Regional Cooperation for
Limited Area Modeling in Central Europe

LACE
nwp central europe

LAM-EPS activities in LACE

Clemens Wastl with contributions of LACE partners

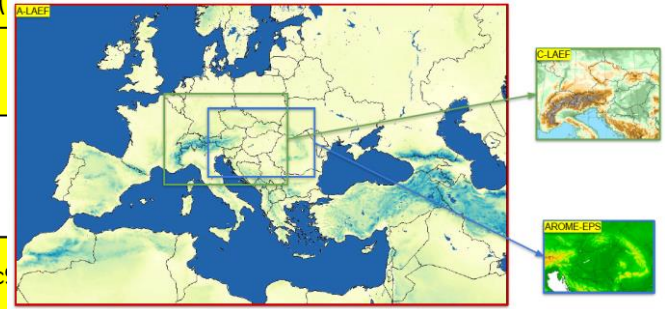
GeoSphere Austria
DHMZ
Czech Hydrometeorological Institute
OMSZ
IMGW
METEO ROMANIA
SHMÚ
ARSO METEO Slovenia

Overview

- **Operational status**
- **Upgrade of ECMWF-ENS and impact on LACE LAM EPSs**
- **Case studies of severe weather events**
- **C-LAEF 1k**
- **Flow dependent perturbations**
- **Statistical EPS**
- **Outlook and plans**

Operational status

	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	8
Forecast length	+72h (00/12 UTC)	+60h (00/12 UTC)	+48h (00/12 UTC)
Members	16+1	16+1	10+1
Assimilation cycle	yes (12h)	yes (3h)	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]	EDA
Model perturbation	ALARO-1 multi-physics + surface stochastic physics (SPPT)	Parameter perturbations (SPP)	-
LBC perturbation	ECMWF ENS (c903)	ECMWF ENS (c903)	ECMWF ENS (c



Upgrade of ECMWF

- **Upgrade of ECMWF-ENS and impact on LACE EPSs**
  - Switch of IFS/ENS to cy48r1 and increase of spatial resolution of ECMWF-ENS from O640 to O1280 on June 27
  - Impact on LACE since A-LAEF, C-LAEF and AROME-EPS are coupled with ECMWF-ENS
  - Several versions of coupling files (horizontal resolution, number of vertical levels, with/without hydrometeors, etc.) have been tested by LACE
  - Finally we ended up with a setup of 8.5km horizontal resolution and 105L in the vertical which entered the common coupling file production at ECMWF
  - Parallel suites to test the impact of the new coupling files on the LACE EPSs (A-LAEF, C-LAEF and AROME-EPS)
  - Small impact, not statistically significant

Upgrade of ECMWF

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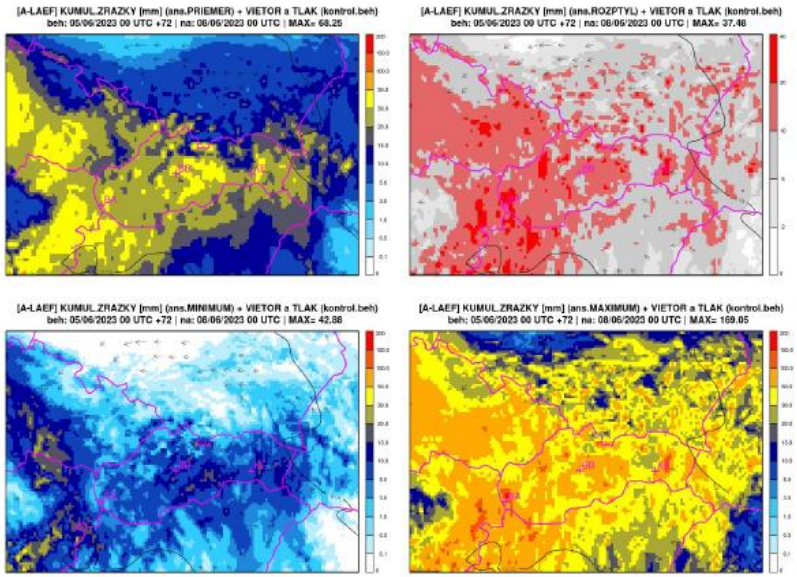
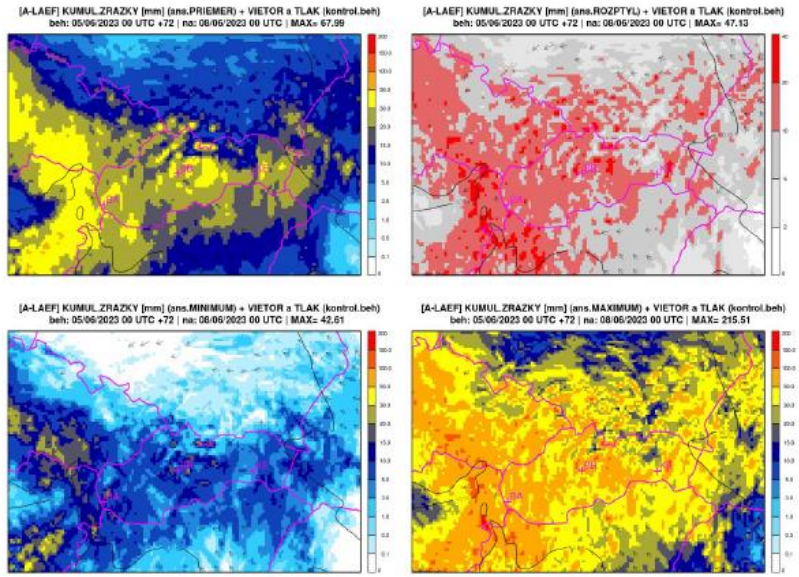
cy47r3 (oper)



cy48r1 (e-suite)



24h accumulated precipitation of A-LAEF (EPS mean, spread, min, max +24h) coupled with ECMWF-ENS cy47r3 (left) and cy48r1 (right) for a test case on 5 June 2023.

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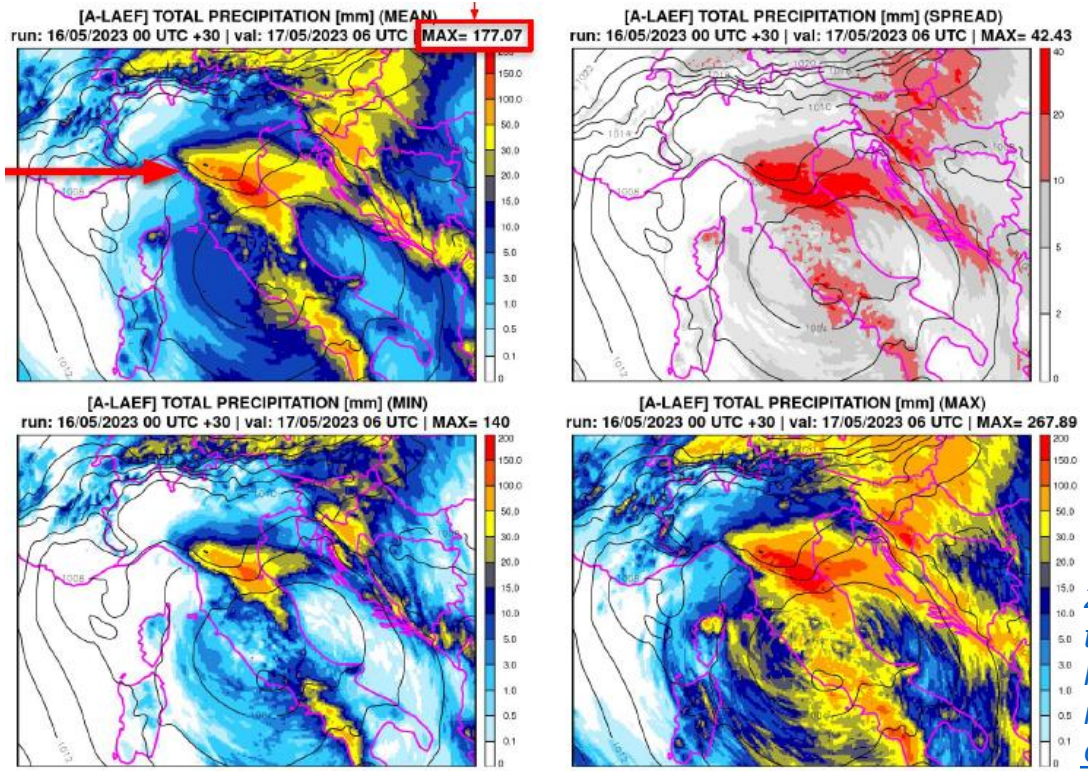
Case studies

- **Flood in Italy, May 2023**

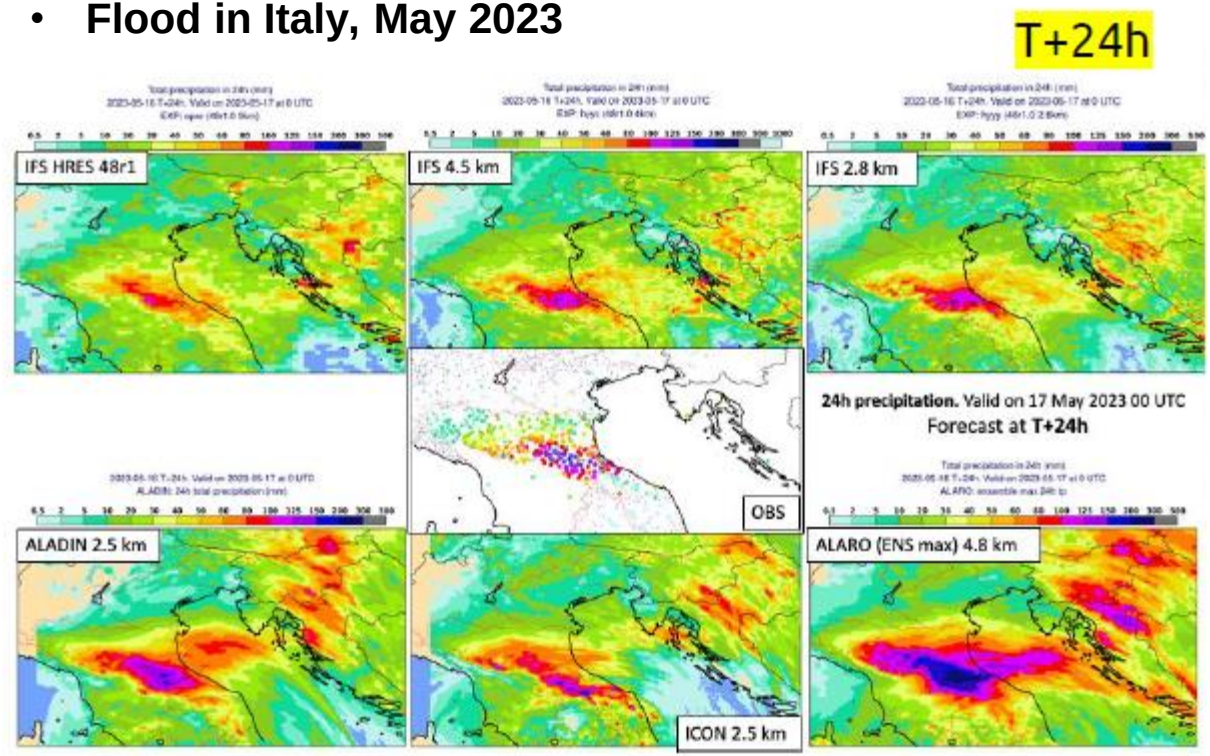


- Several severe weather events in 2023 (snowfall, storm, floods)
- A-LAEF showed benefit of a LAM ensemble system (good performance)
- For example: Extreme flood event in Emilia-Romagna (IT) with several casualties in May
- Well predicted in A-LAEF

24h accumulated precipitation from 06 UTC on 16 May to 06 UTC on 17 May 2023. Ensemble mean (upper left), ensemble spread (upper right), ensemble minimum (lower left) and maximum (lower right) based on A-LAEF 00 UTC run on 16 May.

Case studies

- **Flood in Italy, May 2023**



Comparison of 24h accumulated precipitation (00+24h) simulated by different models.

cluster	average [mm/24h]	physics tuning
1	185.7	microphysics and deep convection
2	183.7	turbulence
3	157.6	turbulence, microphysics and deep convection
4	176.9	ALARO-1 reference

- Much higher precipitation amounts in Italy and Croatia in the LAMs compared to ECMWF
- ECMWF high resolution experiments with convection parametrization
- High precipitation amounts in A-LAEF EPS seem to be related to specific parameterization schemes

C-LAEF 1k

- **Upgrade of C-LAEF to 1km**

– Strong effort in Austria on upgrading C-LAEF to 1km (plan: operationalization end of 2024)

– Extensive testing of deterministic 1km AROME runs in 2022 (SP, optimizations, I/O server, etc.)

– Set up of full C-LAEF 1k suite in May 2023 – running continously since then

– Cy46t1, I/O server, long 00 UTC run (+60), 3h assimilation cycle, SPP perturbations

– Additional control member using EnVar for testing (51 members)

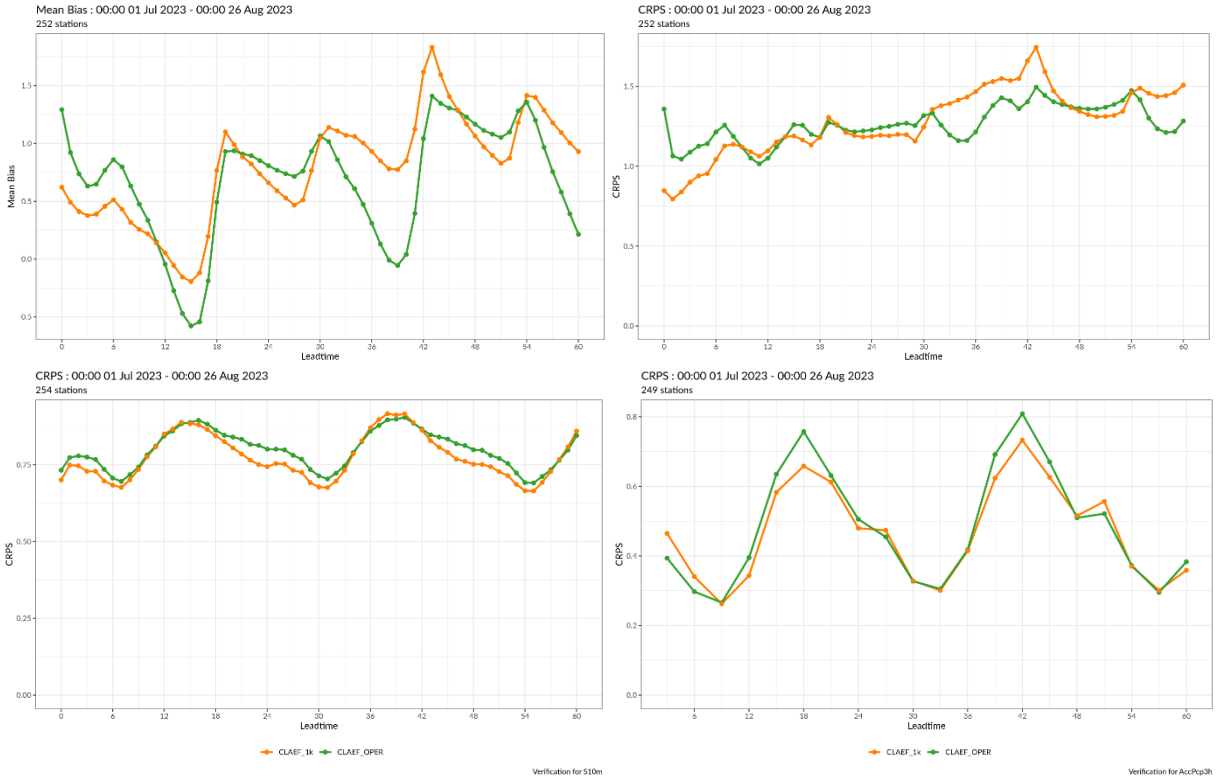
– High amount of computing resources on ATOS needed for the 1km Esuite (1.4 Mio SBUs per day)

– Since end of June the grib-files are shared with Slovenian colleagues

– The performance of C-LAEF 1k is monitored objectively calculating verification scores at 250 stations over various periods and for case studies

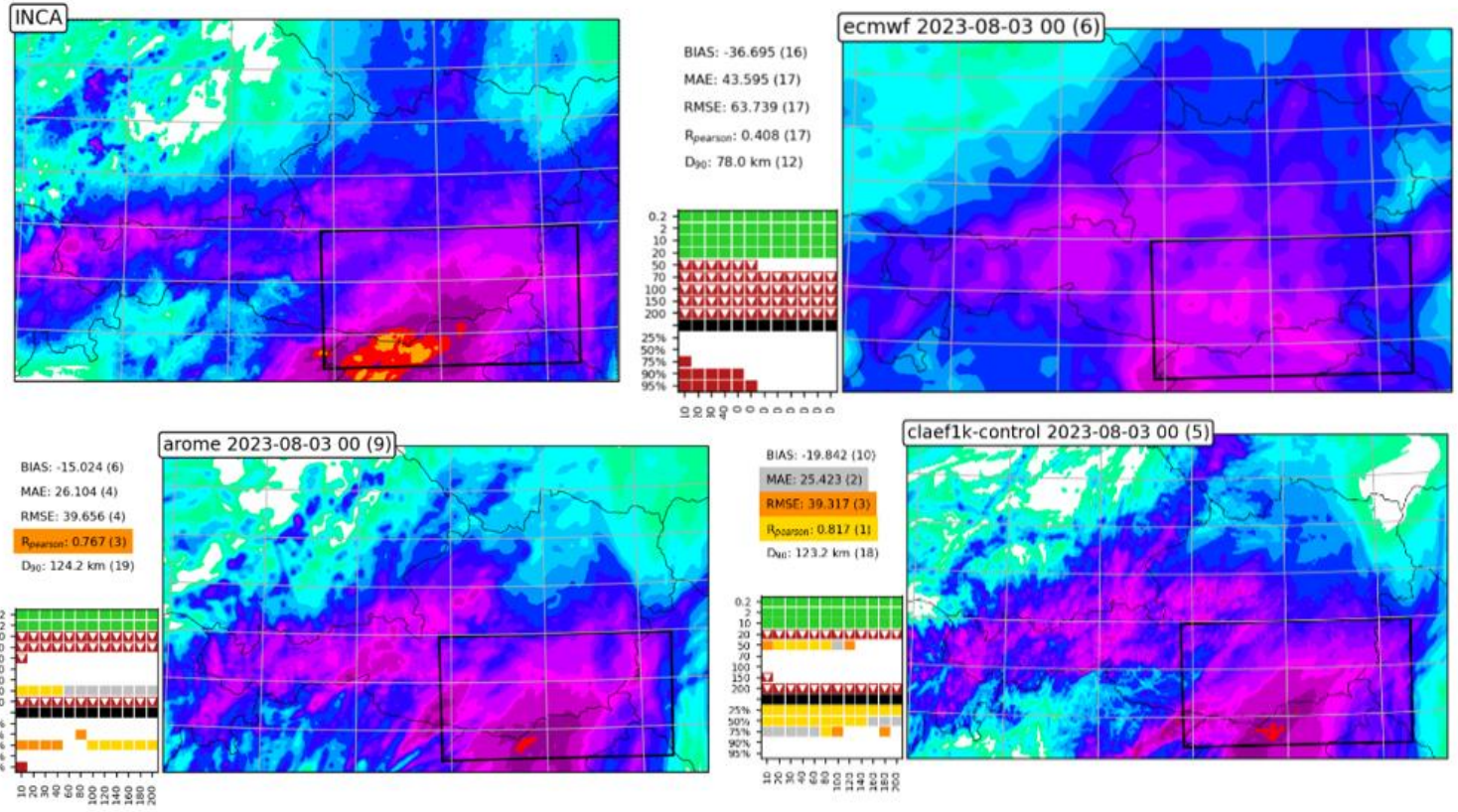
C-LAEF 1k

- **Upgrade of C-LAEF to 1km**
  - Verification of C-LAEF 1k Esuite shows satisfying results
  - For most parameters and most leadtimes the scores for the 1km version are comparable or even better than for the current operational C-LAEF suite



Mean BIAS (upper left) and CRPS (upper right) of 2m temperature; CRPS of 10m wind speed (lower left) and 3h accumulated precipitation (lower right) of C-LAEF OPER (green) and C-LAEF 1k (orange) for the period July and August 2023.

C-LAEF 1k

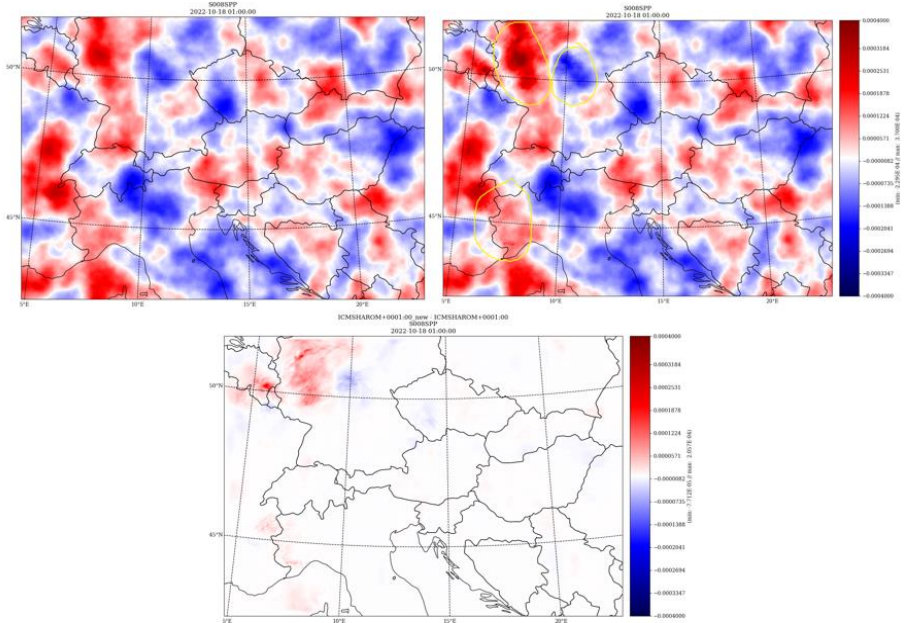


- Flooding event in southern Austria and Slovenia in August
- Good performance of AROME/C-LAEF (amounts and localization)
- Underestimation in ECMWF

48h accumulated precipitation amount (03 August 12 UTC – 05 August 12 UTC) of different models.

Flow dependent perturbations

- **Development of flow-dependent parameter perturbations in C-LAEF**
  - SPP is purely stochastic – no consideration of weather/flow situation
  - Development of intelligent/flow dependent perturbation scheme
  - Adaptation of stochastic patterns by flow dependent weights



Impact of the cloudiness to the stochastic perturbation field of microphysics parameters in SPP. Upper left: SPP without flow dependency, upper right: SPP with flow dependency, lower panel: difference.

Statistical EPS

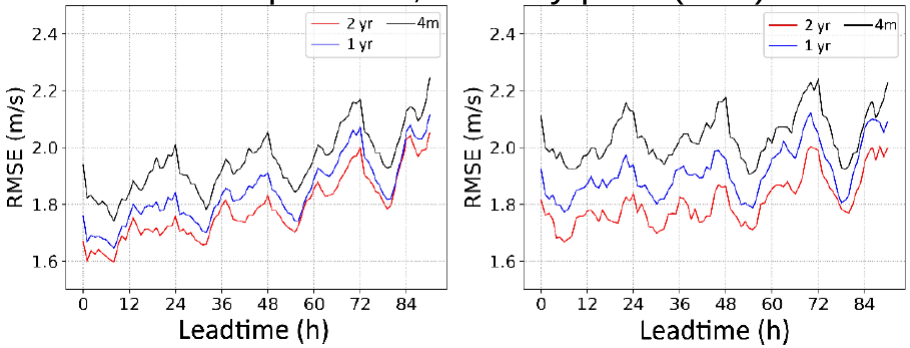
- **Analog-based post-processing on a regular grid (Croatia)**

– Analogies between similar past forecasts, measurements or analyses are very useful if the training dataset is long enough - thus enabling an adequate identification of true analogs

– Reducing the number of degrees of freedom in the matching procedure makes this method interesting for point-based post-processing with NWP input (deterministic, ensemble)

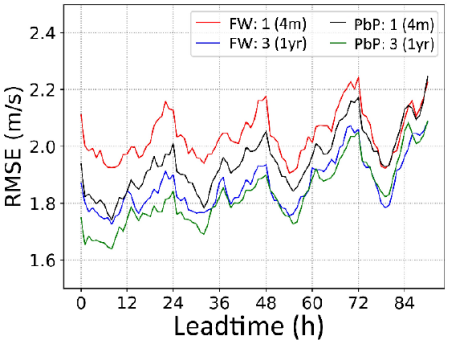
– Point-based analog approach was thoroughly tested as deterministic approach to calibrate A-LAEF

– Gridded products; Point-by-point (PbP) and field-wise (FW); wind and temperature as predictor



Left: Sensitivity of training length measured by RMSE for PbP and FW

Right: Intercomparison of PbP and FW experiments



Statistical EPS

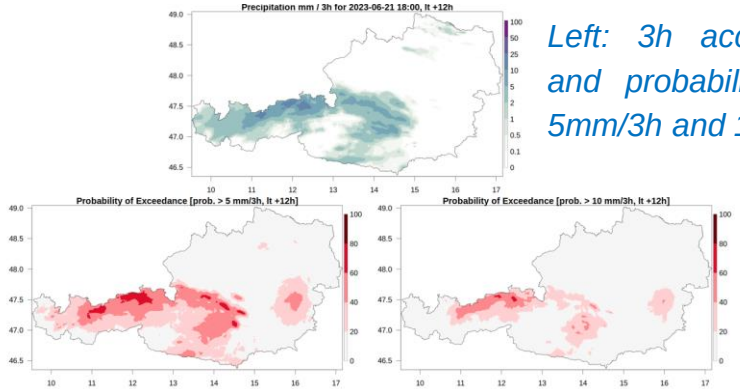
- **Statistical post-processing at GeoSphere Austria**

– SAMOS (standardized anomaly model output statistics) implemented to improve direct model output from ensembles (EMCWF-ENS, C-LAEF) of 2m T and RH, precipitation, 10m wind and gusts

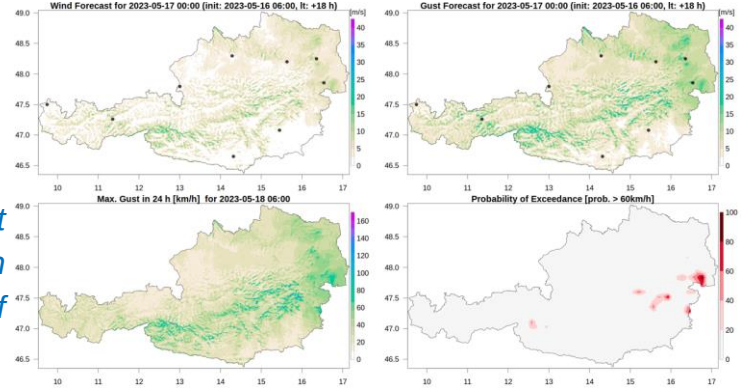
– Training every 3h with a rolling 45 days training period in the past

– SAMOS is providing spatial forecasts in a seamless forecast from analysis to middle-range forecasts

– SAMOS is able to improve the BIAS significantly and is also able to correct the under-dispersion



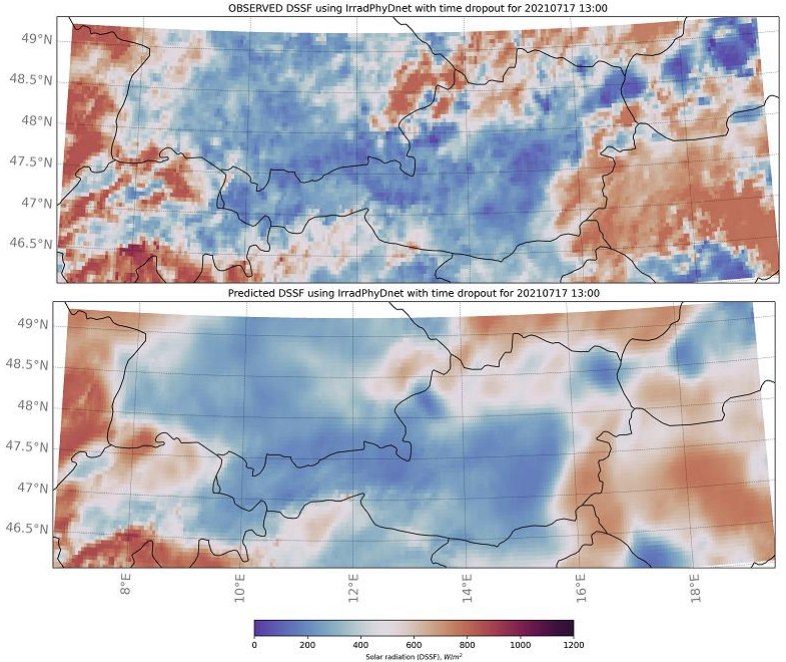
Left: 3h accumulated precipitation and probability of exceedance for 5mm/3h and 10mm/3h



Right: Wind and gust forecast, max gusts in 24h and probability of exceedance for 60km/h

Statistical EPS

- **Physics-informed and data-driven machine learning nowcasing at GeoSphere Austria**
  - Physics-informed nowcasting methods using MSG data are adapted for ont-the-fly operational purposes as well as for re-running some test cases
  - Pre-trained models for 15-minute predictions of cloudiness for the next 3 hours ahead
  - Promising results for both sunny days and overcast days
  - Further work planned in the future



Observed clouds (upper) and cloud output of a machine learning model (lower) for a test case in 2021.

Gfäller, P. (2023): Evaluation of different techniques for solar irradiance nowcasting Masterarbeit Universität Wien, DOI: 10.25365/thesis.73807

Outlook & Plans

Operational plans

A-LAEF: - Upgrade to cy43t or cy46t1 (to be decided)

- Upgrade of upper-air IC uncertainty representation by ENS BlendVar
- Local convection-permitting ALARO-EPS in Slovakia

C-LAEF: - Upgrade to 1km (end of 2024)

- New HPC at GeoSphere Austria
- Flow dependency (assimilation, perturbations)

AROME-EPS: - Implementation of stochastic physics for model error representation (SPP)

Possible cooperation on C-LAEF 1k

Research & development

- Flow-dependent B-matrix in assimilation
- EnVar and Hybrid EnVar in EPS
- Development of flow-dependent model perturbations
- Improved surface perturbations (SPP in surfex)
- Work on statistical post-processing of probabilistic fields
- Extension of data-driven ML ensemble methods
- Development of new/improved probabilistic products

Publications

- **Presentations**
  - Presentation of LACE EPS activities at ACCORD ASW in Tallinn in April 2023 and EWGLAM in Reykjavik in September 2023
  - Presentation of flow dependent SPP at EPS working week in May 2023 in Oslo
- **Publications**

– Bellus, M., A. Simon, 2023: A-LAEF migration to Bologna and extrem weather forecasts, poster at 3rd ACCORD all staff workshop, 27-31 March 2023, https://www.umr-cnrm.fr/accord/IMG/pdf/a-laef_accord_asw_2023.pdf

– Szépszó G., Á. Baran, S. Baran , K. Jávorné Radnóczi , M. Kornyik, D. Tajti , 2023: Operational statistical post-processing of short-range global radiation and low-level wind forecasts (in Hungarian). Légkör 68, 3, 118–125. DOI: 10.56474/legkor.2023.3.1

– Wastl C., M. Belluš and G. Szépsó, 2023: EPS research and development in RC LACE in 2022, 4th ACCORD Newsletter, https://www.umr-cnrm.fr/accord/IMG/pdf/accord-nl4.pdf