A-LAEF: From TC2 status to case studies

LACE nwp central europe

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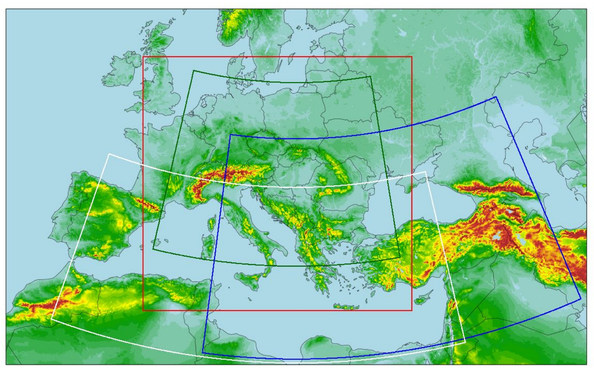
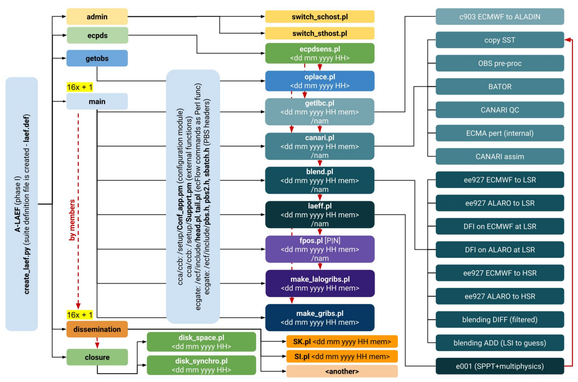
Introduction

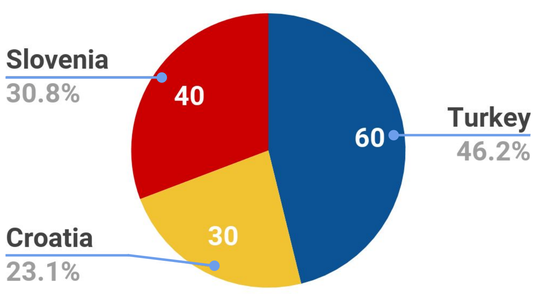
New A-LAEF (ALARO - Limited Area Ensemble Forecasting) system is a sequel to the former ALADIN-LAEF, which was operational on ECMWF HPCF since 2011 (Wang et al., 2011). A meso-scale ensemble system A-LAEF based on ALADIN canonical model configuration ALARO has been developed in the frame of RC LACE consortium and became operational as TC2 application at ECMWF since July 2020. It is focused on short range probabilistic forecasts and profits from the advanced multi-scale ALARO physics (which is adapted to perform on horizontal mesh-sizes of 2-10 km). Its main purpose is to provide a reliable high resolution probabilistic forecast for the national weather services of 8 RC LACE partners (SI, SK, CZ, HR, RO, PL, AT, HU) and Turkey.



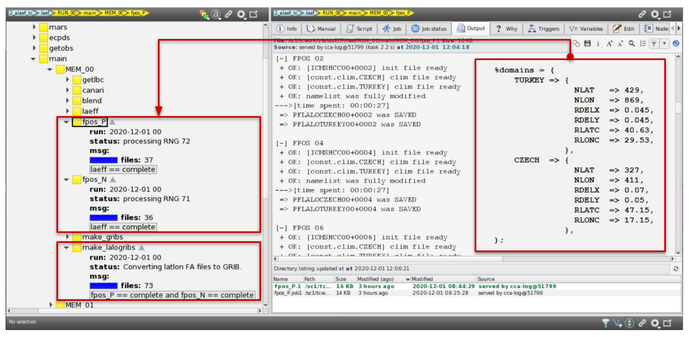
A-LAEF integration domain with model topography, and the post-processing domains: common RC LACE's Lambert domain (red), Czech Republic's (green) and Turkey's (blue) LATLON domains, and new LATLON domain for the ocean models coupling (white).



A-LAEF TC2 suite built under the ecFlow environment. Suite definition file is generated by Python code, while all tasks, include-files and configuration modules are written in Perl. Task dependencies are denoted by the red dashed arrows.



Billing units used for the A-LAEF TC2 operations at ECMWF HPCF during 2020 (numbers in millions of SBUs).



A-LAEF TC2 suite under the ecFlow environment with recently added LATLON post-processing tasks for Czech and Turkish domains.

Uncertainty simulation

In the A-LAEF system we use several strategies to simulate the uncertainty of the initial conditions and of the numerical model. The perturbations at the boundaries are prescribed by the downscaled information from driving global EPS.

IC perturbations

The surface and soil prognostic fields uncertainty in the initial conditions of A-LAEF system is simulated by the ensemble of surface data assimilations - ESDA (Belluš et al., 2016). Each ensemble member has its own data assimilation cycle with randomly perturbed screen-level measurements.

The uncertainty of the upper-air part of the initial conditions used in the A-LAEF system is currently simulated by the upper-air spectral blending (Derková and Belluš, 2007; Wang et al., 2014). It combines the large-scale perturbations provided by the driving global ensemble (ECMWF EPS) with the small-scale perturbations coming from A-LAEF first guess within the pseudo-assimilation cycle.

Model perturbations

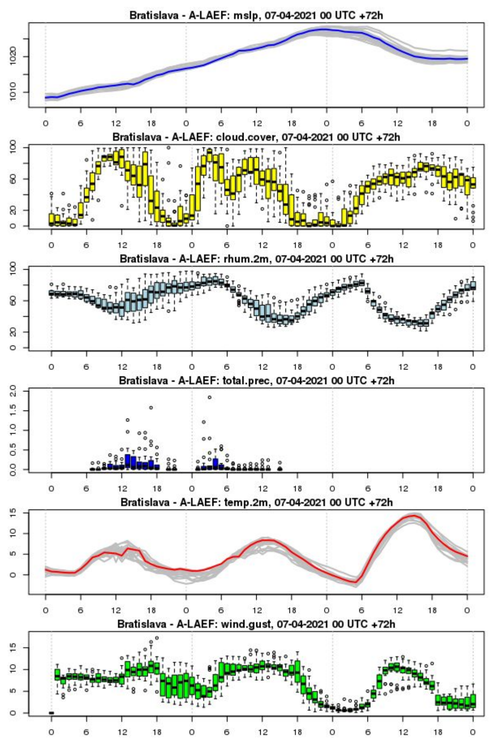
The model uncertainty is simulated by the combination of ALARO multi-physics (four different setups of micro-physics, deep and shallow convection, radiation and turbulence schemes) and the stochastic perturbation of physics tendencies (Wang et al., 2019).

LBC perturbations

The A-LAEF system is coupled to the global ECMWF EPS. The perturbed lateral boundary conditions are retrieved from the first 16 ENS members with a coupling frequency of 6h to account for the uncertainties at the domain boundaries.

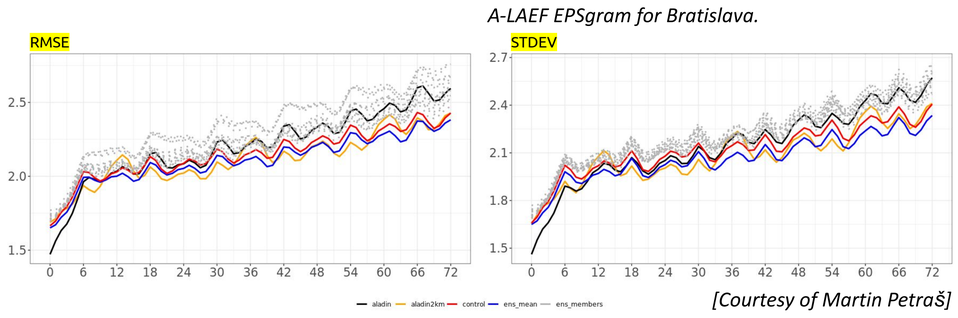
Code version	cy40t1
Horizontal resolution	4.8 km
Vertical levels	60
Number of grid points	750x1250
Grid	linear
Time step	180s
Forecast length	72 h (00/12 UTC)
Members	16+1
IC perturbation	ESDA [surface] spectral blending by DFI [upper-air]
Model perturbation	ALARO-1 multi-physics (4 clusters) + surface stochastic physics (SPPT)
LBC perturbation	ECMWF ENS (c903)

A-LAEF system specifications.



A-LAEF EPSgram for Bratislava.

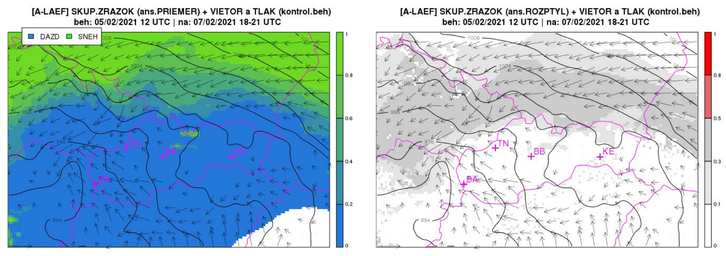
HARP: Statistical verification of T2m for 5 months (Nov 2020 - Mar 2021) for A-LAEF EPS mean (blue), control run (red), perturbed members (grey) and ALADIN/SHMÚ 4.5 km (black), ALARO NH 2 km (orange). Only SK observations are used.



[Courtesy of Martin Petraš]

Products

Different probabilistic maps are generated and published on SHMÚ webpage to cover the needs of general public (http://www.shmu.sk/produkty/nwp/alaef/). Currently, only surface and screen-level parameters are available, but soon the upper-air products will be included. Except that, the A-LAEF probabilistic products are being used by our forecasters. Eventually, they will be utilized as a source of probabilistic information applied to the downstream hydrological models, and even for the commercial sphere as well.



$$M = \frac{\frac{1}{n}\sum_{i=1}^{n} SN_i}{\frac{1}{n}\sum_{i=1}^{n} TP_i} \qquad S = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\frac{SN_i}{TP_i} - \frac{1}{n}\sum_{i=1}^{n}\frac{SN_i}{TP_i}\right)^2}$$

$$\frac{1}{n}\sum_{i=1}^{n} TP_i < 0.1 \rightarrow M = 0$$

M - mean, S - spread
SN - snow, TP - total precipitation

An example of derived probabilistic parameter - Snow fraction (rain=blue, snow=green). A-LAEF ENS mean (left) and ENS spread (right).

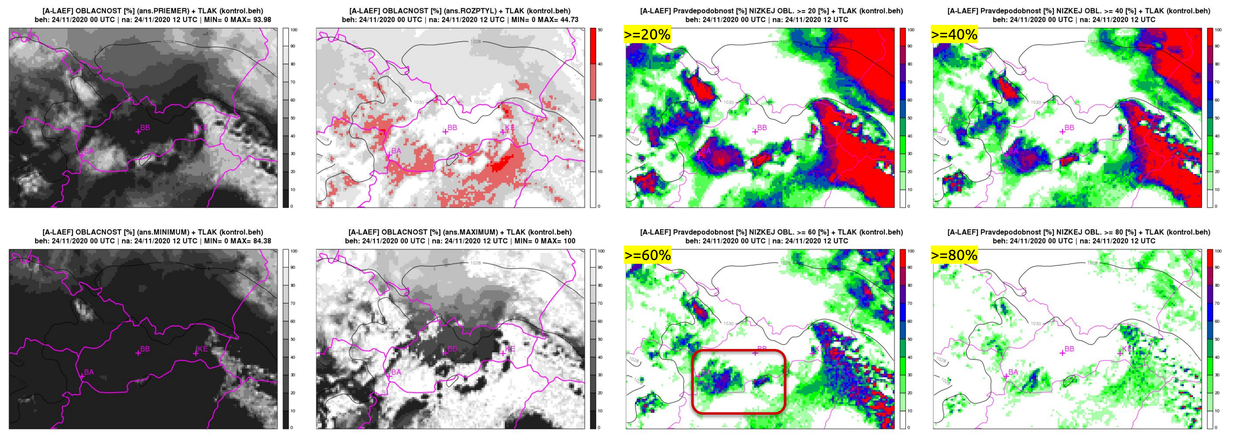
Case studies

Fog situation (24/11/2020)

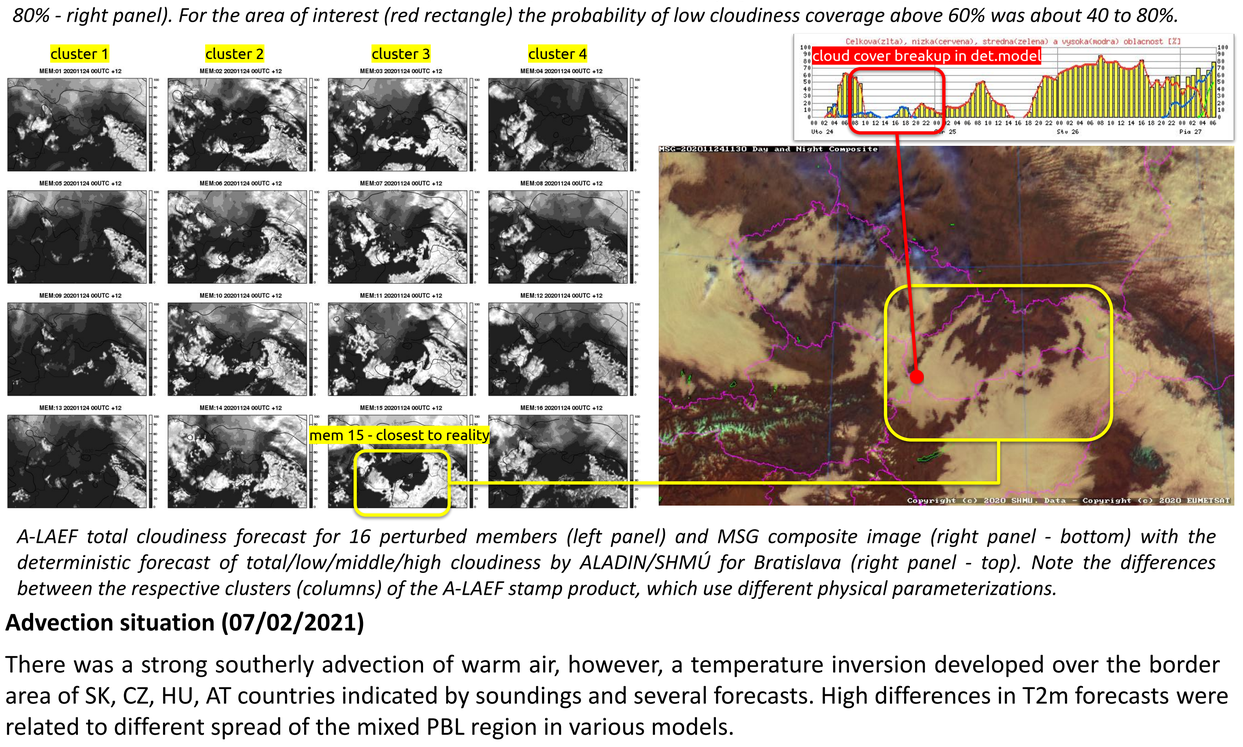
In the anticyclonic situation, the fog was present over large territories and persisted during the whole day over lowlands. The visibility dropped to even less than 100 m at some places (which is relatively rare in Slovakia).

Several NWP models including EPS systems (ECMWF) predicted sunny/relatively warm weather for the noon hours (there should have been a break in the foggy character of previous and later days).

Several members of A-LAEF ensemble also predicted that the cloudiness will vanish, but low cloudiness was still present in many of them. The probability of low cloud cover above 60% (coverage) was still quite high (40-80%).



A-LAEF total cloudiness (EPS mean, spread, min, max - left panel) and probability of low clouds cover for different thresholds (20, 40, 60, 80% - right panel). For the area of interest (red rectangle) the probability of low cloudiness coverage above 60% was about 40 to 80%.

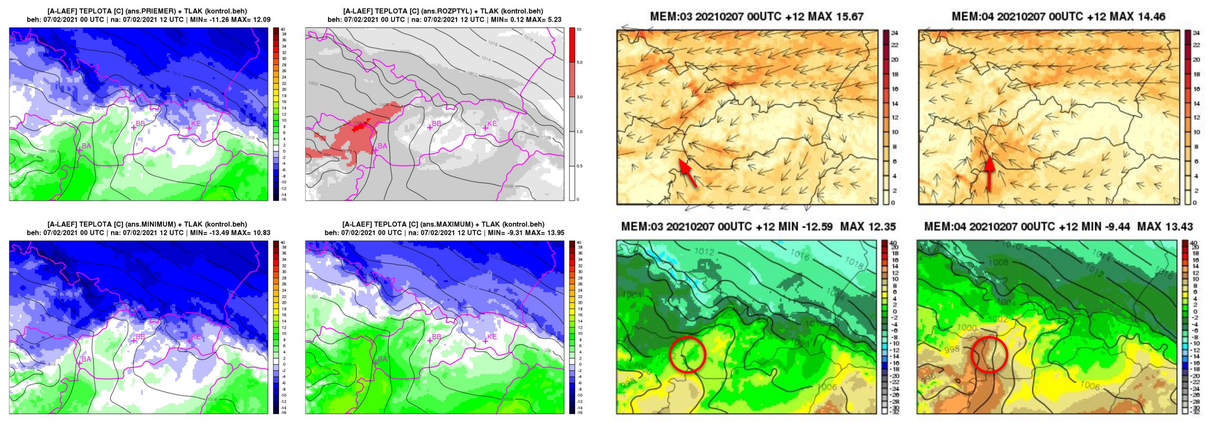


A-LAEF total cloudiness forecast for 16 perturbed members (left panel) and MSG composite image (right panel - bottom) with the deterministic forecast of total/low/middle/high cloudiness by ALADIN/SHMÚ for Bratislava (right panel - top). Note the differences between the respective clusters (columns) of the A-LAEF stamp product, which use different physical parameterizations.

Advection situation (07/02/2021)

There was a strong southerly advection of warm air, however, a temperature inversion developed over the border area of SK, CZ, HU, AT countries indicated by soundings and several forecasts. High differences in T2m forecasts were related to different spread of the mixed PBL region in various models.

Most of the models forecast a "tongue" of warmer air spreading toward North, with different extension. T2m was overestimated by about 10°C in the area of Bratislava. A-LAEF MP clusters 2, 3 (both using QNSE turbulence parameterization with „stable" Geleyn-Cedilnik mixing length) showed significant, systematic improvement compared to clusters 1 and 4 (with the similar setup as our operational deterministic model).



A-LAEF T2m forecast (EPS mean, spread, min, max - left panel) and 10m wind forecast (right panel - top) with T + AT 925 hPa forecast (right panel - bottom) for selected A-LAEF members: 03 (hit) and 04 (miss). The area of interest is denoted by red circle.

Conclusions

A-LAEF system runs operationally as TC2 application on HPCF at ECMWF twice a day since July 2020. The 3-day forecasts based on 00 and 12 UTC network times are being currently disseminated to Slovenia, Slovakia, Romania, Czech Republic, Poland and Turkey (while Croatia is processing the A-LAEF outputs directly at ECMWF site). Despite its rather short operational period it proved already several times, that there is a clear added value over the deterministic models run at SHMÚ with similar setup based on ALARO physics (even the NH one on higher resolution). The benefit was naturally observed for the extreme weather situations, where the uncertainty of the forecast is high. Furthermore, it turned out that the multi-physics clusters of A-LAEF system can be successfully used for the evaluation and understanding of the deterministic model behaviour at some special situations.

Referencies

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