutral and unstable BLs the enforced homogeneous atmospheric conditions close to the surface have no support in reality. Tasks in this WP will be dedicated to investigate the consequences for atmospheric-surface interactions of very low lowest model levels and investigate alternative approaches.

Research and development are published where very tall buildings (O100m) present in the TEB tile are explicitly handled in the atmospheric code of the Meso-NH model, including parameterizations of fluxes between model levels and the buildings. This research and development is now being transferred to the AROME-SURFEX context which will change the until now strict interface between SURFEX and AROME/ALARO at the lowest model level.

Proposed contributors, Estimated efforts M. Hrastinski (Cr) 1.75 PM and J. Mašek 1.0 PM; TOTAL: **2.75 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: It is believed that coupling ALARO to SURFEX is mostly solved, i.e., working fine. Therefore, the focus is shifting towards the performance of more advanced SURFEX options, which is addressed in SU3 WP.

Additionally, with mid to longer-term priority, some activities will focus on (very) stable boundary layer issues, i.e., attempts to improve its prediction. This refers to: i) improving the coupling of surface and atmosphere, i.e., the computation of exchange coefficients

(PH7.4) or investigating the alternatives to the current grid box averaging methods for the computation of surface fluxes, e.g., a stochastic approach (PH7.5), and ii) increase the vertical resolution for better resolving the processes in the shallow stably stratified PBL, i.e., a decrease of the height of the lowest model level and related preparation of the TOUCANS code (PH7.6).

Action/Subject: On the interface of Physics with Dynamics (and time stepping) (PH8)

Description and objectives:

This WP lists specific tasks that are at the interface between physics and dynamics, in terms of codes and of scientific interest.

1) Regarding the physics/dynamics interface, one scientific issue is that local sources and sinks of total water in the physics are automaticaly compensated by local sinks/sources of dry air. The reason is that total mass conservation is the law imposed by the continuity equation of the model even if the physics parametrisations create sources/sinks of total water. Thus, the model does not conserve dry air.

Physics parametrisations are usually solved either at constant pressure or at constant volume. In the non-hydrostatic model, one has to account for the changes in pressure that happen due to physics parametrisations consistently with the choices made in the physics dynamics interface and the dynamics.

2) Attention is given to the relative roles of horizontal and vertical diffusion (turbulence) across scales. The horizontal diffusion will be re-designed and tuned depending on the scale aimed to in the high resolution experiments. The computation of the SLHD diffusion coefficient will be modified to become a function of the total flow deformation. The relation between the horizontal diffusion applied by the model dynamics (SLHD or conventional spectral horizontal diffusion) and the parametrized vertical diffusion will be studied for a range of resolutions. This re-assessment of SLHD and gridpoint-based dissipation also is in link with hyper-resolution model design.

3) For the sake of numerical cost, and with a view on hyper-resolution model design, it could be of interest to study time split solutions in which the dynamics tendencies would be computed over a shorter time step than the physics (rather than compute all tendencies with a same, short time step). Time splitting per se will require specific work in some future, regarding its relevance on numerical stability and accuracy of solution. The task described in this WP is about studying the needed code design for enabling a time split facility in the common codes.

This topic is fully accounted for in RC LACE's "Dynamics & Coupling" area. It is listed here for completeness reasons.

Proposed contributors, Estimated efforts M. Hrastinski (Hr) 0.0 PM, P. Smolikova (Cz) 0.0 PM; TOTAL: 0.0 PM

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Action/Subject: SURFEX: validation of existing options for NWP (SU3)

Description and objectives:

The main objective is to progress with better physics by exploring advanced SURFEX components, also not used before in ACCORD CSCs.

With respect to the nature tile, advanced physical components include the Diffusion Soil scheme (ISBA DIF), Explicit Snow scheme (ES) and Multi-Energy Balance (MEB) scheme. The DIF scheme also offers a number of hydrological options. Assessing the potential of the new options should be done in tight connection to the corresponding assimilation methods (SU1). In addition, options allowing prognostic LAI (A-gs) could provide better surface resistance and transpiration control and opens up the way for assimilation of LAI products (SU2).

Over the land, errors in forecasting low temperatures are related to wrong representation of the stable boundary and surface layer in NWP. Studies are planned, to better understand the problem and to move forward in its solution.

Over the sea tile, turbulent fluxes are calculated using different versions of ECUME scheme. Correct representation of surface fluxes over the sea in important for the simulation of large scale processes. Also, it is linked to the succesful forecasts of fog over the sea. The objective is to test the performance of difference formulations of the ECUME against available observations and to study its relation to the forecasting of fog.

Urban tile, which is described by TEB model, covers relatively small fractions, but is important for the local weather. It is especially important when the model resolution increases. TEB is implemented without data assimilation. Performance of TEB for different city types and different weather conditions needs validation against dedicated obesrvations, including measurement campaigns.

Inland water tile is represented by FLake. FLake is currently operational in the HARMONIE-AROME for MetCoOp. It is implemented without data assimilation, thereby monitoring of its performance is important.

Observations needed for the validation are partly provided by QA3, with tools like Monitor and HARP. However, they should be complimented by special observations: from measurement campigns, non-conventional near-surface observations, flux tower data, and satellite products. All parameterizations include parameters with some level of uncertainty.

There are parameters in SURFEX which are a matter of tuning. Tuning may give a better performance of a certain ACCORD cycle release for a certain domain. CSC details:

AROME: The 1D ocean mixing layer model CMO has been tested and implemented in some AROME configurations at Météo-France (Overseas). The intention is to further improve this coupling for tropical cyclone prediction. The 1D sea ice model GELATO will be tested in Arpege and also in experimental Arctic AROME.

ALARO: Scientifically consistent transition of ALARO-1 from directly called 2-level ISBA to SURFEX should be finalized, addressing also observed fibrillation issues. Goal is to have the necessary changes entering t-cycle (NWP SURFEX commit).

Proposed contributors, Estimated efforts R. Brožková (Cz) 3.0 PM, D. Deacu (At) 8.0 PM, M. Hrastinski (Cr) 1.5 PM, J. Mašek (Cz) 4.0 PM, G. Stachura (Pl) 3.5 PM, S. Schneider (At) 4.5 PM, V. Tarjáni (Sk) 3.0 PM; TOTAL: **27.50 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: Here, both AROME and ALARO scientists contribute, with physics package-related specificities.

AROME-related activities (or both) include: Test, validate and further improve (namelist combinations and code modification) the behaviour of individual components, as well as the full combination, of DIF, ES, MEB in the ACCORD NWP system (SU3.1). Better understand the stable regime in surface and boundary layer and improve model performance in stable conditions (testing XRIMAX, stability functions, RSL, etc.) (SU3.10).

ALARO-related activities include i) the study of snow surface heat balance solvers (V. Tarjani), ii) investigating the performance of snow schemes, with focus on ESS (G. Stachura) and iii) a wider performance of ALARO+SURFEX, including albedo calculation, removing unrealistic areas of town fraction present in ECOCLIMAP II, working with more patches (2 or 3; to improve interactions between soil, snow and vegetation), vegetation related aspects, snow schemes, etc.

Action/Subject: SURFEX: development of new model components (SU4)

Description and objectives:

Main objective of this WP is development of new SURFEX model components or further development of them. In SURFEX, development of existing, under-developed, or still missing components continue, describing more processes and implementing more methods of diagnostic. During this RWP period, the planned development by NWP team includes: increase in sophistication for the Simple Ice scheme (SICE), improving the model performance over snow/glacier areas, the Multi-Energy Budget (MEB) scheme for open land, additional parametrization of fractional snow and improvement of winter aspects in the urban model TEB, new formulations of vegetation roughness (rough sublayer scheme RSL), exploring the use of 1-D ocean model GOTM. Any new development should be contributed via the SURFEX repository to ensure that contributions become part of new SURFEX releases and that they enter new NWP cycles in a consistent way.

Proposed contributors, Estimated efforts M. Hrastinski (Cr) 0.25 PM; TOTAL: **0.25 PM**

Planned timeframe: whole year

Planned deliverable: report

Description of activities: At the time, only work package coordination and editing activities are foreseen.

Action/Subject: Assess/improve quality of surface characterization (SU5)

Description and objectives:

The main objective is to assess and improve quality of surface characterization.

The surface physiography data currently used are:

1) different versions of ECOCLIMAP, from ECOCLIMAP 1 to ECOCLIMAP SG (Second Generation), depending on CSC,

2) the FAO, HWSD and Soilgrids sand, clay and soil-organic carbon databases,

3) the GMTED2010 orography,

4) the Global Lake DataBase (GLDB) v1-3.

We will continue to critically examine these databases and correct if possible, fixing errors, using national data, etc. We will develop parts of the code (PGD, scripts) to use these maps in different CSCs. We will study their impact and monitor the verification scores. Eventual modifications done on regional/domain level will be gathered to consortia wide versions of these databases. In collaboration with the SURFEX team at Météo-France such modifications may also lead to official updates of these databases, as published via the SURFEX web site by Météo-France. We will study the feasibility of creating the fine (hectometric scale) land cover map over Europe using Machine Learning techniques. Specific related tasks are organised under the Machine Learning WP, ML1. We will coordinate possible physiography development with other consortia via EWGLAM/SRNWP.

Proposed contributors, Estimated: M. Hrastinski (Cr) 0.25 PM, S. Oswald (At) 4.0 PM; TOTAL: **4.25 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: The planned activities are partly linked with DEODE and include: (i) soilgrids corrections and studying their impact, (ii) GMTED 2010 orography in MF models, (iii) development of the fine (hectometric) scale cover map for Europe, using the ML approach, (iv) development and documentation of tools for handling the physiography data and (v) activities on increasing the efficiency of PGD.

Action/Subject: Sub-km modelling (HR)

Description and objectives:

The main objective is to achieve up-to-date, realistic and affordable research and pre-operational versions of sub-km AROME-France, HARMONIE-AROME and ALARO. Research is now beginning to extend to the hyper-resolution (O(100-200m) horizontal resolution in grid point space) scale. This research is linked to developments on hectometric scale modelling in DEODE.

Aspects to be studied are

- numerical stability, particularly near steep topography;

- the meteorological and computational effects of using higher order than linear spectral grids;

- the need to revise or retune physics parametrizations, the settings of horizontal numerical diffusion and reworking of the SLHD (link with HR8.4);

- the provision and use of adequate physiography data;

- the availability and quality of observations suitable for the validation of hyper-resolution models;

- the validation and optimization of the model for urban environments.

Simulations of different weather situations are needed in order to study the interactions between resolved and parametrized processes related to convection, turbulence, waves, radiation and microphysics.

The tasks described here are closely related to the progress made in new dynamics schemes (DY1-2-3), 3D-physics (PH1-2-3), high-resolution physiography (SU5), new observation types (DA4) and suitable new validation and verification techniques for hyper-resolutions (MQA2). In addition to this, options for data assimilation settings, ensemble configurations, and computational efficiency aspects will also be considered. These experiments will be done on several (maritime and continental) test domains.
At sub-km and hyper-resolution scales, we enter the grey-zone of shallow convection and turbulence, and the physics parametrizations will need to be revised and retuned accordingly. Field experiments will be used to validate and optimize aspects such as the microphysics (e.g. SOFOG3D) and the urban description (e.g. the WMO 2024 Paris Olympics project). Attention

will be needed for developing computationally affordable 3D-schemes for radiation and turbulence (link with WP PH1-2). It will be assessed whether or not we run into limitations of our present spectral SISL dynamics (work closely related to the DY2-3 WP's).

Activities will also focus on horizontal and vertical diffusion (turbulence) on sub-km scales. The horizontal diffusion will be re-designed and tuned depending on the scale aimed to in the high resolution experiments. The computation of the SLHD diffusion coefficient will be modified to become a function of the total flow deformation. The relation between the horizontal diffusion applied by the model dynamics (SLHD or conventional spectral horizontal diffusion) and the parametrized vertical diffusion will be studied for a range of resolutions.

This topic is partly accounted for in RC LACE's "Dynamics and Coupling" plan. In ACCORD RWP, it is part of the “High Resolution” package. Above, there is a rough estimate on contibution to “Physics” topics.

Proposed contributors, Estimated: R. Brožková (Cz) 3.0 PM and J. Mašek (Cz) 3.0 PM; TOTAL: **6.0 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: The assessment of ALARO-CMC parameterization schemes performance at 1 km and 500 m resolutions, including the sensitivity to the time step length.

Action/Subject: Code Refactoring and Adaptation (CRA)

Description and objectives:

In order to address the uncertain future evolution of the software infrastructures we will follow the approach of separation of concerns as explained in the ACCORD Strategy 2021-2025. The challenge is therefore to develop new layers of software that generate efficient hardware-specific code starting from the high-level abstract code. Given the close relation of the ACCORD codes to ECMWF's IFS code and the fact that ECMWF is putting big efforts in the topic of code adaptation, we (ACCORD) will more or less follow ECMWF's plans in this area. Regular meetings will be organized with ECMWF to keep the developments and plans in accordance. The main task in this work package will be to prepare and carry out the porting of the ACCORD codes on accelerators such as GPUs. Following ECMWF's plans, different porting strategies are envisaged for different parts of the codes. Foremost, the flexibility of the control routines needs to be improved through the introduction of smart (device-aware) data structures (FIELD_API) and a cleaning and refactoring of the control layer routines (CRA1). For the spectral transforms, which are well-delineated and slowly-evolving, yet crucial for performance, a manual hardware-specific porting and optimization is targeted (CRA2.1). For the case of the physics parameterizations, which cover a large part of the code base of the forecast model, and which are evolving much faster than e.g. the spectral transforms, source-to-source transformation tools will be developed (CRA2.2) and applied to the individual parameterizations (CRA2.3). A different strategy to develop an NWP model that is portabile to hetereogeneous architectures is through the use of a Domain-Specific Language (DSL). ECMWF is developing the finite-volume model PMAP with the GT4Py DSL. While the capabilities of this model in terms of scientific questions like stability over steep slopes is investigated in DY2, the performance and portability of this approach are evaluated in this work package (CRA3) During the process of porting pieces of the ACCORD model to accelerators, it is essential to continously test for the correctness of the results, but also e.g. if the performance on CPUs does not degrade. An extension of the regular testing platform of ACCORD, Davai, in these directions will be investigated. The phase 2 of the Destination Earth Extremes On-Demand (DE_330) project contains a task (WP10.2) on code adaptation to EuroHPC infrastructure. Care was taken to align the DE_330 WP10.2 with this ACCORD rolling workplan.

Proposed contributors, Estimated: B. Bochenek (Pl) 4.0 PM, P. Sekula (Pl) 1.0 PM and M. Tudor (Cr) 1.0 PM; TOTAL: **6.0 PM**

Planned timeframe:

Planned deliverable: code modification, documentation updates

Description of activities: The foreseen activities include (i) preparing ACCORD codes for porting to GPUs, (ii) ALARO-CMC refactoring and (iii) integration of the code and testing on various platforms.

4 Summary of resources

Table 1. Resources per WPs and summary

Subject/Action	Manpower [PM]	LACE stays [PM]	ACCORD stays [PM]
PH1: Turbulence and shallow convection	6.75*	1.0	0.0
PH2: Radiation	0.0	0.0	0.0
PH3: Clouds-precipitation microphysics	11.0	0.5	0.0
PH4: Common 1D MUSC framework for parametrization validation	0.5	0.0	0.0
PH5: Model Output Postprocessing Parameters	5.0	0.0	0.0
PH6: Study the cloud/aerosol/radiation (CAR) interactions	6.0	0.0	1.0
PH7: On the interface between the surface and the atmosphere	2.75	0.0	0.0
PH8: On the interface of Physics with Dynamics (and time stepping)	0.0*	0.0*	0.0*
SU3: SURFEX: validation and development of existing components for NWP	27.5	1.5	0.5
SU4: SURFEX: Development of new model components	0.25	0.0	0.0
SU5: Assess/improve quality of surface characterization	4.25	0.0	0.0
HR: Sub-km modelling	6.0	0.0	0.0
CRA: Code Refactoring and Adaptation (formerly SPTR)	6.0	0.0	0.0
TOTAL	76.0	3.0	1.5

LACE research stays:

- Debugging TOMs – Peter Smerkol (4 weeks; CHMI, Prague)
- Development of two-moment scheme with aerosols in the ALARO – David Němec (2 weeks; University of Ghent, Belgium)
- ALARO+SURFEX debugging – Mario Hrastinski (2+2 weeks; CHMI, Prague)
- ALARO+SURFEX debugging – Piotr Sekuła (2 weeks; CHMI, Prague)

ACCORD flat-rates research stays:

- Validation and development of SURFEX options – Gabriel Stachura (2 weeks; CHMI, Prague)
- Study CAR interactions – Piotr Sekuła (4 weeks; CHMI, Prague)

5 Meetings and events

1) 44th LSC meeting
2) 5th ACCORD All Staff Workshop
3) 45th LSC meeting
4) 47th EWGLAM and 32nd SRNWP meeting
5) ALARO-1 Working Days
6) ALARO+SURFEX training
7) ACCORD Physics Working Week (online)
8) ACCORD Surface Working Weeks (2x; online)
9) Surface monthly meetings (online)

6 Risk and constrains

There are many CMC-specific activities and work related to several configurations at high resolutions. Most of these are part of the DE_330 project or local projects. Due to this, the research and development may be slowed down. More coordinated work is needed on ALARO+SURFEX.