Aire Limitée Adaptation dynamique Développement InterNational - Limited Area Ensemble Forecasting (**ALADIN-LAEF**)

LACE nwp central europe

Data assimilation | Physics | Dynamics | Predictability

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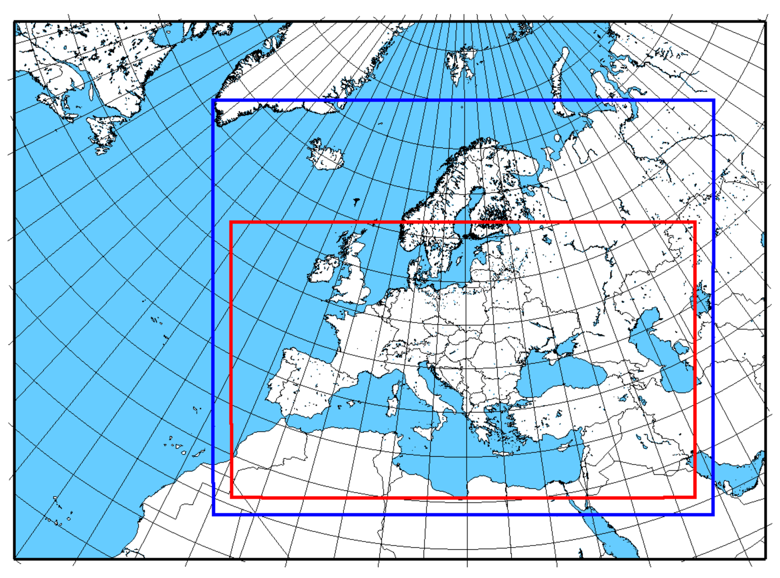
Abstract

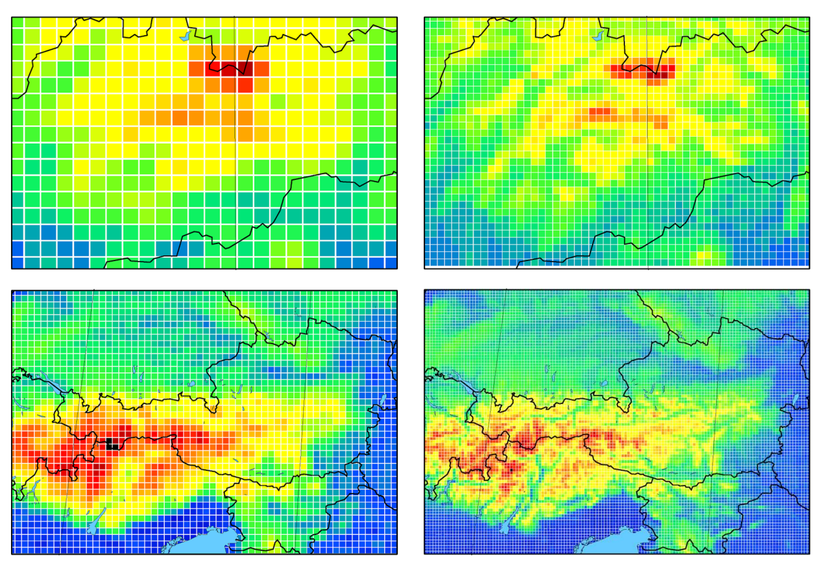
A meso-scale ensemble system ALADIN-LAEF based on the limited area model ALADIN has been developed in frame of RC LACE cooperation, focusing on short range probabilistic forecast and profiting from advanced multi-scale ALARO physics. Its main purpose is to provide forecast on daily basis for the national weather services of RC LACE partners who could not achieve that on their own. It also serves as a reliable source of probabilistic information applied further into the downstream models of hydrology, energy industry and even in the nowcasting.

Introduction

ALADIN-LAEF became operational in 2011, at that time having horizontal resolution of 18 km and 37 vertical levels. In 2013 the first substantial upgrade was made, containing the increase of horizontal and vertical resolutions to 11 km and 45 vertical levels, geographically bigger computational domain and new ensemble of surface data assimilations involving perturbed screen-level conventional observations. Nowadays, the ALADIN-LAEF system faces its further enhancement going towards even finer resolutions (5 km / 60 levels) and implementing several other upgrades.



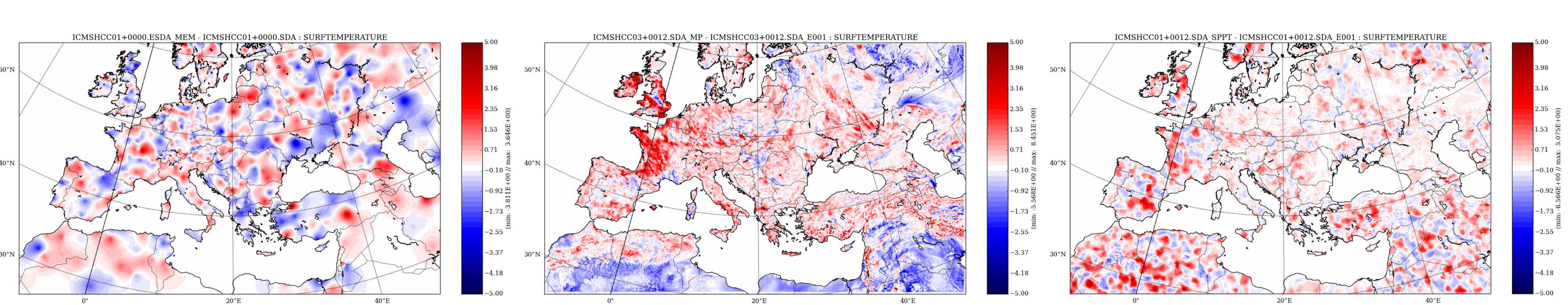
Current ALADIN-LAEF domain (blue) and upcoming domain after upgrade to 5 km horizontal resolution (red).



Model orography for current 11 km grid (left) and new 5 km resolution (right). Tatra mountains in northern part of Slovakia (first row) and Austrian Alps (second row).

Initial condition perturbation

The surface and soil prognostic fields uncertainty in the ICs of ALADIN-LAEF system is simulated by the ensemble of surface data assimilations (ESDA). This method replaced the former Non-Cycling Surface Breeding, which combined short-range surface forecasts driven by perturbed atmospheric forcing and the breeding method for generating the perturbations on surface ICs. The current ESDA method is based on the ALADIN surface data assimilation CANARI which randomly perturbs the observations. The uncertainty of the upper-air part of the ICs used in ALADIN-LAEF system is currently simulated by the breeding-blending cycle. It combines the large-scale perturbations provided by driving global ensemble (ECMWF ENS), with the small-scale perturbations generated by ALADIN-LAEF breeding vectors within the pseudo-assimilation cycle. The upper-air spectral blending by digital filter initialization is used, profiting from the spectral character of ALADIN model. However, an obvious disadvantage of such method is the absence of local measurements for the atmosphere. Therefore, the implementation of the ENS BlendVar procedure is undergoing, to obtain more truthful control analysis and consequently the perturbed members with less initial bias. It consists of the ensemble of 3D-Var assimilations and the upper-air spectral blending. The novelty of ENS BlendVar utilization within the LAM EPS is being in its method for generating the background error statistics (B-matrix).



Surface temperature perturbation by ESDA method (left), multi-physics (middle) and stochastic perturbation of physics tendencies (right).

Model perturbation

The ensemble system ALADIN-LAEF has undergone many changes and upgrades within the couple of years of its existence. The model uncertainty is now simulated by several combinations of different micro-physics, deep and shallow convection, radiation and turbulence schemes. It largely profits from the multi-scale properties of used ALARO-1 physics. The stochastic perturbation of physics tendencies is another approach which has been successfully tested in order to enhance the model uncertainty simulation (for the surface prognostic variables as well as for the upper-air), and it will enter the new operational version soon.

Lateral boundary perturbation

The ALADIN-LAEF system is driven by the global ECMWF ENS. 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. This natural choice for the LBCs perturbation is not only because of the similarity in model physics and dynamics among the ECMWF IFS and ALADIN, but also because of the quality of ECMWF forecasts and their operational availability.

ALADIN-LAEF	current	new
Code version	cy36t1	cy40t1
Horizontal resolution	10,9 km	4,8 km
Vertical levels	45	60
Number of grid points	500x600	750x1250
Grid	quadratic	linear
Time step	450 s	180 s
Forecast length	72 h (00/12 UTC)	72 h (00/12 UTC)
Members	16+1	16+1
IC perturbation	ESDA [surface], breeding-blending [upper-air]	ESDA [surface], blending (Phase I) / ENS BlendVar (Phase II) [upper-air]
Model perturbation	ALARO-0 multi-physics	ALARO-1 multi-physics + surface SPPT
LBC perturbation	ECMWF ENS	ECMWF ENS
SBUs consumed per year	~10 mil	~120 mil

ALADIN-LAEF system specifications for current and new version (new version is expected to become operational till the end of 2018).

ESDA

$$\Delta T_s = \Delta T_{2m} \qquad \Delta W_s = \alpha_s^T \Delta T_{2m} + \alpha_s^H \Delta H_{2m}$$

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

BLENDING

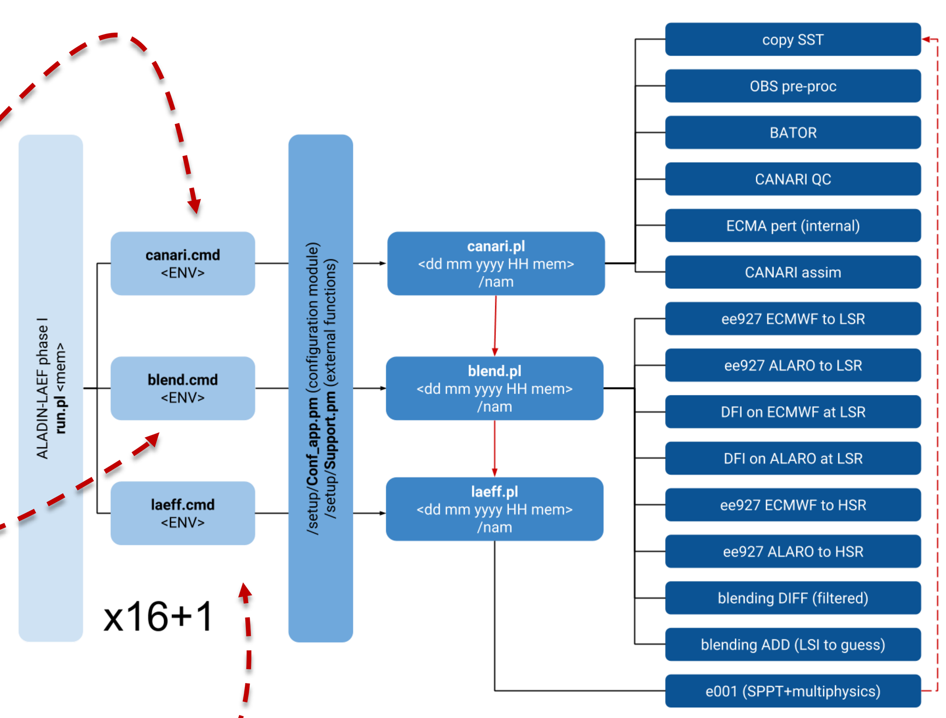
$$IC_{blend}^n = a_{breed}^n + \{ \overline{(a_{sv}^n)_{trunc}} - \overline{(a_{breed}^n)_{trunc}} \}$$

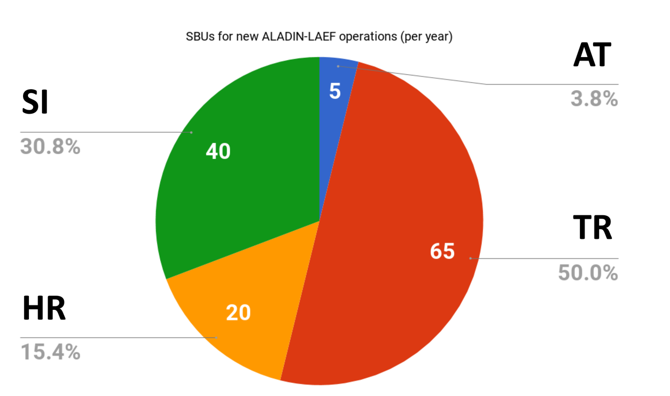
$$IC_{blend}^n = LS^n + a_{breed}^n$$

SPPT+MP

$$\frac{\partial e_j}{\partial t} = A(e_j,t) + P'(e_j,t)$$

$$P'_j(e_j,t) = (1 + r_j(\lambda,\varphi,t)_{D,T}) P_j(e_j,t)$$

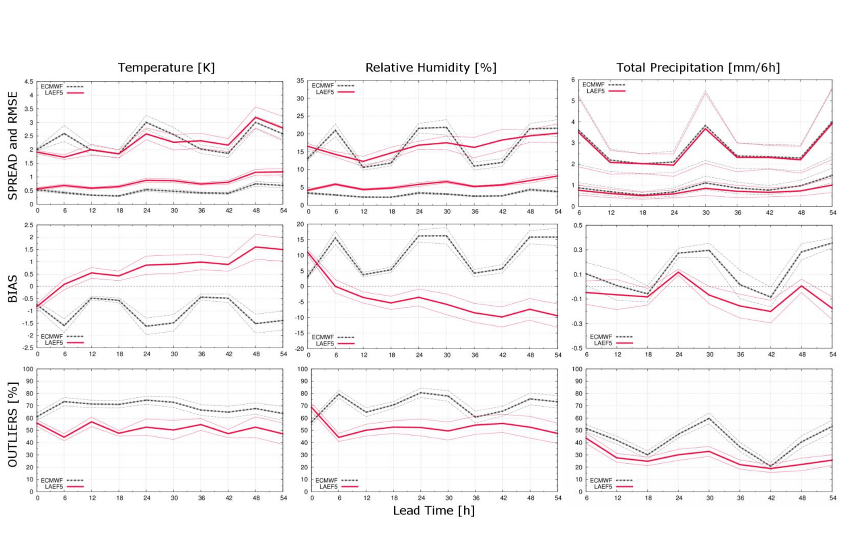




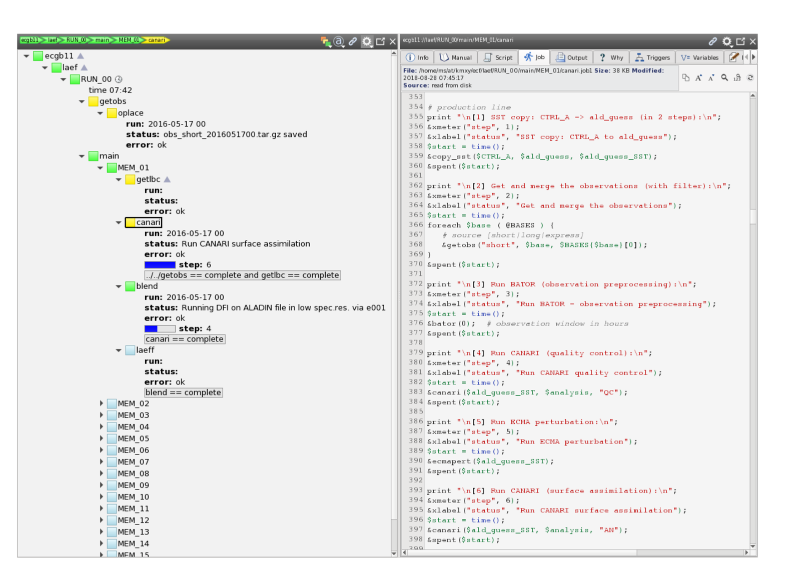
The scripting system of new ALADIN-LAEF Phase I configuration (up) and agreed distribution of billing units necessary for its operations at ECMWF HPS among the LACE partners and cooperating Turkey (right).

Conclusions

The ALADIN-LAEF system runs operationally on High Performance Computer Facility at ECMWF twice a day with the integration starting at 00 and 12 UTC going up to 72 hours. The ensemble consists of 1 unperturbed control run and 16 perturbed members involving initial condition (IC) uncertainty, model error simulation and coupling to perturbed lateral boundary conditions rendered by ECMWF ENS. Till the end of 2018 its upgrade to Phase I is planned, followed by Phase II upgrade later in 2019 (for system specifications please see the table above).



Scores of screen level temperature, relative humidity and 6-hourly total precipitation versus forecast lead time, calculated against SYNOP observations for ECMWF ENS downscaling (black) and new ALADIN-LAEF Phase I (red). Thin lines denote 10% and 90% confidence intervals.



New ALADIN-LAEF suite (Phase I) under the ecFlow environment. Suite definition file is generated by Python code, while all tasks, include files and configuration modules are written in Perl.

Publications

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