Working Area Predictability

Work Plan

Prepared by:	Area Leader: Clemens Wastl
Period:	2025
Date:	September 2024

Introduction and background

Currently three different EPSs are operated within RC LACE: A-LAEF the common EPS of RC LACE and the two convection-permitting, AROME based EPSs C-LAEF (Austria) and AROME-EPS (Hungary). Furthermore, SHMU in Slovakia is working on a high resolution ALARO based EPS for a smaller domain. The development and maintenance of all of these systems is carried out separately at SHMU, GeoSphere Austria and HungaroMet, respectively. To reduce maintenance and to condense development and research it would be crucial to reduce the number of operational EPSs in RC-LACE. Austria, Slovenia and Croatia have already initiated an intensive cooperation to develop a common C-LAEF 1km system. A first test version has already been set up by GeoSphere Austria and is running continuously on Atos with output data provided to Slovenia and Croatia as well. Besides sharing of computer resources (SBUs at the ECMWF) this cooperation also includes some scientific collaboration - e.g. work on the development of EnVar, new observations, flow dependent model perturbations, post-processing, etc.

Strong cooperation and collaboration is currently going on between RC LACE and ACCORD in the EPS area. Sharing of code, participation in common EPS working weeks, regular thematic workshops take place and will continue in the future. Many EPS people of RC LACE are participating in the EU project Destination Earth On-Demand Extremes (DEODE) Phase II where it is planned to run hectrometric scale ensemble systems within the uncertainty work package.

Goals

Substantial upgrades are planned for the three operational EPS in RC LACE in 2025: For A-LAEF an upgrade from cy40t1 to cy46t1 is planned together with a new upper-air spectral blending method and an upgraded version of the multiphysics package. For AROME-EPS in Hungary a switch in the cycle (cy43t2 to cy46t1) and the introduction of SPP is planned and C-LAEF should be replaced by its successor C-LAEF1k by the end of 2025. This transition comprises beside an upgrade in the model cycle (cy43t2 to cy46t1) also an increase of the horizontal resolution from 2.5km to 1km and some substantial improvements in data assimilation (new observation types, EnVar), model error representation (new SPP, flow dependency), dynamics setup and post processing (grib2). This upgrade is done in a cooperation between Austria, Slovenia and Croatia. It is the long term goal that other RC LACE countries are joining this initiative to work together on a common convection permitting LACE EPS.

Besides that, we have to think about alternative ways to improve/extend our EPSs. One important approach in this direction is the use of machine learning (ML) technologies, e.g. the generation of ensemble members by deep learning algorithms, or the creation of data-driven ML-ensembles.

1 Subject: Preparation, evolution and migration

Description and objectives: Maintain and monitor the operational suites of A-LAEF and C-LAEF running on ECMWF's HPC and the AROME-EPS running at the HPC at HungaroMet. Migration and implementations to new HPCs, operational upgrades, new cycles, optimizations and tunings. Implementation of new EPSs.

The main topics for 2025 are:

- ❑ A-LAEF and C-LAEF: Maintenance/monitoring of operational EPSs on ECMWF's HPC in Bologna, upgrades
- ❑ A-LAEF: Implementation of SURFEX for ALARO
- ❑ A-LAEF: Development of an ALARO-based convection-permitting EPS coupled to the regional ensemble A-LAEF, running at new SHMU HPC
- ❑ A-LAEF: Implementation of ENS BlendVar assimilation method in the A-LAEF system to improve the simulation of upper-air ICs uncertainty
- ❑ C-LAEF: C-LAEF 1k for Austria, Slovenia and Croatia, extended domain, data provision, product generation, pre-operational status
- ❑ C-LAEF: Reanalysis of C-LAEF for 2011 – 2020 period.
- ❑ AROME-EPS: Optimization and tuning of convection-permitting ensemble system on HPC at HungaroMet, upgrade to cy46t1
- ❑ AROME-EPS: Introduction of model perturbations (SPP) in operational AROME-EPS

Proposed contributors & Estimated efforts: Martin Belluš and Maria Derkova (SHMU), Katalin Jávorné-Radnóczi, N.N. (HungaroMet), Clemens Wastl, Florian Weidle, Christoph Wittmann (GeoSphere Austria), Jure Cedilnik, Benedikt Strajnar (ARSO), Endi Keresturi (DHMZ) – 18 PM

Planned time-frame and deliverable: Permanent. Stable and state-of-the-art operational suites of all three EPSs in RC LACE.

Planned stays:

1. Martin Belluš – A-LAEF upgrade

2 Action/Subject: Model perturbations

Description and objectives: Research and development concerning model perturbations in the three EPSs within RC LACE. Study ways to represent uncertainty in the atmospheric models itself and how to best incorporate this into the models.

The main topics for 2025 are:

- ❏ A-LAEF: Stochastic perturbation of fluxes instead of tendencies in order to preserve the energy balance in perturbed model.
- ❏ C-LAEF: Introduction of new parameters in SPP – dynamics parameters, etc.
- ❏ C-LAEF: Development of flow-dependent model perturbations; Investigate the possibility of using AI
- ❏ AROME-EPS: Add model perturbations to AROME-EPS at HungaroMet. Work on SPP, tests, verification, optimization

Proposed contributors & Estimated efforts: Martin Belluš (SHMU), Clemens Wastl (GeoSphere Austria), Endi Keresturi (DHMZ), Katalin Jávorné-Radnóczi and N.N. (HungaroMet) – 6 PM

Planned time-frame and deliverable: Ongoing. Reports on the experiments; exchange of expertise; improvements of the operational implementations of convection-permitting ensembles; scientific publications and presentations

Planned stays:

1. Endi Keresturi (4 weeks at GeoSphere Austria) – flow dependent SPP perturbations/C-LAEF1k

3 Action/Subject: Initial condition perturbations

Description and objectives: Research and development concerning initial condition perturbations in the three EPSs within RC LACE.

The main topics for 2025 are:

- ❏ A-LAEF: Preparation of flow-dependent B-matrix for local 3D-Var assimilation systems based on ALARO CMC using A-LAEF operational outputs
- ❏ C-LAEF: EnVar and Hybrid EnVar in C-LAEF1k to create initial conditions for ensemble members. Test what perturbations are suitable and perform the best.

Proposed contributors & Estimated efforts: Martin Belluš (SHMU), Florian Meier and Florian Weidle (GeoSphere Austria), Benedikt Strajnar (ARSO) - 2 PM

Planned time-frame and deliverable: Ongoing. Reports on the experiments; exchange of expertise; improvements of the operational implementations of convection-permitting ensembles; scientific publications and presentations

Planned stays:

4 Action/Subject: Surface perturbations

Description and objectives: Research and development concerning surface perturbations in the three EPSs within RC LACE.

The main topics for 2025 are:

- ❑ C-LAEF and AROME-EPS: Implementation of surface perturbations in AROME-EPS; SPP in SURFEX, implementation testing, verification

Proposed contributors & Estimated efforts: Clemens Wastl (GeoSphere Austria), N.N. (HungaroMet) - 1 PM

Planned time-frame and deliverable: Ongoing. Reports on the experiments; exchange of expertise; improvements of the operational implementations of convection-permitting ensembles; scientific publications and presentations

Planned stays:

5 Action/Subject: Lateral boundary condition perturbations

Description and objectives: Research and development concerning lateral boundary condition perturbations in the three EPSs within RC LACE.

The main topics for 2025 are:

No topics planned for 2025

Proposed contributors & Estimated efforts:

Planned time-frame and deliverable: Ongoing. Reports on the experiments; exchange of expertise; improvements of the operational implementations of convection-permitting ensembles; scientific publications and presentations

Planned stays:

6 Action/Subject: Statistical EPS and user-oriented approaches

Description and objectives: Research and development concerning statistical calibration of EPS data to reduce systematic errors; integration of AI technologies to EPS creation; research and development of new products; user-oriented approaches to increase the reputation of EPS

The main topics for 2025 are:

- ❏ A-LAEF: Continuation work on methods for machine learning (ML) based post-processing of probabilistic fields
- ❏ C-LAEF and AROME-EPS: Work on statistical post-processing of EPS data (e.g. more flexible calibration methods, etc.)
- ❏ C-LAEF: Generation of ensemble members by deep learning algorithms
- ❏ C-LAEF: Extension of data-driven ML ensemble modelpoint nowcasting towards a hybrid (data-driven + NWP) and days-ahead system; extension of spatial nowcasting with physics-informed ML using NWP data for the days-ahead and looking into ensemble generation;
- ❏ C-LAEF: Investigation of (ensemble) foundation models for post-processing (point with extension to spatial)
- ❏ ALL: Development of new probabilistic products to meet users requirements
- ❏ ALL: Development of decision-making criteria based on EPS for various users (e.g. hydrology, renewable energy, road safety, mountaineers, etc.)

Proposed contributors & Estimated efforts: Iris Odak Plenković, Endi Keresturi, Ivan Vujec (DHMZ), Alexander Kann, Markus Dabernig, Irene Schicker (GeoSphere Austria), Martin Belluš (SHMU), Katalin Jávorné-Radnóczi (HungaroMet) – 11 PM

Planned time-frame and deliverable: Ongoing. Reports on the experiments and on new products; exchange of expertise; scientific publications and presentations

Planned stays:

1. Ivan Vujec (4 weeks at GeoSphere Austria) – ML based post-processing methods

Summary of resources [PM]

Subject	Person Months	LACE	ACCORD
S1: Preparation, evolution and migration	**18**	**1**	
S2: Model perturbations	**6**	**1**	
S3: IC perturbations	**2**		
S4: Surface perturbations	**1**		
S5: LBC perturbations			
S6: Statistical EPS and user-oriented approaches	**11**	**1**	
Total:	**38**	**3**	

Meetings and events (2025)

- ❑ 44th LSC Meeting, Poland/Croatia, March 2025
- ❑ 5th ACCORD All Staff Meeting, ???, April 2025
- ❑ 45th LSC Meeting, Poland/Croatia, September 2025
- ❑ 46th EWGLAM and 31st SRNWP joined meeting, ???, September 2025
- ❑ 5th ACCORD EPS working week, Vienna, autumn 2025
- ❑ Other international EPS related conferences and workshops