

Working Area Physics

# Progress Report

<b>Prepared by:</b>	Physics Area Leader Mario Hrastinski
<b>Period:</b>	January - December 2025
<b>Date:</b>	26 <sup>th</sup> February 2025

## 0 General Remarks

The intention is to foster thematic collaborations across ACCORD and CSC teams, in the area of Physics parameterizations. Besides the ongoing development plans within the three CSCs, we intend to organize scientific exchanges (ideas, results, experiences, shared reporting, etc.) and an increased topical-wise animation (in the form of regular videomeetings, or a common workshop). In the shorter term, we can learn and be inspired from each other's work on the same parameterizations due to the new set-up of the RWP. In the (very) long term, there can be a natural tendency of parameterization convergence due to the increasing resolution.

## 1 Summary

Several mid- to long-term developments have now reached the tuning stage, with only relatively minor refinements expected compared to the progress already achieved. These include:

- the operational application of CAMS aerosols within the ALARO CSC framework;
- the TOUCANS scheme: (i) a new turbulence length scale, (ii) introducing 3D effects and (iii) adjustment enabling the safe decrease of the lowest model level;
- the coupling of ALARO with SURFEX; with the choice of advanced features nearly completed and focus shifting towards initialisation aspects

Currently, the most dynamic development topic is the two-moment microphysics scheme in ALARO CSC with CAMS aerosols. The liquid phase processes are largely consolidated, while the focus is now turning towards ice, snow and graupel aspects. More broadly, activities across most teams are progressively concentrating on surface-related aspects (including physiography) and high-resolution adjustment.

Overall, the work plan is approximately 80% fulfilled. The remaining gap mainly reflects the impact of staff departures (notably at SHMU and GeoSphere Austria), the effort devoted to DE\_330 activities and local priorities such as cycle upgrades and the preparation of new configurations.

Two major events were organized in 2025: the ALARO-1 Working Days and the ALARO + SURFEX Working Week (WW). Finally, the group maintained a high level of visibility through (i) numerous presentations at ACCORD Consortium events (and wider), (ii) contributions to the common IAL code and (iii) scientific publications and theses. More details are provided in the following sections.

## 2 Overview of 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 mountainous 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)

ALARO CSC: Developments of the TOUCANS turbulence scheme will continue with priorities in three main directions: (i) finalization of the baseline version of the TKE-based mixing length formulation, its further upgrade and tuning for potential operational application (PH1.1), (ii) revision of TOMs parameterization (PH1.2) and (iii) addressing the 3D turbulence effects (PH1.3 - ALARO specific development and PH1.8 - common work with other CSCs).

**Contributors, efforts:** R. Brožková (Cz) 2.75 PM, M. Hrastinski (Cr) 2.75 PM, J. Mašek (Cz) 0.50 PM and P. Smerkol (Si) 5.25 PM; TOTAL: **11.25 PM**

**Planned timeframe:**

**Planned deliverable:** code modification, documentation updates

**Sub-action: Turbulence length scale computation**

**Contributors:** R. Brožková (Cz) 2.75 PM, M. Hrastinski (Cr) 2.75 PM and J. Mašek (Cz) 0.25 PM

**Efforts:** 5.75 PM

**Documentation, deliverable:** namelist, presentations and publication

**Status/description:** ONGOING

Two related activities were carried out in Q1-Q2: (i) revision of the manuscript submitted to the Monthly Weather Review and (ii) tuning for potential operational application. The revision focused on sensitivity experiments with the single-column model (MUSC). In convective cases (ARMCU and BOMEX), better agreement with LES was obtained when (i) cloud water sedimentation and its autoconversion to rain were disabled and (ii) the simplified mass-flux-type shallow convection scheme was strengthened. In more stable cases (DYCOMS-II and GABLS1), improvements were achieved through increased vertical resolution and aimed tuning, although the general applicability of the latter remains to be confirmed. The experiments also suggest that the TKE-based Turbulence Length Scale (TLS) formulation may require a prescribed lower limit to ensure a more favourable trade-off between the momentum and heat mixing in very stable conditions. The paper was published in November, at which time Mario also defended his doctoral thesis at the University of Zagreb, Faculty of Science, Department of Geophysics. Finally, recent TOUCANS developments, including TKE-based TLS and mixture of non-local and local flux Richardson number formulations were phased to CY50T1.

The tuning encompassed internal parameters that affect the regime-dependent TLS near the PBL top and the smooth near-surface transition, as well as other schemes, including thermodynamic adjustment, the cloud scheme, and soil-vegetation interaction. The impact was evaluated across stratocumulus, deep convection, strong wind with precipitation, and very stable cases. With the proposed tuning, the scores are mostly satisfactory, although certain biases could still be reduced. However, during summer afternoons, the standard deviations of near-surface temperature, relative humidity, and wind speed increase. Possible contributing factors are the noisiness of the PBL height field (Fig. 1) and, particularly, the transport of moisture (Fig. 2). For the latter, additional work is foreseen on the shallow convection closure, presumably NDIFFNEB. More details can be found in Radmila's talks at ALARO-1 Working Days (WD). The work will continue in 2026.

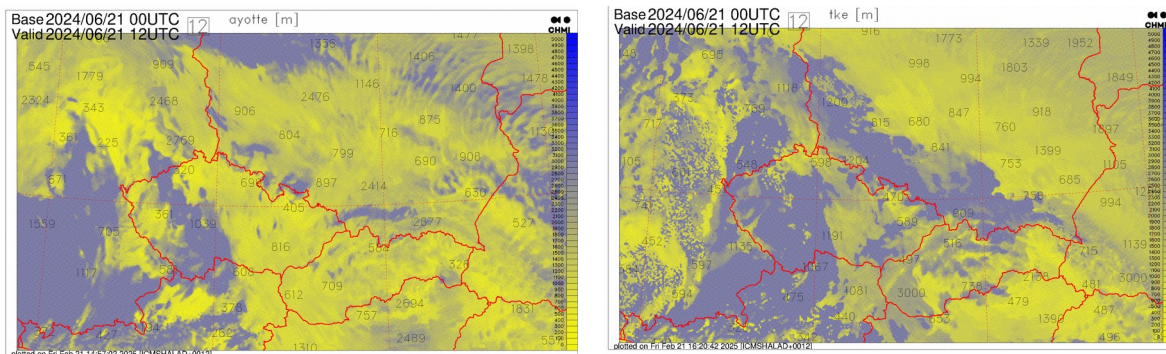


Fig. 1. Planetary boundary layer height, diagnosed at 12:00 UTC on 21 June 2024 using (i) Ayotte's weak-capping inversion method (left) and (ii) a TKE-profile-based method (right).

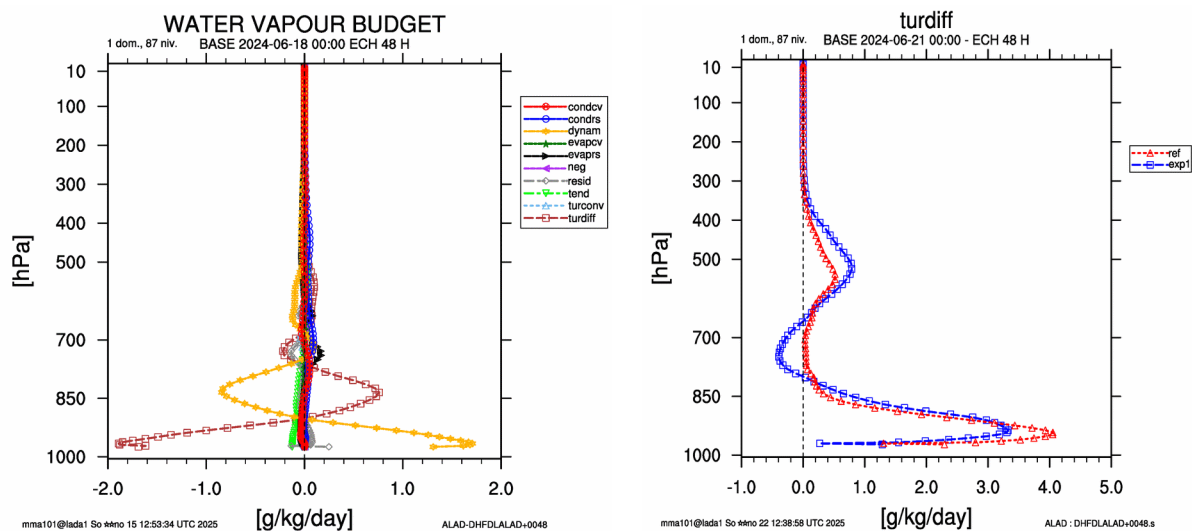


Fig. 2. Domain-averaged water vapor budget differences in convective period (18-21 June 2024) for (i) original (left) and (ii) tuned settings (right) of the new TLS formulation, both relative to the reference.

**Sub-action: Third-Order Moments (TOMs)**

**Contributors:** J. Mašek (Cz) 0.25 PM and P. Smerkol (Si) 5.25 PM

**Efforts:** 5.50 PM

**Documentation, deliverable:** report, code and documentation

**Status/description:** ONGOING

The work on this topic was carried out during a research stay at CHMI, Prague (April), and locally at ARSO. First, the ACDIFV3 subroutine was revised and checked against the documentation. Additionally, several bugs affecting ACDIFV3 inputs were also found in the

ACMRIP and ACPTKE subroutines, but their impact on numerical stability proved negligible.

Further efforts focused on the so-called temporal term ( $A_t$ ). Thereby, it was found that  $A_t$  was already coded by modifying the ZKTROV variable in the code ( $K_H$  in the documentation). However, it was also multiplied by factor  $F_\epsilon^{-2}$ , which is considered a bug. After removing the new implementation of  $A_t$  and fixing the old one, the stability was not improved. Finally,  $A_t$  was removed from the code because: (i) time derivatives were neglected in the Mellor-Yamada second-order system used to get the approximations for TOMs, and (ii) the associated improvement in stability was related to bugs in the code and came at the cost of reducing the TOMs contribution.

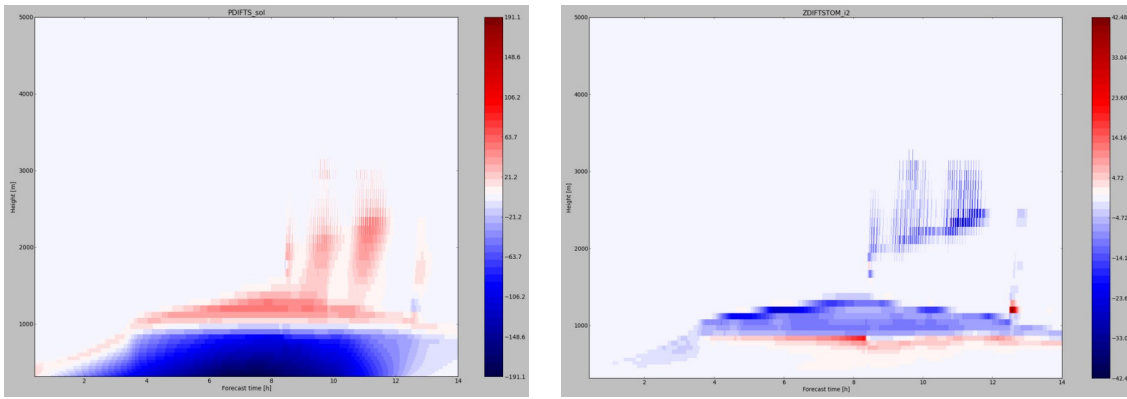


Fig. 3: Temporal evolution of turbulent heat flux ( $\overline{w^3 s^2_{sL}}$ ) profile in the ARMCU case with TOMs included (left) and relative difference from the experiment without TOMs (right).

The final version of the code (see Smerkol 2025 for details), with  $A_t$  temporarily enabled for consistency, was evaluated against the non-refactored counterpart using spectral norms and confirmed to be equivalent. However, without  $A_t$ , the simulation blew up in the first timestep due to numerical instability in a very few suspicious points. The analysis continued using MUSC in idealized ARMCU and GABLS1 cases. First, the oscillations in flux Richardson number ( $R_{if}$ ) and stability dependency function ( $F_\epsilon$ ) were noticed above the PBL, even with TOMs contribution switched off. These were mitigated by (i) increasing the critical value of TKE and TTE from  $10^{-7}$  to  $10^{-4}$   $m^2/s^2$ , forcing  $R_{if}$  to  $R_{if-max}=0.3336$  whenever TKE/TTE smaller than their critical value and (ii) setting  $R_{if-min}=-3$  (originally  $R_{if-min}=-1000$ ).

Further, turbulent heat fluxes were analyzed with and without TOMs in the ARMCU case (Fig. 3). When TOMs are turned on, temporal oscillations appear after 8-h above the cloud layer (Fig. 3, left), i.e., in regions of low TKE/TTE. These oscillations persist even with a reduced timestep and are likely related to instability in the 3D model. As for the general behaviour of the TOMs contributions, we see that they (Fig. 3, right): (i) have mostly counter-gradient effect, (ii) occur near the bottom of the cloud layer and its top, and (iii) can locally dominate the total flux.

Finally, the ACDIFV3 code is considered fully debugged and no longer a source of numerical instability. Further work should focus on debugging other TOUCANS subroutines, the solver matrix and its conditioning, interactions with dynamics in the 3D model, and suppressing TOMs above the PBL (instabilities may be linked to strong gradients near the tropopause). In parallel, more detailed MUSC tests and LES comparisons are planned. During Q3 and Q4, some effort was devoted to preparing the stay report. However, the main focus was on the MicroHH LES model implementation, aiming to evaluate the TOMS solver. Further details are provided in the HR section at the end of this chapter.

**Sub-action: Towards the 3D turbulence (cf. Dynamics & coupling report)**

**Contributors:** M. Hrastinski (Cr) and P. Smolíková (Cz)

**Efforts:** 0.00 PM

**Documentation, deliverable:** stay report (previous)

**Status/description:** ONGOING

Although being a part of the PH1 package in ACCORD RWP (task PH1.3), this topic is reported in the “Dynamics and coupling” area of RC-LACE. It was initiated in the context of the (sub-)kilometer ALARO CSC optimization and link to the Semi-Lagrangian Horizontal Diffusion. An overview of recent activities was presented at the ALARO-1 Working Days: [https://opensource.umr-cnrm.fr/attachments/download/6184/Towards\\_3D\\_turbulence\\_MH.pdf](https://opensource.umr-cnrm.fr/attachments/download/6184/Towards_3D_turbulence_MH.pdf).

**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 CO<sub>2</sub>+ 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).

**Contributors, efforts:** NONE

**Planned timeframe:**

**Planned deliverable:** NONE

**Status/description:** PENDING

No progress has been made, since no workforce is currently available or priority is given elsewhere. The topics that are waiting to be opened are: (i) introducing 3D radiation effects and (ii) revision of broadband gaseous transmissions (or a hybrid approach to them). However, the latter is considered “not easy to win” and probably not that urgent.

### **Action/Subject: Clouds-precipitation microphysics (PH3)**

**Introduction and objectives:** Currently, the RC-LACE developments within this package are conducted under the ALARO CSC. The focus is on the two-moment microphysics scheme, mainly on cloud ice and snow aspects. Minor adjustments are also made to the two-moment cloud water and rain scheme.

**Contributors, efforts:** R. Brožková (Cz) 0.50 PM, M. Derková (Sk) 0.25 PM, D. Němec (Cz) 10.75 PM and M. Tudor (Cr) 0.25 PM; TOTAL: **11.75 PM**

**Planned timeframe:**

**Planned deliverable:** code modification, short report and namelist

#### **Sub-action: Development of two-moment ALARO microphysics scheme with aerosols**

**Contributors:** D. Němec (Cz) 10.75 PM

**Efforts:** 5.25 PM

**Documentation, deliverable:** short report and code modification

**Status/description:** ONGOING

The development of the two-moment microphysics scheme largely focused on cloud ice processes, which can utilize information from CAMS climatological aerosols for activation.

Previously, the phase partitioning between cloud water and ice was driven by the FONICE function; this has now been replaced by a more advanced treatment within the double-moment ice parameterization. Tests were performed for the MPACE case using MUSC. Initial results revealed several issues, including overly rapid glaciation leading to abrupt snow production in waves and excessively reduced precipitation accumulation. These issues were discussed during the research stay at the University of Ghent in September, followed by additional work in Q3-Q4 2025, which helped to mitigate the excessively rapid glaciation.

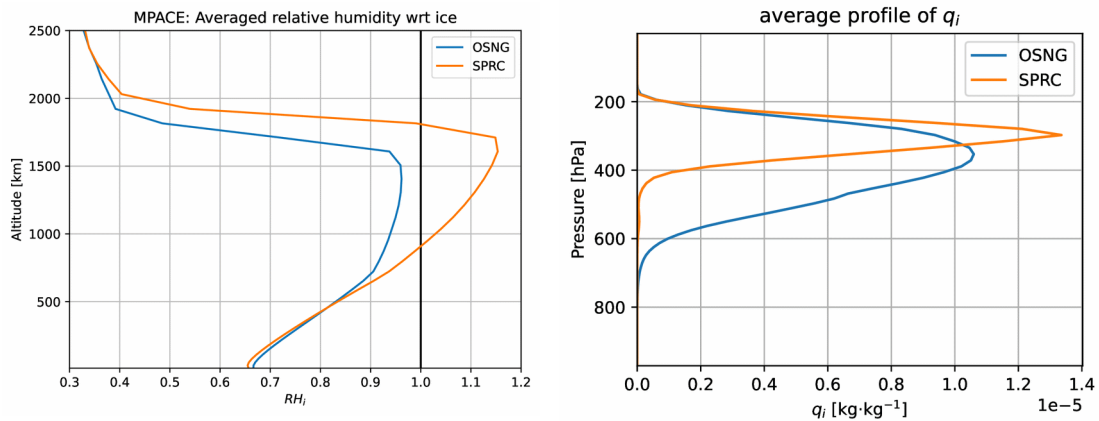


Fig. 4: Relative humidity computed with respect to ice from the MPACE case (6-h average from the second part of the simulation; left panel) and snapshot of cloud ice mass fraction ( $q_i$ ) at 22 UTC on 26.8.2023. (convective case) from 3D simulations (right panel).

Further, the double-moment ice parameterization requires substantial adjustment of assumptions made about the water vapour supersaturation over ice. In the current model configuration (LNEIGE=.TRUE.), supersaturation over ice is not permitted; however, with the double-moment ice scheme, it must be allowed. After testing several approaches, the most successful was found to be weighting the saturation-specific humidity over ice and over liquid water by the ice fraction. The weighted sum of these two saturation mass fractions then defines the grid-box saturated water vapour specific mass. This approach enables the frequently observed supersaturation over ice in the troposphere while maintaining realistic cloud cover and cloud ice fractions (Fig. 4). In addition, the following cloud ice processes were implemented:

- activation (DeMott 2010)
- homogeneous freezing at  $T=236.15$  K
- heterogeneous freezing (Bigg 1953)
- deposition
- secondary ice production via the Hallett-Mossop process

- the possibility of small raindrops freezing into cloud ice

To continue the development of the double-moment scheme, a suitable parameterization of snow was investigated. Therefore, all snow-related equations were re-derived, and two versions of snow parameters were tested. The first approach, used in the UK Met Office's CASIM scheme, represents snowflakes as thin cylinders, ultimately delivering 'flat' particles. In contrast, the second approach, proposed by Vázquez-Martín et al. (2021) and based on in situ measurements of snow particle microphysical properties, represents slightly rounded snowflakes. The latter approach seems to deliver better results. However, the tests of double-moment snow and graupel will continue in 2026. Finally, the two-moment rain and cloud water scheme was slightly adjusted, mainly focusing on raindrop fall speed and optimisation of the activation process.

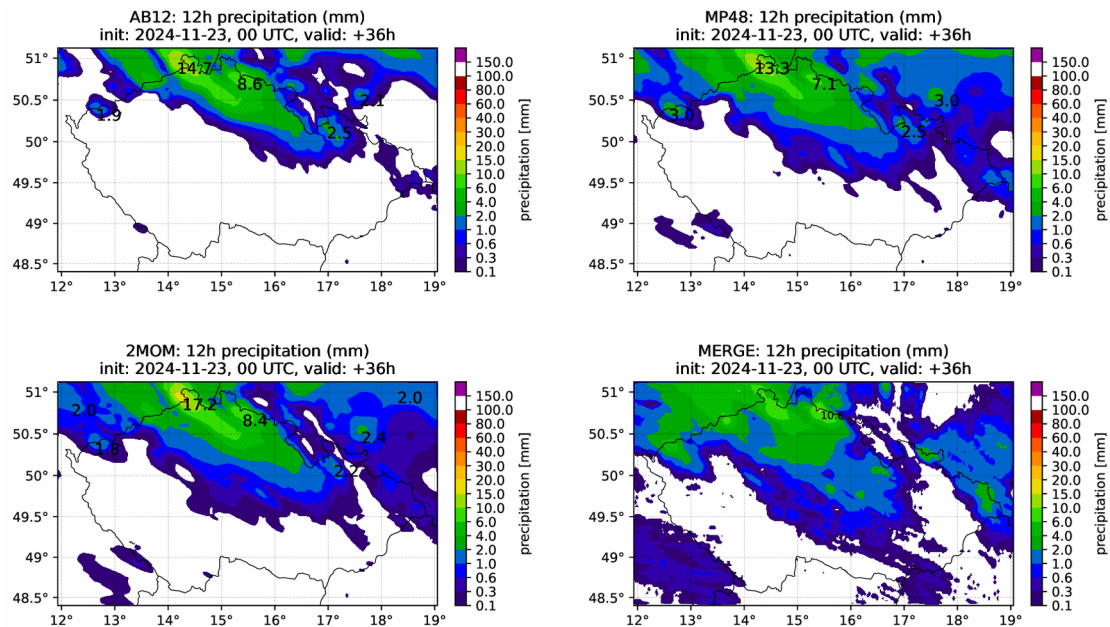


Fig. 5: 12-hour accumulated precipitation (24 November 2024; 00:00-12:00 UTC) from forecasts obtained utilizing: (i) one-moment scheme with Abel-Boutle size distribution (top left), (ii) one-moment scheme with Marshall-Palmer size distribution (top right), and (iii) the two-moment scheme (bottom left). Radar measurements corrected with rain gauges are shown for reference (bottom right).

In addition, following CHMI forecasters' reports of underpredicted light precipitation in several cases, a new configuration of the current one-moment scheme was introduced into the e-suite and subsequently became operational. The main point was re-activating the Marshall-Palmer (MP) size distribution. The lack of light precipitation was attributed to excessive evaporation when using the Abel-Boutle size distribution (LAB12=.TRUE.), which typically produces small raindrops when the rain mass fraction is low (e.g., drizzle). However, when light rain is caused by the melting of large ice particles, thereby forming bigger droplets, it

tends to fail. Therefore, the switch was made back to MP size distribution (LAB12=.FALSE.). The impact is shown in Fig. 5. Finally, contributions from Radmila Brožková and Maria Derková include training a student on cloudiness determination and preparation of SHMU's national contribution for the ALARO-1 Working Days, respectively.

## **Action/Subject: Common 1D MUSC framework for parameterization 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 parameterizations 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 parameterizations 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.

**Contributors, efforts:** M. Tudor (Cr) 0.25 PM; TOTAL: **0.25 PM**

**Planned timeframe:**

**Planned deliverable:** code contribution and stay report

**Status/description:** ONGOING

At ALARO-1 Working Days, David Němec gave a talk on running MUSC, preparing new cases, and content of his private GitHub repository (access is available on request): <https://github.com/DavNemec/musc>. Currently, seven well-documented cases from the literature are available, mainly for testing turbulence and microphysics: ARMCU, BOMEX, DYCOMS-II\_rf01, DYCOMS-II\_rf02, GABLS1, MPACE, and SCLD. For most of the above cases, there are available outputs from the MicroHH and MesoNH LES simulations and stored locally at CHMI. Additionally, an online ACCORD MUSC seminar was held on 13 May 2025, where David presented his MUSC-related activities.

Finally, an on-site ACCORD MUSC Workshop was held in Toulouse between 6th and 10th October 2025. The objective was to run MUSC for all three CSCs using the CY49T2 (DEODE) executable for one or two cases (ARMCU and GABLS1), both with and without SURFEX. The associated scripts and necessary input files were provided to Alexandre Mary for testing within the DAVAI framework. Further details can be found at: [https://opensource.umr-cnrm.fr/projects/accord/wiki/MUSC\\_WW\\_2025](https://opensource.umr-cnrm.fr/projects/accord/wiki/MUSC_WW_2025).

## 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.

**Contributors, efforts:** A. Simon (Sk) 2.00 PM and H. Tóth (Hu) 0.50 PM; TOTAL: **2.50 PM**

**Planned timeframe:**

**Planned deliverable:** code modification, documentation updates

**Status/description:** ONGOING

Within this package, activities in Q1 and Q2 primarily focused on the local preoperational implementation of available developments (visibility and cloudiness diagnostics in AROME/HU) or their phasing into higher cycles (accreted precipitation scheme in ALA2E at SHMU). Additionally, at SHMU, diagnostics of Vertically Integrated Liquid (VIL) was developed. During Q3 and Q4, the computation of cloud surface skin temperature was also implemented. The details are provided below as two separate sub-actions.

**Sub-action: Implementing new diagnostic variables in AROME/HU**

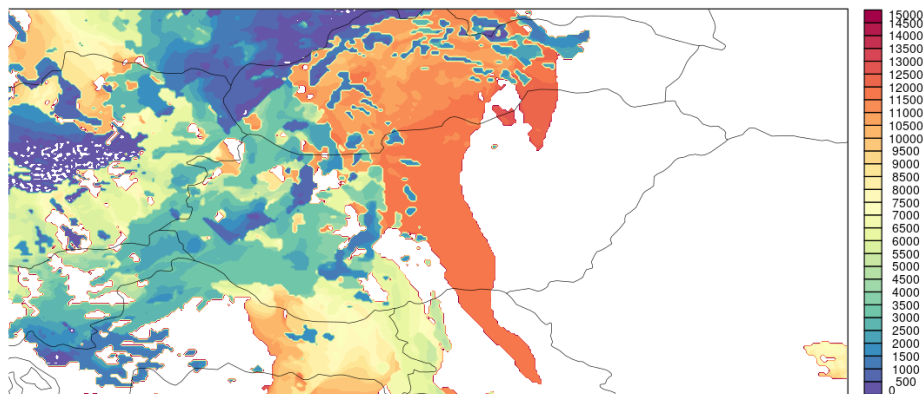
**Contributors:** H. Tóth (Hu) 0.50 PM

**Efforts:** 0.50 PM

**Documentation, deliverable:** short report

**Status/description:** ONGOING

Visibility and cloud diagnostics have been implemented in AROME/HU (CY46T1) for aviation forecasting. Visibility due to fog (VISICLD; based on cloud liquid/ice water content) and hydrometeors (VISIHYDRO; depends on rain, snow and graupel) is computed at each time step at the lowest model level. The new cloud diagnostics, based on the CHMI's modset, include: cloud ceiling (ATMOCLD.CEIL.P/H; the first level from the ground with fraction > 50%), cloud base (ATMOCLD.BASE.P/H; the first level from the ground with fraction > 10%), and cloud top (ATMOCLD.TOP.P; the first level from the top with fraction > 10%). P/H in the Fullpos name of the field denote the values at pressure and height levels, respectively.



*Fig. 6: Predicted cloud ceiling height (in meters) at 6 UTC on 16 June, 2025.*

A missing value is assigned if no cloud is detected. The height is defined as the distance between the ground and the cloud, with zero value if the ceiling or the base matches the lowest model level. An example of cloud ceiling diagnostics is shown in Fig. 6. The above variables are available to the forecasters, while the first feedback is expected in spring 2026.

**Sub-action:** The wet snow accretion scheme and vertically integrated liquid diagnostics in CY49T2\_bf\_sfx at SHMU

**Contributors:** A. Simon (Sk) 2.00 PM

**Efforts:** 2.00 PM

**Documentation, deliverable:** short report and code modification

**Status/description:** ONGOING

At the beginning of 2025, the CY49T2\_bf\_sfx modset, including the **apl\_alaro** branch required also for the DE\_330 project, was ported and tested. Several bugs were identified, including the one related to wind gust diagnostics in the old **aplpar** branch. The missing accreted precipitation scheme (acwsnow.F90 subroutine) was implemented into **apl\_alaro** branch and tested against older cycles (CY46T1 and CY48T3); the results were very similar. Finally, CY49T2\_bf\_sfx with **apl\_alaro** was tested in the operational ALA2E configuration ( $\Delta x=2$  km) for two weeks in July 2024, showing mostly neutral scores compared to CY48T3, with slight improvements in precipitation and wind speed.

To enable comparison of high-resolution model results with available observations, diagnostics of VIL (Greene and Clark, 1972) was developed. VIL can be considered a measure of vertically integrated radar reflectivity, representing the total amount of hydrometeors (liquid, snow, and graupel), and is often used for hail detection. The algorithm was first tested within an academic environment, with prescribed radar reflectivity profiles and analytical VIL solutions. Afterwards, a new subroutine was written (adiab/gppvildbx.F90, called from pp\_obs/pos.F90). The current output parameter is named VIL\_DBZ.MAX, derived from simulated radar reflectivity (dBZ) and geopotential.

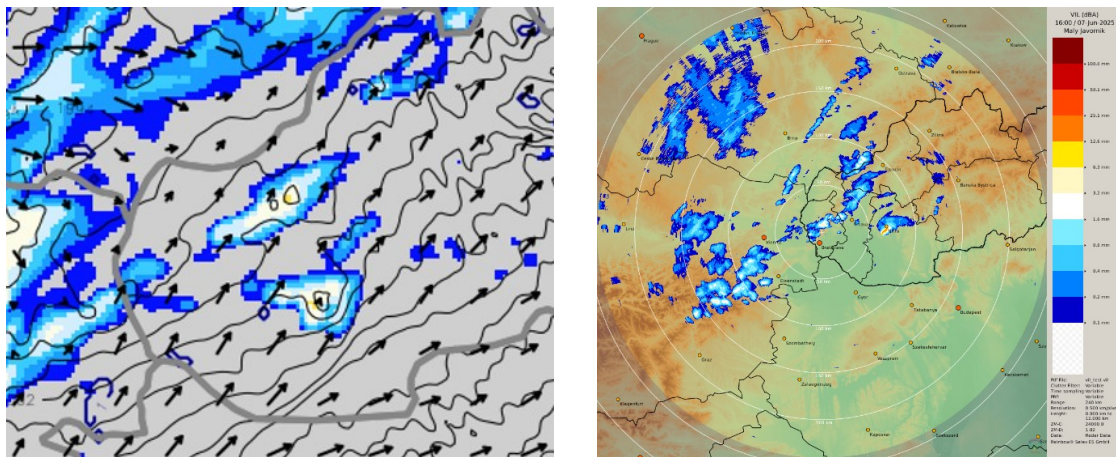


Fig. 7: 6-h forecast of the ALA2E model based on 7 June 2025 12 UTC zoomed to western Slovakia, showing the simulated VIL [mm], 800hPa geopotential height and wind (left). Radar diagnostics of VIL [mm] from 7 June 2025 16 UTC (right).

Initial tests show that model-based VIL is much lower in storm cores (7-8 mm) than radar-diagnosed VIL (20-30 mm), mainly because the model could not reproduce the very high reflectivities ( $> 60$  dBZ) observed in the presence of hail (Fig. 7). Since VIL is especially sensitive above 55 dBZ, this explains the large gap between model and observations. Further work is planned, including vertical integrals of rain, snow, and graupel, which can be used to tune the model's microphysics.

**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 parameterizations 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 (n.r.t.) aerosols require substantial data transfer in the coupling files, other more optimal solutions will be tested.

**Contributors, efforts:** J. Mašek (Cz) 1.25 PM and P. Sekuła (Pl) 2.00 PM; TOTAL: 3.25 PM

**Planned timeframe:**

**Planned deliverable:** code contribution, technical report and stay report

**Status/description:** ONGOING

Development activities within this package are largely completed. During Q1 and Q2, Ján Mašek worked on phasing the related code into CY50T1. Together with Piotr Sekuła, he finalized the technical document on the use of CAMS aerosols in three CSCs, available at: [https://www.rlace.eu/media/files/Physics/2024/PS\\_JM-CAMS\\_aerosols\\_in\\_three\\_CSCs.pdf](https://www.rlace.eu/media/files/Physics/2024/PS_JM-CAMS_aerosols_in_three_CSCs.pdf).

Piotr Sekuła also prepared a technical presentation for the ALARO-1 Working Days on running ALARO with CAMS aerosols. Associated tests of vertical aerosol distribution showed only a minor impact on the summer 2-m temperature warm bias, with the total aerosol amount in the column being more important. For his scientific stay in Prague (Q4), it was proposed to tune the stratospheric background values using ALARO CSC with n.r.t. aerosols in clear-sky cases, verifying the predicted surface global radiation against measurements from the Czech radiation network. The work revealed a systematic overestimation of surface global radiation at noon in summer by 10-20 W/m<sup>2</sup>. Such an overestimation is far too large to be compensated for by adding stratospheric background aerosols.

As a first step, the solar constant was updated from 1366 to 1361 W/m<sup>2</sup>. Sensitivity tests followed, revealing several factors contributing to the overestimated surface global radiation: old ozone climatology, uncertain surface albedo, and its spectrally flat treatment in the ACRANEB2 radiation scheme. The CAMS ozone climatology for the period 2004-2024 was obtained, and ECOCLIMAP-II surface albedo was tested in ALARO + SURFEX. The impact of spectral albedo was investigated using the ecRad scheme, for the time being, with Tegen aerosols (Fig. 8).

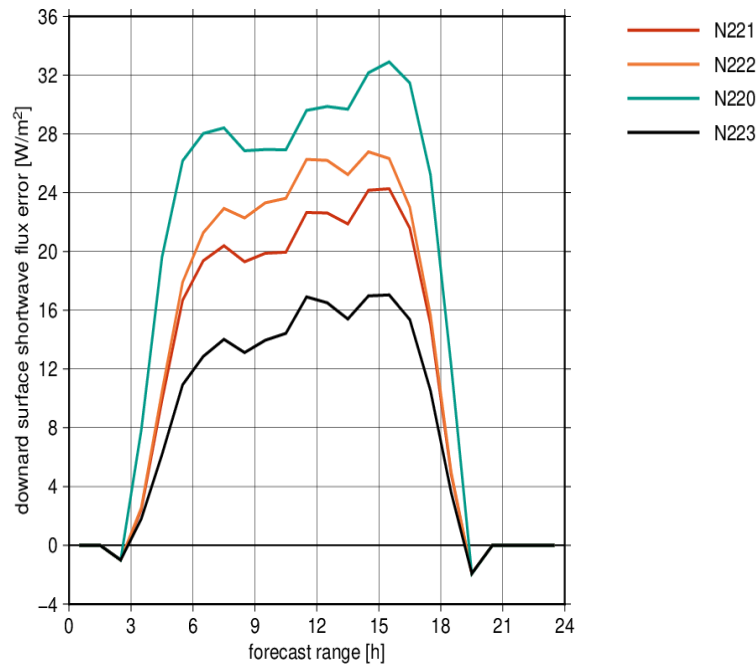


Fig. 8: Impact of spectrally flat albedo on bias of the surface global radiation for station Praha-Libuš on 01-Jul-2025: N220 - ACRANE2, no aerosols; N222 - ecRad, no aerosols, spectrally flat albedo as in ACRANE2; N221 - ecRad, no aerosols, spectrally varying albedo; N223 - ACRANE2, n.r.t. CAMS aerosols. The simulations were performed with ALARO + SURFEX using updated solar constant, CAMS climatological ozone, and assuming Lambertian surface.

Each of these steps can reduce the bias in surface global radiation by several  $\text{W/m}^2$ , although there is strong variation in bias among stations, and there may also be seasonal dependence. The residual bias can partly be explained by errors in ACRANE2 clear-sky transmissions with respect to the more accurate ecRad scheme. It would be incorrect to compensate for this error by tuning stratospheric background aerosols; instead, they should be tuned using the ecRad scheme. Currently, there are two obstacles to performing such tuning using ALARO CSC: (i) ecRad in CY48T3 is available under APLPAR, but it is not yet interfaced with n.r.t. CAMS aerosols; and (ii) the generalised Geleyn formula desired for direct albedo is not yet available in SURFEX. An important conclusion is that addressing spectrally varying surface albedo in the ACRANE2 scheme would be highly desirable, although it would imply abandoning the single short-wave band.

The second issue addressed during the stay was evaluation of a cheaper option where 3D n.r.t. CAMS aerosol MMRs (Mass Mixing Ratios) would be vertically integrated to enter the model as 2D fields at coupling instants. Then they would be inflated back to 3D using idealized vertical distribution, and used in the coupling scheme as usual. The test simulating this approach has shown considerable deterioration of aerosol fields by advection, when the true aerosol profile differs significantly from idealized profile (idealized profiles typically have maximum at the ground, while real profiles can peak higher in PBL).

## **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 parameterizations.

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 characterized 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.

**Contributors, efforts:** M. Hrastinski (Cr) 1.25 PM, J. Mašek (Cz) 2.25 PM, and P. Smolíková (Cz) 0.75 PM; TOTAL: **4.25 PM**

**Planned timeframe:**

**Planned deliverable:** code modification, short report and presentation

**Sub-action: ALARO + SURFEX: validation, tuning and initialization**

**Contributors:** J. Mašek (Cz) 2.25 PM

**Efforts:** 2.25 PM

**Documentation, deliverable:** code modification and stay report

**Status/description:** ONGOING

Because of its direct link to the SU3 package and related work by other people, Jan's work is described there.

**Sub-action: Modifying the code to distinguish vertical levels 'seen' by dynamics and turbulence**

**Contributors:** M. Hrastinski (Cr) 1.25 PM and P. Smolíková (Cz) 0.75 PM

**Efforts:** 2.00 PM

**Documentation, deliverable:** code modification and stay report

**Status/description:** ONGOING

To safely decrease the model's lowest level while retaining the constant-flux approximation in the turbulence scheme and enabling the use of Monin-Obukhov similarity theory, the TOUCANS scheme code was revised. The changes described below were implemented in CY46T1mp\_op3. Preliminary tests were performed for a 24 June 2022 mesoscale convective system case using CHMI's operational domain and 88 vertical levels, i.e., one more than in the standard configuration. Thereby, an additional level was squeezed between level 87 and the surface to facilitate testing the impact of the forcing height, while levels 87 and 86 were slightly adjusted. A new variable, NFLEVTUR (KLEVTUR), was defined in YOMDIMV and replaced KLEV in all TOUCANS-related subroutines. By definition,  $NFLEVTUR (KLEVTUR) \leq KLEV$ , and for  $KLEVTUR = KLEV$ , the new code produces results identical to those of its unmodified counterpart.

However, experiments with  $KLEVTUR < KLEV$  suggested that the initial concept, assuming a constant-flux layer extending from half-level  $\overline{KLEVTUR}$  down to the surface, requires revision, as it leads to abrupt changes in the tendency due to turbulent diffusion. To obtain a smooth tendency profile and a non-zero value at the full level  $KLEV$ , turbulent fluxes between half-levels  $\overline{KLEVTUR - 1}$  (the lowest level at which fluxes are diagnosed from full level gradients and based on the TKE formalism) and  $KLEV$  (the surface) are interpolated in height (linearly or quadratically); see Fig. 9. The surface turbulent fluxes are computed using the adjusted bulk formulation, in which the forcing level is tied to the full level  $KLEVTUR$  rather than  $KLEV$ , as follows:

$$(\overline{\psi'w'})_s = C_\psi \sqrt{u^2(Z) + v^2(Z)} [\overline{\psi}(Z) - \overline{\psi}_s]$$

where  $\psi = (u, v, s_L, q_t)$  denotes zonal/meridional wind, static energy, and total specific moisture, respectively; the subscript "s" indicates surface values;  $Z$  is the forcing level height; while  $C_\psi$  are drag coefficients for momentum and heat/moisture.

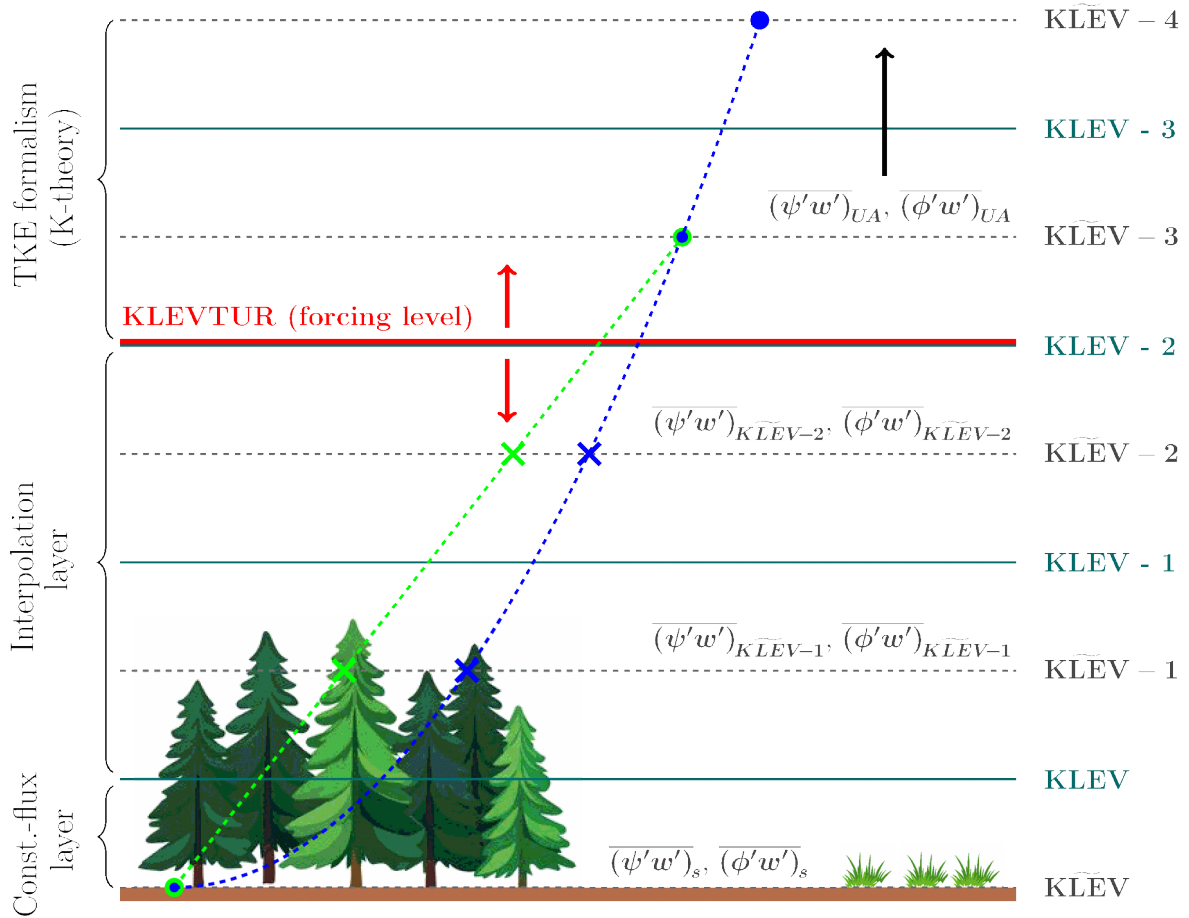


Fig. 9: Illustration of the proposed approach for safely lowering the first model level (KLEV) by (i) decoupling it from the forcing level in the turbulence scheme (KLEVTUR) and (ii) introducing an interpolation layer to ensure a non-zero near-surface tendency due to vertical turbulent diffusion. The red arrows indicate the variable nature of KLEVTUR, while the circles and “X” markers represent fluxes computed by the TOUCANS scheme and interpolated values, respectively. Tilded overbars denote model half-levels.

This adjustment ensures a smooth near-surface tendency profile with non-zero values at full level KLEV (Fig. 10a-c). Furthermore, the associated domain-averaged turbulent fluxes of heat and moisture closely match those of the reference 87-level configuration, while their profiles are rather smooth. In contrast, the 88-level experiment, with the forcing level tied to KLEV, exhibits a pronounced near-surface spike, with differences from the reference occurring mainly over mountainous regions. More details can be found in the report referenced in Section 3.1. Future work will include a more comprehensive evaluation using the 101-level configuration prepared by Petra Smolíková. Minor refinements of the concept are possible, particularly in the diagnostics of turbulent energies below KLEVTUR.

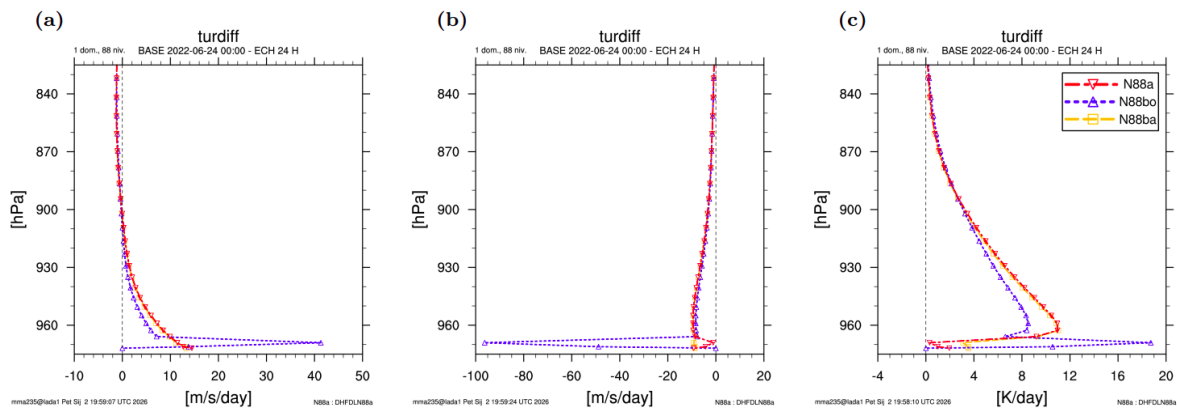


Fig. 10: Domain-averaged vertical profiles of turbulent diffusion tendency after 24-h of integration in the summer convection case on 24 June 2022 for: (a) zonal wind, (b) meridional wind and (c) temperature. N88a, N88bo and N88ba correspond to  $KLEV = KLEVTUR=88$  experiment (red), as well as original N88b (blue) and adjusted N88b experiments (orange) with  $KLEV < KLEVTUR$ , respectively.

## Action/Subject: On the interface of Physics with Dynamics (and time stepping) (PH8) (cf. Dynamics & coupling report)

**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 parameterizations create sources or sinks of total water. As a result, the model does not strictly conserve dry air. Physics parameterizations 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 parameterized 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.

**Contributors, efforts:** NONE

**Planned timeframe:**

**Planned deliverable:** code modification, stay report

**Status/description:** ONGOING

**Although being a part of the PH packages in ACCORD RWP, this action/subject is reported in “Dynamics and coupling” area of RC-LACE. It was initiated in the context of adapting the SLHD for (sub-)kilometer horizontal resolution. However, the latest activities were related to the coupling of hydrometeors in three CSC’s within the DEODE project.**

## **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 parameterizations 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. In addition, at Geosphere Austria, colleagues are testing various components for the European stand-alone SURFEX at hectometric scales.
- **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.

**Contributors, efforts:** D. Deacu (At) 1.00 PM, M. Derková (Sk) 0.25 PM, M. Hrastinski (Cr) 1.75 PM, J. Mašek (Cz) 3.00 PM, M. Nestiak (Sk) 0.25 PM, D. Neubauer (At) 1.50 PM, A. Otruba (Cz) 1.50 PM, N. Pristov (Si) 0.50 PM, S. Schneider (At) 0.50 PM, P. Sekuła (Pl) 2.50 PM, G. Stachura (Pl) 2.50 PM, V. Tarjáni (Sk) 0.50 PM and M. Tudor (Cr) 0.50 PM;  
**TOTAL: 16.25 PM**

**Planned timeframe:**

**Planned deliverable:** code modification, documentation updates

**Status/description:** ONGOING

**Sub-action: Towards the operational application of ALARO with SURFEX****Contributors:** J. Mašek (Cz) 0.50 PM, P. Sekuła (Pl) 0.25 PM and G. Stachura (Pl) 2.00 PM**Efforts:** 2.75 PM**Documentation, deliverable:** short report**Status/description:** ONGOING

A smooth scientific transition of ALARO CSC from the old ISBA scheme to SURFEX is considered completed, while the differences cannot be further diminished due to different underlying physiographies. The activation of NWP-attractive SURFEX options (not available in old ISBA) and associated tuning are ongoing. To ensure a safe starting point, the initial ALARO + SURFEX NWP configuration is based on AROME Météo-France and adjusted to our goals/constraints, with input from SURFEX experts. The main adjustments are: (i) replacing ECOCLIMAP-I physiography with ECOCLIMAP II for enhanced vegetation representation, (ii) using three nature patches together with satellite-based albedo, (iii) activating Town Energy Balance (TEB) with LGADEN=.TRUE. and the Building Energy Module (BEM), and (iv) applying ECUME sea fluxes instead of ECUME6. More details can be found in Jan's talk from ALARO + SURFEX WW ([https://opensource.umr-cnrm.fr/attachments/download/6401/presentation\\_v1.pdf](https://opensource.umr-cnrm.fr/attachments/download/6401/presentation_v1.pdf)). The proposed configuration is expected to evolve further, while some components, including FLAKE and ORORAD, still require thorough validation.

During the stay of Gabriel Stachura at CHMI in March, the following topics were addressed:

- inclusion of snow from urban vegetation in the total snow reservoir field in the atmospheric file (continued from last year)
- addressing the warm bias of 2-m temperature in ALARO coupled with SURFEX
- tuning of chosen D95 snow scheme parameters

Related to (1), the code was modified so that the snow from urban vegetation ( $TWSNOW_{garden}$ ) is accounted for in the total snow from the urban tile ( $TWSNOW_{total}$ ; DIAG\_MISC\_TEBn subroutine):

$$TWSNOW_{town} = TWSNOW_{roof} f_{roof} + TWSNOW_{road} f_{road} + TWSNOW_{garden} f_{garden}$$

where  $f_{roof}$ ,  $f_{road}$  and  $f_{garden}$  denote relative fractions of roofs, roads and gardens. Aiming to reduce the warm bias of 2-m temperature, the following parameters of D95 scheme were addressed:

- XTAU\_SMELT [s] – a lower limit of timestep in melting rate calculation to prevent the timestep-dependence (default value is 300 s)

- XWSNV [1] – a coefficient that scales surface roughness length in calculation of snow fraction over vegetation
- XWCRN [kg/m<sup>2</sup>] - critical snow water equivalent value that affects snow fraction over the bare ground

The comparison with the reference (ALARO + ISBA) was performed for the winter period with snow (12-14 January 2021), during which ALARO + SURFEX was considerably warmer. Decreasing XTAU\_SMELT mainly affects snow evolution but not the 2-m temperature, which is the most sensitive to changes in XWCRN. To bring the biases closer, snow fractions in the ISBA/SURFEX run were adjusted by doubling/halving the critical snow water equivalent via XWCRN. The impact on bias ranged from 0.1 to 0.2 °C, with only a marginal effect on standard deviation. A more detailed investigation suggested that the influence is largest in areas with thin snow cover or where it has just melted.

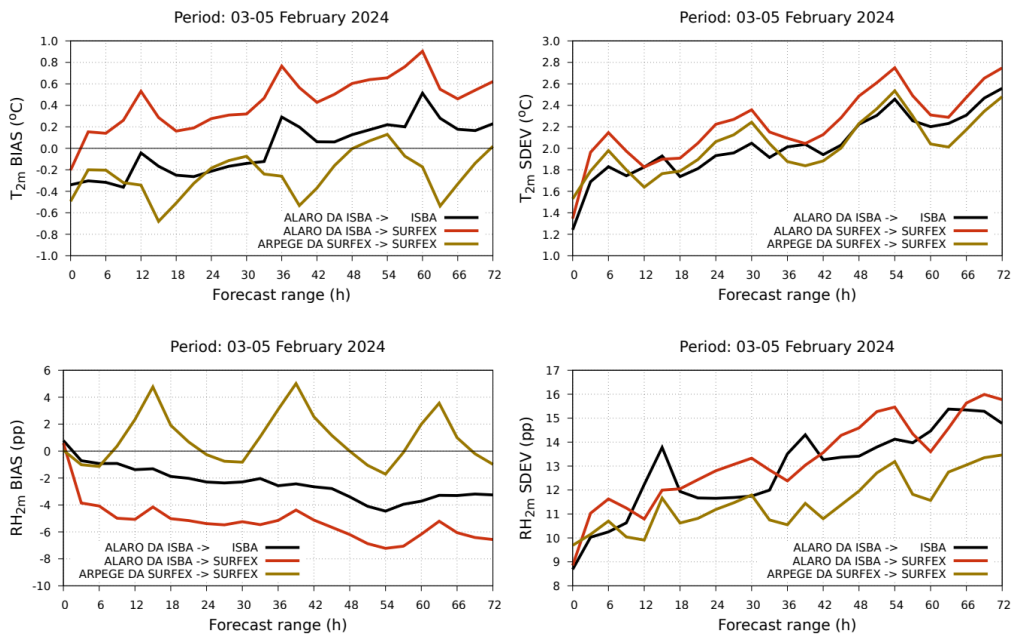


Fig. 11: Comparison of ALARO + SURFEX simulations initialized from ALARO + ISBA or ARPEGE+SURFEX DA against the ALARO + ISBA reference: 2-m temperature (top left) and 2-m relative humidity biases (bottom left) and respective standard deviations (top right and bottom right).

This ultimately raised the issue of initialization, which was investigated during a period with little snow (3-5 February 2024) ALARO + SURFEX, initialized from ALARO + ISBA Data Assimilation (DA), exhibits a warm bias due to too dry soil (Fig. 11, top panels). When initialized from ARPEGE + SURFEX DA: (i) temperature bias and random error are reduced, (ii) negative bias of relative humidity is corrected, but its diurnal amplitude increases, and (iii) random error of RH is smaller than the ISBA reference (Fig. 11, bottom panels). Given this,

surface data assimilation becomes an urgent task, since meaningful tuning cannot be achieved without the reliable surface initialization. An outlook on steps toward ALARO + SURFEX DA, along with open questions, is given in Alena Trojáková's talk at ALARO + SURFEX WW (<https://opensource.umr-cnrm.fr/attachments/6412>).

**Sub-action: Activating advanced SURFEX options (not available in old ISBA scheme)**

**Contributors:** M. Hrastinski (Cr) 0.75 PM, J. Mašek (Cz) 2.25 PM, A. Otruba (Cz) 1.50 PM, P. Sekuła (Pl) 0.50 PM and G. Stachura (Pl) 0.50 PM

**Efforts:** 5.50 PM

**Documentation, deliverable:** short report

**Status/description:** ONGOING

At the ALARO + SURFEX WW in Prague, Gabriel Stachura tested the ORORAD option to account for orographic effects on radiation. The option is activated through the PGD key LORORAD, together with at least one of the sub-options: LDSV (sky view factor), LDSH (shadow factor), or LDSL (slope factor). A case study was carried out on 23 February 2021 (CHMI's domain and using CY49T2\_bf\_sfx code), in the presence of a persistent high-pressure system, showing considerable impact on surface solar radiation and 2-m temperature (differences of several °C). The comparison against observations is yet to be made.

During the research stays of Piotr Sekuła and Mario Hrastinski at CHMI in June, the impact of traffic sources, industrial emissions, and the Building Energy Module (BEM) were investigated. Previous studies indicated that traffic-related heat sources can dominate under very stable conditions, resulting in unrealistic increases in canyon air temperature ( $T_c$ ) and often leading to numerical instability. To mitigate this issue, the related formula was revised, while the maximum change of  $T_c$  due to traffic sources within a single timestep is constrained by a namelist variable, e.g., 5 °C. A test with traffic sources set to 250W/m<sup>2</sup> was performed on 12 January 2021, wherein the revised formula prevented temperature spikes at the lowest model levels and ensured a numerically stable solution. The impact of both sources is stronger in the summer. At the urban station Praha-Karlov, nights are ~ 0.3 °C colder in the experiment without industrial sources, with the maximum difference of ~ 0.5 °C occurring at 02:00 UTC.

Within BEM, the waste heat sources ( $H_{waste}$ ) from HVAC (Heating, Ventilation, and Air Conditioning) systems are accounted for, with  $T_c$  protection equivalent to that for traffic and industry sources. Since HVAC systems can also extract humidity from the canyon, further protection against negative humidity values was introduced. This ensured numerical stability, with a strong impact in the first 12-h of the forecast. Further analysis indicates spin-up and initialization issues that need to be discussed with the SURFEX support team or advanced BEM users.

Further, the new method for albedo calculation in SURFEX is implemented in the subroutine `albedo_mg16.F90`, following Masek et al. (2016). It can be chosen by the MG16 key in the integration namelist, while the computation is performed separately for sea, inland waters and nature; including nature in the town. The new method introduces the parameter `rlamb`, specifying the proportion of Lambertian reflection and is adjustable via the namelist. The variation of direct albedo with solar elevation for solid surfaces is considerably smaller than over the water, which can be accounted for through appropriate values of `rlamb`. By default, `rlamb` is set to 0 for water and to 0.6 for land, snow, and ice. The differences in direct albedo are strongest near sunrise and sunset (Fig. 12), while negligible during daytime. The impact on surface temperature is relatively small, wherein the domain averaged values differ up to 0.06°C from those obtained with the reference method. This difference, i.e., underestimation, occurs since at low solar elevation the new formula yields higher albedo than the reference.

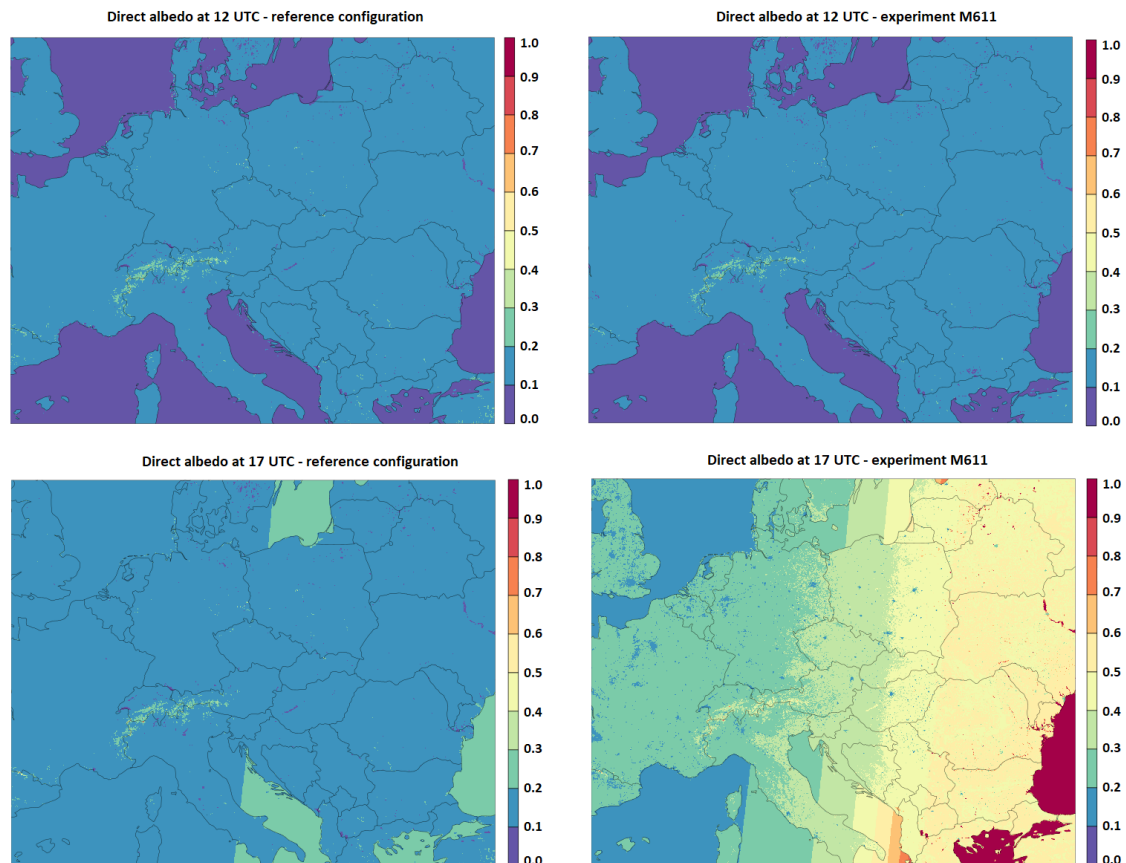


Fig. 12: The daytime direct albedo from: (a) reference configuration based on the old method and (b) experiment using newly implemented method. (c)-(d) show the same as (a)-(b) but during the sunset.

Fixes for ALARO with SURFEX were phased to CY49T2 (contains SURFEX 8.1+), thus enabling the future ECOCLIMAP SG use (see below). The associated code contribution was submitted to CY49T2\_bf. However, integration into IAL code is pending due to a request to

split commits for individual fixes. After SURFEX 9 becomes available, the above fixes also need to be submitted there.

During Q3 and Q4, ALARO + SURFEX activities in Prague moved to CY48T3, which is the next operational cycle. ALARO 2-m interpolation after SURFEX (option LCLS\_TOUCANS=T, after Dian 2016) was abandoned, since in the town it also includes roof contribution that should be excluded. Therefore, Dian's (2016) screen-level interpolation was implemented cleanly on the patch level under option N2M=5. It was verified that for a single tile and patch, it yields 2-m quantities very close to the old method. For multiple tiles and patches, however, the 2-m temperature can differ by several tenths of K, and in the town by more than 1 K.

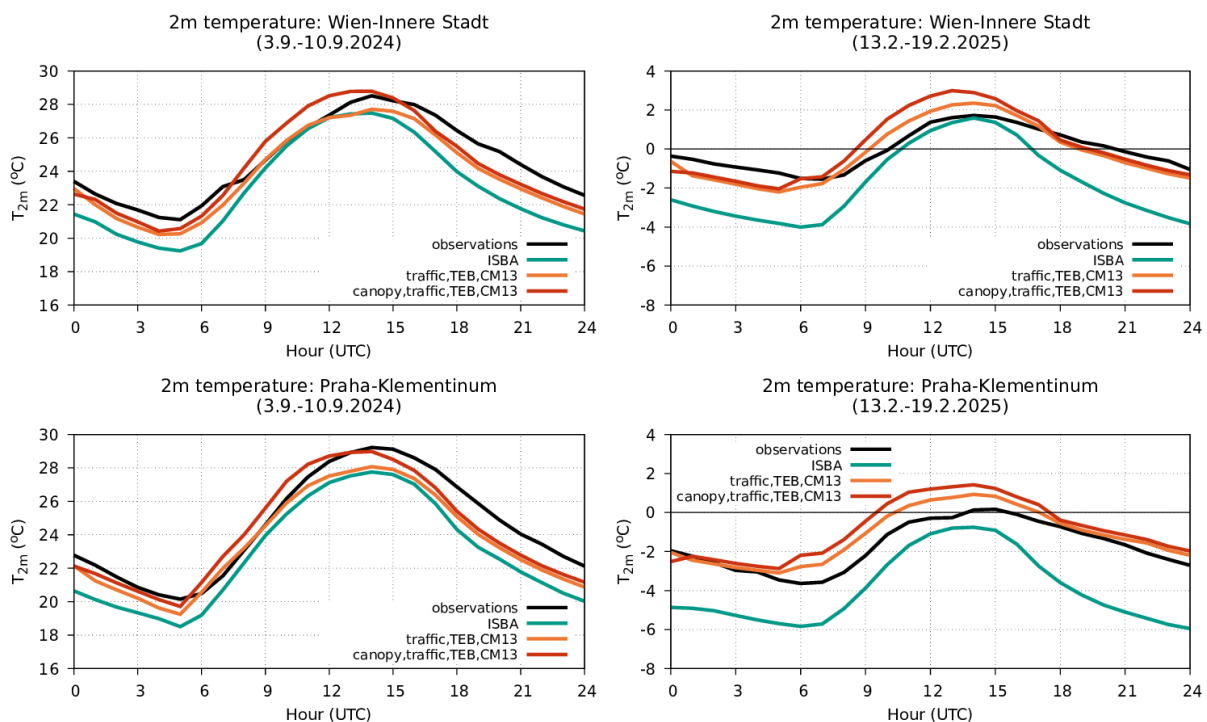


Fig. 13: Observed and forecast mean daily evolution of urban 2m temperature: left - hot period; right - cold period with snow; top - Vienna; bottom - Prague. Color key: black - SYNOP measurements (taken on building roof) ; green – ALARO + ISBA, orange – ALARO + SURFEX without urban canopy; red – ALARO + SURFEX with urban canopy. Traffic heat sources were on.

The new method enabled us to evaluate the impact of the urban canopy scheme cleanly. Verification performed for Prague and Vienna showed a flatter diurnal evolution of T2m without the urban canopy scheme (Fig. 13). On the other hand, the urban canopy scheme better captures the summer daily maxima. More cases and towns should be evaluated to see whether this conclusion is generally valid. The inclusion of traffic heat sources was also inspected. Due to their unrealistic temporal variation (switch-on at 6:00 and switch-off at

18:00 local time, regardless of day of week, etc.) and problematic evaluation of observed traffic impact, it was decided not to use the traffic sources in ALARO + SURFEX, even though their implementation is now numerically stable with TOUCANS turbulence. As for industry heat sources, the realism of their distribution in ECOCLIMAP-II is still to be inspected.

**Sub-action: Preparation and organization of the ALARO + SURFEX Working Week**

**Contributors:** M. Derková (Sk) 0.25 PM, M. Hrastinski (Cr) 0.25 PM, J. Mašek (Cz) 0.75 PM, M. Nestiak (Sk) 0.25 PM, N. Pristov (Si) 0.50 PM, P. Sekuła (Pl) 0.25 PM and M. Tudor (Cr) 0.50 PM

**Efforts:** 2.75 PM

**Documentation, deliverable:** short report

**Status/description:** COMPLETED

The preparation activities for the working week included compiling a document with basic information about SURFEX and instructions for executing the PGD-PREP-SURFEX script chain. Ján Mašek prepared the scripts, the necessary code (based on CY49T2\_bf\_sfx), and the experiments on "Belenos". Piotr Sekuła compiled the document using his and Mario's notes from the crash course held in December 2024 during their research stay in Prague. Additional contributions came from colleagues who participated onsite or remotely in the working week but were not involved in other SU3 sub-actions.

**Sub-action: Investigating numerical oscillations in the surface energy balance solver**

**Contributors:** V. Tarjáni (Sk) 0.50 PM

**Efforts:** 0.50 PM

**Documentation, deliverable:** short report

**Status/description:** CLOSED (there is no workforce as Viktor left SHMU)

Viktor Tarjáni continued his work on developing and testing a numerically more stable scheme for the snow surface heat balance equation, focusing on offline SURFEX runs. A linear stability analysis was performed for both the original and newly proposed schemes. The issues with the original scheme typically occur in thin snowpacks, near static neutrality and for timesteps exceeding 30 s. An alternative scheme, based on the tangent linear approximation, proved numerically stable even for very long time steps and a wide range of gradient Richardson numbers, i.e., static stability conditions. However, this improved stability comes at the cost of somewhat larger errors. To address this, further alternatives were proposed to achieve a better balance between stability and accuracy.

The overview of activities on this topic, including previous developments, is shown on the Slovakian national poster from the 5<sup>th</sup> ACCORD All Staff Workshop ([https://www.umr-cnrm.fr/accord/IMG/pdf/national\\_poster\\_slovakia\\_shmu\\_5thasw\\_2025.pdf](https://www.umr-cnrm.fr/accord/IMG/pdf/national_poster_slovakia_shmu_5thasw_2025.pdf)). Unfortunately, with Viktor's departure from SHMU, SURFEX activities are frozen due to insufficient manpower, and their continuation is not expected in 2026.

**Sub-action: Implementation of ECOCLIMAP-SG physiography in the ALARO CSC**

**Contributors:** M. Hrastinski (Cr) 0.75 PM

**Efforts:** 0.75 PM

**Documentation, deliverable:** short report

**Status/description:** ONGOING

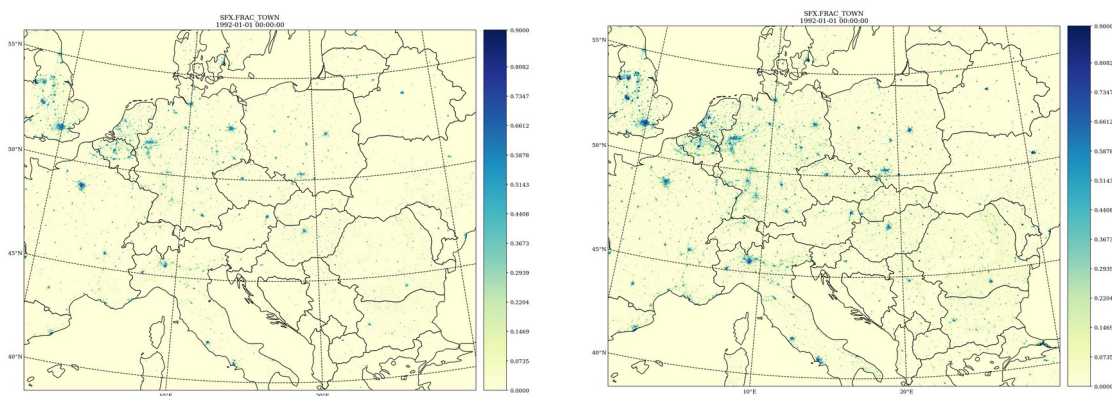


Fig. 14: The town fraction for CHMI's operational domain obtained from: (a) ECOCLIMAP-II physiography with filtering of values < 5% and (b) ECOCLIMAP-SG physiography (without filtering).

This activity started during the ALARO + SURFEX WW and continued during the first half of the following stay. Unlike ECOCLIMAP-I and -II ( $\Delta x=1$  km), in ECOCLIMAP-SG ( $\Delta x=0.3$  km; available since SURFEX v8.1+), the concept of covers is simplified. Each land cover is "pure", i.e., it contains a single vegetation type. There are 33 covers in total: 20 vegetation, 10 urban and 3 water types. In addition, primary vegetation-related parameters, such as Leaf Area Index (LAI), visible and near-infrared albedos for soil and vegetation, tree height, root, ground and sea ice depths, defined and averaged by cover in the ECOCLIMAP first generation, are now provided to the PGD step via the namelist NAM\_DATA\_ISBA. These parameters can be specified as uniform values, e.g., for depths, or as input maps derived from satellite data.

The implementation largely followed the ECOCLIMAP-SG wiki page instructions (<https://opensource.umr-cnrm.fr/projects/ecoclimate-sg/wiki>). However, although the use of the latest cover file is recommended, employing versions newer than V0.0 and V0.1 resulted in a crash of the PGD step. Subsequent steps, including integration, were successful except when LGARDEN=.TRUE. (third urban patch) was activated, which led to a PGD crash due to insufficient memory. The preliminary comparison of the town fraction against ECOCLIMAP-II (Fig. 14) suggests an increase in ECOCLIMAP-SG, while urban areas are also widened. In contrast to ECOCLIMAP-II, no filtering of small town fractions is required, i.e., those below 5%. Finally, the comparison of sea and inland water fractions points to new features provided by ECOCLIMAP-SG.

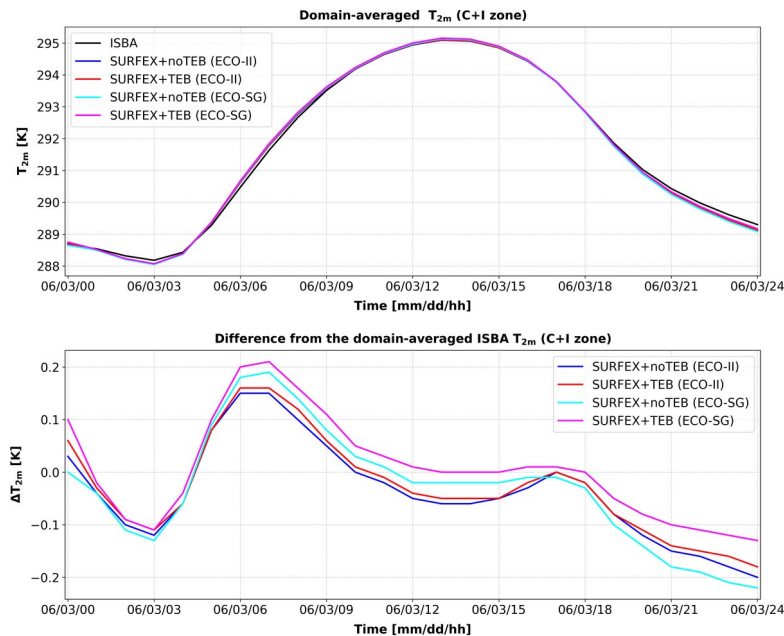


Fig. 15: Domain-averaged: (a) 2-m temperature for various experiments (see legend) and (b) corresponding differences relative to the reference based on the ISBA scheme, for the summer case 3 June 2025.

Further, the comparison of vegetation roughness length indicates that ECOCLIMAP-SG values are roughly three times higher, with sharper spatial transitions. The largest differences between the two datasets occur in southern Sweden. Finally, domain-averaged 2-m temperature and 10-m wind speed were also compared. In the summer case (Fig. 15), ECOCLIMAP-SG simulations are slightly warmer than those from ECOCLIMAP-II during daytime and cooler at nighttime. The impact of TEB is also more pronounced with ECOCLIMAP-SG. In winter, the influence of ECOCLIMAP-SG physiography and ALARO + SURFEX (relative to ALARO + ISBA) is even more pronounced. More detailed validation is required, focusing on LGARDEN=.TRUE. Option.

In Q4, effort was devoted to completing the report and preparing the presentation for the ACCORD Autumn Surface WW.

**Sub-action: Preliminary ALARO + SURFEX experiments at IMGW**

**Contributors:** P. Sekuła (Pl) 1.50 PM

**Efforts:** 1.50 PM

**Documentation, deliverable:** short report

**Status/description:** ONGOING

The Polish team has taken the first step toward implementing the ALARO model with SURFEX for NWP over a domain with  $\Delta x=2.4$  km. The initial SURFEX setup included ECOCLIMAP-II physiography, three nature patches, the 3-L force-restore soil scheme, the TEB scheme with the garden option enabled, anthropogenic heat fluxes from industry, and no traffic-related heat sources.

The ALARO + SURFEX model was verified during monthly periods in summer and winter 2024. During the winter period (January 2024), ALARO with SURFEX performed better than ALARO with ISBA, particularly for T2m and RH2m. However, during the summer period (August 2024), especially under high-temperature conditions exceeding 30°C, ALARO with SURFEX performed somewhat worse than ALARO with ISBA. In both experiments, the models were run with dynamical adaptations enabled.

**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
- additional parameterization 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.

**Contributors, efforts:** M. Hrastinski (Cr) 0.25 PM; TOTAL: **0.25 PM**

**Planned timeframe:** whole year

**Planned deliverable:** update to the RWP

**Status/description:** ONGOING

To this date, activities have been limited to work package coordination and editing.

## **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.

**Contributors, efforts:** D. Deacu (At) 3.00 PM; TOTAL: **3.00 PM**

**Planned timeframe:**

**Planned deliverable:** code modification, documentation updates

**Status/description:** ONGOING

**Sub-action:** Investigating the impact of ECOCLIMAP-FG and ECOCLIMAP-SG vegetation distribution in Alpine valleys

**Contributors:** D. Deacu (At) 3.00 PM

**Efforts:** 3.00 PM

**Documentation, deliverable:** report

**Status/description:** ONGOING

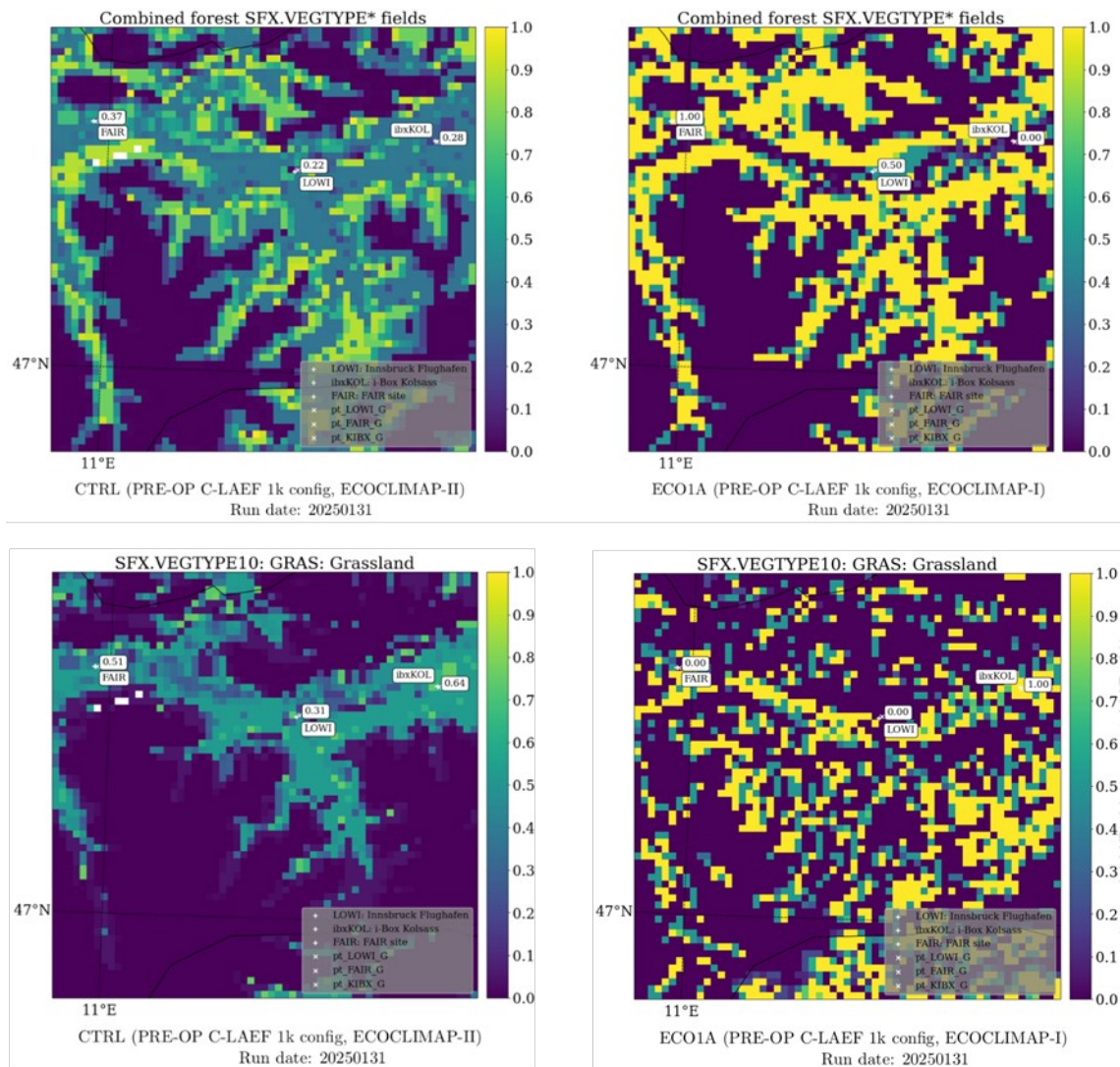


Fig 16: Forest (top) and grass (bottom) fractions derived from ECOCLIMAP-II (left) and ECOCLIMAP-I (right). The Inn Valley is the west-east oriented valley in the upper half of the panels. LOWI marks the location of the Innsbruck Airport.

At Geosphere Austria, Daniel Deacu has investigated the impact of ECOCLIMAP-I, ECOCLIMAP-II and ECOCLIMAP-SG vegetation distribution in Alpine valleys. Thereby, a substantial change in the behaviour of the pre-operational NWP system (C-LAEF AlpeAdria) near the surface was observed when switching from the ECOCLIMAP-I to the ECOCLIMAP-II physiographic dataset. This prevented the implementation of a set of SURFEX changes targeting soil freezing, which had improved simulations with previous PGD and CLIM files, derived from ECOCLIMAP-I. A comparison of the fields from the two physiographic datasets revealed large differences over the Alps. For instance, the total forest fraction derived from ECOCLIMAP-II was overestimated over the bottom of the Inn Valley and underestimated over its slopes. Many grid cells dominated by vegetation and located on the valley bottom had unrealistically high forest fraction values, exceeding 35 % (upper-left panel in Fig. 16). In reality, this fraction is very low and much closer to that derived from ECOCLIMAP-I (upper-right panel in Fig. 16). This unrealistic forest fraction leads to unrealistic values of surface parameters, such as the aerodynamic and thermal roughness lengths (Fig. 17), and albedo. Therefore, this apparently undocumented ECOCLIMAP-II issue introduces errors that require compensation in areas that already pose challenges for simulations. One solution would be an upgrade to a version that allows the use of fields derived from the ECOCLIMAP-SG dataset (Fig. 18).

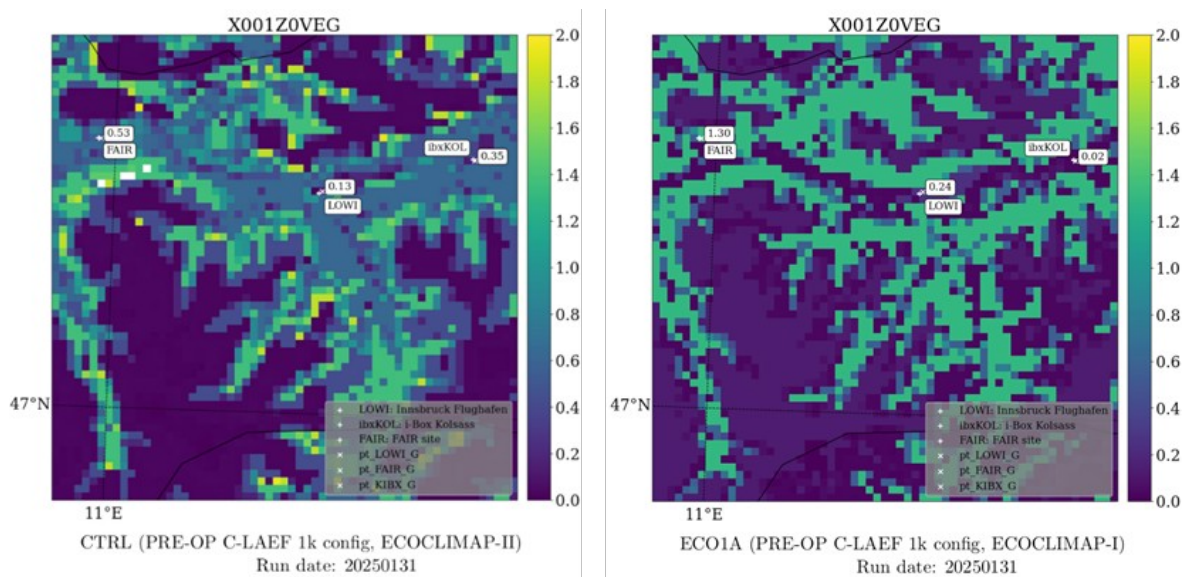


Fig. 17: The aerodynamic roughness length of the vegetation cover (m).

Finally, given that Sandro Oswald left Geosphere Austria, there is no workforce to continue his DEODE and PGD-related activities. Therefore, part of the plan remains unexecuted.

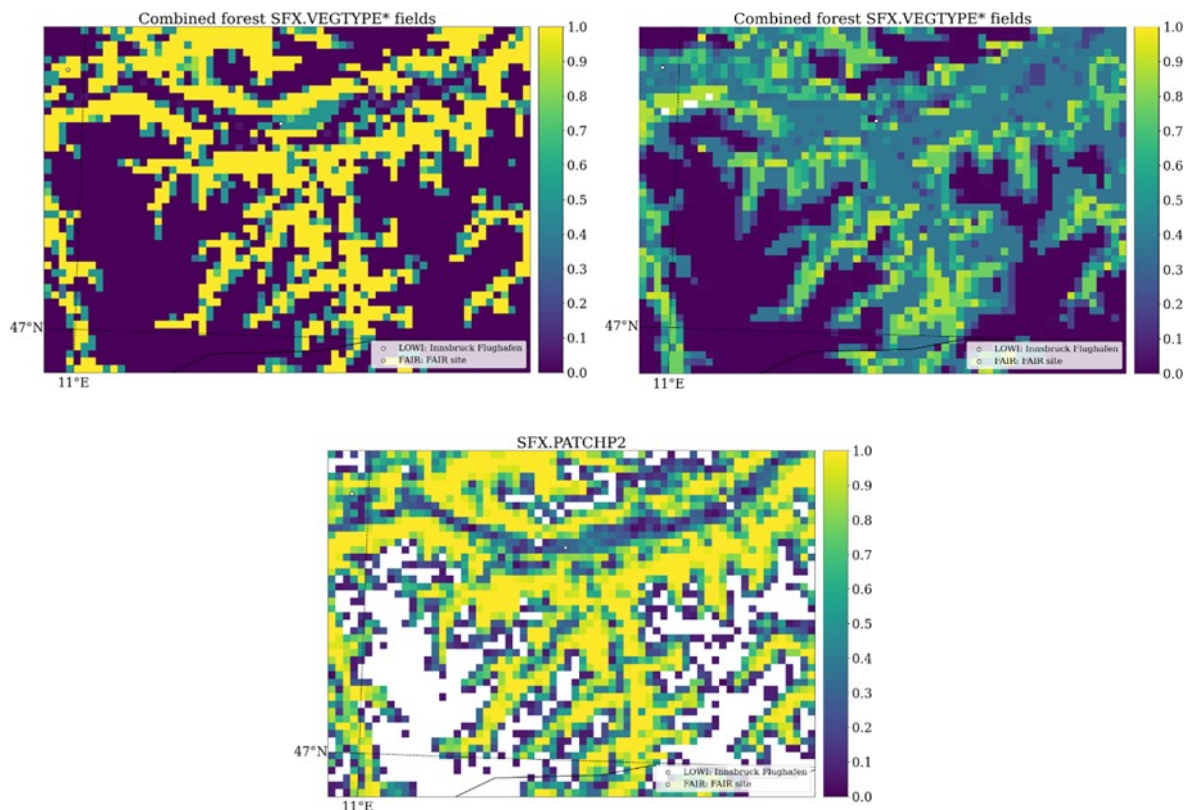


Fig. 18: Forest fraction derived from ECOCLIMAP-I (top-left), ECOCLIMAP-II (top-right) and ECOCLIMAP-SG (bottom).

## 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 parameterizations, 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 parameterized 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 parameterizations must be revised and retuned. Field experiments will be used to validate and optimize 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 subject is partly accounted for in RC-LACE's "Dynamics and Coupling" plan. In ACCORD RWP, it is part of the "High Resolution" package.**

**Contributors, efforts:** R. Brožková (Cz) 1.00 PM; P. Smerkol (Si) 2.75 PM and J. Cedilnik (Si) 0.50 PM; TOTAL: **4.25 PM**

**Planned timeframe:**

**Planned deliverables:** code modifications, scripts, namelists and reports

**Status/description:** ONGOING

The HR package includes various contributions, such as those related to dynamics and initialization. Here, only physics-related aspects are considered. However, there can be partial overlapping with activities in the “Dynamics & coupling” area.

**Sub-action: Convective condensation feedbacks in ALARO at 1 km**

**Contributors:** R. Brožková (Cz) 1.00 PM

**Efforts:** 1.00 PM

**Documentation, deliverable:**

**Status/description:** ONGOING

When moving to the resolution of approximately 1 km the question is whether we could completely switch-off the moist deep convection parameterization 3MT. To recall, the 3MT scheme has been developed to specifically address partly resolved convective activity by the model, hence it is different from more common schemes based on the quasi-equilibrium hypothesis. The work was to test the proportion of condensation within updraughts w.r.t. the grid-scale one (thermodynamic adjustment) when moving to a higher resolution of 1 km about. It was found there is less activity of the convective scheme, and that this drop is also due to a shorter time-step used. Another factor of interest, regarding the resolution, is the spectral truncation. While the reference having 2.3 km resolution has a linear truncation, the experiment at 1 km has a quadratic one and so the shortest wave length changes in function of this.

Preliminary conclusions so far are: results show that for high precipitation cases it is still better to keep at least 3MT updraught active, while downdraught activity is very small anyway. So one can drop the downdraught scheme. The shorter time-step, the less convective scheme activity is observed.

**Sub-action: Large eddy simulations with ALADIN input at ARSO**

**Contributors:** P. Smerkol (Si) 2.75 PM and J. Cedilnik (Si) 0.50 PM

**Efforts:** 3.25 PM

**Documentation, deliverable:** scripts and newsletter article

**Status/description:** ONGOING

At ARSO, as part of Uroš Kosmač's master's degree (link to the thesis is provided below), the MicroHH LES model was configured to perform real-case simulations over a selected subdomain of the AROME model (CY48T3, DEODE configuration with ECOCLIMAP-SG physiography) with  $\Delta x=200$  m and 90 vertical levels. MicroHH was forced with interpolated orography and initial and lateral boundary conditions obtained from the AROME model. However, due to the doubly periodic lateral boundary conditions in MicroHH, the orography near the domain edges had to be smoothed to avoid artificial terrain discontinuities and numerical instabilities. This was achieved by setting the edge values to the domain minimum and applying cosine smoothing over 10-gridpoint-wide strips along all four lateral boundaries, gradually transitioning to the original orography toward the interior. A similar approach was applied to other 2D surface boundary conditions, including liquid water potential temperature and total specific water content, while for wind no-slip condition was imposed.

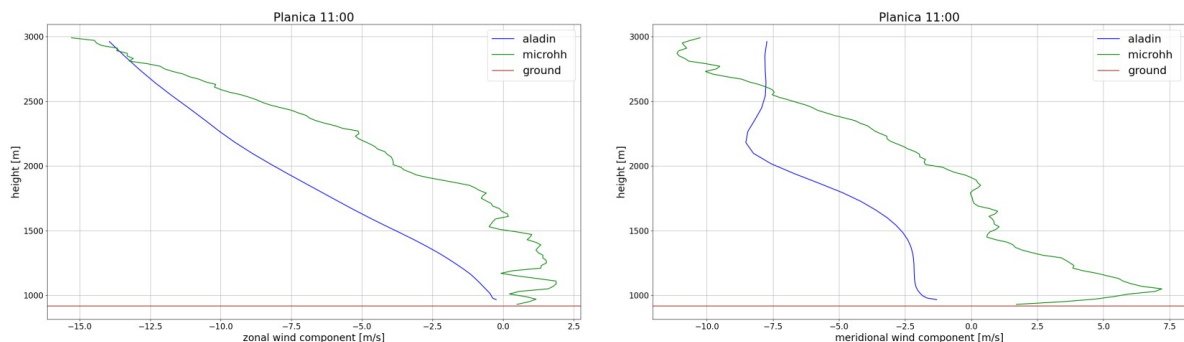


Fig. 19: Results for the Barje case at 08:00 UTC, i.e., 5-h after the MicroHH LES model initialisation, at the Sodan-RASS measurement site: profile of the virtual temperature (left) and profile of relative humidity (right).

The MicroHH LES model ( $\Delta x=40$  m) was compared against AROME ( $\Delta x=200$  m) in two cases: (i) a late-summer weak inversion with fog over flat terrain and (ii) early-spring strong near-surface winds that change direction with height within the complex terrain. In the first case (Barje), MicroHH preserved the near-surface inversion and fog layer, whereas AROME mixed the PBL too strongly (Fig. 19). However, the cooling and moistening rates in MicroHH are somewhat exaggerated, which is attributed to the static bottom boundary condition. In the second case (Planica), unlike AROME, LES captured the observed wind reversal (Fig. 20) and cold-air retention in the valley (not shown).

Despite limitations of the initial MicroHH configuration due to (i) artificial smoothing near the lateral boundaries, (ii) static lower boundary conditions, and (iii) the absence of time-dependent external forcing, the conducted experiments demonstrate that LES initialised from NWP output can provide valuable process-level insight and serve as a reference for turbulence and physical scheme development. More information can be found in the forthcoming ACCORD Newsletter No. 8 or the above-mentioned thesis (see Section 3.3 for details).

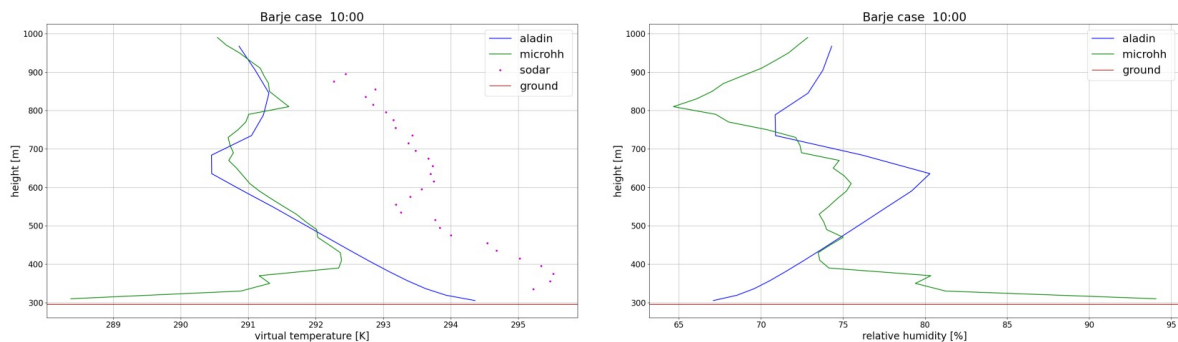


Fig. 20: Results for the Planica case (ski jump hill) at 10:00 UTC, i.e., 5-h after the MicroHH LES model initialisation: profile of the zonal wind (left) and profile of meridional wind (right).

## 3 Documents and publications

### 3.1 Research stay reports<sup>1</sup>:

Gabriel Stachura, 2025: *Towards smooth integration of ALARO with SURFEX, ACCORD flat-rate (two weeks) & RC-LACE research stays (one week), Prague, 10.03.2025. - 28.03.2025.* (available at: [https://www.rlace.eu/media/files/Physics/2025/GS\\_2025P\\_SNOW.pdf](https://www.rlace.eu/media/files/Physics/2025/GS_2025P_SNOW.pdf))

Peter Smerkol, 2025: *Solving instabilities of solver in ACDIFV3 routine, RC-LACE research stay, Prague, 31.03.2025.-25.04.2025.* (available at: [https://www.rlace.eu/media/files/Physics/2025/PS\\_2025P\\_TOMS.pdf](https://www.rlace.eu/media/files/Physics/2025/PS_2025P_TOMS.pdf))

Mario Hrastinski, 2025: *Implementation and preliminary evaluation of the ECOCLIMAP-SG physiography data in the ALARO-CMC model, RC-LACE stay, Prague, 09.06.2025.-20.06.2025.* (available at: [https://www.rlace.eu/media/files/Physics/2025/MH\\_2025P\\_ECO-SG.pdf](https://www.rlace.eu/media/files/Physics/2025/MH_2025P_ECO-SG.pdf))

Mario Hrastinski, 2025: *Adjusting the TOUCANS code to distinguish between vertical levels used by the turbulence scheme and the model dynamics, RC-LACE research stay, Prague, 10.06.2024. - 21.06.2024., 14.10.2024. - 25.10.2024., 07.07.2025. - 18.07.2025. and 01.12.2025. - 12.12.2025.* (available at: [https://www.rlace.eu/media/files/Physics/2025/MH\\_2024-2025P\\_KLEVTUR.pdf](https://www.rlace.eu/media/files/Physics/2025/MH_2024-2025P_KLEVTUR.pdf); topic is shared with the Dynamics & Coupling area)

### 3.2 Presentations

#### RC-LACE phy.-surf. people presentations at 5th ACCORD All Staff Workshop:

Martina Tudor: [LACE activities in the surface area](#)

David Nemeč: [Initial Steps in Double-Moment Microphysics in ALARO](#)

Ján Mašek: [Status of ALARO with SURFEX](#)

<sup>1</sup> Two more reports are in preparation (CAR and TEB in ALARO + SURFEX), while one needs the final approval (TEB in ALARO + SURFEX).

Mario Hrastinski: [Physics activities in RC-LACE](#)

**RC-LACE phy.-surf. people presentations at 47th EWGLAM & 32nd SRNWP Meeting:**

Martina Tudor: [Coupling ALARO physics with SURFEX](#)

Mario Hrastinski: [Physics activities in RC-LACE](#)

**ACCORD Autumn Surface Working Week 2025:**

Piotr Sekuła: [Albedo developments in SURFEX model](#)

Gabriel Stachura: [Recent developments and encountered problems related to snow and soil in SURFEX coupled to ALARO](#)

Ján Mašek: [TEB in ALARO + SURFEX](#)

Mario Hrastinski: [Preliminary results of ALARO experiments with ECOCLIMAP-SG](#)

In addition, two major events took place in Q1 and Q2: (i) ALARO-1 Working Days 2025 (3-5th March, IMGW, Krakow, Poland) and (ii) ALARO + SURFEX WW 2025 (2–6th June, CHMI, Prague, Czech Republic). Presentations and recordings can be found at:

- <https://www.rlace.eu/alaro/alaro-1-working-days-2025>
- [https://opensource.umr-cnrm.fr/projects/accord/wiki/ALARO1\\_Wds\\_2025](https://opensource.umr-cnrm.fr/projects/accord/wiki/ALARO1_Wds_2025)
- [https://opensource.umr-cnrm.fr/projects/accord/wiki/ALARO+SURFEX\\_WW\\_2025](https://opensource.umr-cnrm.fr/projects/accord/wiki/ALARO+SURFEX_WW_2025)

### 3.3. List of published papers and theses:

Hrastinski, M., Mašek, J., Bašták Ďurán, I., Grisogono, B., and Brožková, R. (2025): Regime-dependent turbulence length scale formulation for NWP models based on turbulence kinetic energy, shear and stratification. *Mon. Wea. Rev.*, **153** (11), 2571–2591, <https://doi.org/10.1175/MWR-D-24-0184.1>.

Hrastinski, M. (2025): Improvement of turbulence parameterization in the ALADIN model. *Doctoral thesis*. University of Zagreb, Faculty of Science, Geophysics Department, 128 pp. Available at: <https://repozitorij.pmf.unizg.hr/object/pmf:15016> (last accessed: 25.02.2025.).

Kosmač, U. (2025): Turbulence in simulacije velikih turbulentnih vrtincev. *Master thesis*. University of Ljubljana, Faculty of Mathematics and Physics, 84 pp. Available at: <https://repozitorij.uni-lj.si/IzpisGradiva.php?id=177223> (last accessed: 25.02.2025.).

Smerkol, P., N. Kastelec and J. Cedilnik (2026): Large eddy simulations with ALADIN input, *ACCORD Newsletter*, **8**, ??-??

## 4 Activities of management, coordination and communication

Preparation/organization of the ALARO-1 Working Days and the ALARO + SURFEX WW. I have also participated at:

- 44<sup>th</sup> LSC Meeting, 6-7 March 2025, Krakow, Poland
- 5<sup>th</sup> ACCORD All Staff Workshop, 31 March - 4 April 2025, Zalakaros, Hungary
- ALARO + SURFEX Working Week, 2-6 June 2025, Prague, Czech Republic
- ALARO + SURFEX research stay, 9-20 June 2025, Prague, Czech Republic
- Research stay on vertical levels, 7-18 July 2025, Prague, Czech Republic (in collaboration with „Dynamics & Coupling” area)
- 45<sup>th</sup> LSC Meeting, 10-11 September 2025, Ljubljana, Slovenia
- 47<sup>th</sup> EWGLAM & 32<sup>nd</sup> SRNWP Meeting, 22 – 25 September 2025, Norrköping, Sweden
- ALARO + SURFEX research stay, 13-24 October 2025, Prague, Czech Republic
- Research stay on vertical levels, 1-12 December 2025, Prague, Czech Republic (in collaboration with „Dynamics & Coupling” area)
- Regular DE\_330 physics team monthly meetings

## 5 Research stays

Seven research stays were executed (19 weeks in total; 12 funded by RC-LACE and 7 from ACCORD DAP):

- ***<sup>2</sup>Towards smooth integration of ALARO with SURFEX*** - Gabriel Stachura (3 weeks: 10-28 March 2025, CHMI, Prague)
- ***Solving instabilities of TOMs solver in ACDIFV3 routine*** – Peter Smerkol (4 weeks: 31 March – 25 April 2025, CHMI, Prague)
- ***Implementation and preliminary evaluation of the ECOCLIMAP-SG physiography data in the ALARO-CMC model*** (2 weeks: 9-20 June 2025, CHMI, Prague)
- ***Activating advanced options in the ALARO with SURFEX framework*** – Piotr Sekuła (2 weeks: 9-20 June 2025, CHMI, Prague)

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<sup>2</sup> This stay is partly funded from ACCORD DAP (2 weeks).

- **Activating advanced options in the ALARO with SURFEX framework** – Mario Hrastinski (2 weeks: 13-24 October 2025, CHMI, Prague)
- **<sup>3</sup>Tuning stratospheric background values for ALARO using CAMS n.r.t. aerosols** - Piotr Sekuła (4 weeks; 23-27 June & 1-19 December 2025)
- **<sup>4</sup>Development of two-moment scheme with aerosols in ALARO CSC** - David Němec (2 weeks: 15-26 September 2025, Univ. Ghent, Belgium)

## 6 Summary of resources

Summary of resources during Q1-Q4 2025 is shown in Table 1.

Table 1. Resources per WPs and summary

Subject/Action	Manpower		LACE stays		ACCORD stays	
	planned	realized	planned	realized	planned	realized
*PH1: Turbulence and shallow convection	6.75	11.25	1.00	1.00	0.00	0.00
PH2: Radiation	0.00	0.00	0.00	0.00	0.00	0.00
PH3: Clouds-precipitation microphysics	11.00	11.75	0.25	0.25	0.25	0.25
PH4: Common 1D MUSC framework for parametrization validation	0.50	0.25	0.00	0.00	0.00	0.00
PH5: Model Output Postprocessing Parameters	5.00	2.50	0.00	0.00	0.00	0.00
PH6: Study the cloud/aerosol/radiation (CAR) interactions	6.00	3.25	0.00	0.00	1.00	1.00
*PH7: On the interface between the surface and the atmosphere	2.75	4.25	1.00	1.00	0.00	0.00
*PH8: On the interface of Physics with Dynamics (and time stepping)	0.00	0.00	0.00	0.00	0.00	0.00
SU3: SURFEX: validation and development of existing components for NWP	27.50	16.25	1.75	1.75	0.50	0.50
SU4: SURFEX: Development of new model components	0.25	0.25	0.00	0.00	0.00	0.00
SU5: Assess/improve quality of surface characterization	4.25	3.00	0.00	0.00	0.00	0.00
*HR: Sub-km modelling	7.00	4.25	0.00	0.00	0.00	0.00
TOTAL	71.00	57.00	4.00	4.00	1.75	1.75

(\*) accounted for in other area (at least partly)

## 7 References

Bigg, E. K., 1953: The supercooling of water. *Proceedings of the Physical Society. Section B*, **66 (8)**, 688–694., DOI: [10.1088/0370-1301/66/8/309](https://doi.org/10.1088/0370-1301/66/8/309)

DeMott, P. J., A. J. Prenni, X. Liu, S. M. Kreidenweis, M. D. Petters, C. H. Twohy, M. S. Richardson, T. Eidhammer, and D. C. Rogers, 2010: Predicting global atmospheric ice nuclei distributions and their impacts on climate. *Proceedings of the National Academy of Sciences of the United States of America*, **107 (25)**, 11217–11222, DOI: [10.1073/pnas.0910818107](https://doi.org/10.1073/pnas.0910818107)

3 This stay is fully funded from ACCORD DAP.

4 This stay is partly funded from ACCORD DAP (1 week).

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