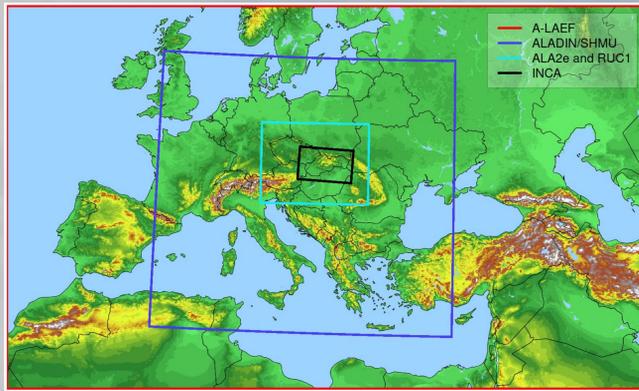


ALADIN (ALARO) systems at SHMU				
CSC	A-LAEF	ALADIN/SHMU	ALA2E	RUC1/ALA1
status	operational (common RC LACE)	operational		test mode
code version	CY40T1bF07+	CY46T1bF07	CY48T3	CY46T1bF07
physics	ALARO-1vB (multi-physics + surface SPPT)		ALARO-1vB	
dx	4.8 km	4.5 km	2.0 km	1.0 km
points	1250 x 750	625 x 576	512 x 384	1024 x 768
vertical levels	60	63	87	87
time step	180 s	180 s	90 s	30 s
forecast ranges + frequency	72/-72/- hourly	78/72/72/60 hourly	72/-72/- hourly	hourly, up to +12h or 48h (ALA1)
coupling model	ECMWF ENS (c903@cy48t2), 6h (time-lagged)	ARPEGE (long- & short cut off), 3h	ECMWF, 3h (time-lagged)	ARPEGE, 1h (time-lagged), SCC
surface data assimilation	ensemble surface data assimilation (ESDA) by CANARI	CANARI	A-LAEF CNTRL init downscaling	CANARI
upper-air data assimilation	spectral blending by DFI	Blending by DFI + 3D-Var		3D-Var
initialization	none	none	DFI	DFI
HPC	Atos Sequana XH2000 AMD (ECMWF)	NEC HPC - 240 nodes, 6230 Intel Xeon Gold Scalable Processors (Cascade Lake), Omni-Path, Linux		
nodes	85	40	40	40



Operational highlights
Upgrade of ALA2E to CY48T3 and RUC1 to CY46T1

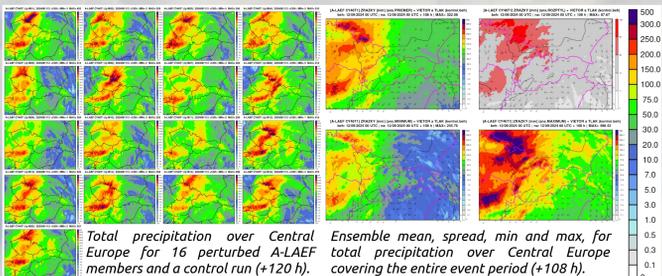
Near future plans
RUC development, VHR, climate modeling, convection-permitting EPS, upgrade ALADIN/SHMU to 87L

Highlights of the research and development

- Dynamics:** Experiments on hydrostatic/non-hydrostatic runs in RUC and A-LAEF
- DA:** Technical implementation of OOPS system (OOVAR) in CY48T3
- RUC:** CY46T1 and 87 levels, SCC, case studies, CANARI deep soil wetness tests: see the RUC1 poster on this EWGLAM meeting (Neštiak et al.)
- EPS:** A-LAEF e-suite with CY46T1+, new ALARO multiphysics (EL0, EL1, prognostic graupel, etc.), probabilistic calculation of the SPEI index for drought monitoring, case study of severe floods caused by the storm Boris (12.-16.9.2024)
- ALA2E:** Introduction of CY48T3, adding diagnostic parameters and graupels
- Climatological modelling:** Downscaling of ERA 5 reanalyses
- Physics and diagnostics:** Graupel and simulated radar reflectivity parameterizations tested in CY48T3, reduction of oscillations in offline SURFEX
- Quality control:** HARP IO for Obsoul TEMP, higher vertical data density
- DE_330_MF (DEODE) project:** start of the next phase, preparatory work

A-LAEF development

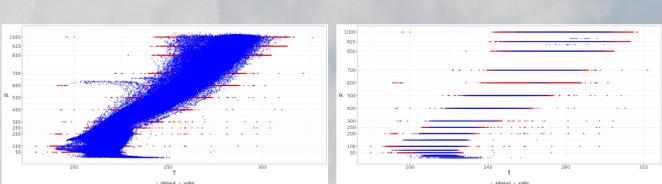
The A-LAEF (CY46T1+) e-suite was set up under the new time-critical user on Atos@ECMWF, featuring a completely new multiphysics approach based on the latest ALARO-1 code developments from CHMI (led by Jan Mašek), along with stochastic perturbations of the ISBA surface prognostic fields ported from CY40T1. In addition to two base tunings, the multiphysics approach also utilizes two different mixing length computations: EL0 (Geleyn-Cedilnik) and EL1 (revised Bougeault-Lacarrère with the inclusion of a shear term). These are linked to the PBL height computations using the weak capping inversion method versus the TKE-based method, respectively. Moreover, new CLIM files for the A-LAEF domain were prepared, incorporating updated physiographic fields, including their low spectral truncation version for blending. This should contribute to further improvements in the representation of surface fields. The new code used in the A-LAEF system (e-suite) also includes prognostic graupels, diagnostics for 16 distinct precipitation types, lightning flashes, and more.



On-demand A-LAEF (CY46T1+) e-suite forecasts for +120/108 hours ahead, focusing on the extreme precipitation totals expected in Central Europe, which caused massive flood damage and loss of life in Austria, Czech Republic, Poland, and Slovakia. The A-LAEF forecast is from Wednesday 12 UTC and Thursday 00 UTC. Persistent rainfall affected Central Europe particularly from Friday to Sunday - September 13 to 15, 2024.

HARP IO for OBSOUL TEMP

Harp has been enhanced to read radiosonde (TEMP) data in OBSOUL format, expanding its capabilities beyond the existing support for SYNOP. We have (in collaboration with Alena Trojáková) identified potential opportunities for using OBSOUL for verification with a higher vertical data density. Despite potential benefits for future applications, more research is needed to assess the feasibility and implications of verification at these levels. Figure on left demonstrates a more extensive distribution of data across pressure levels (blue OBSOUL, red VOBS). Figure on right shows concentration of observations at standard upper-air pressure levels (blue OBSOUL, red VOBS).

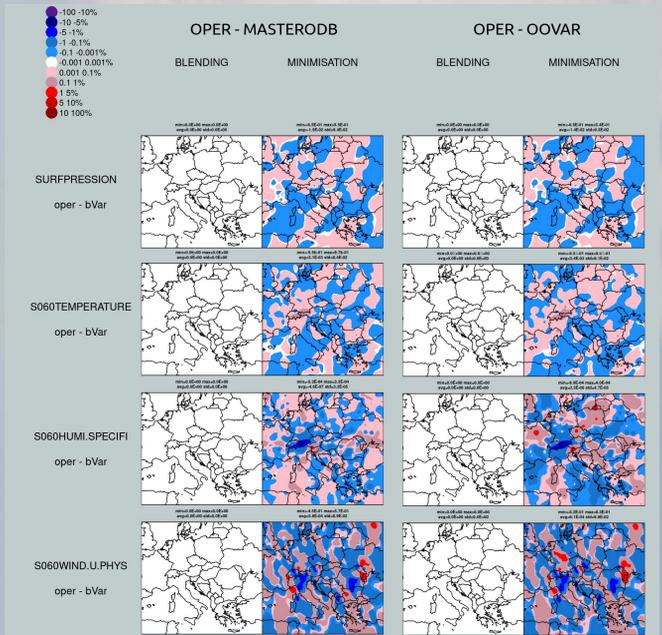


Implementation of OOPS system for data assimilation at CY48T3

The general idea of Object-Oriented Prediction System is to handle data assimilation algorithmic components in a more generic and flexible way, which eases development and testing. The implementation of OOPS data assimilation executable (OOVAR) was done during ACCORD Data Assimilation Working Week in Vienna remotely.

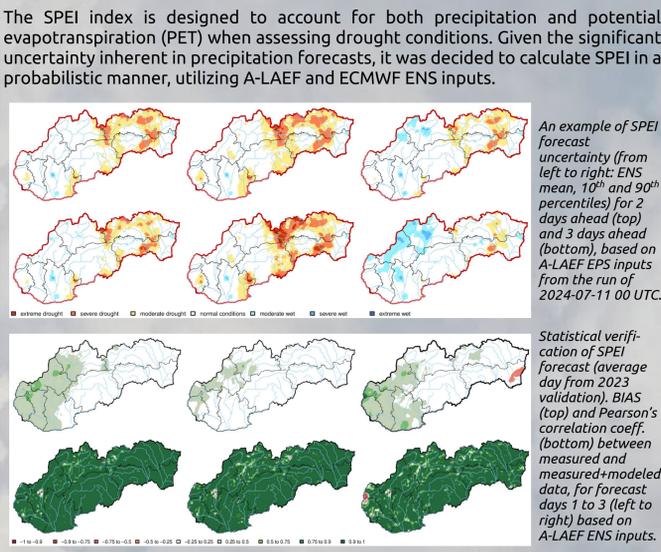
First task of the implementation was the compilation of OOVAR and other executables at SHMU HPC system with help of Oldřich Španiel. Following task was to upgrade operational suite (oper) from CY46T1 to CY48T3 by introducing new mandatory files like errgrb files (splitted from old file) etc.

The 3D-VAR without VARBC was chosen for the first OOVAR setup, to be close as possible to the operational data assimilation setup. The OOVAR setup incorporates the E002 and E131 configurations in one step. As can be seen, the differences between OPER - MASTERODB and OPER - OOVAR are in remarkable match with slightly more extremes in OOVAR setup.



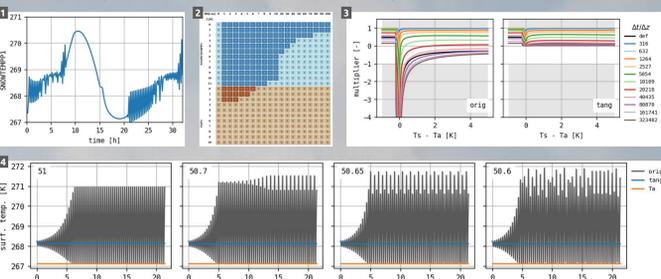
Probabilistic computation of SPEI

The drought research and monitoring is important and discussed topic in the recent years, because of frequent occurrence and strong intensity of droughts. SHMU monitors the meteorological and soil drought since 2015. Standardized Precipitation and Evapotranspiration Index (SPEI) is used for evaluation of drought in Slovakia, utilizing floating window with accumulation period of 30 days. The SPEI index is designed to account for both precipitation and potential evapotranspiration (PET) when assessing drought conditions. Given the significant uncertainty inherent in precipitation forecasts, it was decided to calculate SPEI in a probabilistic manner, utilizing A-LAEF and ECMWF ENS inputs.



Stability of surface heat balance equation numerical solvers

Parasitic oscillations have been observed in some idealized single column offline SURFEX experiments using Explicit snow or Crocus schemes (Fig. 1). It was found that oscillations originate in a snow surface layer, penetrating also into a deeper snow eventually ground layers (Fig. 2). Analysis suggested that they are due to numerical treatment of nonlinear turbulent heat transfer terms H and LE in surface heat balance equation (SHBE). Linear stability analysis reveals that LE component can give rise to unstable oscillations in certain situations. Numerical instability is strongest in the vicinity of neutrally stable atmospheric condition but it can be controlled via the ratio of time step length to layer thickness to some extent. A few alternative numerical schemes for SHBE have been derived and examined. One based upon tangent linear approximation shows improved stability compared to original one (Fig. 3). We also examined change of parasitic oscillations behavior in response to change of control parameter (input radiation heat flux) for a constant forcing. Original scheme showed transition from regular to irregular oscillations for narrow parameter range through the cascade of period-doublings typical for chaotic systems. In contrast tangent linear scheme showed relaxation toward steady surface temperature without any oscillations (Fig. 4).



Increasing the number of vertical levels in ALADIN/SHMU (summer period)

During the testing of 87L configuration (DEV) in summer period (half year of cycling, one month of statistics - July) the DFI in blending was tuned with help of Radmila Brožková due to increased occurrence of the smilg trajectory underground messages.

Also the space consistent coupling was implemented to the 87L configuration.

The visualisation of verification in the form of scorecards shows scores for various parameters at various levels and forecasts ranges of new 87L configuration in comparison with operational ALADIN/SHMU 63L (labeled as OPER) for July 2024. Score of one parameter of one forecast range is composed by two triangles. The upper and lower triangle represents score in BIAS and RMSE respectively. The green color shows improvement, while the red color represents deterioration.



ALA2E switch from CY43T2 to CY48T3

The CY48T3 cycle was tested and introduced to ALA2E operational suite on 15 May 2024 (ALA2E is a dynamic adaptation with initial conditions from the A-LAEF control member). The higher cycle enabled to switch on the calculation of several diagnostic parameters (e.g. MLCAPE, MUCAPE, Updraft Helicity, Lightning density, Cloud base height, Cloud top pressure), which are provided for forecasters. We use the parameterization of graupels (LGRAPRO=T), which was tested in both convective and winter cases. Despite advantages (higher simulated radar reflectivity, stronger convective outflows) we encountered negative features as intense surface graupel precipitation in winter (probably instead of snow). Tuning of the RWBF1 parameter slightly decreased the graupel precipitation but at the cost of worse scores in summer (not shown).

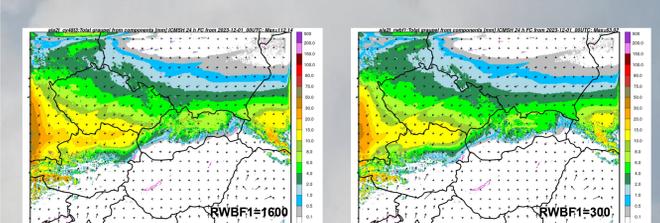


Fig. Left: Cumulated 24h surface graupel precipitation from the 1 December 2023 00 UTC run. Right: The same but in the experiment with RWBF1=300 (with slightly less graupel)

An experimental, bigger domain (AL20) was prepared (960 x 800 pts, 3.9 times more than for the operational ALA2E). The impact of the bigger domain was tested and compared to the reference ALA2E forecasts with CY48T3 (RF20 experiment) and previous operational CY43T2 suite (SH20). In a case study, the short-range (until +24h) forecasts of respective parameters were similar for the reference and bigger domain, differences could be seen in individual convective precipitation patterns (e.g. close to the border of the operational ALA2E domain). The impact of the bigger domain on scores (August 2023, February 2024) was rather ambiguous (in 2m temperature and precipitation closer to the 4.5 km resolution ALADIN/SHMU results).

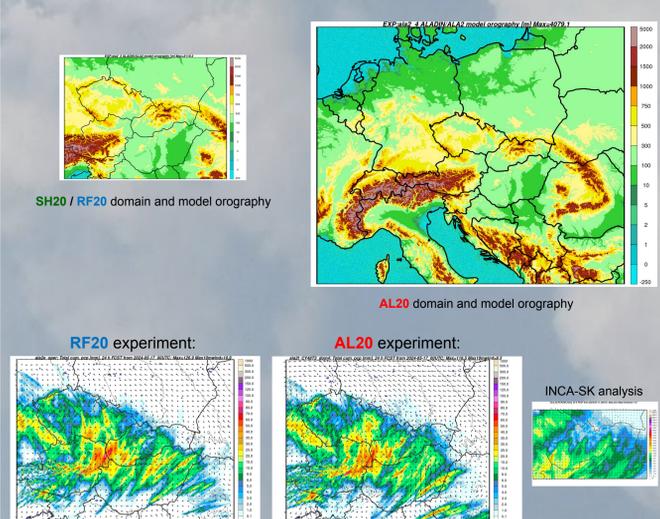


Fig. 24h cumulated precipitation forecast of ALA2E with CY48T3 Left: RF20 experiment with the small-size operational domain. Right: AL20 experiment with bigger domain. The comparison with INCA-SK indicated that the precipitation was overestimated in both experiments (probably due to graupel scheme impact).

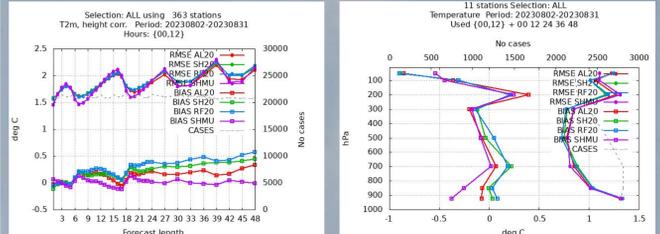


Fig. Verification scores for the experiment with the big domain and with CY48T3 (AL20), small-size domain and previous cycle 43T2 (SH20), small-size domain and CY48T3 (RF20) and operational ALADIN/SHMU. Left: height-corrected 2m temperature, Right: vertical temperature profile.