Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
nwp central europe

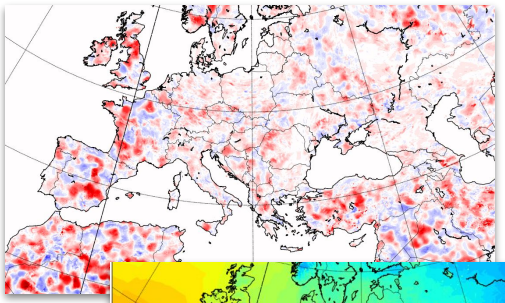
LAM-EPS activities in LACE

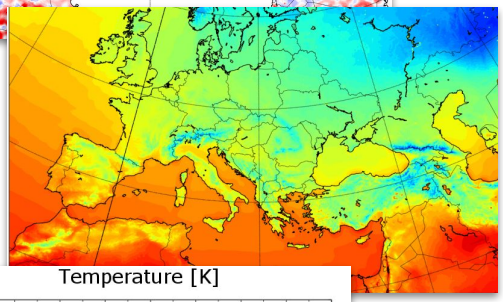
Martin Belluš with contributions of M. Szűcs, M. Dian, Ch. Wittmann, F. Weidle, Y. Wang, C. Wastl, S. Taşcu, R. Pomaga, Iris Odak Plenković and E. Keresturi

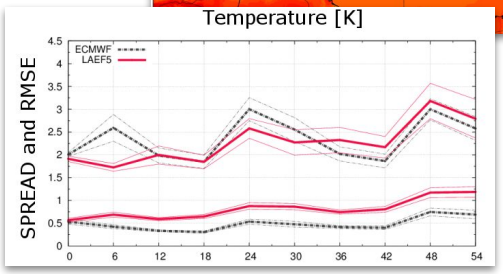
DHMZ SHMU ARSO METEO Slovenia OMSZ ZAMG ROMANIA ANM

Overview of activities since last AHW

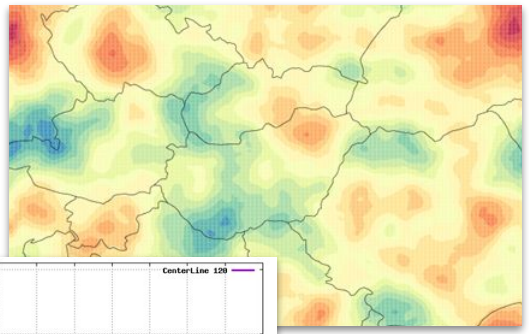
ALADIN-LAEF

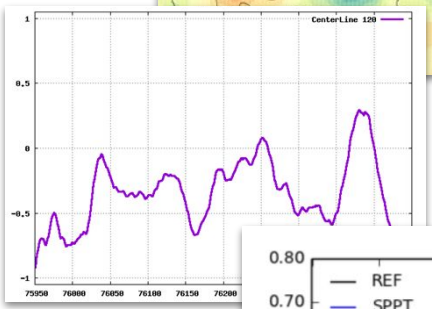


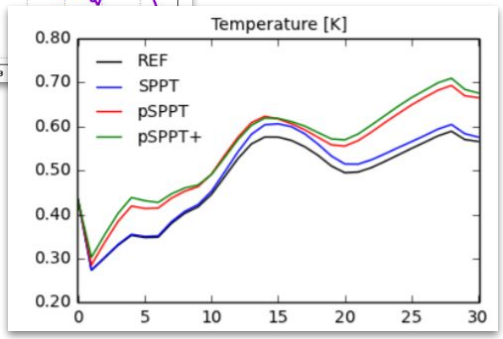




AROME-EPS







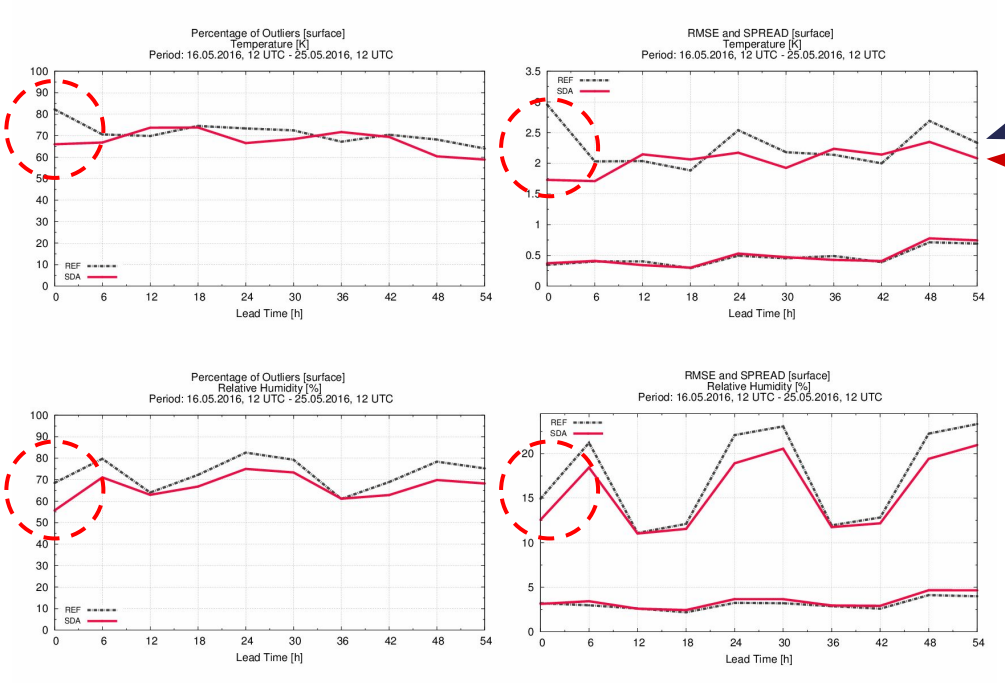
ALADIN-LAEF

Subjects:

- coupling issue (solved)
- phase I configuration
- phase I scores
- phase I operations

ALADIN-LAEF - coupling issue

Formerly used configuration 901 can not be applied to convert the IFS gribs to ALADIN FA files, new IFS geometry is not supported. GL tool can be used but it has limitations considering the vertical interpolations [combination with ee927 is possible]. Moreover, there was a hidden bug regarding SFC temperature interpolation (sea + land) [assim cycle can be used, but for DADA devastating].



downscaled LBCs (ref)

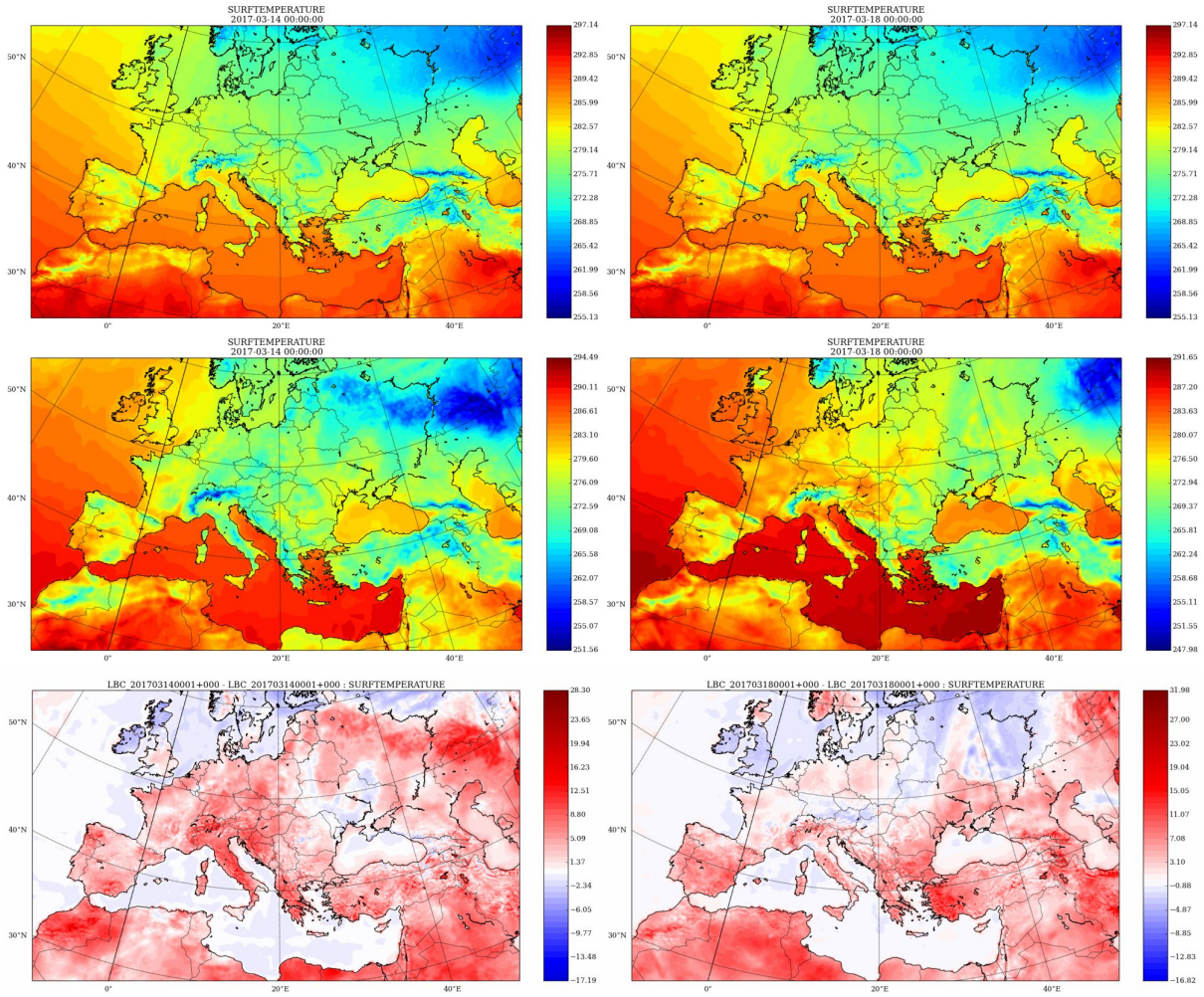
SDA (exp)

Temperature (up) and relative humidity (bottom) verification scores for the period of 10 days from 16 to 25 May 2016, 12 UTC run of the full LAEF ensemble (16 members). The percentage of outliers (left) and RMSE of the ensemble mean with ensemble spread (right) are shown for the reference (downscaled ECMWF LBCs, black dashed) and surface data assimilation experiment (SDA, red).

ALADIN-LAEF - coupling issue (solved)

There were two fixes applied to the GL tool (kudos to Ulf Andrae):

- surface fields interpolation (*ala/intp_ecmwf_surface.f90*)
- data extrapolation to e.g. deep fjords not visible in ECMWF (*grb/fill_missing.f90*)



SST/LST initial conditions for 2 different days of March 2017 (left and right) produced with bugged version of interpolation tool in the first row and fixed one in the second row. The impact on SST/LST field is rather huge (shown in the third row as a difference between the first two).

ALADIN-LAEF - phase I configuration

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:

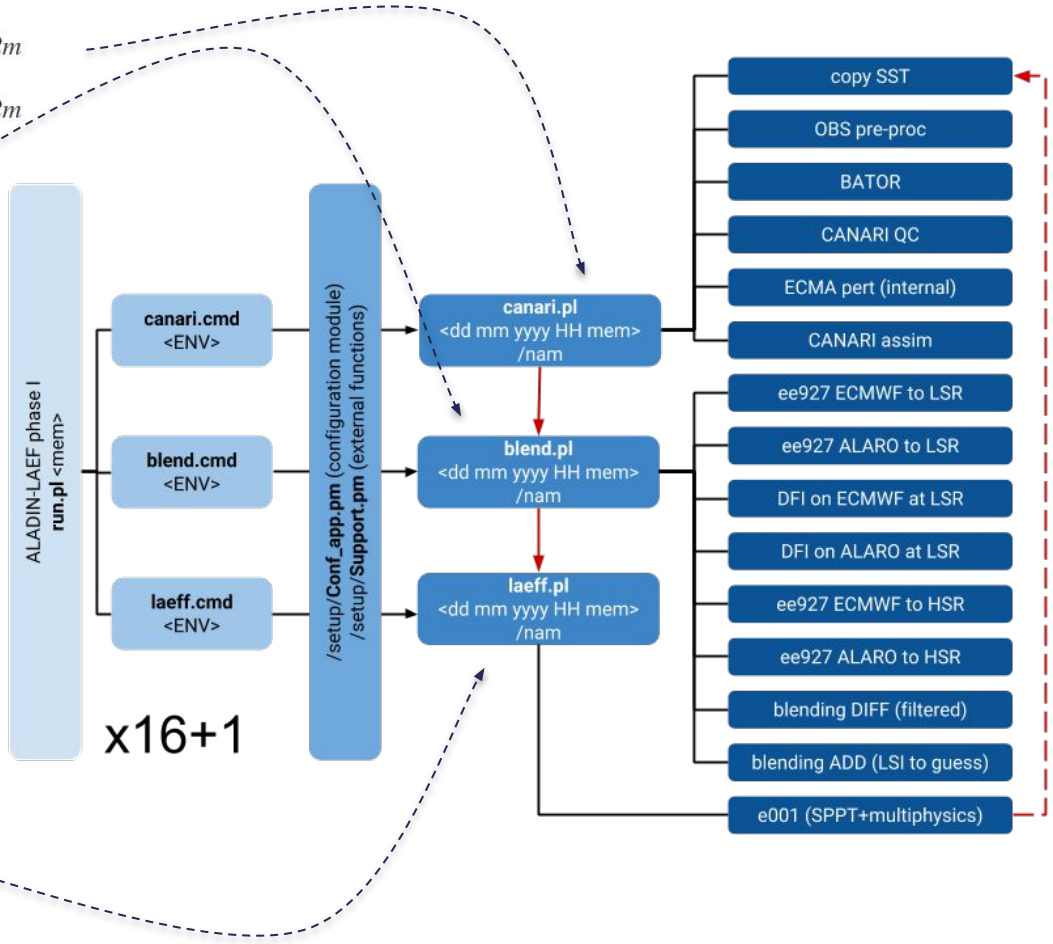
$$IC^n_{blend} = a^n_{breed} + \{ \overline{(a^n_{sv})_{trunc}} - \overline{(a^n_{breed})_{trunc}} \}$$

$$IC^n_{blend} = LS^n + a^n_{breed}$$

SPPT + MP:

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

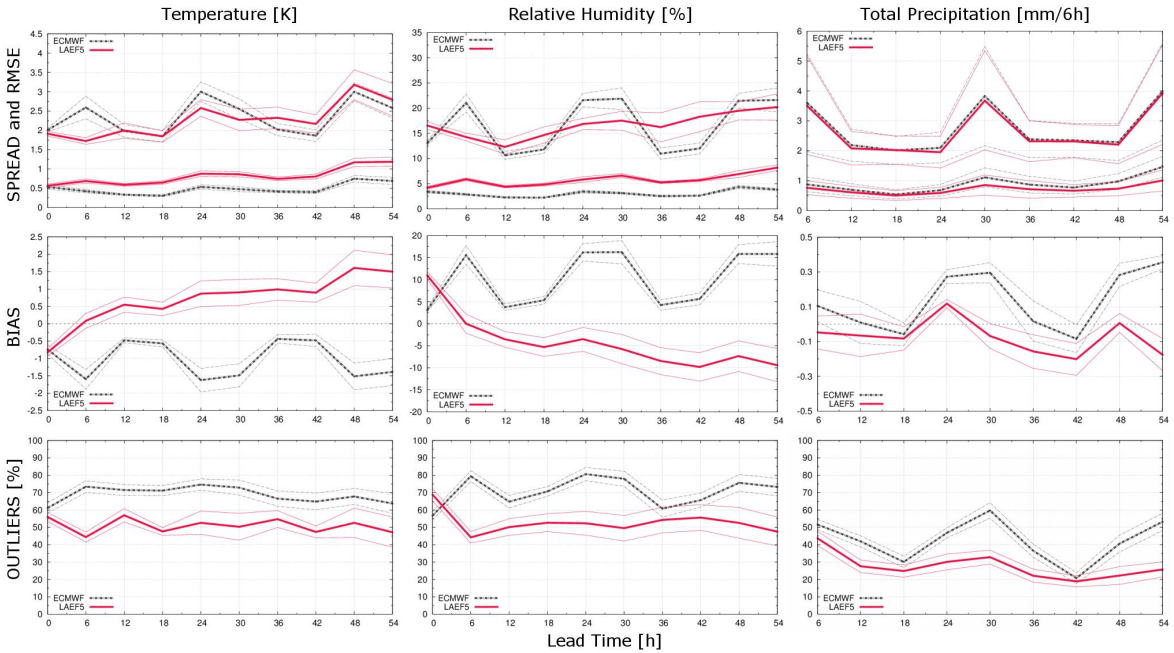
$$P'_j(e_j, t) = (1 + r_j(\lambda, \varphi, t)_{D,T}) P_j(e_j, t)$$



ALADIN-LAEF - phase I scores

The added value of new ALADIN-LAEF over the downscaled ECMWF ENS is obvious for the surface parameters, while it is rather neutral in the upper-air.

surface

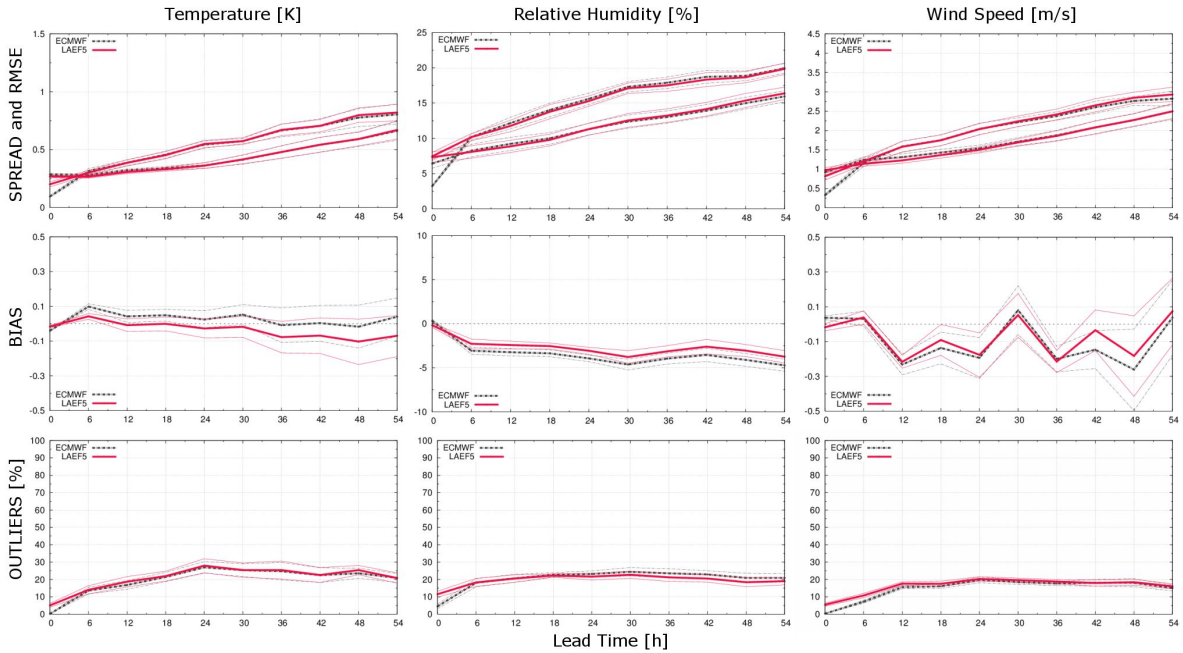


ALADIN-LAEF phase I (red lines) and ECMWF-EPS downscaling (gray dashed lines) for surface parameters. The thin lines denote 10% and 90% confidence intervals for given experiment.

ALADIN-LAEF - phase I scores

The added value of new ALADIN-LAEF over the downscaled ECMWF ENS is obvious for the surface parameters, while it is rather neutral in the upper-air.

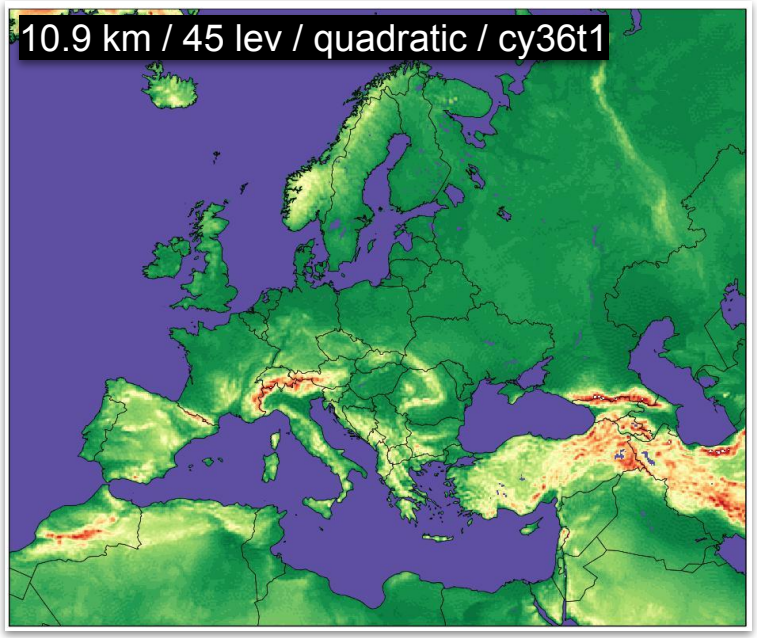
500 hPa



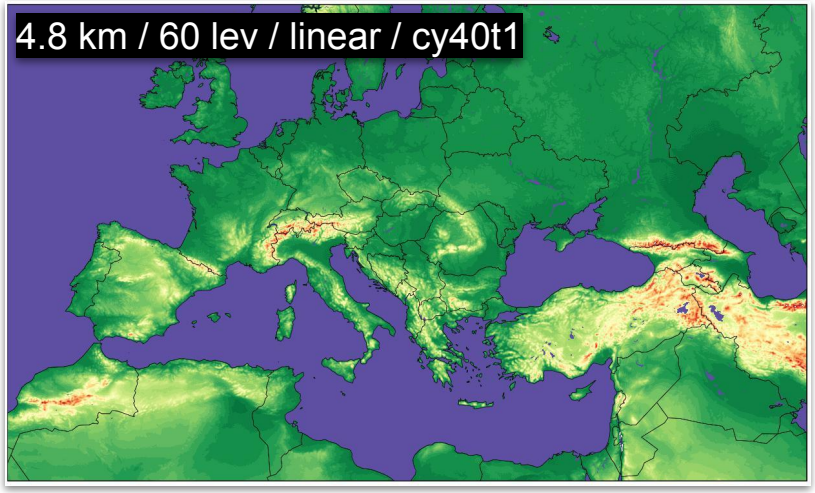
ALADIN-LAEF phase I (red lines) and ECMWF-EPS downscaling (gray dashed lines) for 500 hPa parameters. The thin lines denote 10% and 90% confidence intervals for given experiment.

ALADIN-LAEF - phase I operations

current



new

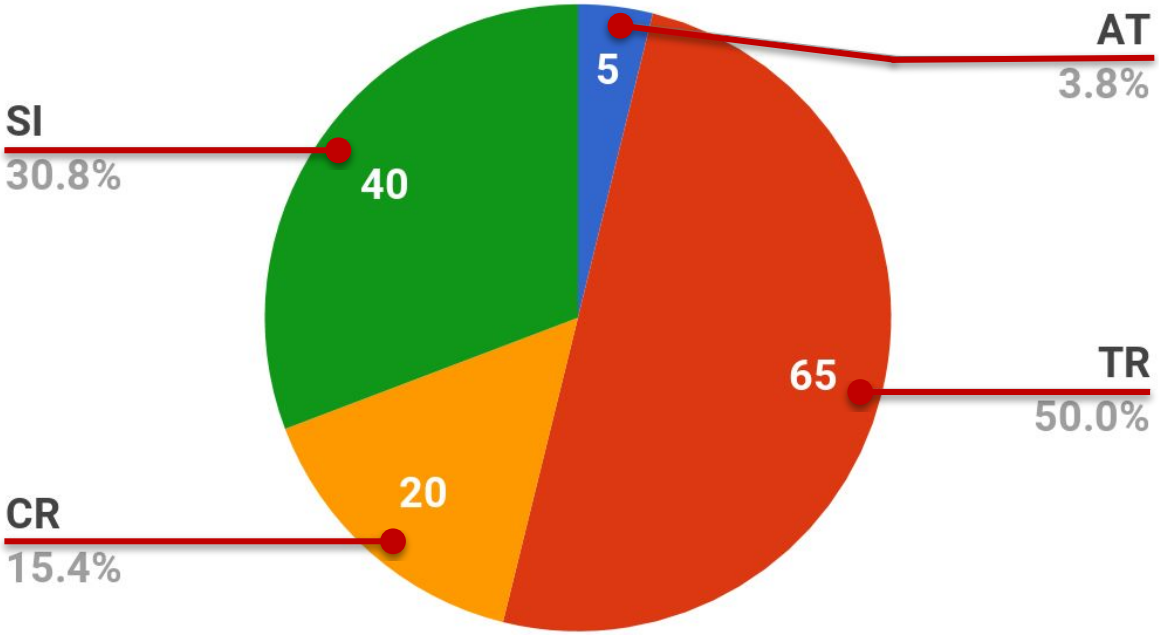


new ALADIN-LAEF

- phase I: ESDA+Blend (IC); SPPT+ALARO-1 MP (model)
- phase II: ENS BlendVar (IC)

ALADIN-LAEF - phase I operations

New ALADIN-LAEF on 5 km with 60 vertical levels (and new physics) becomes too expensive regarding the billing units despite its reduced computational domain, that it is not any more possible to have it operational under the austrian account at ECMWF HPCF. Its cost in comparison with the current system is about 12-times higher (130 Mio SBUs per year).



SBUs for new ALADIN-LAEF operations at ECMWF HPCF (values in Mio per year).

AROME-EPS

Subjects:

- AROME-EPS in LACE countries
- new SPG
- partial model tendencies perturbation
- parameter perturbation
- Jk 3DVar for IC perturbation

AROME-EPS - in LACE countries

new HPC soon (May 2018)

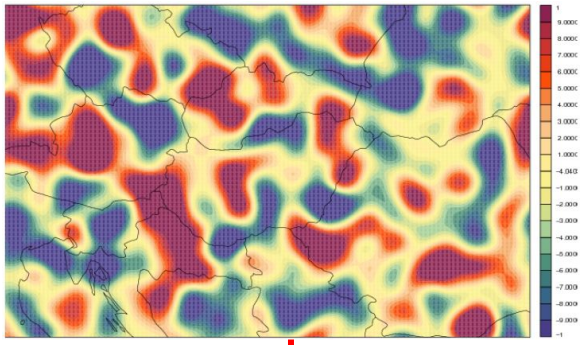
- high resolution AROME-EPS with more members
- EDA and SPPT
- combination of members from different runs is considered (lagged)

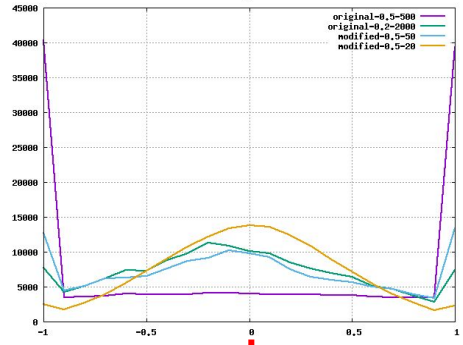
new HPC since October 2017

- not sufficient for their convection-permitting EPS
- C-LAEF (based on AROME 2.5 km) will be executed at ECMWF cluster
- partial tendencies perturbation
- parameter perturbation scheme
- Jk-3DVar method for IC

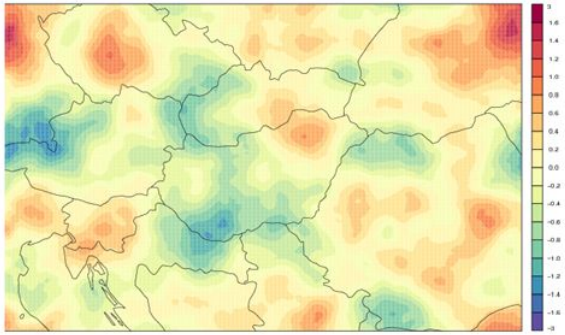
AROME-EPS - new SPG

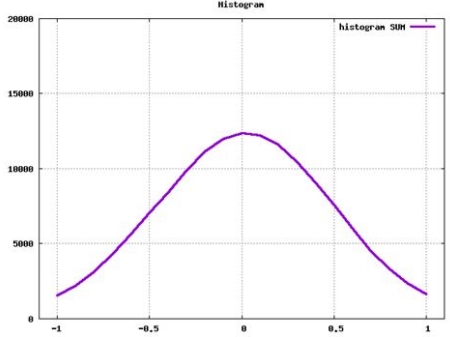
The main disadvantage of original pattern generator is that exactly the same time correlation belongs to all the spatial scales. New SPG allows model errors to be represented at various scales. Larger spatial scales are associated with larger temporal scales (and vice-versa). Pattern features are correctly tunable by the namelist values and statistical distribution of RND numbers corresponds to the Gaussian distribution (which is not true for original generator applied on LAM domain).





original SPG





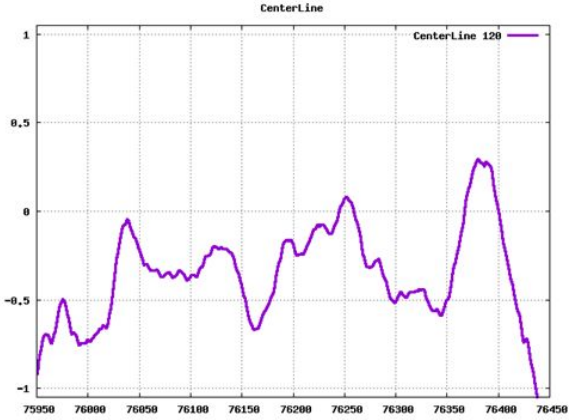
new SPG

Random field generated by SPG (in ALADIN code implementation) for Hungarian AROME domain (left) and the statistical distribution of random numbers (right).

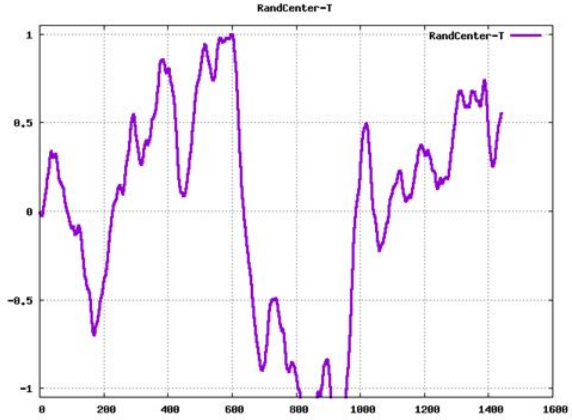
AROME-EPS - new SPG

The main disadvantage of original pattern generator is that exactly the same time correlation belongs to all the spatial scales. New SPG allows model errors to be represented at various scales. Larger spatial scales are associated with larger temporal scales (and vice-versa). Pattern features are correctly tunable by the namelist values and statistical distribution of RND numbers corresponds to the Gaussian distribution (which is not true for original generator applied on LAM domain).

spatial variability



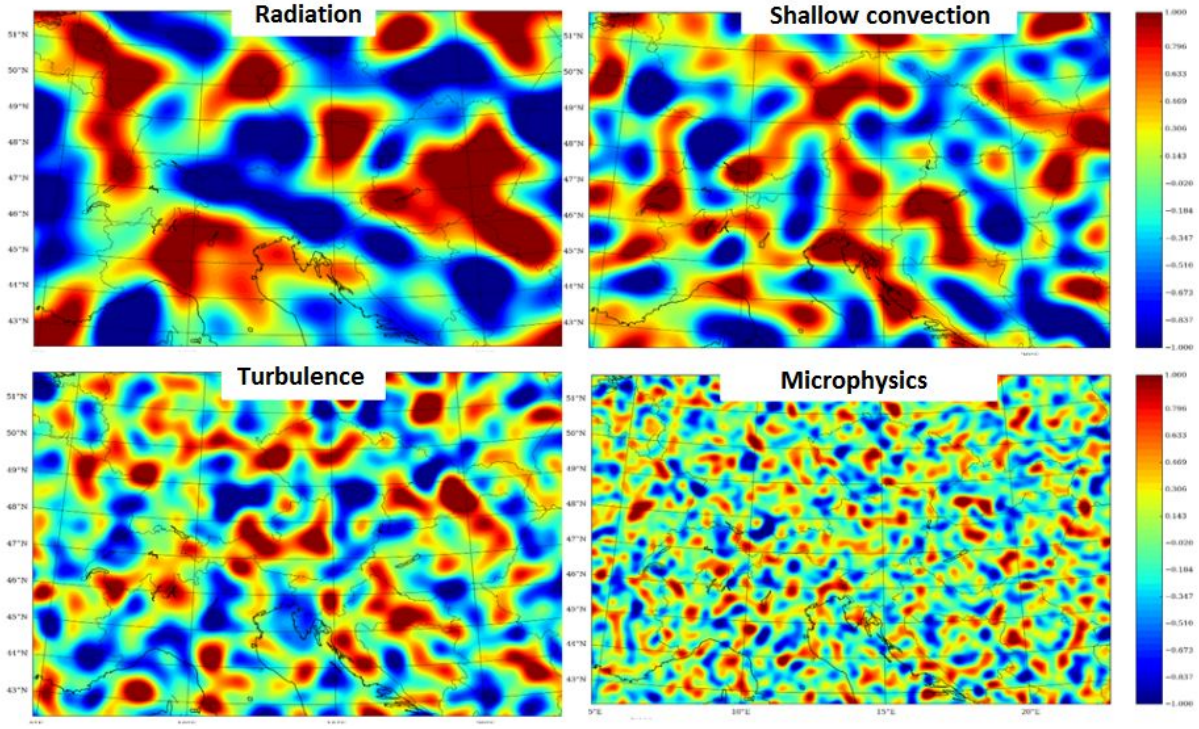
temporal variability



An x-oriented cross-section of the random pattern generated by SPG in ALADIN code implementation (left) and the time evolution of the random value of a given gridpoint in the center of the domain (right).

AROME-EPS - partial model tendencies perturbation

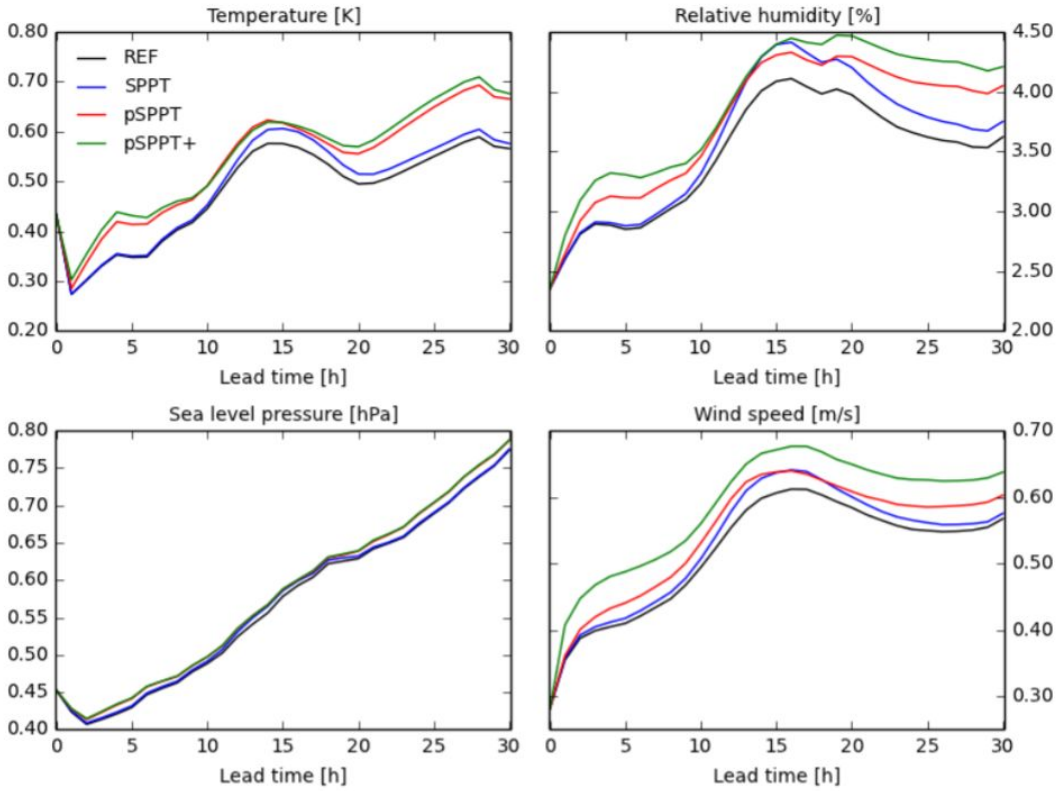
The tendencies (T, q, u, v) of radiation, turbulence, shallow convection and microphysics are perturbed separately using separate random patterns for each. Not only the seed is changed, but also the spatial and temporal scales are adapted for the different parameterizations.



Different perturbation patterns with adapted scales for given physics schemes in AROME.

AROME-EPS - parameter perturbation

As a next step the former partial tendency approach for shallow convection, radiation and microphysics was combined with the parameter perturbation in turbulence. The key parameters like mixing length, autoconversion threshold, dissipation of TKE, critical Richardson number, etc. are perturbed by using different stochastic patterns with predefined scales according to the uncertainty range of the parameters (consulted with Meteo-France).



pSPPT+ (partial + param.)
pSPPT (partial tendency)
SPPT (classic)
REF (no SPPT)

Ensemble spread averaged over July 2016 and January 2017 for 4 different C-LAEF experiments. REF is an ensemble without any stochastic physics, SPPT is the original ECMWF approach where total tendencies are perturbed, pSPPT is a partial tendency approach and pSPPT+ is a combination of pSPPT and parameter perturbation for the turbulence scheme.

AROME-EPS - Jk 3DVar for IC perturbation

The general idea is similar to spectral blending but technically different. The goal is to include global model information directly into LAM variational assimilation. It is achieved by combination of large scale (GM-EPS) with small scale (LAM-EPS) perturbations. As a result the IC and LBC perturbations are also more consistent.

Cost function (3DVar):

$$J(x) = \underbrace{\frac{1}{2}(x - x_b)^T B^{-1}(x - x_b)}_{J_b} + \underbrace{\frac{1}{2}(y - Hx)^T R^{-1}(y - Hx)}_{J_o}$$

Cost function in Jk blending method:

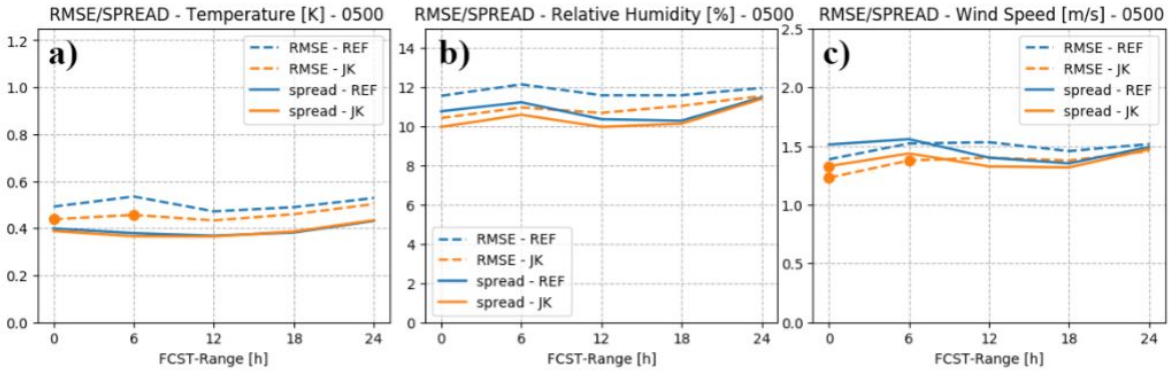
$$J(x) = J_b + J_o + \underbrace{\frac{1}{2}(x - x_{ls})^T V^{-1}(x - x_{ls})}_{J_k} = J_b + J_o + J_k$$

Large scale perturbations.

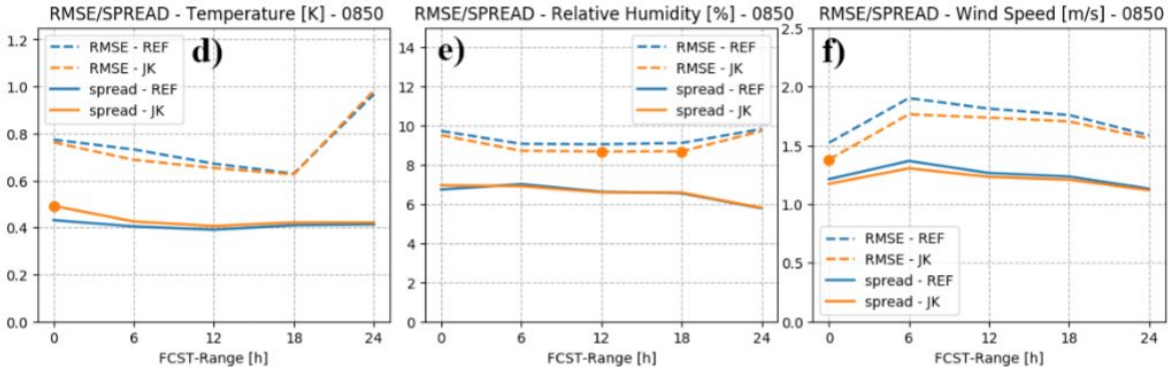
AROME-EPS - Jk 3DVar for IC perturbation

(Endi's PhD)

500 hPa



850 hPa



REF (3DVar without Jk)

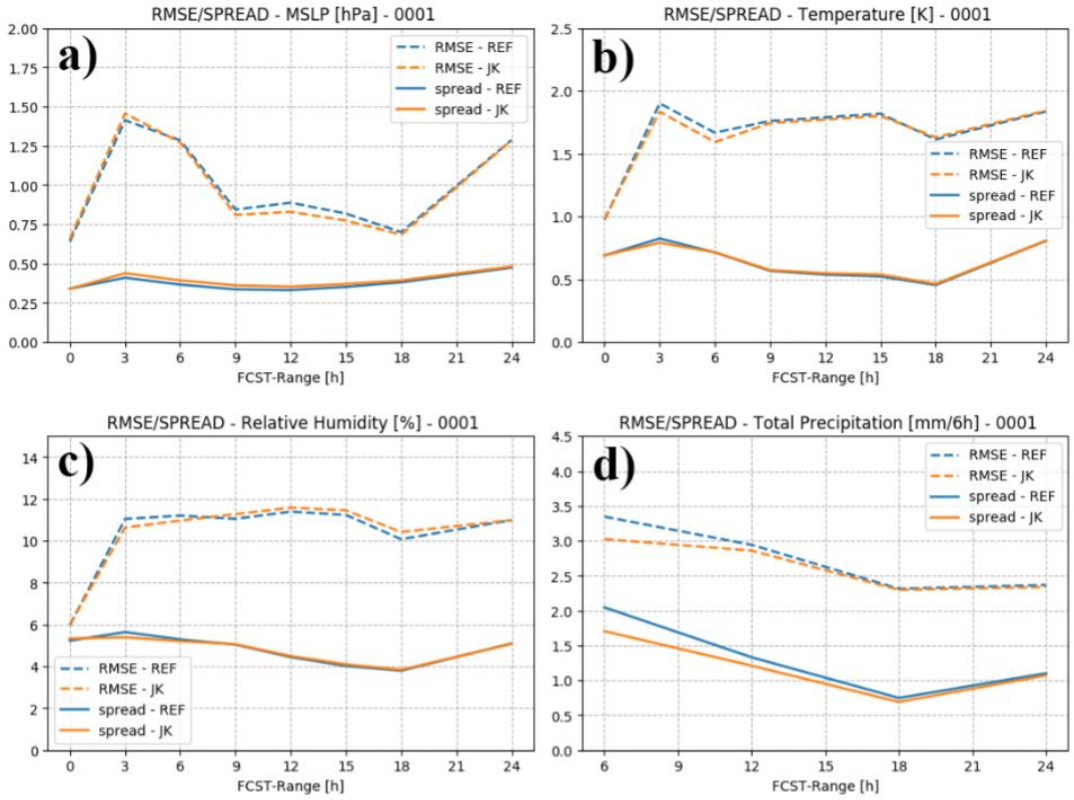
Jk (3DVar with Jk)

RMSE of ensemble mean (dashed) and ensemble spread (solid) of REF (AROME-EPS with 3DVar without Jk term) - blue and Jk - orange for (a) T500; (b) RH500; (c) W500; (d) T850; (e) RH850 and (f) W850. The verification period is July 2016. Forecast ranges with statistically significant differences are marked with a bullet symbol.

AROME-EPS - Jk 3DVar for IC perturbation

(Endi's PhD)

surface



REF (3DVar without Jk)

Jk (3DVar with Jk)

RMSE of ensemble mean (dashed) and ensemble spread (solid) of REF (AROME-EPS with 3DVar without Jk term) - blue and Jk - orange for (a) MSLP; (b) T2M; (c) RH2M and (d) RR06. The verification period is July 2016. Forecast ranges with statistically significant differences are marked with a bullet symbol.

Publications

Published papers:

- Wang Y., M. Belluš, A. Ehrlich, M. Mile, N. Pristov, P. Smolíková, O. Španiel, A. Trojáková, R. Brožková, J. Cedilnik, D. Klarić, T. Kovačić, J. Mašek, F. Meier, B. Szintai, S. Tascu, J. Vivoda, C. Wastl, Ch. Wittmann, 2017: "**27 years of Regional Co-operation for Limited Area Modelling in Central Europe (RC LACE)**", published online on 26 January 2018 in BAMS, DOI: 10.1175/BAMS-D-16-0321.1

- Ihász I., A. Mátrai, B. Szintai, M. Szűcs, I. Bonta, 2017: "**Application of European numerical weather prediction models for hydrological purposes**", published in Időjárás on January 2018, DOI: 10.28974/idojaras.2018.1.5

Submitted papers:

- Keresturi E., Y. Wang, F. Meier, F. Weidle, Ch. Wittmann, 2018: "**Improving initial condition perturbations in a convection permitting ensemble prediction system**", submitted to Quarterly Journal of the Royal Meteorological Society

Publications

RC LACE stay reports (available online):

- Martin Dian, 2017: ***Supersaturation problem in models with SPPT***, Report on stay at ZAMG, 27/03~21/04, 2017, Vienna, Austria
- Martin Belluš, 2017: ***IC and model perturbations for new ALADIN-LAEF***, Report on stay at ZAMG, 24/04~19/05, 2017, Vienna, Austria
- Mihály Szűcs, 2017: ***Implementation of Stochastic Pattern Generator (SPG) in ALADIN code***, Report on stay at ZAMG, 12/06~21/07, 2017, Vienna, Austria
- Raluca Pomaga, 2017: ***Revision of ALADIN-LAEF multiphysics and its combination with SPPT***, Report on stay at ZAMG, 10/07~04/08, 2017, Vienna, Austria
- Simona Taşcu, 2017: ***Revision of LAEF multiphysics***, Report on stay at ZAMG, 10/07~14/07, 2017, Vienna, Austria
- Martin Belluš, 2017: **New ALADIN-LAEF phase I**, Report on stay at ZAMG, 16/10~10/11, 2017, Vienna, Austria
- Iris Odak Plenković: **Work on analog-based post-processing method (I)**, Report on stay at ZAMG, 13/11~09/12, 2017, Vienna, Austria
- Iris Odak Plenković: **Work on analog-based post-processing method (II)**, Report on stay at ZAMG, 02/02~03/03, 2018, Vienna, Austria

Outlook

Main goal:

- make ALADIN-LAEF phase I operational at ECMWF HPCF

Current topics:

- parameter and/or process-based stochastic physics perturbation
- ENS BlendVar within ALADIN-LAEF (phase II)
- experiments with flow-dependent B-matrix
- 3D SPG for vertical structure of random patterns
- non-Gaussian noise distribution
- drying effect when stochastic physics is used
- convection-permitting ensembles (C-LAEF at 2.5 km)

Thank you for your attention!