REQUEST FOR A SPECIAL PROJECT 2026–2028

MEMBER STATE: Austria

Principal Investigator[1]: Clemens Wastl (clemens.wastl@geosphere.at)

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Project Title: Improving the Simulation of Orographic Convection with C-LAEF

To make changes to an existing project please submit an amended version of the original form.)

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ………….	
Starting year: (A project can have a duration of up to 3 years, agreed at the beginning of the project.)	2026	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for project year:		**2026**	**2027**	**2028**
High Performance Computing Facility	[SBU]	10.000.000	15.000.000	15.000.000
Accumulated data storage (total archive volume)[2]	[GB]	5.000	25.000	45.000

EWC resources required for project year:		**2026**	**2027**	**2028**
Number of vCPUs	[#]			
Total memory	[GB]			
Storage	[GB]			
Number of vGPUs[3]	[#]			

Continue overleaf.

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide annual progress reports of the project's activities, etc.
[2] These figures refer to data archived in ECFS and MARS. If e.g. you archive x GB in year one and y GB in year two and don't delete anything you need to request x + y GB for the second project year etc.
[3]The number of vGPU is referred to the equivalent number of virtualized vGPUs with 8GB memory.

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Extended abstract

Introduction

C-LAEF 1k is a convection-permitting limited-area ensemble forecasting system developed by GeoSphere Austria in collaboration with the Croatian Meteorological and Hydrological Service and the National Meteorological Service of Slovenia. This NWP system relies on the AROME model (version cy46t1) with a grid spacing of 1 km and is expected to become operational in 2026. Despite substantial improvements obtained at this resolution, deficiencies in the simulation of orographic convection still exist. These include convective timing, location and structure, as well as precipitation intensity, type and structure. Therefore, increased forecast accuracy requires continuous improvement of key aspects such as surface representation, surface-atmosphere interactions, turbulence parametrizations, radiation, microphysics and data assimilation.

Meteo-France and GeoSphere Austria have recently submitted to ANR and FWF a proposal for a bilateral research project (AMCoM - Advancing the Modelling of fine-scale circulations, energy balance and Convective processes in Mountainous regions) that aims to enhance our understanding of orographic convection and improve its representation in NWP models. AMCoM targets some of the key processes impacting orographic convection, namely surface processes and surface-atmosphere interactions, turbulence and radiation. In addition, the project includes research to increase the reliability and accuracy of ensemble forecasts of orographic convection. As well, AMCoM is integrated within the ongoing TEAMx (Transport and Exchange processes in the Atmosphere over Mountains - programme and experiment) program (Rotach et al. 2022) to leverage sophisticated observational datasets over the Eastern Alps provided by the latter. Figure 1 illustrates the spatial domains of the models participating in the AMCoM project, including C-LAEF 1k. Also shown in this figure are the target areas of the TEAMx Observational Campaign and the relevant supersites and forest tower sites.

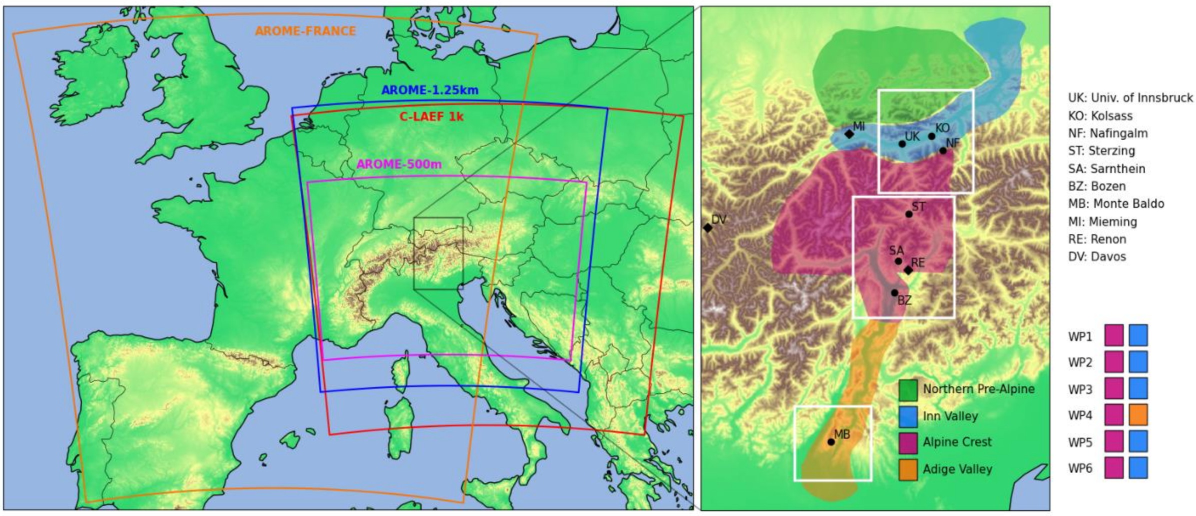

Figure 1. Left panel: The domains of the models participating in the AMCoM project, including C-LAEF 1k (in red). Right panel: The coloured areas are the target areas of the TEAMx Observational Campaign. The relevant supersites and forest tower sites are marked with closed circles and diamonds, respectively, and listed on the right.

GeoSphere Austria's contribution to AMCoM will focus on improving surface processes, surface-atmosphere interactions and ensemble forecasting of orographic convection. In case the French National Research Agency (ANR) rejects the AMCoM proposal, GeoSphere Austria will pursue its research contribution as a separate fallback project. Hereafter, "the project" will refer either to our contribution to AMCoM or to our fallback project.

NWP modellers, including those within the ACCORD consortium, will benefit from the outcomes of our project.

Scientific Plan

The AROME model used by C-LAEF 1k will initially be upgraded to cycle 49 to allow for the activation of new or recently upgraded schemes, such as the multi-layer soil, MEB and RSL schemes. The project is structured into two work packages. The first package will evaluate and improve the representation of land surface processes that impact the surface-atmosphere interactions and are crucial for the accurate simulation of orographic convection. The primary focus is on enhancing the representation of forest-atmosphere processes, including the exchange of heat, moisture and momentum. To that end, the ISBA-MEB (Boone et al. 2017) in combination with the multi-layer soil scheme, and the roughness sublayer parameterization (Shapkalijevski et al. 2022) will be evaluated and improved to enhance the accuracy of canopy-top fluxes and upslope flows over forested slopes.

The second work package will investigate and address uncertainties in forecasting convection in mountainous regions. The research will start with probabilistic validation, which includes a detailed investigation of whether the deficiencies of deterministic models are well represented in the ensemble. The focus will next switch to the process-based stochastic parameter perturbation scheme (SPP, Ollinaho et al., 2016) that represents model uncertainties in C-LAEF 1k. The uncertainty contributions of key parameterizations with substantial impact on orographic convection will be analyzed in detail. Adjustments to the perturbation scheme will be implemented and tested with the goal of improving forecast skill and uncertainty representation in the ensemble. Finally, we aim to identify and perturb critical surface parameters that influence convective initiation in mountainous regions and to use an extended SPP scheme to perturb these key surface parameters.

Justification of the Resources Requested

C-LAEF 1k employs a horizontal grid of 1500 x 1350 points (Fig. 1) with a grid spacing of 1 km and 90 vertical levels. The cost of running one of its ensemble members (e.g. the control member) for one 24-hour forecast is approximately 25,000 SBUs with the current version (cy46t1). However, since we plan to upgrade the model to cycle 49 so that we can employ multi-layer soil, MEB (for the representation of forests), the RSL (roughness sublayer) scheme, we are unable to predict the additional cost of activating these schemes at this time. We will therefore assume that the additional computational cost will not exceed 10 % of the current cost. The estimated cost of running one ensemble members for one 24-hour forecast would then rise to approximately 28,000 SBUs.

Additional experiments will be conducted on a subdomain covering the Eastern Alps for simulations of convection under weak synoptic forcing, if the forecast accuracy is deemed almost unaffected. This would reduce the computational cost by about 50 %.

We also plan to run two one-month-long experiments with continuous data assimilation cycles using a single (control) member. The cost of running such an experiment with the model upgraded to cy49 is estimated to be 6 M SBUs (200,000 SBUs/day).

Due to computational constraints, the 17-member ensemble-forecast experiments will be conducted on the half domain and for specific case studies. The cost of such an experiment is estimated to be 17*28,000 = 476,000 SBUs

The deterministic experiments using the aforementioned surface parameterization schemes will be first conducted for selected case studies (e.g., severe convection events). Results from these experiments will be next used to build two model configurations, which will be run in two one-month-long data assimilation experiments. The ensemble forecasts will be initialized from the output of these data assimilations experiments.

C-LAEF 1k Configuration	Model domain	Number of daily 48-h forecast runs per experiment	Computational cost per experiment (SBUs)	Number of experiments	Total computational cost (SBUs)
Single-member forecasts	Full	1	56,000	50	2.8 M
Single-member forecasts	Half	1	28,000	50	1.4 M
Single-member data assimilation	Half	30	6 M	2	12 M
17-member ensemble forecast	Half	1	476,000	50	23.8 M

The total computational cost over the 3-year period is 40 M SBUs. For the requested number of simulations, we consider that 45 000 GB of storage on ECFS are sufficient.

References

Boone, A., and Coauthors, 2017: The interactions between soil–biosphere–atmosphere land surface model with a multi-energy balance (ISBA-MEB) option in SURFEXv8–Part 1: Model description. Geosci. Model Dev., 10, 843–872. https://doi.org/10.5194/gmd-10-843-2017

Ollinaho, P., and Coauthors, 2016: Towards process-level representation of model uncertainties: Stochastically perturbed parametrizations in the ECMWF ensemble. Quart. J. Roy. Meteor. Soc. 143, 408–422, https://doi.org/10.1002/qj.2931

Rotach, M. W., and Coauthors, 2022: A Collaborative Effort to Better Understand, Measure, and Model Atmospheric Exchange Processes over Mountains. Bull. Amer. Meteor. Soc., 103, E1282–E1295, https://doi.org/10.1175/BAMS-D-21-0232.1

Shapkalijevski, M. M., Viana Jimenez, S., Boone, A., Rodier, Q., Le Moigne, P., and Samuelsson, P. 2022. Introducing a roughness-sublayer in the vegetation atmosphere coupling of HARMONIE-AROME. ACCORD newsletter, 2, 82-172. https://www.umr-cnrm.fr/accord/IMG/pdf/accord-nl2.pdf