Small National Meteorological Services Join Together For (Big) Operational Numerical Weather Prediction System

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ACCORD
A Consortium for COnvection-scale modelling Research and Development

LACE nwp central europe

Introduction

Small teams do not have the manpower to develop a NWP model and maintain its operational applications and this is often combined with insufficient HPC resources to run a large system locally. Therefore the 8 members of Regional Cooperation for Limited Area forecasing in Central and southeast Europe (RC LACE, Austria, Croatia, Czechia, Hungary, Poland, Romainia, Slovakia and Slovenia) are developing the NWP model within the ACCORD consortium and multiple local operational applications as well as two joint applications aimed at ensebmle forecasting: A-LAEF and very recently C-LAEF, both running as time critical applications at ECMWF HPC. This poster describes the A-LAEF application that is also supported by SBUs from Turkye.

ALARO Limited Area Ensemble Forecasting System (A-LAEF System)

A-LAEF is a regional ensemble forecasting system based on the ALARO CSC, running as a Time Critical-2 (TC2) application on the HPCF at ECMWF (Belluš, Tudor, Abellan, 2022). It is developed by SHMÚ in collaboration with the RC LACE consortium. The operational runs of the A-LAEF TC2 application are funded using SBUs provided by Slovenia, Croatia, and Turkey (full ECMWF members). The system consists of 16 perturbed ensemble members and one unperturbed control run, producing forecasts twice daily for up to 72 hours. Its domain covers an area that extends beyond the boundaries of the European continent, with the spatial resolution of 4.8 km and 60 vertical levels. Operational since 2019, A-LAEF has been utilized by LACE partners and Turkey to provide reliable probabilistic forecasts. It has successfully predicted numerous extreme weather events across Europe and consistently delivers high-quality probabilistic forecasts. Recently, it has been employed as a probabilistic input for hydrological models and for the calculation of climatological characteristics, such as the SPEI index. Currently, an upgraded version of A-LAEF is under testing, incorporating the latest ALARO physics developments along with several technical enhancements (inline grib2 generation, etc.).

Modelling uncertainty

These strategies are employed to simulate undertainty in the A-LAEF system:

- **initial conditions uncertainty**

  a) ensemble of surface data assimilation (ESDA) [perturbed T2m and RH2m OBS, perturbed first guess] **ESDA:**

  $$\Delta T_s = \Delta T_{2m}$$
  $$\delta T_p = \frac{1}{2\pi} T_{2m}$$
  $$\delta W_s = \alpha_s^T \Delta T_{2m} + \alpha_s^H \Delta H_{2m}$$
  $$\delta W_p = \alpha_p^T \Delta T_{2m} + \alpha_p^H \Delta H_{2m}$$

  b) upper-air spectral blending by DFI [combination of GM and LAM uncertainty] **BLENDING:**

  $$IC^n_{blend} = \alpha^n_{a-laef} + \overline{(\alpha^n_{ecmwf})_{trunc}} - \overline{(\alpha^n_{a-laef})_{trunc}}$$
  $$IC^n_{blend} = LS^n + \alpha^n_{a-laef}$$

- **lateral boundary conditions uncertainty** perturbations inherited from the first 16 members of ECMWF ENS [via standard coupling, global IFS ENS gribs via ECPDS dissemination]

- **numerical model uncertainty**

  a) ALARO-1 multi-physics [4 different physics clusters]

  b) stochastic physics for surface prognostic fields **SPPT + MP:**

  $$\frac{\partial e_j}{\partial t} = A(e_j, t) + P'(e_j, t)$$
  $$P'(e_j, t) = (1 + r_j(\lambda, \psi, t)_{D,T} P_j(e_j, t)$$ [stochastic perturbation of physics tendencies (SPPT) for 7 surface prognostic fields: surface temperature, surface liquid water content, surface frozen water content, snow albedo, snow reservoir water content, snow density and water intercepted by vegetation; control run without SPPT]

A-LAEF domain

The initial condition perturbation is achieved using ensemble of surface data assimilation (ESDA) using perturbed T2m and RH2m observations and perturbed first guess combined with upper-air spectral blending by DFI. Lateral boundaries are perturbed using different members from the IFS ensemble for LBCs. The numerical model uncertainty is emulated using the surface stochastic physics and multiphysics in the upper air. The data covering the whole domain are too much to be transferred operationally to all interested parties simultaneously, to decrease the burden on the transfer lines, data over smaller subdomains are transferred.

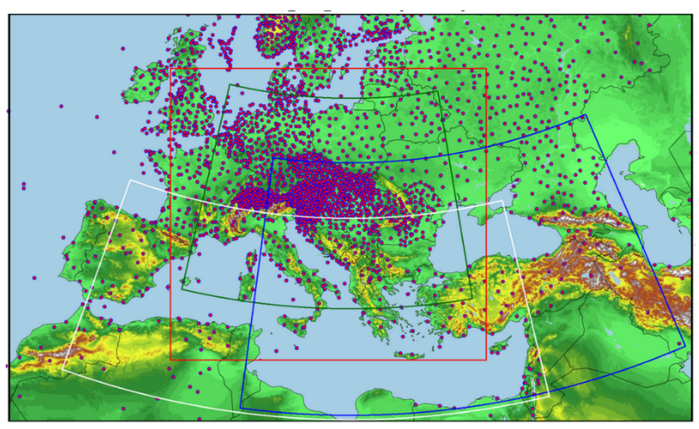


Figure 1. A-LAEF integration domain and all postprocessing domains, with the observations retrieved from OPLACE (sites shown)

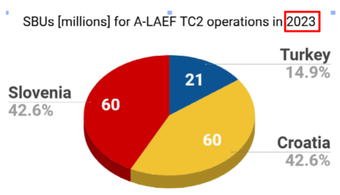


Figure 2. SBUs used for A-LAEF TC2 app in 2023

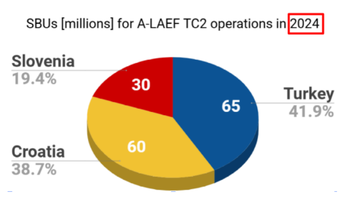


Figure 3.SBUs used for A-LAEF TC2 app in 2024

The operational TC2 suite consumes 130 M SBUs per year.

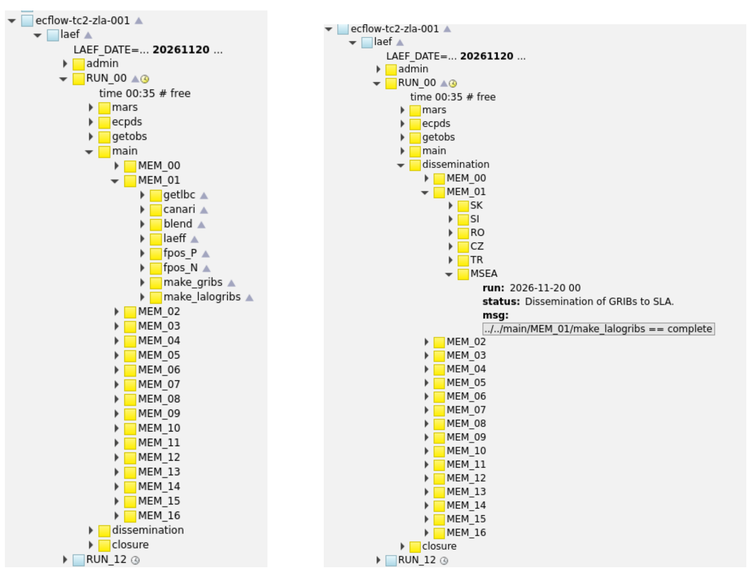


Figure 4.A-LAEF ecflow suite

Surface perturbations (SPPT)

The stochastic perturbation of ISBA surface prognostic fields was phased into CY46T1. At each time step in grid-point space, stochastic perturbations are applied to the physics tendencies of surface fields (7 fields in total). Direct perturbations of deep soil prognostic fields, such as deep soil temperature or moisture, were intentionally avoided. They naturally undergo much slower temporal changes, exhibiting a delayed response compared to the surface parameters.

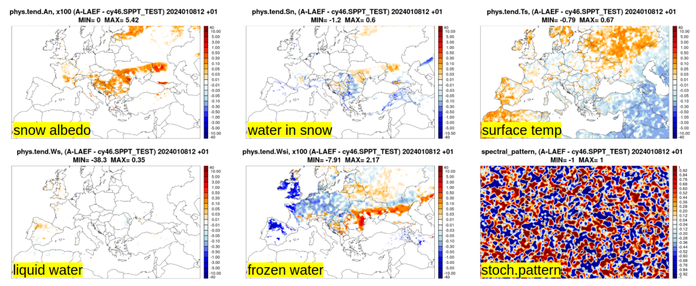


Figure 5. Snow albedo (top left), snow water (top centre), surface temperature (top right), liquid water (bottom left), frozen water (bottom centre) and stochatstic pattern (bottom right) physics tendency examples.

A-LAEF upgrades

The system has been upgraded to use more recent code version with new multi physics perturbation system and using new fields to describe the surface that represent substantial improvement to the one used previously. It currently runs 16 perturbed and a control member twice a day starting at 00 and 12 UTC up to 72 hours on 60 levels with 4.8 km resolution with linear grid.

Increasing vertical and horizontal resolution will be supported by single precision, but is limited by the coontributions of the members to the SBU pool.

The research and development activities include:

- development of the suite that would enable A-LAEF system to use SURFEX for the surface scheme has to be done with utmost caution since the move to ALARO with SURFEX has had its difficulties in deterministic mode and the implementation of surface perturbations has to be executed carefully without violating ALARO physics constraints.
- in order to facillitate a larger team participating in the development, the A-LAEF system components are being built into the common TACTUS scripting system leading to several challenges, like implementing the multi physics system, running the system without SURFEX in surface data assimilation and cycling and so on.
- the current time critical suite scripting system is a combination of little Python and much larger portion of Perl code that utilizes EcFlow functionality and has a command line monitoring support too, it is very reliable and efficient.
- younger researchers and developers would benefit from using more Python based and rnized scripting system like Tactus, but with the prospect of ML/AI assisted code translators the above discussion should become irrelevant.
- the ensemble system could benefit from using more advanced data assimilation techniques like ensemble variational assimilation, both for surface (2DEnVer) and upper air (3DEnVar) which requires dedicated manpower and computational resources for development and future operational maintenance.
- using AI tools for code maintenance as well as to complement the NWP forecast with additional members and/or other products is general ambition, but has to comply with local and EU legislation, rules and recommendations and other agreements and rely on hardware infrastructure.

Storm 26th-27th March 2026

Severe wind and intense precipitation 26th-27th March 2026 affected Croatia and its neighbours. The figurs below are from the A-LAEF operational forecast using the old cycle. Ther forecast performed well, although the measured extremes at several locations exceed the forecast values.



Fig 6. DHMZ entrance.



Fig 7. nearby



Fig 8. DHMZ parking



Fig 9. Met station

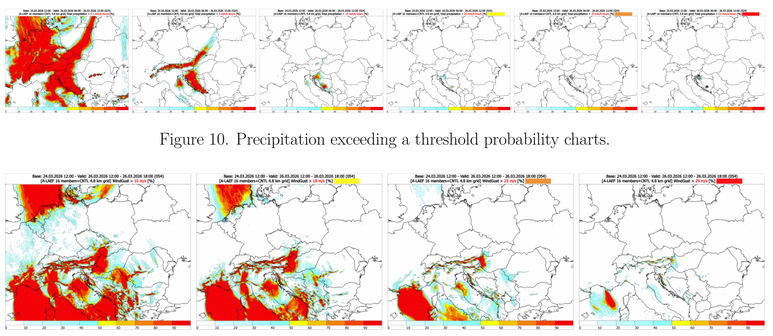


Figure 10. Precipitation exceeding a threshold probability charts.

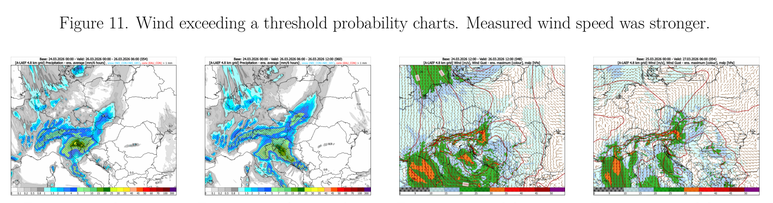


Figure 11. Wind exceeding a threshold probability charts. Measured wind speed was stronger.

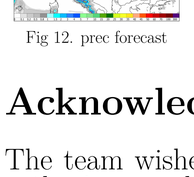


Fig 12. prec forecast

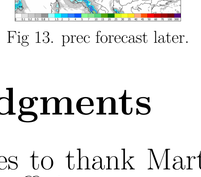


Fig 13. prec forecast later.

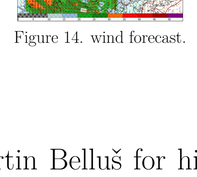


Figure 14. wind forecast.

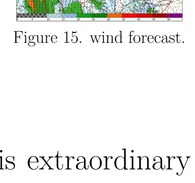


Figure 15. wind forecast.

Acknowledgments

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