Regional Cooperation for
Limited Area Modelling in Central Europe

LACE
nwp central europe

LAM-EPS activities in LACE

Clemens Wastl with contributions of RC LACE partners

DHMZ SHMU ARSO METEO Slovenia OMSZ IMGW ZAMG ROMANIA ANM

Operational ensembles

	A-LAEF	C-LAEF	AROME-EPS
CMC	ALARO	AROME	AROME
Code version	cy40t1	cy43t2	cy43t2
Horizontal resolution	4.8 km	2.5 km	2.5 km
Vertical levels	60	90	60
Runs per day	2	8	1
Forecast length	+72h (00/12 UTC)	max. +60h (00 UTC)	+48h (00 UTC)
Members	16+1	16+1	10+1
Assimilation cycle	yes (12h)	yes (3h)	-
Coupling	ECMWF ENS (6h)	ECMWF ENS (1h)	ECMWF ENS (1h)
IC perturbation	ESDA [surface], spectral blending/DFI [upper-air]	ESDA [surface], EDA, Ensemble-JK [upper-air]	-
Model perturbation	ALARO-1 multi-physics + surface stochastic physics (SPPT)	hybrid stochastic scheme comb. of parameter and tendency perturbations	-
LBC perturbation	ECMWF ENS (c903)	ECMWF ENS (c903)	ECMWF ENS (c903)

A-LAEF (LACE)

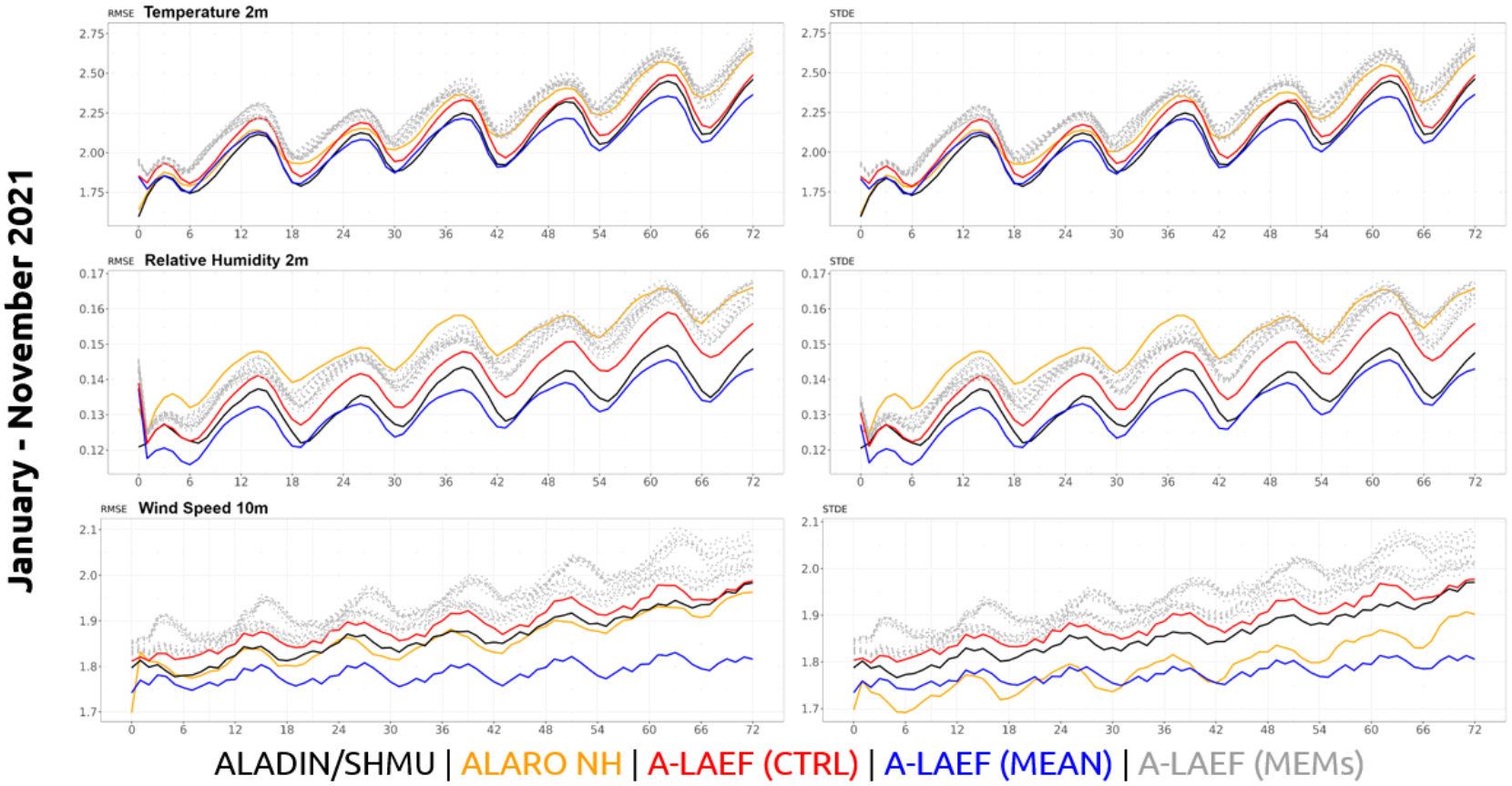
A-LAEF work in 2021:

- **Operational activities**
  - added Mediterranean Sea domain (MSEA) for ocean models coupling - NEMO, SHYFEM
  - upgrade of ECMWF-ENS coupling files to cy47r2 (L91 => L137 for ENS) in May 2021, to cy47r3 in October 2021
  - OBS backup implemented (using GTS data generated at SHMU and uploaded to OPLACE)
  - A-LAEF GRIBs dissemination optimization, scripts for archiving to ECFS, CZ/TR fullpos optimization
  - upgrade of ECMWF software packages (eccodes, cdo, ecflow)

- **Research & Development**
  - precipitation phase calculation from EPS data
  - implementation and testing of incremental DFI step in spectral blending procedure
  - upgrade of obsoul_merge tool (v07) - added whitelisting, zipped files support, strict formatting mandatory since cy46
  - development of A-LAEF EPSgrams for RC LACE webpage using Perl/R
  - preparation of A-LAEF export version and organization of online training
  - work on gridded analog-based post-processing for gridded forecasts
  - integration of full A-LAEF domain on new NEC HPC@SHMU

A-LAEF (LACE)

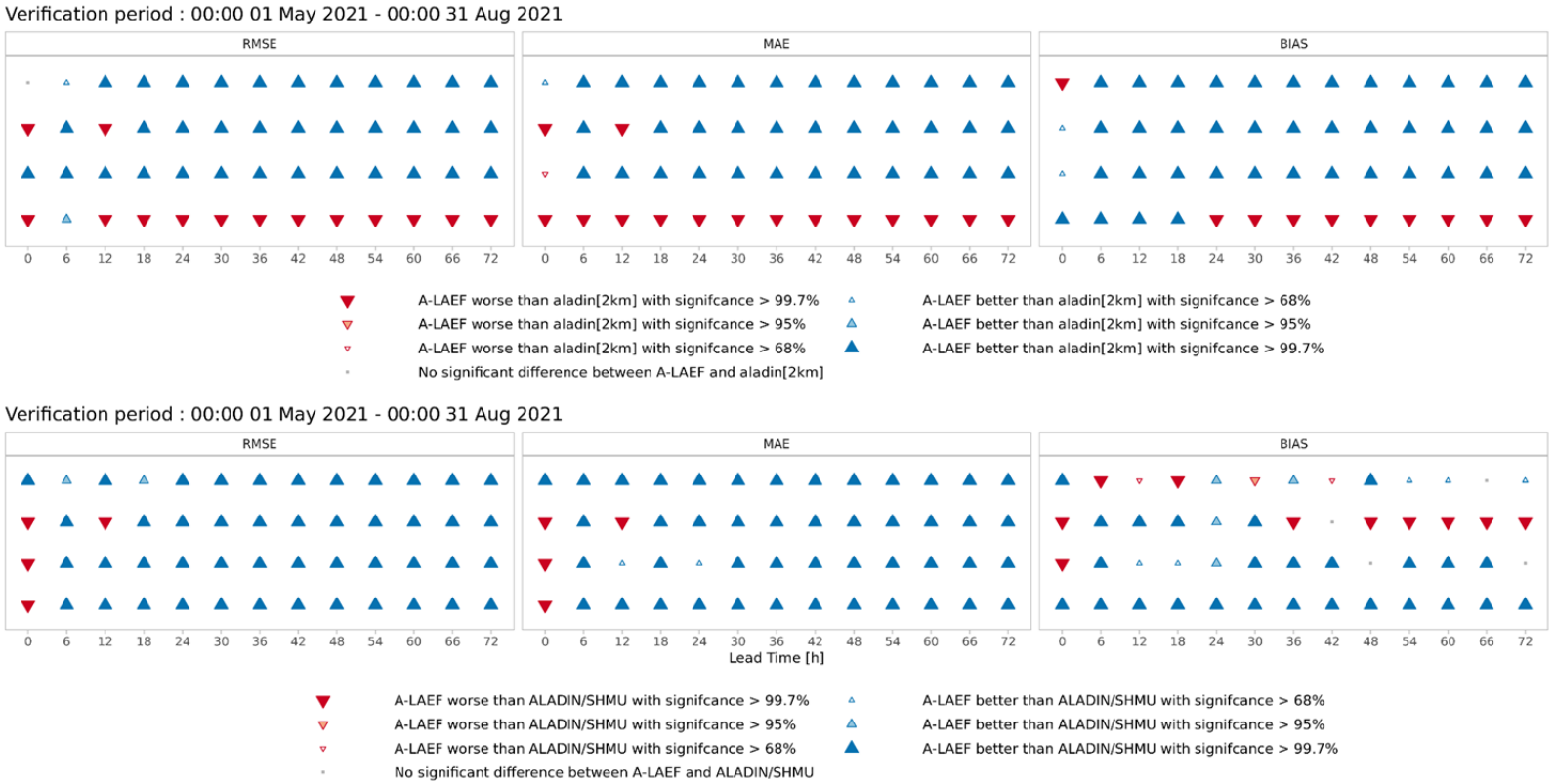
Long term verification with HARP:



Verification period 01/01/2021 - 30/11/2021 (00 and 12 UTC runs included) - SK stations. ALARO NH is dynamical downscaling (2 km) of ARPEGE.

A-LAEF (LACE)

Long term verification with HARP:

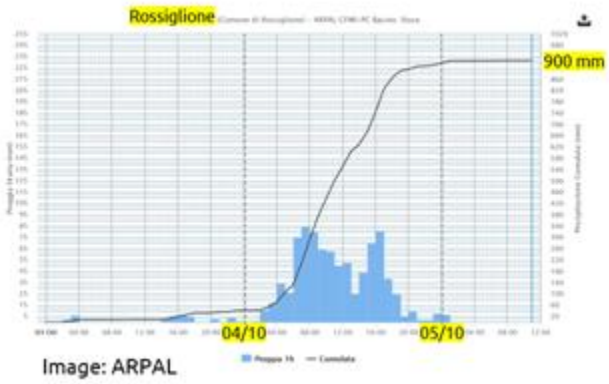


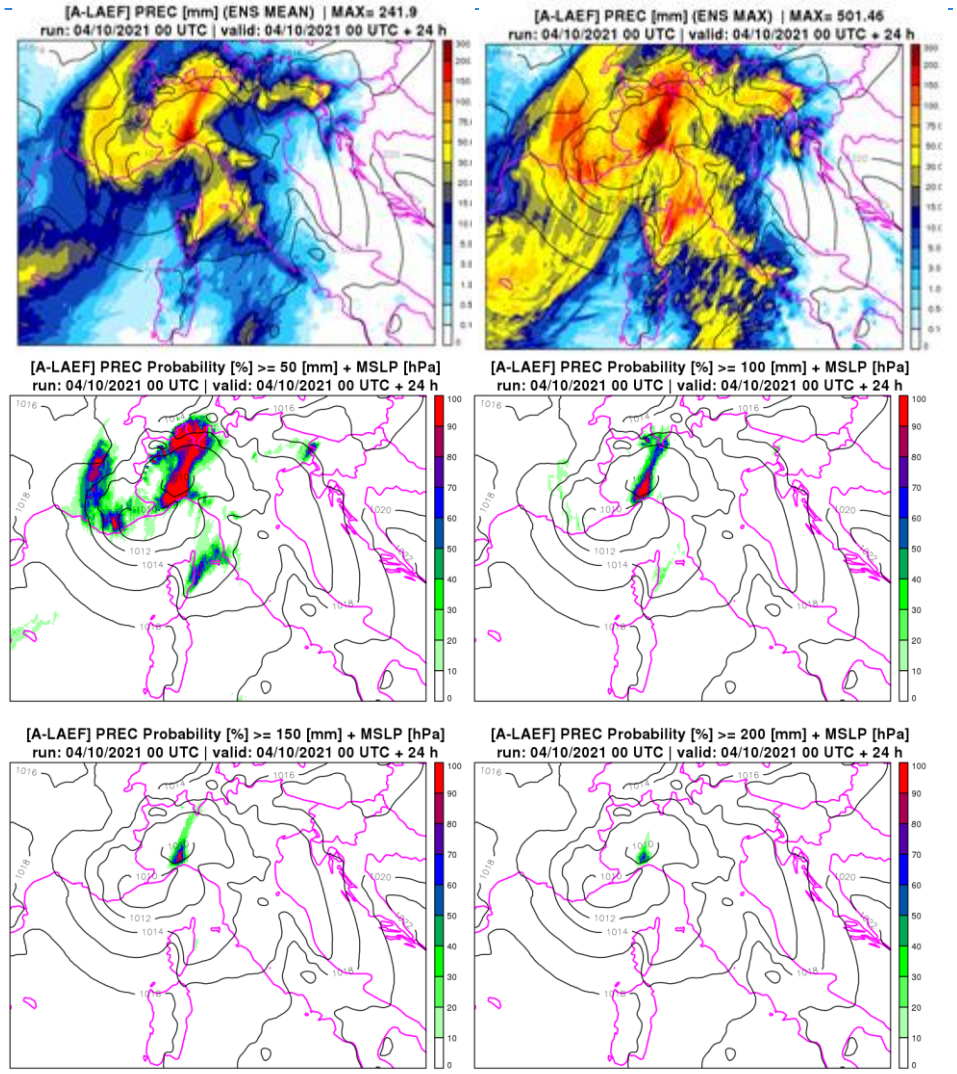
HARP score card of A-LAEF (4.8 km) vs. det. ALADIN/SHMU oper (4.5 km) and ALARO NH (2 km) - May-August 2021 for 96 SK stations

A-LAEF (LACE)

A-LAEF performance at severe weather events:

- record rainfall in Italy (04/10/2021)
- 740mm in 12h/178mm rainfall in 1h
- floods, landslides, etc.
- A-LAEF ensemble successfully captured the precipitation event
- well localized patterns (even with unusually high probabilities of extreme precipitation amounts)

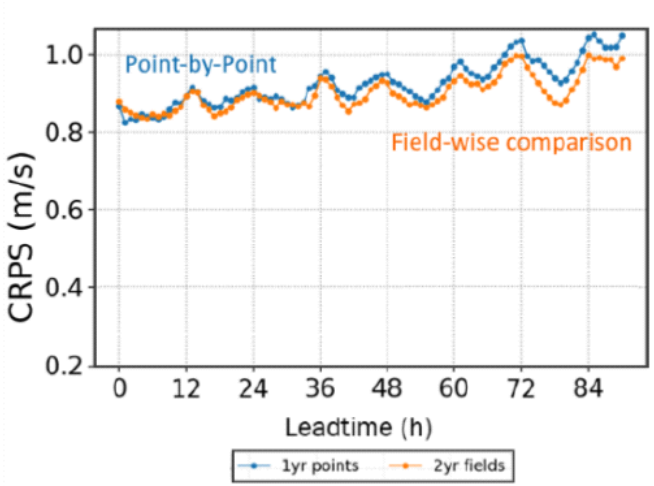


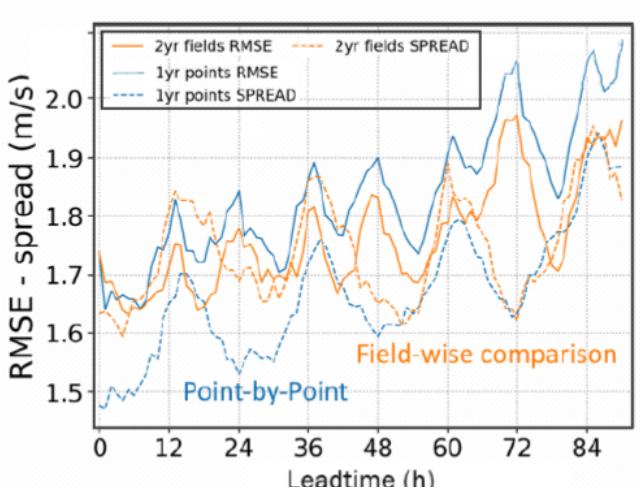


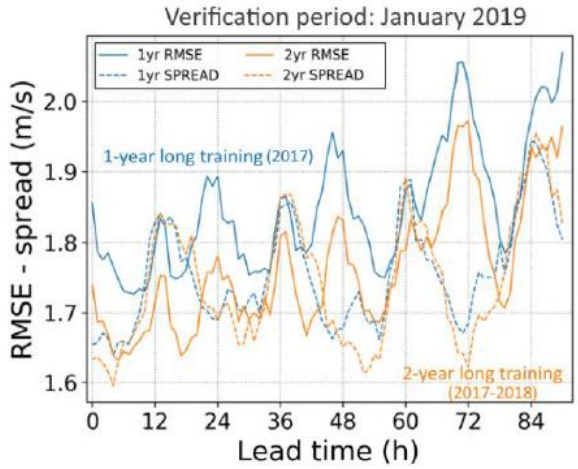
A-LAEF (04/10/2021 00 UTC run) precipitation forecast for the next 24h. Ensemble mean, ensemble max, probabilities for NN > 50, 100, 150, 200mm/24h.

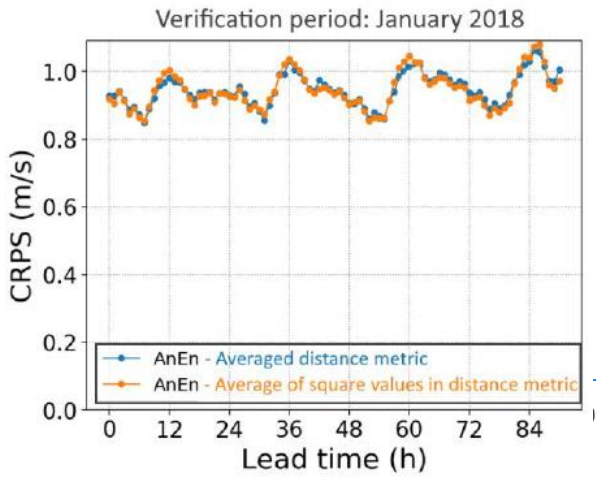
A-LAEF (LACE)

Analog-based post-processing for gridded forecasts:
algorithms for two analog-based experiments that produce gridded products were developed and tested









CRPS (left) and RMSE-spread (right) for the Point-by-Point analog-based approach is compared to the Field-wise approach during January 2019. All forecasts are verified using INCA analysis wind speed values.

The intercomparison of the Field-wise analog-based method approach that uses a 1-year-long training dataset (2017) and the one that uses a 2-years-long training dataset (2017-2018) using the RMSE-spread plot.

AROME-EPS (Hungary)

Overview on AROME-EPS activities in 2021:

- **Operational activities**
  - upgrade of operational AROME-EPS to cy43t2 in April 2021
  - upgrade of ECMWF-ENS coupling files to cy47r2 (L91 => L137 for ENS) in May 2021
  - upgrade of coupling frequency in AROME-EPS from 3h to 1h in May 2021
  - reorganization of coupling file production by ECMWF with 903

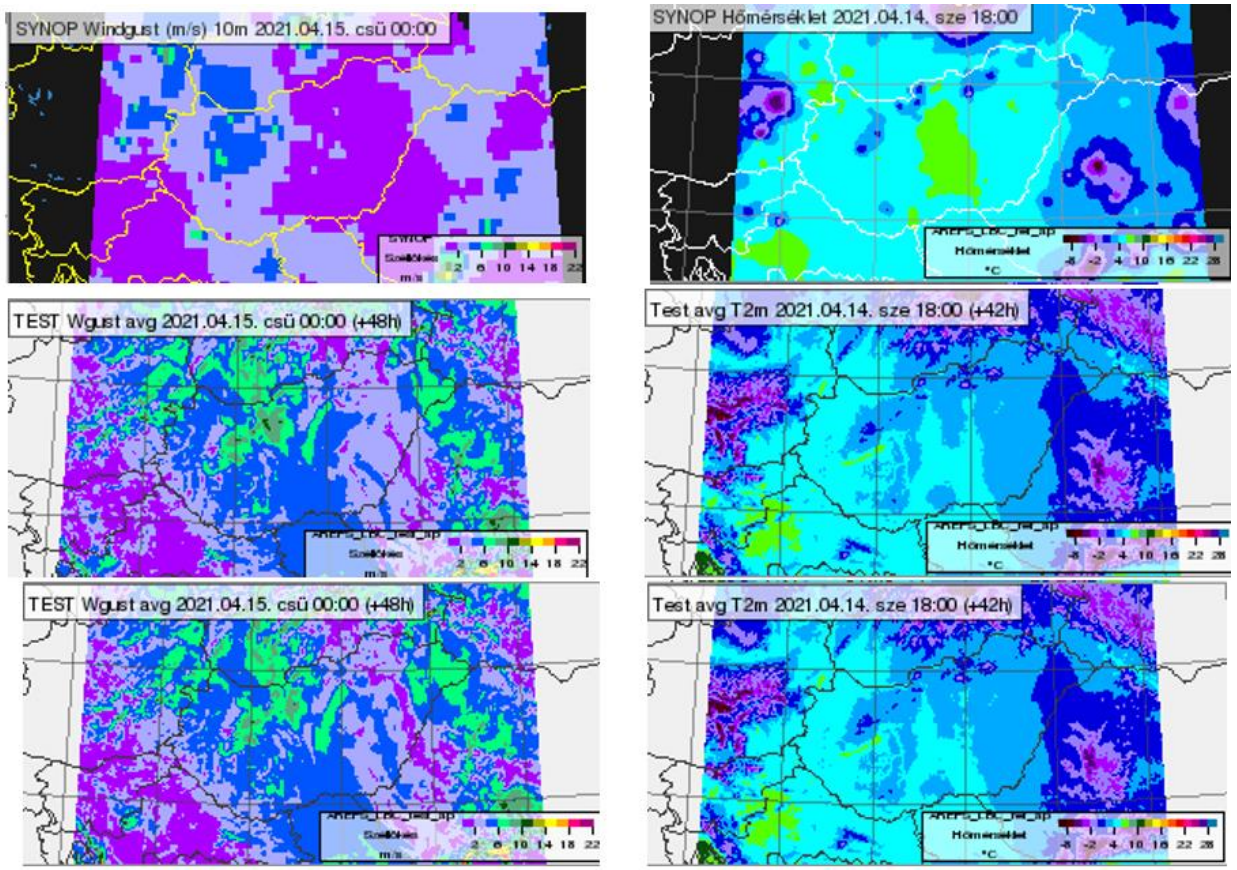
- **Research & Development**
  - testing of impact of higher coupling frequency (1h vs. 3h) for 3 selected case studies
  - testing of impact of new EMCWF-ENS coupling files for 3 selected case studies
  - comparison of AROME-EPS and ECMWF-ENS for a convective test case
  - testing of additional AROME-EPS runs (12 and 06 UTC)

AROME-EPS (Hungary)

Testing of higher vertical and temporal resolution of ECMWF LBCs:

- upgrade of ECMWF-ENS coupling files to cy47r2 (L91 => L137) in May 2021
- general slight positive impact of the higher vertical resolution of LBCs is visible only in the forecasts longer than 24h

- upgrade of coupling frequency of operational AROME-EPS suite from 3h to 1h in May 2021
- significant differences were not noticed
- 1h coupling shows a slight improvement



Wind gusts at 00 UTC on 15 April 2021 (left) and T2m at 18 UTC on 14 April 2021 (right) based on SYNOP measurements (top), ensemble mean of AROME EPS forecasts started at 00 UTC on 13 April 2021 with 1h (middle) and 3h (bottom) coupled LBCs.

AROME-EPS/C-LAEF

Common coupling file production for RC-LACE by ECMWF:

- coupling files from ECMWF-ENS runs were produced under time-critical option 3 at ECMWF and were used by Hungarian AROME-EPS as coupling files in the past
- coupling files for A-LAEF (with 903) and C-LAEF (901/927) were produced on their own
- 901 configuration was very slowly (not parallelized) and only available up to cy36
- since the requirements for LBCs of AROME-EPS and C-LAEF are rather similar it was planned to find a common setup with 903 to reduce duplicated work
- communication with ECMWF and set-up of a common LBC production with 903 by ECMWF in spring 2021
- additional costs of the new requirements (~ 6x more expensive) were compensated by a reorganization of the 903 setup running in TC-3 at ECMWF
- the switch to the new setup was implemented with ECMWF upgrade to cycle 47r2 on 11 May 2021

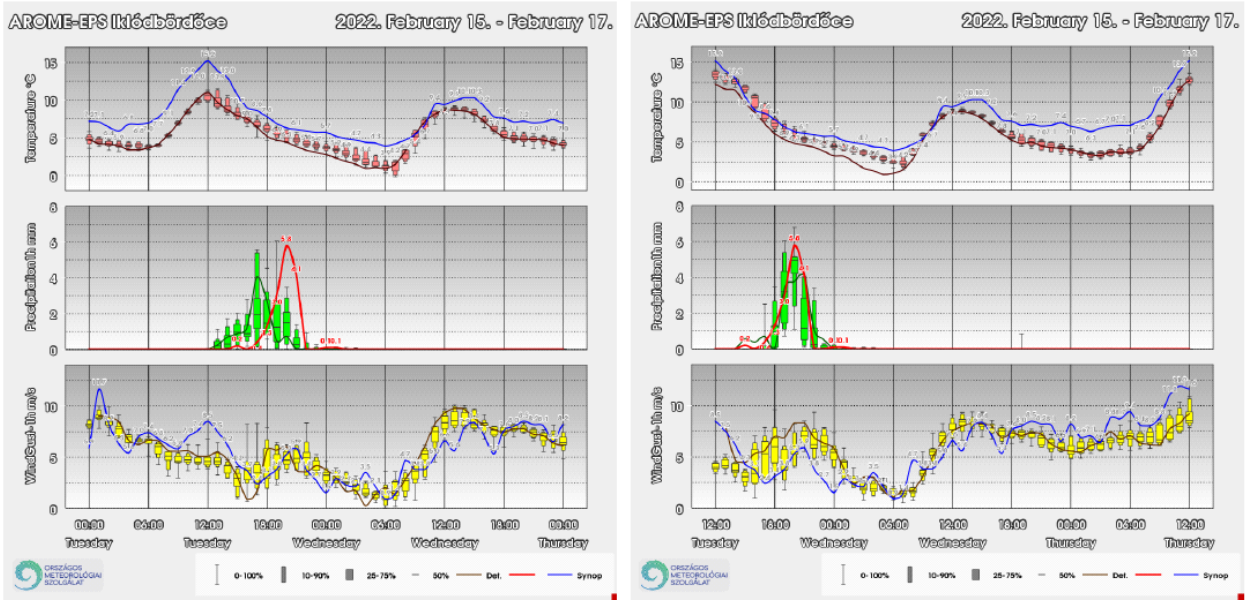
Reorganization of ECMWF ENS coupling file production for RC-LACE.

LACE_EF	47R1	Next Config - 47R2	Comments
00/12	11 Members - 3-hourly to STEP=12 47 levels	**17 Mem. - hourly to STEP=18** **60 levels**	New config ~6 times more expensive than existing one.
06/18	11 Members - 3-hourly to STEP=60 47 levels	**17 Mem. - hourly to STEP=72** **60 levels**	But cost compensated by new job organisation.

AROME-EPS (Hungary)

Testing of additional AROME-EPS runs:

- increased computing capacity at OMSZ introduced in 2021
- additional AROME-EPS forecast initialized at 12 UTC as e-suite
- available for forecasters since February 2022
- better scores for most surface variables
- advantage of the new run comes from the more current global run
- planned to be operational in April 2022



EPSgram for near-surface parameters for AROME-EPS run at 00 (left) and 12 UTC (right) on 15th February 2022 at Iklódbördőce, in the Southwest of Hungary. 2 meter temperature (top panel), hourly precipitation (middle panel) and 10 meter wind gust (bottom panel) forecasts (bars: AROME-EPS, line: AROME deterministic) and measurements (blue and red lines with numbers) are shown.

C-LAEF (Austria)

Overview on C-LAEF activities in 2021:

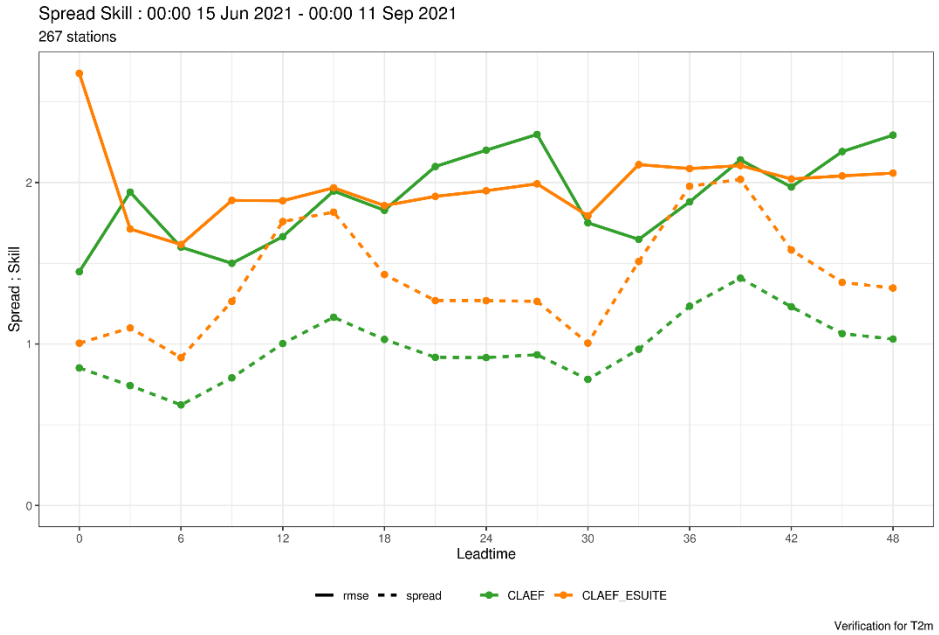
- **Operational activities**
  - upgrade of ECMWF-ENS coupling files to cy47r2 (L91 => L137 for ENS) in May 2021
  - coupling file production by ECMWF with 903 configuration for a common domain
  - major upgrade of C-LAEF on December 6th (cy43t2, 3h assim cycle, new parameters, surface perturbation scheme, 2m diagnostics)
  - operational production of EPS maps and EPSgrams with Visual Weather
  - continuous HARP verification (oper and e-suite)
  - Operational provision of C-LAEF data for ESSL (European Severe Storm Laboratory)

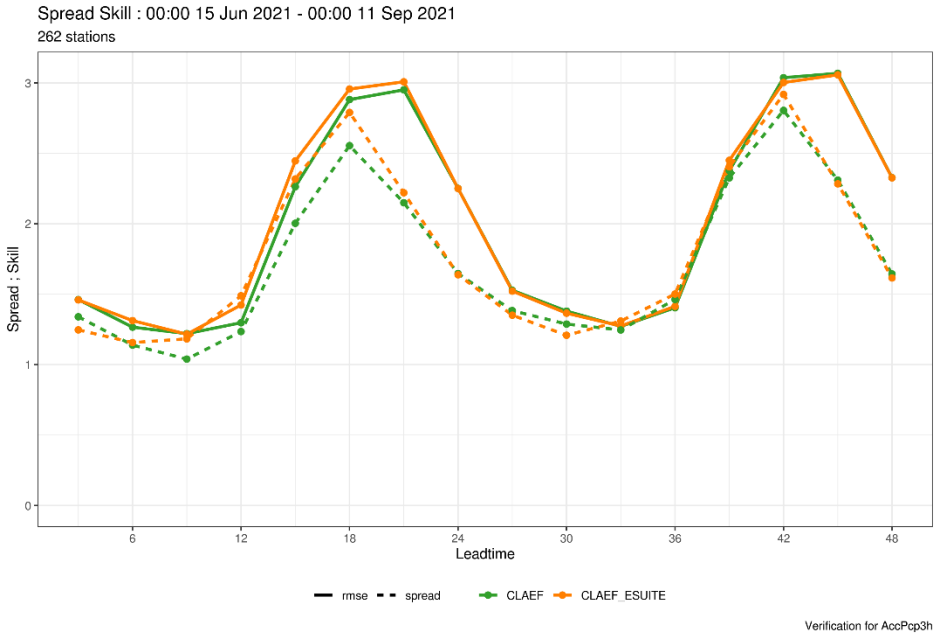
- **Research & Development**
  - full cy43t2 e-suite of C-LAEF during summer period (Jun-Sep) at the ECMWF HPCF
  - investigation and verification of C-LAEF performance for severe weather events
  - implementation of new surface perturbation scheme in C-LAEF e-suite
  - extension of C-LAEF SPP scheme by additional perturbations in physics parametrizations; implementation of SPG pattern generator
  - preparation and provision of C-LAEF data for the SRNWP EPS project (summer 2020)
  - set-up of C-LAEF for Turkish domain – support, scripts, input files, etc.

C-LAEF (Austria)

Verification of C-LAEF cy43t2 e-suite:

- full cy43t2 e-suite of C-LAEF during summer (Jun-Sep) and winter (Nov-Dec) period at the ECMWF HPCF
- 16 + 1 members, 4 runs per day (1 long), 6h assimilation cycle, same resolution, same perturbation scheme as in C-LAEF oper
- cy43t2 additionally contains a surface perturbation scheme
- implementation of continuous HARP verification for C-LAEF and C-LAEF e-suite



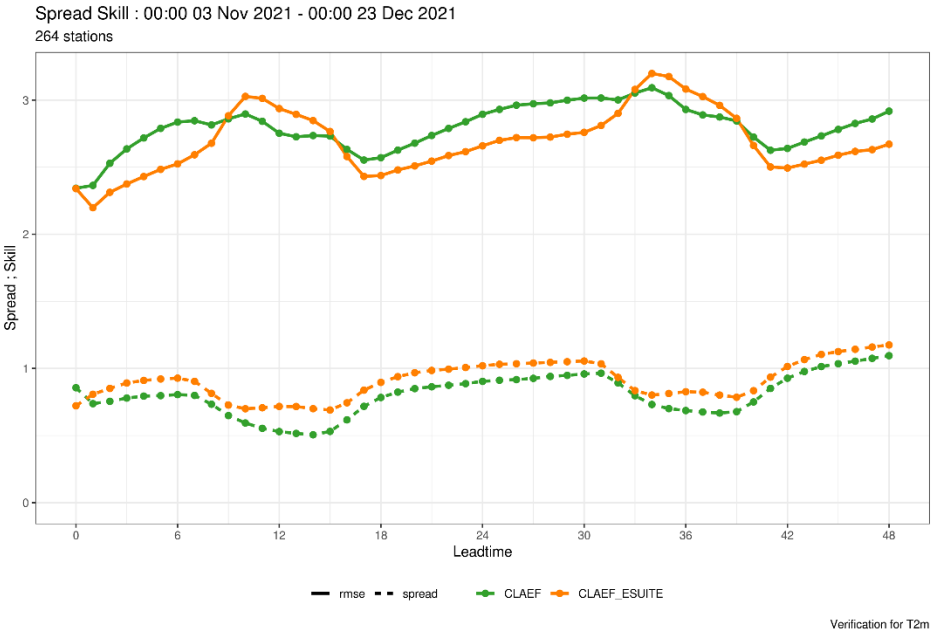


Spread and RMSE of T2m (left) and 3h accumulated precipitation (right) of C-LAEF and C-LAEF cy43t2 e-suite for summer 2021.

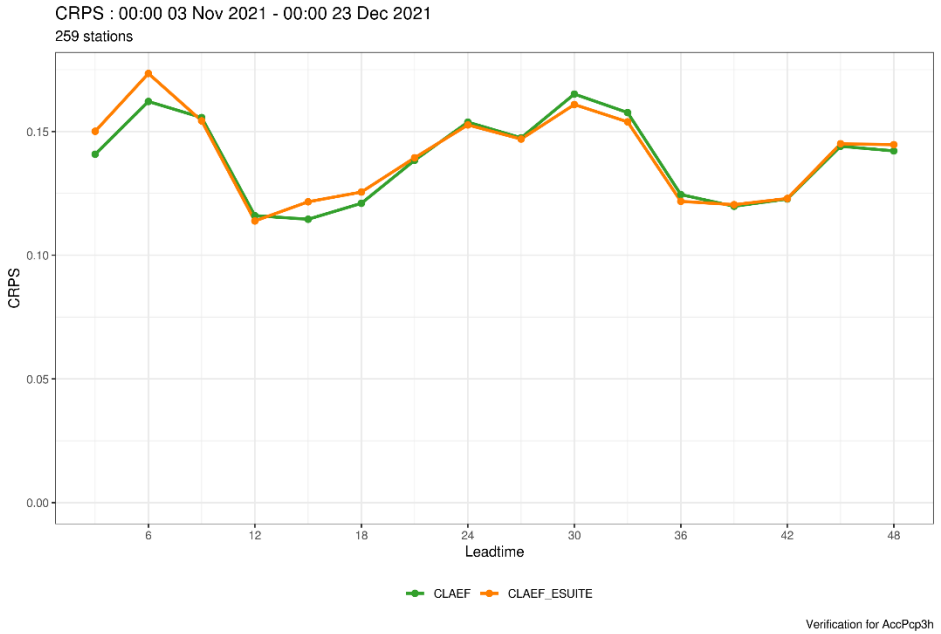
C-LAEF (Austria)

Verification of C-LAEF cy43t2 e-suite:

- quite good performance for most investigated parameters
- operational switch to cy43t2 on Decemer 6th 2021
- 3h assim cycle, surface perturbation scheme, new parameters (helicity, precip type, ww symbols, etc.), improved 2m diagnostics, improved assimilation (B-Matrix, modified weights, etc.)



Spread and RMSE of T2m of C-LAEF and C-LAEF cy43t2 e-suite for November/December 2021.

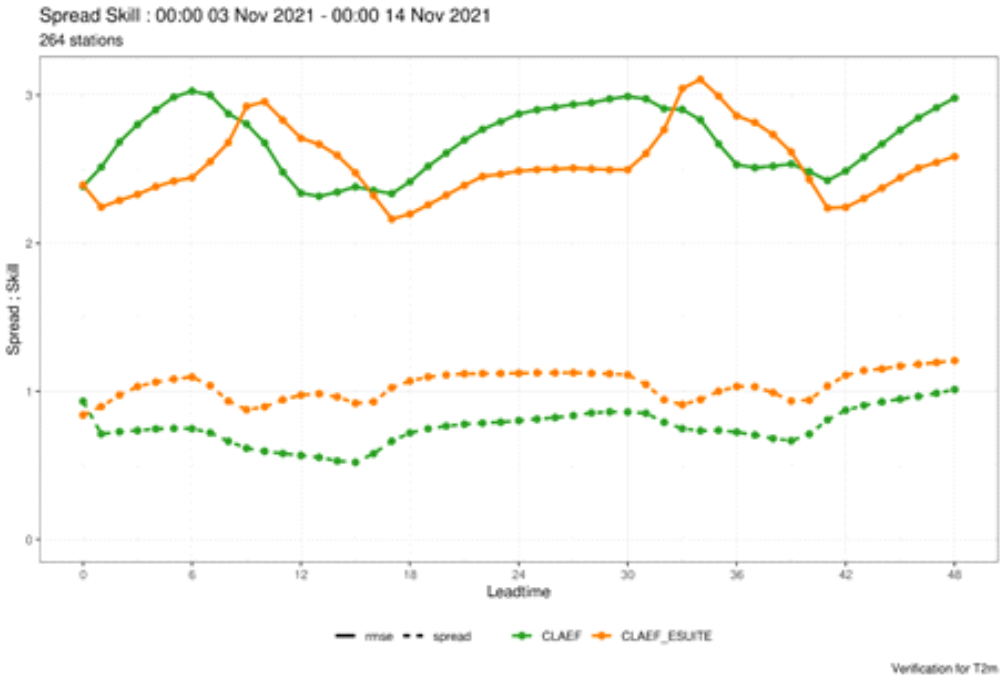


CRPS of 3h accumulated precipitation for C-LAEF and C-LAEF e-suite for November/December 2021.

C-LAEF (Austria)

Implementation of new surface perturbation scheme in C-LAEF e-suite:

- development of new surface perturbation scheme
- adapted Meteo France version
- seasonal or constant fields (vegetation index, vegetation heat coefficient, leaf area index, land albedo, land roughness length) are taken from the unperturbed control run and are perturbed with different seed in each member
- prognostic fields (soil moisture, soil temperature, snow depth, sea surface fluxes) are taken from the surface analysis (CANARI) and are then perturbed with different seed in each member
- this means that those prognostic fields are cycled in each member and can develop independently

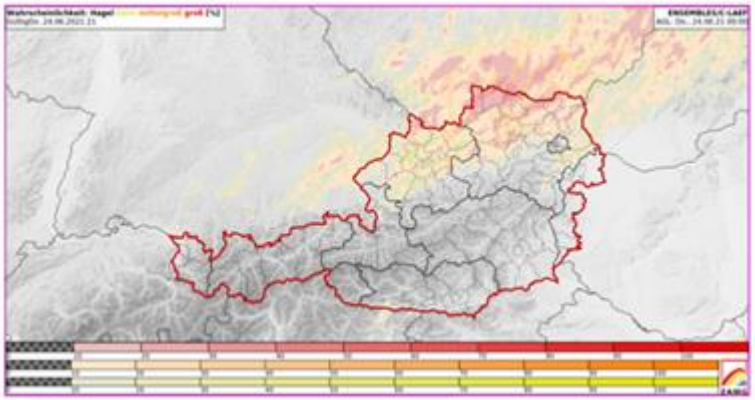


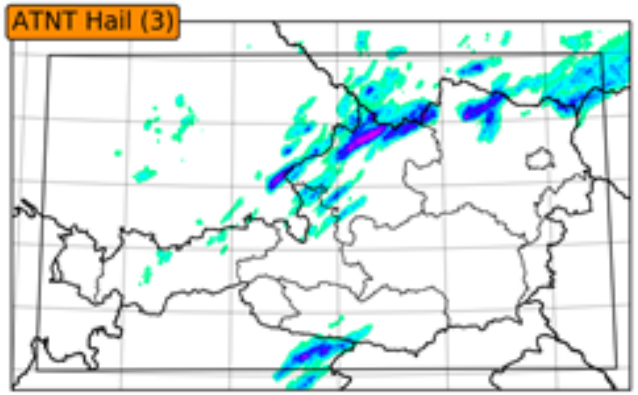
Spread and RMSE of T2m of C-LAEF and C-LAEF cy43t2 e-suite (with surface perturbation scheme) for a test period in November 2021.

C-LAEF (Austria)

C-LAEF performance at severe weather events:

- severe hailstorm and a devastating tornado occurred near the Austrian/Czech border with about 250 persons injured in the afternoon/evening of 24 June 2021
- situation was very well captured by C-LAEF predicting high probability of large hail, massive wind gusts (> 100km/h) and strong lightning





Massive hailstones near the Austrian/Czech border and devastating tornado (upper panel; www.hagel.at; www.stern.de).
C-LAEF probability of hail (left) and hail analysis (right) for 24/06 21 UTC (lower panel).

C-LAEF (Austria)

Extension of C-LAEF SPP scheme:

- operational C-LAEF comprises model error representation by perturbation of tendencies (shallow convection, microphysics, radiation) and parameters (turbulence)
- extension of SPP parameter perturbations to other parametrizations to increase physical consistency
- implementation of SPG pattern generator
- set-up of e-suite with 13 perturbed parameters
- extension to more parameters
- more tuning necessary before operationalisation

Scheme	Parameter	Physical meaning	Default	Range
Radiation	RSWINHF	Shortwave inhomogeneity factor	1	0.6 - 1
	RLWINHF	Longwave inhomogeneity factor	1	0.6 - 1
Microphysic	RCRIAUTI	Snow Autoconversion threshold	0.2e-3	0.2e-4 - 0.25e-3
	RCRIAUTC	Rain Autoconversion threshold	1e-3	0.4e-3 - 1e-3
	VSIGQSAT	Constant for subgrid condensation	0.02	0 - 0.1
Turbulence	XLINI	Minimum mixing length	0	0 - 0.2
	XCTD	Constant for dissipation	1.2	0.98 - 1.2
	XCTP	Constant for T-P correlations	4.65	1.035 - 22.22
	XCEP	Constant for V-P correlations	2.11	0.225 - 4.0
	XCED	Constant for dissipation of TKE	0.85	0.4 - 2
	XPHI_LIM	Threshold value for Sc^{-1} and Pr^{-1}	3	1 - 4.5
	XCET	Constant for transport of TKE	0.4	0.072 - 1.512
Diffusion	SLHDEPSH	Strength of SLHD	0.060	0.01 - 0.09
	SLHDKMIN	Diffusion function minimum	0	-1 - 1
	SLHDKMAX	Diffusion function maximum	6	4 - 12
Surface	XRIMAX	Critical Richardson Number	0.2	0 - 0.2
	XFRACZ0	Coefficient of orographic drag	5	2 - 10
	XCMF	Closure coefficient at bottom level	0.065	0 - 0.1
Convection	XABUO	Coefficient of the buoyancy	1	0.7 - 1.5
	XBDETR	Coefficient of the detrainment	1e-6	0 - 1
	XENTR_DRY	Coefficient for dry entrainment	0.55	0.1 - 0.699

Parameters which are perturbed stochastically in the SPP scheme currently implemented in a C-LAEF e-suite (in yellow boxes).

Publications

Published papers:

- A. Simon, M. Belluš, K. Čatlošová, M. Derková, M. Dian, M. Imrišek, J. Kaňák, L. Méri, M. Neštiak and J. Vivoda, 2021: "Numerical simulations of 7 June 2020 convective precipitation over Slovakia using deterministic, probabilistic and convection-permitting approaches", Időjárás, Vol. 125, No. 4, DOI:10.28974/idojaras.2021.4.3 (pp. 571–607).
- J. Vivoda, M. Belluš, M. Derková, 2021: "High performance computing and weather forecasting at SHMU" (ENG version), HPC Focus, p44-53, ISSN 2729-9090, https://vs.sav.sk/magazine/issues/magazine_2021010_print.pdf
- C. Wastl, Y. Wang, A. Atencia, F. Weidle, C. Wittmann, C. Zingerle, E. Keresturi, 2021: C-LAEF: Convection-permitting Limited-Area Ensemble Forecasting system. Quarterly Journal of the Royal Meteorological Society, 147, 1431– 1451. https://doi.org/10.1002/qj.3986.

Submitted papers:

- K. Jávorné-Radnóczi and B. Tóth, 2021: Short range probabilistic forecasts at Hungarian Meteorological Service: evaluation of AROME-EPS and impact of EDA, submitted to Idojaras.

Contributions to the 1st and 2nd ACCORD newsletters

EPS working week in Innsbruck (25 – 29 April 2022)