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

Overview

- **Operational upgrades**
- **New EPSgrams for A-LAEF**
- **Migration of operational suites of A-LAEF and C-LAEF to new Atos HPC in Bologna**
- **EDA in AROME-EPS (Hungary)**
- **SPP in C-LAEF (Austria)**
- **Statistical EPS**
- **Outlook and plans**

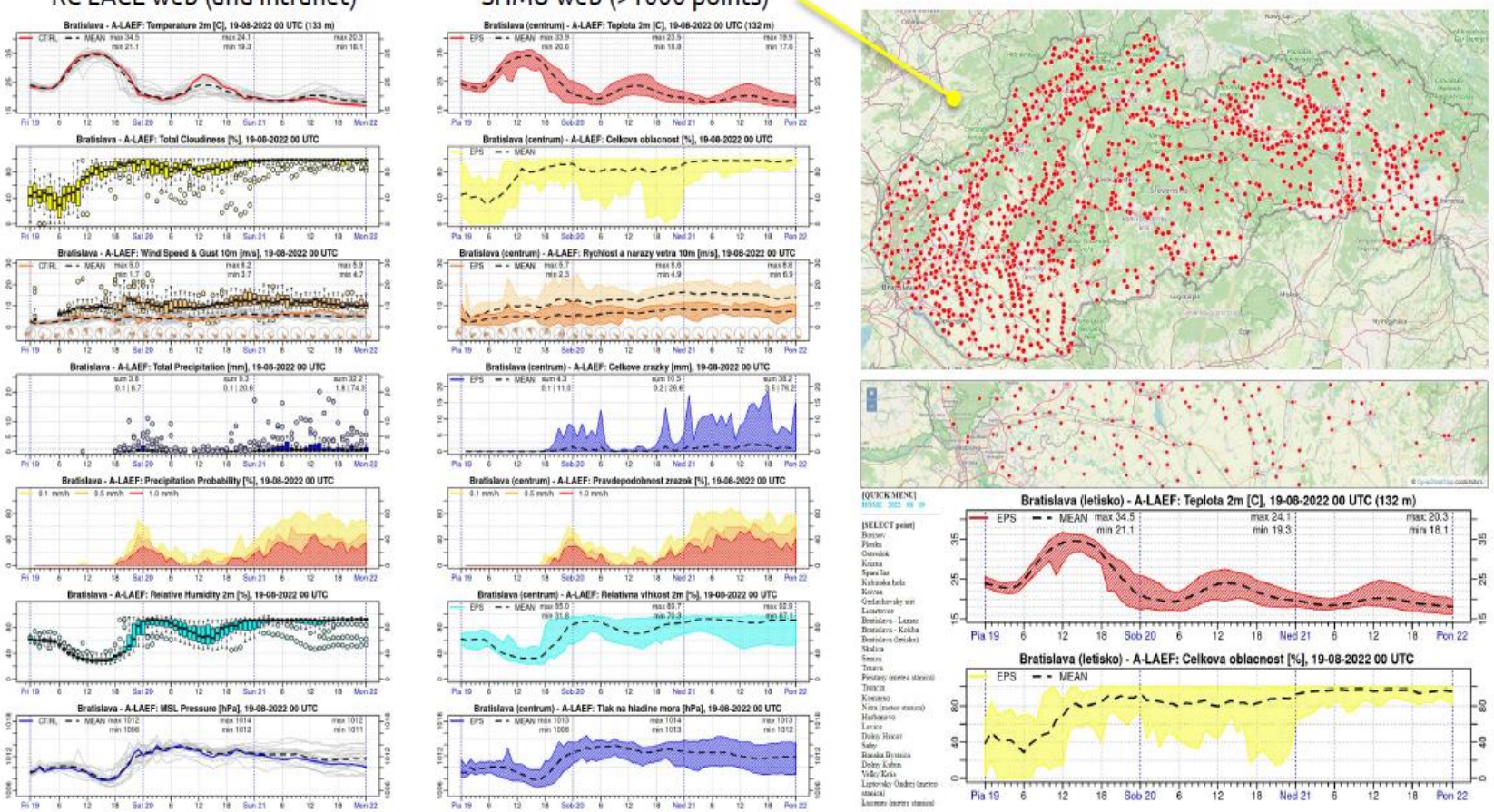
Operational ensembles

	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	2
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)	-
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)

New products for A-LAEF

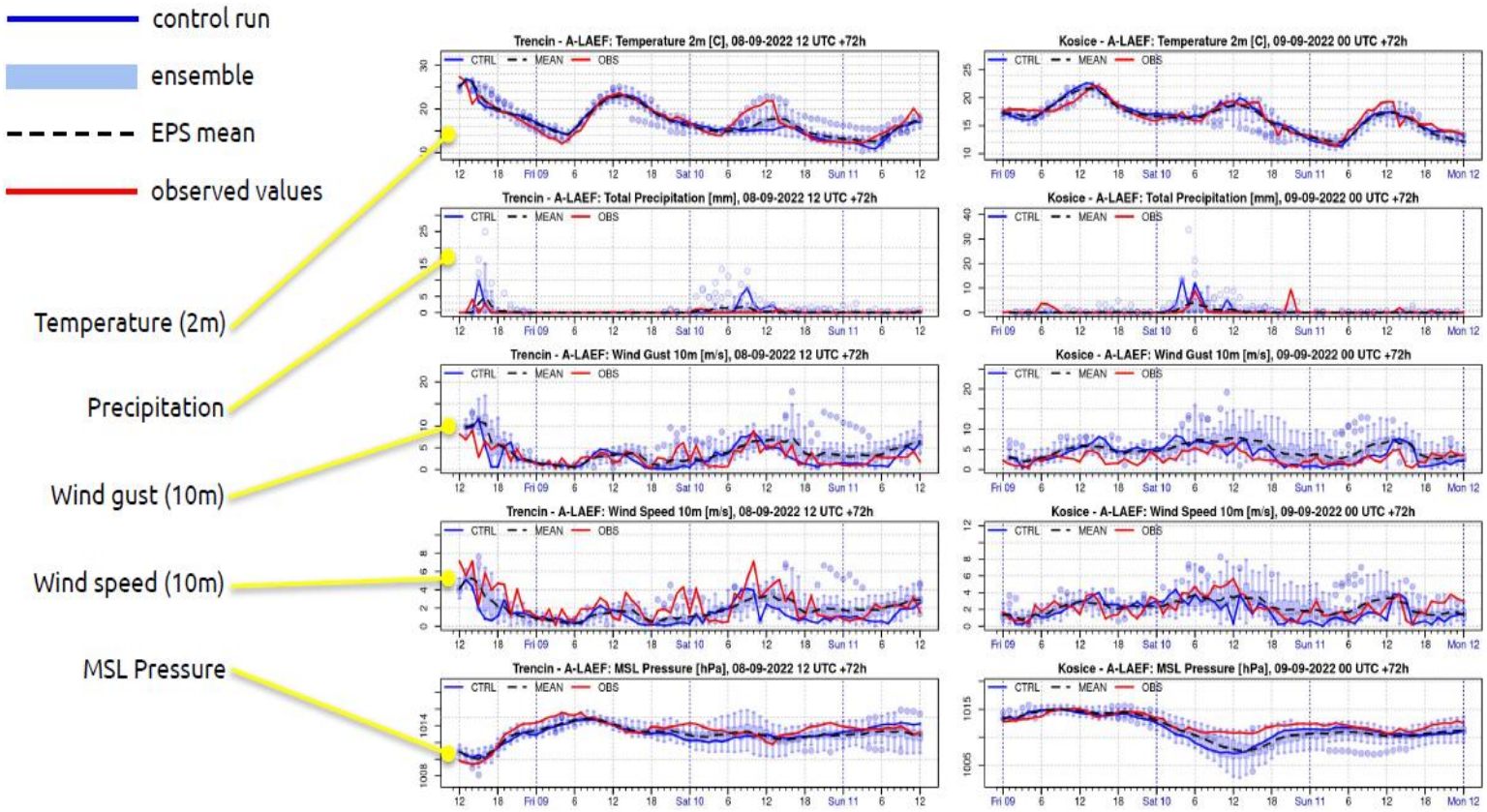
RC LACE web (and intranet)

SHMU web (>1000 points)



Redesigned/upgraded Epsgrams and simplified version for the public SHMU webpage.

New products for A-LAEF



Verification of A-LAEF Epsgrams using automatic weather station data.

ECMWF Atos migration

- **Migration of operational suites of A-LAEF and C-LAEF to new Atos HPC in Bologna**
  - First access to new HPC in March/April 2022
  - Training course in March 2022
  - A lot of time spent for ENV issues and optimizations
  - Stability problems at the beginning
  - Keeping consumption of SBUs on current level – some jobs run substantially faster
  - Double amount of SBUs available (expansions planned)
  - Final migration has to be finished till end of October

  A-LAEF:
  - First suite of A-LAEF in August
  - Upgrade of c903 LBC production (cy48t2) with multi-domain processing
  - Ectrans connection to OPLACE to fetch observation files
  - Child processes added for live monitoring of tasks‘ progress
  - Conversion of FA files to grib not yet working
  - Issue with shuffle in assimilation
  - Still cy40t2, upgrade planned to cy43t2 oder cy46t1 in 2023

ECMWF Atos migration

- **Migration of operational suites of A-LAEF and C-LAEF to new Atos HPC in Bologna**

  C-LAEF:

  – First stable suite in July (coupling files, observations, etc. copied from ecgate)

  – Verification during the summer months (July, August) shows comparable results

  – A lot of optimization for tasks arrangement (number of cores, CPUs, etc.)

  – Start on operational TC2 users in August - pre-operational suite running since end of August

  – Use of coupling files from ECMWF-ENS Esuite on Atos since September

    • Bug with spectral subtruncation

    • Differences between old and new couplingfiles (currently under investigation)

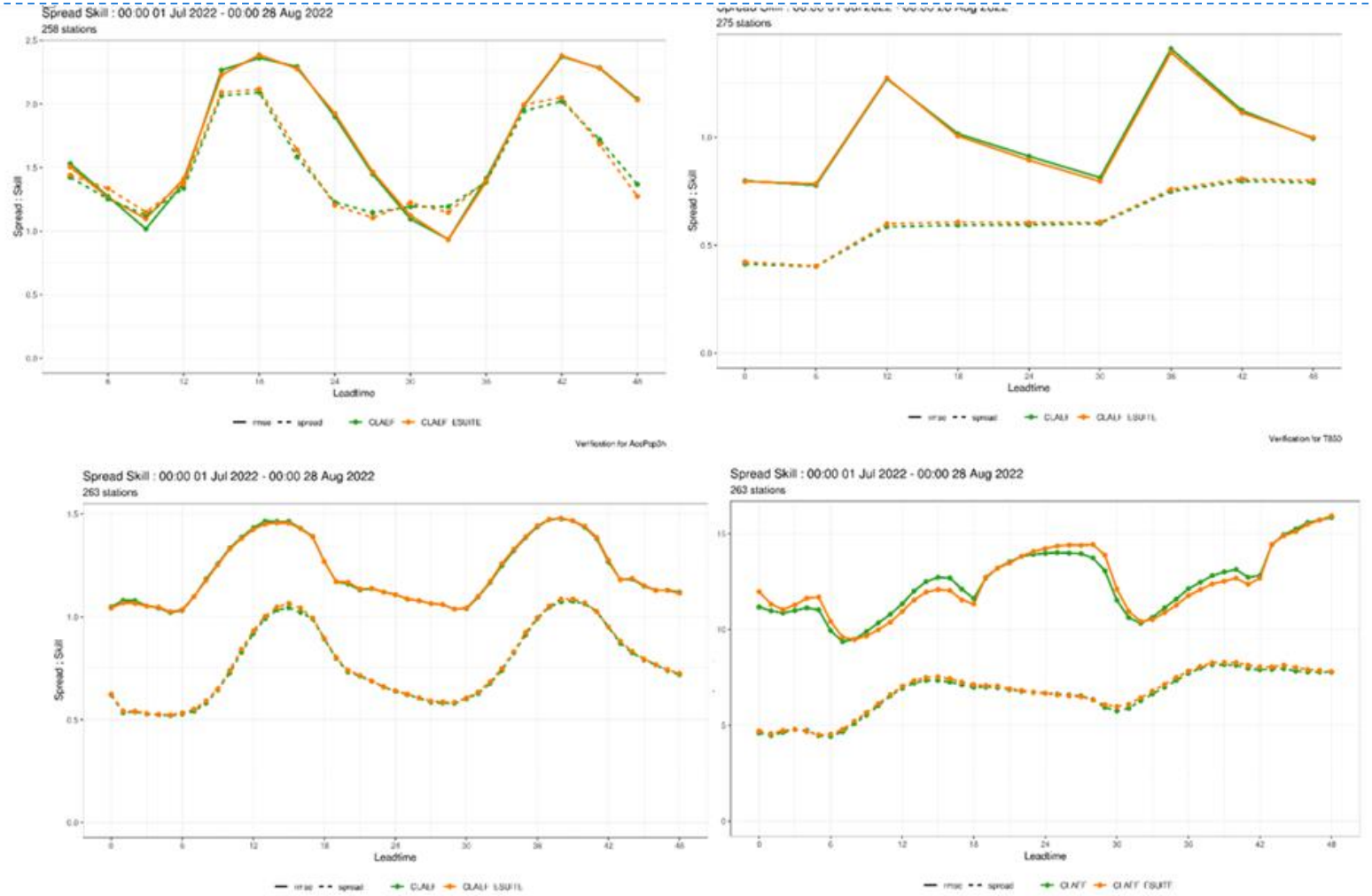
    • Random crashes of integration with these couplingfiles (trajectory out of atmosphere)

  – Some crashes at beginning of integration (maybe related to intel-mpi, open-mpi currently tested)

  – Ecaccess-triggering for operational users not yet working

  – Ectrans to ZAMG not yet working

ECMWF Atos migration

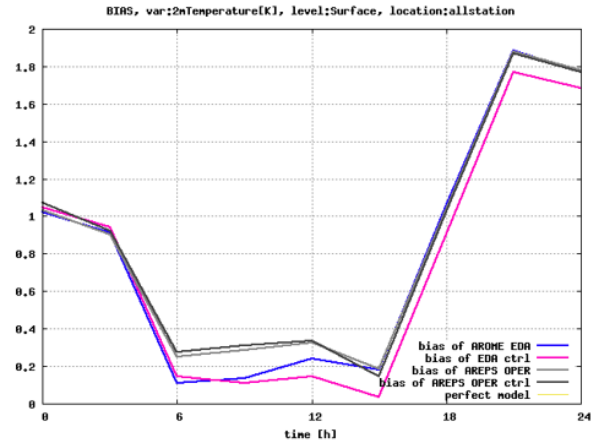


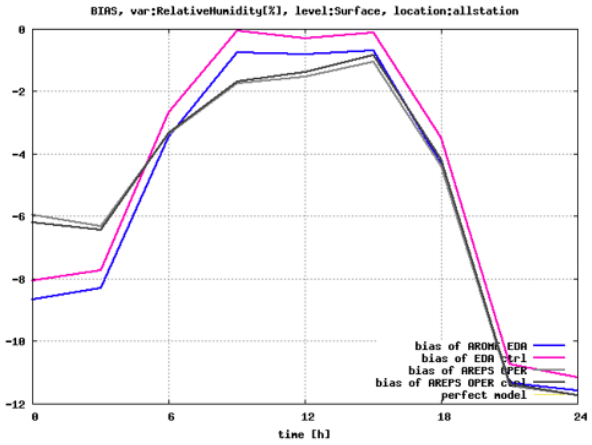
Spread (solid) and skill (dashed) of operational C-LAEF (Cray, green) and C-LAEF E-suite (Atos, yellow) for 01/07/2022 - 28/08/2022 at all Austrian stations. 3h accum. precip, 850 hPa T, u-comp of wind, 2m RH.

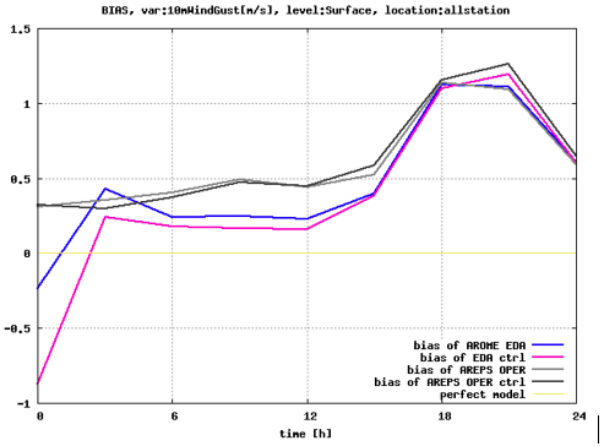
EDA in AROME-EPS

- **Introduction of EDA in AROME EPS (Hungary):**
  - Operational AROME-EPS is dynamical downscaling of the first 11 members of ECMWF-ENS at 2.5 km horizontal resolution and 60 vertical levels
  - Experiments to introduce local perturbations using EDA
  - 3 hourly assimilation cycle, using OI-main for surface and 3D-Var for upper air analysis
  - 1-month experiment with EDA in CY43T2 (July 2021) plus 1 case study (1st July)
  - Offline perturbation of observations after screening

EDA in AROME-EPS

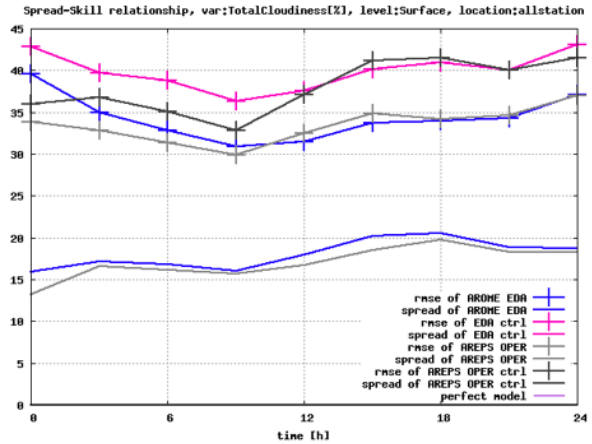


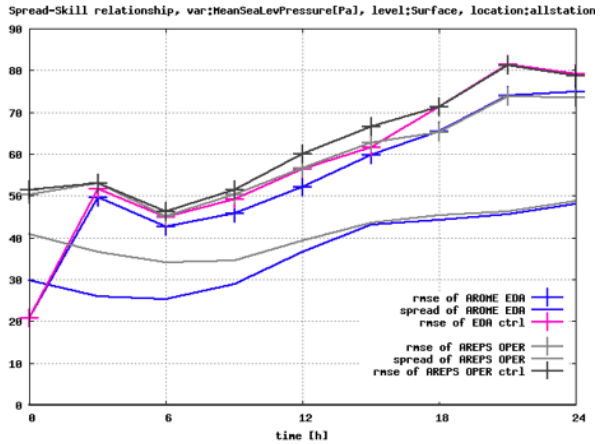


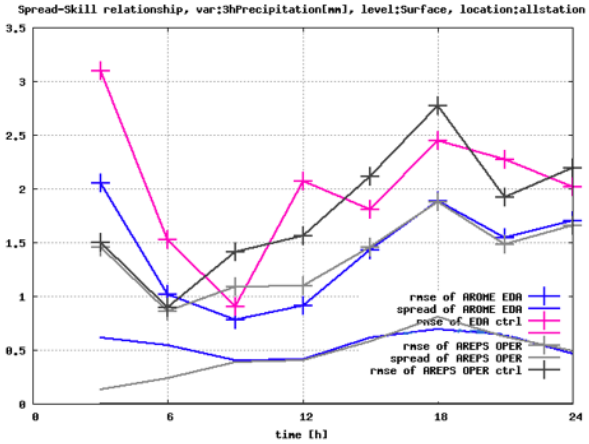


Bias of 2m temperature and relative humidity and 10m wind gust based on operational AROME-EPS mean (grey), AROME-EPS-EDA mean (blue), control member of operational AROME-EPS (black) and control member of AROME-EPS-EDA (pink) averaged for 30 Hungarian stations in July 2021.

EDA in AROME-EPS







Spread (–) and RMSE (+) of total cloud cover, mean sea level pressure and precipitation based on operational AROME-EPS mean (grey), AROME-EPS-EDA mean (blue), control member of operational AROME-EPS (black) and control member of AROME-EPS-EDA (pink) averaged for 30 Hungarian stations in July 2021.

EDA in AROME-EPS

- **Introduction of EDA in AROME EPS (Hungary):**
  - Applying EDA in the AROME-EPS causes noticeable improvements for surface parameters
  - EDA decreases the error of surface parameters during day time, but it has slight impact during the evening hours
  - Spread of 10m wind, 2m temperature and humidity increases with EDA for the whole forecast
  - RMSE and spread of precipitation are increasing during the first few hours with EDA while the impact is almost neutral later
  - Similar conclusions can be drawn for mean sea level pressure and cloudiness
  - Hardly no impact on the upper air fields
- **Planned to become operational in 2023**

SPP in C-LAEF

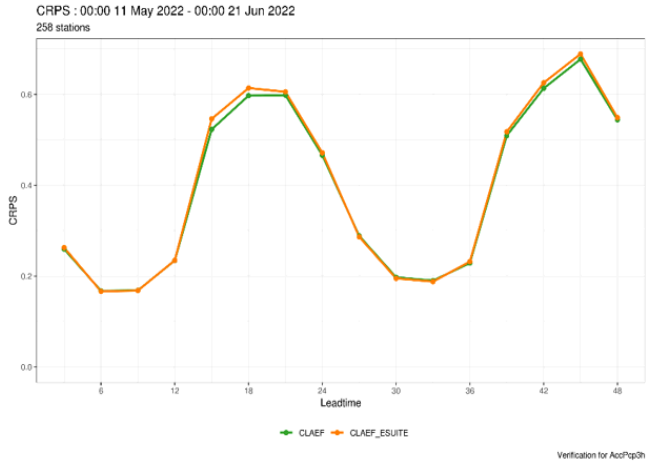
Extension of C-LAEF SPP scheme:

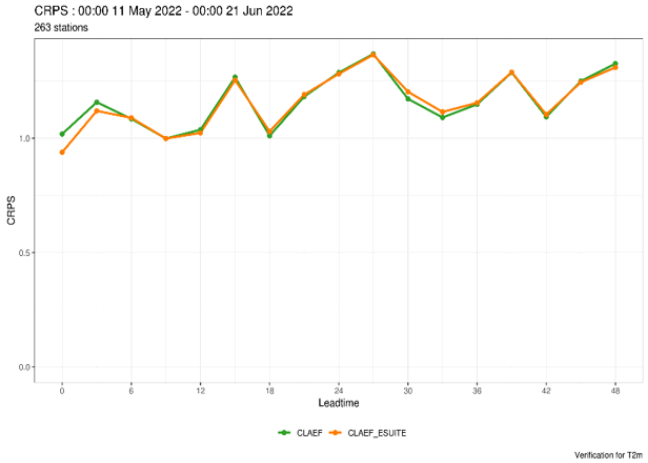
- operational C-LAEF comprises model error representation by perturbation of tendencies (shallow convection, microphysics, radiation) and parameters (turbulence)
- Implementation of full SPP parameter perturbation scheme to increase physical consistency
- Implementation of SPG pattern generator
- Set-up of E-suite with 13 perturbed parameters
- A lot of tuning necessary
- SPP is cheaper (5%) than hybrid system
- Verification of E-suite over 6 weeks in summer 2022
- Migration of E-suite to Atos
- Operationalization planned in 2023

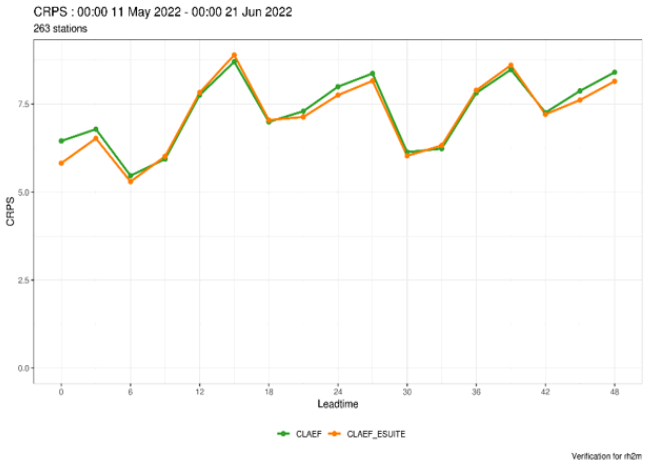
Scheme	Parameter	Physical meaning	Default	Range
Radiation	RSWINHF	Shortwave inhomogeneity factor	1	0.6 - 1
	RLWINHF	Longwave inhomogeneity factor	1	0.6 - 1
Microphysic	RCRIAUTI	Snow Autoconversion threshold	0.2e-3	0.2e-4 - 0.25e-3
	RCRIAUTC	Rain Autoconversion threshold	1e-3	0.4e-3 - 1e-3
	VSIGQSAT	Constant 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
Diffusion	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
	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

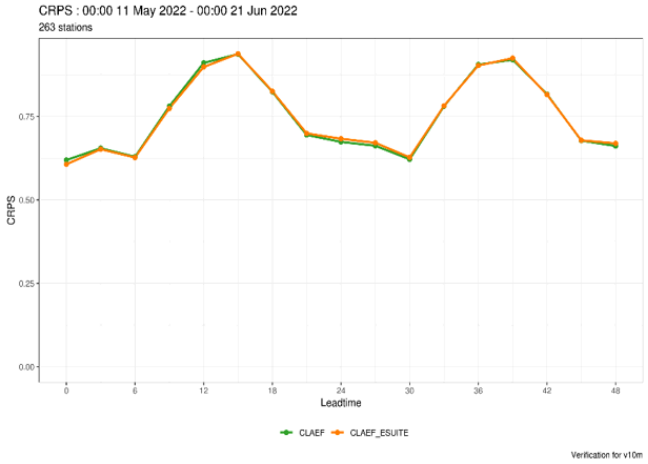
Parameters which are perturbed stochastically in the SPP scheme currently implemented in a C-LAEF E-suite (yellow boxes).

SPP in C-LAEF









CRPS of operational C-LAEF with hybrid stochastic perturbation scheme (green) and C-LAEF E-suite with new SPP scheme (orange) for 3h accum. precip., 2m temperature, 2m relative humidity and v-component of 10m wind for the period 11 May–21 June 2022.

Statistical EPS

- **Statistical post-processing of EPS data at ZAMG**
  - SAMOS (standardized anomaly model output statistics) and GEMOS (global ensemble model output statistics) have been implemented at ZAMG to improve direct model output from ensembles (EMCW-ENS, GFS, C-LAEF)
  - Current implementation comprises 2m T and RH, precipitation and 10m wind speed
  - SAMOS/GEMOS is providing spatial forecasts and offers a seamless forecast from analysis over short-range to middle-range forecasts.
  - Verification shows that SAMOS/GEMOS is able to improve the BIAS of the EPSs significantly and is also able to correct the under-dispersion of the ensembles

SAMOS (Standardized Anomaly Model Output Statistics):

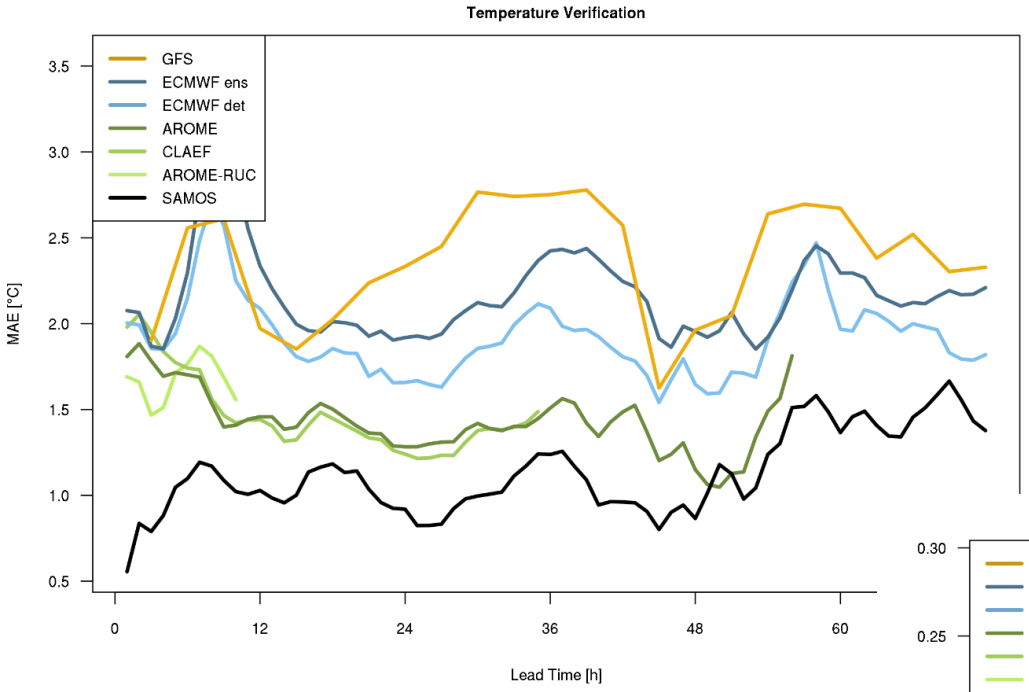
$$\frac{y-\mu_y}{\sigma_y} = \mathcal{N}(\mu,\sigma)$$
$$\mu = b_0 + b_1\, mean(\frac{ens_1-\mu_{ens_1}}{\sigma_{ens_1}}) + b_2\, mean(\frac{ens_2-\mu_{ens_2}}{\sigma_{ens_2}}) + \ldots$$
$$\sigma = c_0 + c_1\, sd(\frac{ens_1-\mu_{ens_1}}{\sigma_{ens_1}}) + c_2\, sd(\frac{ens_2-\mu_{ens_2}}{\sigma_{ens_2}}) + \ldots$$

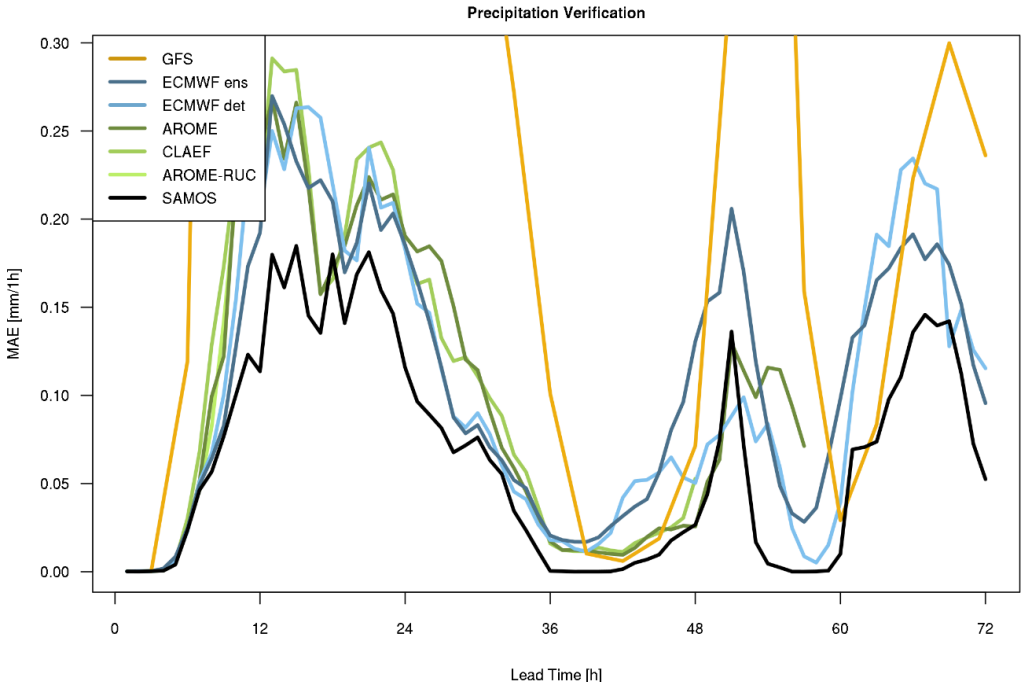
GEMOS (Global Ensemble Model Output Statistics):

$$y = \mathcal{N}(\mu,\sigma)$$
$$\mu = b_0 + b_1 m_1 + b_2 m_2 + \ldots + lat + lon + alt + \sin(doy) + \cos(doy)$$
$$\sigma = c_0 + c_1 s_1 + c_2 s_2 + \ldots$$

Ensemble mean and standard deviation in SAMOS and GEMOS approach.

Statistical EPS





MAE of 2m temperature for SAMOS (left) and MAE of 1-h accum. precip. with GEMOS (right) in comparison to direct model output for a case study in Austria.

Outlook & plans

Operational plans:

A-LAEF:

- Upgrade to cy43t or cy46t1 (to be decided)
- Upgrade of upper-air IC uncertainty representation by ENS BlendVar

C-LAEF:

- Operationalization of SPP in C-LAEF
- Upgrade to 1km until 2025
- Set-up of split system with ECMWF and ZAMG HPC

AROME-EPS:

- Operationalization of EDA in AROME-EPS
- Expansion of operational runs (e.g. 06 UTC)

Research & development:

- Development of flow-dependent model perturbations
- Stochastic perturbation of fluxes
- Flow-dependent B-matrix in assimilation
- EnVar in EPS
- Generation of ensemble members by deep learning algorithms
- Work on analog-based post-processing of probabilistic fields on a regular grid
- Development of new/improved probabilistic products
- Increase the reputation of EPS by user-oriented approaches