Working Area Predictability

Work Plan

Prepared by:	Area Leader: Clemens Wastl
Period:	2024
Date:	September 2023

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 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 OMSZ, respectively. Because this situation is far away from optimal there exists the idea of merging all of the region EPSs to one common RC LACE system. But, there are some obstacles to reach this - different views (ALARO/AROME physics, surfex), computer power, etc. However, cooperation between the national weather services within RC LACE is strenghtened. A first step in this direction is a potential cooperation between Austria and Slovenia on the C-LAEF 1k system. A first test version has already been set up by GeoSphere Austria and is running continuously since summer 2023 with output data provided to Slovenia as well. Croatia is also very interested in this system (after extension of the domain to the south). Besides sharing of computer resources (SBUs at the ECMWF) this cooperation could also include some scientific collaboration - e.g. work on the development of EnVar for an ensemble system, flow dependent model perturbations, etc. Another source of uncertainty for the EPS area in RC LACE at the moment is the EU initiative Destination Earth (DestinE), where also a lot of effort is put into a hyper-resolution model setup.

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 (mostly online, but also some physical meetings) have been recently initiated and should continue in the future.

Goals

The main goals for 2024 are in many points very similar to those of the previous years. Three EPSs are already running operationally within RC LACE, but continuous work has to be spent on maintenance, migration and further improvements. For the near future significant upgrades of the EPSs are foreseen, especially in the direction of higher resolution (towards 1km). However, despite the HPC upgrades (e.g. new HPC at GeoSphere Austria) we will definitely not have enough HPC capacity to run a common 1km EPS on the large RC LACE domain in the next few years. At least for the local EPSs (C-LAEF, AROME-EPS, ALARO-EPS) it should be possible to go towards 1km until 2025, especially with the use of some new technologies (single precision, GPU code, etc.). However, 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.
Another important point in the EPS area is to ensure that the EPS outputs are being accordingly utilized in order to maximize their potential. Therefore a lot of work is planned in the subject S6 (Statistical EPS and user-oriented approaches) which also covers the implementation of new ML based methods. To reach all of these goals it will be crucial to strengthen the cooperation within RC LACE and ACCORD on this topic. The EU initiative Destination Earth will of course be another important issue in the near future, since many of our staff working on EPS will be working in this project (DEODE).

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 OMSZ. Migration and implementations to new HPCs, operational upgrades, new cycles, optimizations and tunings. Implementation of new EPSs.

The main topics for 2024 are:

- ❏ A-LAEF and C-LAEF: Maintenance/monitoring of operational EPSs on ECMWF's HPC in Bologna, upgrades
- ❏ A-LAEF: Upgrade of the upper-air IC uncertainty simulation by ENS BlendVar
- ❏ A-LAEF: Development of an ALARO-based convection-permitting EPS coupled to the regional ensemble A-LAEF, running at new SHMU HPC
- ❏ C-LAEF: Upgrade of C-LAEF to 1km – test suites, optimizations, verification, pre-operational status
- ❏ C-LAEF: C-LAEF 1k for Slovenia and Croatia, extension of domain, data provision, product generation, R&D
- ❏ C-LAEF: New HPC at GeoSphere Austria – migration, tests for C-LAEF 1k
- ❏ AROME-EPS: Optimization and tuning of convection-permitting ensemble system on HPC at OMSZ
- ❏ AROME-EPS: Introduction of model perturbations (SPP) in operational AROME-EPS

Proposed contributors & Estimated efforts: Martin Belluš and Maria Derkova (SHMU), Katalin Jávorné-Radnóczi, Gabriella Tóth (OMSZ), Clemens Wastl, Florian Weidle, Christoph Wittmann (GeoSphere Austria), Jure Cedilnik (ARSO), Endi Keresturi (DHMZ) – 20 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 (4 weeks at GeoSphere Austria) – 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 2024 are:

- ❏ A-LAEF: Stochastic perturbation of fluxes instead of tendencies in order to preserve the energy balance in perturbed model.
- ❏ C-LAEF: Improvement of stochastic parameter perturbations (SPP) with special focus on convective hazards (e.g. processes in microphysics)
- ❏ C-LAEF: Development of flow-dependent model perturbations
- ❏ AROME-EPS: Add model perturbations to AROME-EPS at OMSZ. Work on SPP, tests, verification, optimization

Proposed contributors & Estimated efforts: Martin Belluš (SHMU), Clemens Wastl (GeoSphere Austria), Endi Keresturi (DHMZ), Gabriella Tóth and Katalin Jávorné-Radnóczi (OMSZ) – 10 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. Gabriella Tóth (4 weeks at GeoSphere Austria) – model perturbations (SPP) in AROME-EPS
2. Endi Keresturi (4 weeks at GeoSphere Austria) – flow dependent SPP perturbations

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 2024 are:

- ❏ A-LAEF: Utilization of A-LAEF operational forecasts for flow-dependent B-matrix computation to be used in local assimilation cycles of RC LACE members.
- ❏ C-LAEF: Explore the use of EnVar and Hydrid EnVar in C-LAEF 1k; verification

Proposed contributors & Estimated efforts: Martin Belluš (SHMU), Florian Meier and Florian Weidle (GeoSphere Austria) - 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:

1. Martin Belluš (4 weeks at GeoSphere Austria) - flow-dependent B-matrix

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 2024 are:

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

Proposed contributors & Estimated efforts: Clemens Wastl (GeoSphere Austria), Gabriella Tóth (OMSZ) - 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 2024 are:

No topics planned for 2024

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 2024 are:

- ❏ A-LAEF: Continuation work on methods for analog-based post-processing of probabilistic fields on a regular grid
- ❏ A-LAEF: Objective identification of convection objects and of severe storms in ensemble outputs using deep NN
- ❏ C-LAEF and AROME-EPS: Work on statistical post-processing of EPS data (e.g. new calibration methods)
- ❏ 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; extension of spatial nowcasting with physics-informed ML using NWP data for the days-ahead and looking into ensemble generation;
- ❏ 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 (OMSZ) – 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. Iris Odak Plenković/Ivan Vujec (4 weeks at GeoSphere Austria) - analog-based post-processing methods

Summary of resources [PM]

Subject	Person Months	LACE	ACCORD
S1: Preparation, evolution and migration	**20**	**1**	
S2: Model perturbations	**10**	**2**	
S3: IC perturbations	**2**	**1**	
S4: Surface perturbations	**1**		
S5: LBC perturbations			
S6: Statistical EPS and user-oriented approaches	**11**	**1**	
Total:	**44**	**5**	

Meetings and events (2024)

- ❑ 42nd LSC Meeting, March 2024
- ❑ 4th ACCORD All Staff Meeting, Norrköping, March/April 2024
- ❑ 3rd ACCORD EPS working week, April 2024
- ❑ 43rd LSC Meeting, September 2024
- ❑ 46th EWGLAM and 31st SRNWP joined meeting, September 2024
- ❑ Other international EPS related conferences and workshops