Working Area Physics

Work Plan Proposal

Prepared by:	Physics Area Leader Mario Hrastinski
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1 Introduction

Current research and development activities within the RC-LACE physics group focus on enhancing the scale-independent ALARO-1 package to support operational forecasts at mesh sizes of approximately 1-5 km. The development of various schemes for high-resolution modelling, consolidated within the ALARO-1 package, has been ongoing for more than 10 years. Most individual schemes have reached the tuning and validation stages, with continuous upgrades to the most influential components in line with the relevant literature. Several countries also use AROME CSC, where current development efforts are primarily focused on surface processes.

The benefits of the high resolution with ALARO-1vB have been seen for quite some time and continue to grow with recent developments. Current activities are mainly focused on its adaptation to the (sub-)kilometre mesh size and optimisation across several grey zones (e.g., deep convection, turbulence and gravity wave drag), as well as on coupling with the SURFEX model and leveraging its advanced options. Majority of related activities are reported 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 contributions from RC-LACE countries: SU3 (SURFEX: validation and development of existing components for NWP) and SU5 (Assess/improve quality of surface characterisation), 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 1 km.

Research will continue to enhance the description of physical processes at sub-km resolutions (study of turbulence in the grey zone, two-moment microphysics scheme). Experiments in very fine resolution (with ALARO and AROME) will indicate the problems that should be tackled. Additionally, an enhanced description of the 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)

Introduction and objectives: A substantial part of the foreseen work on turbulence and convection is related to (very) high-resolution runs and the grey zone, which intertwines with activities in the "Dynamics & coupling area" (for more details, see the following two paragraphs). However, at current mesh sizes of operational models, there is a need to (partly specific for ALARO): (i) enhance the mixing length computation (PH1.1), (ii) improve the stability of the TOMs solver (PH1.2), and (iii) investigate the performance within a very stable boundary layer (PH7).

To improve CSC's performance at 500 m mesh size or finer, activities should focus on pragmatic approaches to enhance the scale-aware properties of turbulence and shallow convection schemes. It is worth noting that a scale-aware convection scheme in AROME and HARMONIE-AROME is already beneficial at current operational resolutions (approximately 500 m to 2.5 km). In addition, various approaches to addressing the 3D effects of turbulence have been explored within the ACCORD Consortium, building on the outcomes of the side-meeting discussion at the 2022 All Staff Workshop:

- **short/mid-term plans**; study, implement and validate quasi-3D formulations, including Goger et al. (2018, 2019) (for mountaineous areas) and Moeng et al. (2010) approaches (for strong convection clouds)
- **longer-term plans** (towards "full 3D turbulence"):

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

  - full 3D turbulence requires computing the horizontal divergence of horizontal fluxes, and it is important to understand first 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) 1.50 PM, R. Brožková (Cz), J. Mašek (Cz), P. Smolíková (Cz) 2.25 PM[1] , and P. Smerkol (Si) 3.00 PM; TOTAL: **6.75 PM**

Planned timeframe: whole year

Planned deliverables: code modifications, documentation updates and stay reports

1 The PMs refer to all three colleagues from Cz together.

Description of activities: Developments of the TOUCANS turbulence scheme will continue with priorities in the following directions: (i) enhancing the performance of the TKE-based mixing-length formulation, focusing on PBL height assessment and evaluation of the impact of the stability parameter (PH1.1); (ii) improving the numerical stability of the TOMs solver (PH1.2); (iii) addressing 3D effects of turbulence (PH1.3) and scale-awareness of the scheme in whole (PH8.4), reported under the "Dynamics & coupling" area; and (iv) reformulating the shallow convection cloudiness (needed in the radiation scheme). Thereby, in the scope of (iii), a contribution to CY51 is planned, as well as phasing the developments from CY46T1 into CY48T3.

In addition, the preparation and validation of the single-precision ALARO-1 configuration with TOUCANS will continue, as reported under the SY package of the ACCORD RWP 2026. Further related activities are foreseen within the PH7 package, including preparation for a safe reduction of the lowest model-level height and investigation of very stable boundary-layer regimes.

Action/Subject: Radiation (PH2)

Introduction and objectives: Recent focus has been on interfacing the ACRANEB2 radiation scheme with CAMS aerosols and on the externalisation of cloud effective radii, as addressed within the PH6 work package. Apart from that, minor improvements in the ACRANEB2 scheme are foreseen, including: (i) interfacing and testing the single-precision version in a 3D model, (ii) inclusion of CFC-11 and CFC-12 in the CO2+ composite, and (iii) addressing the impact of clouds on the broadband surface albedo. In future, a revision of gaseous transmissions is also possible. Plugging ecRad into APL_ALARO and addressing the 3D effects of radiation are also considered. At the side meeting of the All Staff Workshop 2022 about 3D effects in physics, the following workplan has 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 the above work plan, evaluate the manpower needs for its realisation 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: **0.00 PM**

Planned timeframe: whole year

Planned deliverable: code, report

Description of activities: There is no capacity/workforce for radiation-related activities in 2026. However, if the space opens, a comparison of ACRANEB2 and ecRad schemes, started during Sophia Schäfer's stay at CHMI in 2024, might continue. 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)

Introduction and objectives: The main aim is the development of the two-moment microphysics scheme. The work on the liquid phase is far advanced, while the ice phase is under development.

Proposed contributors, Estimated efforts: D. Němec (Cz) 10.00 PM and M. Tudor (Cr) 0.25 PM; TOTAL: **10.25 PM**

Planned timeframe: whole year

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

Description of activities: The development of the two-moment microphysics scheme within the ALARO framework, utilising CAMS aerosols, will primarily focus on ice processes, including cloud ice, snow, and graupel. Minor refinements to the two-moment rain scheme may also be implemented. This work is also the subject of David's PhD.

Additionally, two collaborative activities with colleagues outside RC-LACE are ongoing: (i) an in-depth evaluation of the ALARO two-moment scheme against observations in the tropics (with Debasish Mahapatra and Kwinten Van Weverberg; University of Ghent and RMI), and (ii) validation of ALARO, AROME, and HARMONIE-AROME microphysics schemes in the MPACE case, including preparation for a publication (with numerous colleagues from the ACCORD teams).

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

Introduction and objectives: Maintain and regularly update a shared "MUSC" 1D testing environment for AROME-France, HARMONIE-AROME, and ALARO, enabling evaluation of physics parametalready did some investigation)erisations against Cloudnet and LES data in idealised experiments.

A beta version of the common MUSC environment (for the three CSCs), based on cy46t1, was created during the Working Week in 2021 and validated for at least some cases without SURFEX. However, additional work is required for ALARO and SURFEX. To increase the number of available "ideal" cases, David's approach will be tested for all three CSCs to provide a diverse set of meteorological situations (for evaluating and comparing all parametrisations available across the CSCs). Accordingly, a yearly training and/or working days should be organised to maintain and upgrade the common MUSC version, based on a new cycle.

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

Planned timeframe: whole year

Planned deliverable: code modifications, 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)

Introduction and objectives: There is a growing need for new post-processing parameters from NWP systems to support applications in aeronautics, the green energy sector, automated forecasting, and other end-users. This need is reflected in the ongoing efforts of many NMSs within ACCORD. In this WP, we address activities on the model output, as produced mostly from the executables available from compilation (i.e., MASTERODB).

Post-processing activities are coordinated within this package to avoid duplication. In 2021, an inquiry was conducted to update the list of diagnostic and output fields considered by local teams. The inquiry also aimed to determine whether these outputs should be computed during model runtime (requiring specific model fields) or handled offline in downstream post-processing. Only the first outputs clearly fall within the scope of ACCORD RWP (common codes).

As a result of the 2021 inquiry (aka PH5 questionnaire), model output fields have been grouped into four categories, aiming to foster greater synergy across teams at the ACCORD level. Post-processing needs for sectors such as traffic, energy, and tourism/sports can be assigned to tasks based on the required output category. Dedicated topical meetings (per category) are planned, allowing involved teams to share their plans and encourage transversal collaboration. Another goal of WP PH5 is to coordinate the implementation activities of selected parameters into the common code across all three CSCs, including their tuning and validation. Validation of new post-processing parameters (related to MQA) may require new data types (DA3–DA4). Post-processing specific to ensemble forecasts is addressed separately in EPS packages, as is related work in DA.

Proposed contributors, Estimated efforts: A. Simon (Sk) 3.00 PM and M. Tudor (Cr) 0.25 PM; TOTAL: **3.25 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: Foreseen activities include the development of diagnostic parameters for high-resolution modelling and tuning physics, e.g. cloud-top skin temperature, and refinement of Vertical Integrated Liquid (VIL) computation. Additionally, some time will be devoted to editing the WP, organizing the workflow and preparing documentation.

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

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

In RC-LACE, only activities specific to the ALARO CSC are currently foreseen, focusing on testing and tuning the configuration for operational use and relying on validation against measured incoming solar radiation data (also related to MQA3). Since near-real-time aerosols require substantial data transfer in the coupling files, other more optimal solutions will be tested.

Proposed contributors, Estimated efforts: J. Mašek (Cz) 0.75 PM, P. Sekuła (Pl) 3.00 PM, and M. Tudor (Cr) 0.25 PM; TOTAL: **4.00 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: Following Piotr Sekula's stay in Q4 2025, it is proposed to tune the stratospheric background values, aiming to achieve a closer match between ACRANEB2 and ecRad fluxes. To enable this in ALARO CSC (CY48T3), it is required to: (i) interface ecRad with CAMS n.r.t. aerosols and (ii) implement a generalised Geleyn formula for direct albedo in SURFEX.

In addition, to reduce the computational cost of 3D n.r.t. aerosols, temporal interpolation could be tested instead of full advection, at least until the microphysics scheme necessitates the latter. This implementation can leverage the coupling scheme infrastructure, preliminarily explored by Petra Smolíková.

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

Introduction and objectives: This WP deals with the interaction 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 parameterisations.

The inability to properly model the stable boundary layer has been a long-standing problem, with direct consequences for essential near-surface variables such as T2m. This topic was raised during a side meeting at 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 examine the possible impact of the additional term in scalar-flux formulations and learn from relevant observations through 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) 1.50 PM and J. Mašek 1.00 PM; TOTAL: **2.50 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: The coupling of ALARO to SURFEX is now considered completed. Thus, the focus has shifted toward activating more advanced SURFEX options (addressed in SU3 WP) and initialisation aspects (addressed in SU1 WP). The second set of developments for ALARO with SURFEX is available on top of CY49T2_bf; it should be phased into the IAL repository once CY51, including SURFEX version 9, is opened for surface developments (task PH7.1).

In addition, work is ongoing in CY46T1 to prepare and test the ALARO CSC code for a safe reduction of the lowest model level, aiming at better resolving processes in the statically stable PBL (task PH7.6). The code is largely complete, requiring only minor refinements for turbulence energy diagnostics below the forcing level. In 2026, the associated code will be phased into CY48T3 and CY51. In collaboration with the "Dynamics & Coupling" area leader, a high-resolution vertical-level configuration has been prepared, and testing is ongoing.

With a mid- to long-term priority, and depending on the available workforce, further activities are planned related to (very) stable boundary layer issues. This includes (I) enhancing the coupling between the surface and atmosphere, e.g., by adopting the so-called 'z-less' scaling (PH7.4) or (ii) exploring alternatives to the current grid-box averaging methods for surface flux computation, such as the stochastic approach (PH7.5).

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

Introduction and objectives: This WP lists specific tasks at the interface between physics and dynamics, in terms of the code and of the scientific interest.

Regarding the physics-dynamics interface, one scientific issue is that local sources and sinks of total water in physics are automatically compensated by local sinks or sources of dry air. This occurs because total mass conservation is enforced by the model's continuity equation, even when physics parameterisations create sources or sinks of total water. As a result, the model does not strictly conserve dry air. Physics parameterisations are typically solved at either constant pressure or constant volume. In a non-hydrostatic model, changes in pressure induced by the physics must be accounted for consistently with the choices made in both the physics-dynamics interface and the dynamics..

Further, attention is given to the respective roles of horizontal and vertical diffusion (turbulence) across scales. Horizontal diffusion will be redesigned and tuned according to the target resolution in high-resolution experiments. In particular, the computation of the SLHD diffusion coefficient will be modified to depend on the total flow deformation. The interplay between horizontal diffusion applied by the model dynamics (SLHD or conventional spectral horizontal diffusion) and parametrised vertical diffusion will be investigated across a range of resolutions. This reassessment of SLHD and gridpoint-based dissipation is also closely linked to the design of hyper-resolution configurations.

To reduce numerical cost and with a view toward hyper-resolution model design, it may be of interest to investigate time-splitting approaches in which dynamical tendencies are computed with a shorter time step than physical tendencies, rather than applying a uniformly short time step to all processes. Time splitting itself will require dedicated future work to assess its impact on numerical stability and solution accuracy. The task described in this WP focuses on studying the necessary code design to enable a time-splitting facility within the common code framework.

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) 0.00 PM, P. Smolikova (Cz) 0.00 PM; TOTAL: 0.00 PM

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

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

Introduction and objectives: The main objective is to enhance the physical realism of the system by exploring more advanced SURFEX components, including options not previously used in ACCORD CSCs.

For the nature tile, these advanced components include the Diffusion Soil scheme (ISBA-DIF), the Explicit Snow scheme (ES), and the Multi-Energy Balance (MEB) scheme. The ISBA-DIF scheme also provides several hydrological options. The assessment of these new components should be carried out in close coordination with the corresponding data assimilation developments (SU1). In addition, options enabling prognostic LAI (A-gs) may improve the representation of surface resistance and transpiration control, while opening the way for the assimilation of LAI products (SU2).

Over land, errors in forecasting low temperatures are often linked to inadequate representation of the statically stable PBL and the surface layer in NWP models. Dedicated studies are planned to enhance the understanding of associated deficiencies and to advance towards improved solutions.

Over the sea tile, turbulent fluxes are computed using different versions of the ECUME scheme. An accurate representation of surface fluxes over the sea is crucial for simulating large-scale processes and is also closely related to the successful forecasting of sea fog. The objective is to evaluate the performance of different ECUME formulations against available observations and to assess their impact on fog prediction.

The urban tile, described by the TEB model, typically covers relatively small fractions but plays an important role in simulating local weather conditions. Its relevance increases with the model resolution. TEB is currently implemented without data assimilation. Its performance across different city types and weather conditions requires thorough validation against dedicated observations, including targeted measurement campaigns.

The inland water tile is represented by FLake, which is operational within the HARMONIE-AROME CSC for MetCoOp. It is also implemented without data assimilation; thus, monitoring and evaluation of its performance are critical.

Observations required for validation are partly provided by MQA3, through tools such as Monitor and HARP. However, these datasets should be complemented by dedicated observations, including measurement campaigns, non-conventional near-surface observations, flux-tower data, and satellite products. All parameterisations include parameters with some level of uncertainty. Within SURFEX, numerous parameters are prone to tuning, which may improve the performance of a given ACCORD cycle release for a specific domain. However, its applicability and robustness must be carefully assessed. CSC specific details are:

- **AROME:** The 1D ocean mixed-layer model CMO has been tested and implemented in selected AROME configurations at Météo-France (Overseas). The objective is to further enhance ocean-atmosphere coupling, particularly for improved tropical cyclone prediction. The 1D sea-ice model GELATO will be tested in ARPEGE and in an experimental Arctic AROME configuration.
- **HARMONIE-AROME:** The plan is to release CY46H with ISBA-DIF, ES, and MEB as default configurations.
- **ALARO:** The objective is to undertake the necessary steps toward the operational implementation of ALARO coupled with SURFEX and to ensure that the required developments are incorporated into the most recent t-cycle.

Proposed contributors, Estimated efforts: [2]D. Deacu (At), D. Neubauer (At), S. Schneider (At) 13.00 PM; R. Brožková (Cz), J. Mašek (Cz) 7.00 PM; M. Hrastinski (Cr) 1.25 PM; P. Sekuła (Pl) and G. Stachura (Pl) 7.00 PM; TOTAL: **28.25 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: The main focus is on preparing the ALARO CSC coupled with SURFEX for operational implementation and on enhancing AROME performance, both for the C-LAEF AlpeAdria system and for hyper-resolution applications within the DEODE framework.

For ALARO CSC, the emphasis is shifting towards initialisation aspects (addressed under SU1 WP), to be followed by dedicated tuning activities. Several SURFEX options still require thorough validation, including advanced TEB features (e.g., industrial heat sources and the urban canopy scheme), the ORORAD scheme, and screen-level diagnostics. In contrast, some schemes and options are already excluded from the first operational ALARO + SURFEX configuration, including FLAKE, LGARDEN, and traffic-related sources (due to their unrealistic temporal variation).

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

Introduction and objectives: Within SURFEX, activities are foreseen to improve existing, underdeveloped, or still-missing components; the aim is to represent additional physical processes and implement improved diagnostic capabilities. During this RWP period, the NWP team plans the following developments:

- enhancing the sophistication of the Simple Ice scheme (SICE), to improve performance over snow and glacier areas
- the Multi-Energy Budget (MEB) scheme for open land surfaces

2 All contributions in the SU3 package are accounted for per country.

- additional parameterisation of fractional snow and improved representation of winter aspects in the urban model TEB
- new formulations for vegetation roughness (roughness sublayer scheme – RSL)
- exploring the use of 1-D ocean model GOTM

All new developments should be contributed through the SURFEX repository to ensure their integration into future SURFEX releases and consistent inclusion in upcoming NWP cycles.

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)

Introduction and objectives: The main objective is to assess and improve the quality of surface characterisation. The surface physiography data currently used are:

- different versions of ECOCLIMAP, from ECOCLIMAP 1 to ECOCLIMAP SG (Second Generation), depending on CSC
- the FAO, HWSD and Soilgrids sand, clay and soil-organic carbon databases
- the GMTED2010 orography
- the Global Lake DataBase (GLDB) v1-3

We will continue to examine the available physiographic databases and correct identified deficiencies where possible (e.g., fixing errors and incorporating national datasets). Necessary developments in the code (PGD, scripts) will be implemented to enable the use of these maps across different CSCs. Their impact will be systematically evaluated, and verification scores will be monitored. Eventual modifications introduced at the regional or domain level will be consolidated into the consortium-wide database versions. In collaboration with the SURFEX team at Météo-France, such improvements may also lead to official updates of the databases distributed via the SURFEX website. We will also investigate the feasibility of generating a fine-resolution (hectometric-scale) land-cover map over Europe using machine learning techniques. Specific related tasks are organised under the Machine Learning WP (ML1). Coordination of physiography developments with other consortia will take place through EWGLAM/SRNWP.

Proposed contributors, Estimated: M. Hrastinski (Cr) 0.50 PM; TOTAL: **0.50 PM**

Planned timeframe: whole year

Planned deliverable: code modifications, testing and validation

Description of activities: The activities include further evaluation of the ECOCLIMAP-SG physiography with ALARO CSC, and its integration into the existing procedure for updating roughness length fields for use within the ALARO + ISBA framework.

Action/Subject: Sub-km modelling (HR)

Introduction and objectives: The main objective is to achieve up-to-date, realistic and affordable versions of sub-km AROME-France, HARMONIE-AROME and ALARO. Research extends to the hyper-resolution scale (i.e., O[100-200m] horizontal resolution in grid point space). There is a clear link with 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 parametrisations, the settings of horizontal numerical diffusion and reworking of the SLHD, 3D aspects
- 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 optimisation of the model at these VHR grid scales and grid sizes
- exploring the predictability and data assimilation at very high resolution

Simulations of different weather situations are needed to study the interactions between resolved and parametrised 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 (from within DA1-2-3) and suitable new validation and verification techniques for hyper-resolutions (MQA2). In addition, options for initialisation and computational efficiency will be addressed. Options for data assimilation settings and ensemble configurations will also be considered. The associated experiments are performed on several (maritime and continental) test domains.

At sub-km and hyper-resolution scales, we enter the grey zones of shallow convection and turbulence, where the related physics parameterisations must be revised and retuned. Field experiments will be used to validate and optimise aspects such as cloud microphysics (e.g. SOFOG3D) and urban description (e.g. the WMO 2024 Paris Olympics project). LES data will be considered, especially in the context of idealised cases. Attention is also needed to develop computationally affordable 3D schemes for radiation and turbulence (link with WP PH1-2). It will be assessed whether we run into limitations of our present spectral SISL dynamics (work closely related to the DY WP's).

Activities will also focus on horizontal and vertical diffusion (turbulence) on sub-km scales. The horizontal diffusion will be redesigned and tuned in dependence on the scale for high-resolution experiments. The impact of how the VHR models are initialised will be assessed (is any "warm-up" phase useful?).

The list of tasks below is the outcome of discussions by the ACCORD/MG and in association with the WG-VHR. The tasks are organised in four main packages:

- HR1: studying the scientific added value
- HR2: studying the impact of surface conditions
- HR3: studying the numerical stability aspects
- HR4: preparing a shared experimental environment on ECMWF's ATOS platform (can use the results of the DEODE project)

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. Below is a rough estimate of contributions to "Physics" topics.

Proposed contributors, Estimated: R. Brožková (Cz), J. Mašek (Cz) 8.00 PM[3]; M. Hrastinski (Cr) 3.00 PM, M. Tudor (Cr) 0.50 PM; P. Smerkol (Si) 1.50 PM; and A. Simon (Sk) 1.00 PM; TOTAL: **14.00 PM**

Planned timeframe: whole year

Planned deliverable: code modification, testing and validation

Description of activities: Given CHMI's plan to increase the resolution of their operational model ($\Delta x \approx 1.2$ km) and transition to SURFEX, substantial effort is required to test and tune the parameterisation settings. A similar activity is foreseen at DHMZ, with $\Delta x \approx 1.3$ km, but still within ALARO + ISBA framework. Further, at SHMU, the evaluation of deep convection and microphysics schemes at 0.5-1.0 km scales is foreseen, along with the implementation and assessment of the single-precision code. Finally, at ARSO, some effort is foreseen to enhance the MicroHH LES model capability for real-case simulations. This includes improving the representation of orography and refining the treatment of lateral boundary conditions.

3 The PMs refer to both colleagues from Cz together.

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	0.50	0.00
PH2: Radiation	0.00	0.00	0.00
PH3: Clouds-precipitation microphysics	10.25	0.25	0.50
PH4: Common 1D MUSC framework for parametrization validation	0.25	0.00	0.00
PH5: Model Output Postprocessing Parameters	3.25	0.00	0.00
PH6: Study the cloud/aerosol/radiation (CAR) interactions	4.00	0.00	0.50
*PH7: On the interface between the surface and the atmosphere	2.50	**0.00	**1.00
*PH8: On the interface of Physics with Dynamics (and time stepping)	0.00	0.00	0.00
SU3: SURFEX: validation and development of existing components for NWP	28.25	2.75	0.50
SU4: SURFEX: Development of new model components	0.25	0.00	0.00
SU5: Assess/improve quality of surface characterization	0.50	0.00	0.00
*HR: Sub-km modelling	14.00	0.00	0.00
TOTAL	70.00	3.50	1.50

(*) subject/action shared with another area and (**) stays in collaboration with the "Dynamics & Coupling" area (not accounted here)

REMARK: Overall commitments remain in line with those for 2025. The focus is now shifting toward the operational implementation of several developments, particularly ALARO coupled with SURFEX. In addition, some teams are progressing toward kilometric resolution and the CY48T3 in operations, with commitments and/or results to be reported at least partly within quality assurance packages.

Research stays (20 weeks; 14 funded by RC-LACE and 6 from ACCORD-DAP)**:**

- ***Solving instabilities of TOMs solver*** **–** Peter Smerkol (2 weeks in Q3 or Q4; CHMI, Prague)[4]
- ***Towards the operational application of ALARO with SURFEX (and/or some TOUCANS scheme-related topic)*** **–** Mario Hrastinski (2 + 2 weeks in Q2 and Q3; CHMI, Prague)
- ***Development of the two-moment microphysics scheme with CAMS aerosols in ALARO CSC*** **–** David Němec (3 weeks in Q3; University of Ghent, Belgium)[5]
- ***Towards the operational application of ALARO with SURFEX*** - Piotr Sekuła (5 weeks in Q2 or Q3; CHMI, Prague)

4 This stay was originally planned for 4 weeks. Due to Peter's limited availability, 2 weeks were reallocated to ALARO + SURFEX stays of Piotr Sekuła and Gabriel Stachura.

5 Partly funded from ACCORD-DAP (see Table 1).

- **Testing ALARO with SURFEX at kilometric resolution in CY48T3** – Gabriel Stachura (4 weeks in Q1; CHMI, Prague)[6]
- ***Tuning stratospheric background values for ALARO CSC*** **–** Piotr Sekuła (2 weeks in Q2; CHMI, Prague)[7]

5 Meetings and events

- 46th LSC meeting, Zagreb, Croatia
- 6th ACCORD All Staff Workshop, Marrakech, Morocco
- ACCORD Surface Working Week, Prague, Czech Republic
- 47th LSC meeting, Bucharest, Romania
- 48th EWGLAM and 33rd SRNWP meeting, Kilkenny, Ireland
- ACCORD Surface Working Week (online; autumn)
- ACCORD Physics Working Week (onsite or online)
- ACCORD Surface monthly meetings (online)

6 Risk and constrains

There are many CSC-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 and some stuff departures, the research and development may be slowed down.

6 Partly funded from ACCORD-DAP (see Table 1 for details).

7 Fully funded from ACCORD-DAP (see Table 1).