NWP related activities in 2025-2026 @SHMU

6th ACCORD All Staff Workshop, 13.-17.4.2026, Marrakech, Morocco

(www.shmu.sk) **nwp@shmu.sk** => Martin Imrišek - Michal Neštiak - Viera Rattayová - André Simon - Oldřich Španiel - Martin Vozár - Roman Zehnal (with support of Martin Petrovič, Peter Váš, Peter Kaňák, Ľuboslav Okon and colleagues, who left SHMU in 2025: Martin Belluš, Mária Derková, Adam Otruba, Jozef Pecho, Martin Petraš, Viktor Tarjáni)

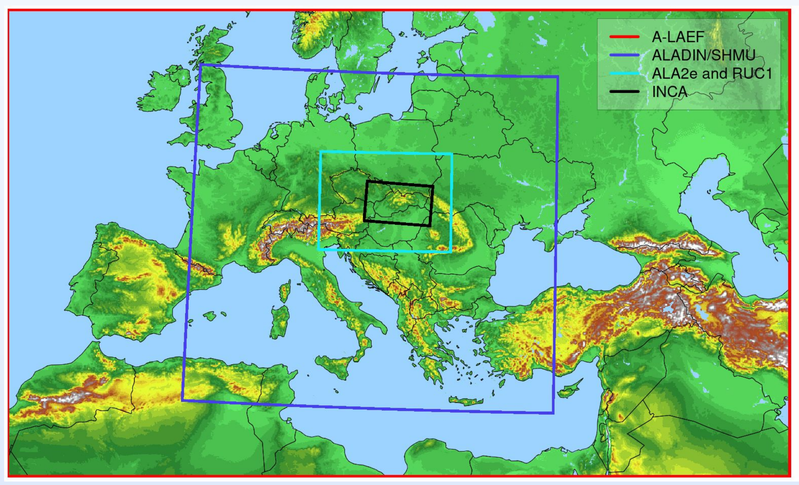
ACCORD — A Consortium for COnvection-scale modelling Research and Development

LACE nwp central europe

ALADIN

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	87	87	87
time step	180 s	180 s	90 s	30 s
forecast ranges + frequency	72/-/72/- hourly	102/72/72/72 hourly	84/-/84/- 0,5 hourly	hourly, up to +12h or +30h (00 UTC)
coupling model	ECMWF ENS (c903@cy48t2), 6h (time-lagged)	ARPEGE (long- & short cut off), 3h	ECMWF, 3h (time-lagged)	ARPEGE (time-lagged), 1h, 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	60



Operational highlights

Upgrade of ALADIN/SHMU to 87L, ALA2E: 30 min. output frequency

Near future plans

RUC development - upgrade to CY48T3, AI/ML nowcasting, single precision, severe weather diagnostics

Highlights of the research and development

Single precision: Continuous work on testing (CY48T3, CY49T2)

DA: Radar data assimilation, SEVIRI data assimilation

Physics: VIL (Vertical Integrated Liquid) diagnostics

RUC: Radar data assimilation (ALA1 version)

EPS: Hectometric-resolution mini-EPS tested on case studies

MQA: Predictability of thunderstorms with diagnostic parameters and indices

AI/ML: Preparatory work, data for training

Applications: NWP forecasts for global radiation nowcasting (APVV project)

DE_330_MF (DEODE) phase 2 project: Comparison of three canonical configurations (ALARO, AROME, HARMONIE-AROME) at 500 m horizontal resolution. ALARO-EPS experiments (6+1 members) with new multi-physics and surface SPPT at 1000 m and 750 m spatial resolution.

A-LAEF status

martin.bellus@gmail.com, jan.masek@chmi.cz, andre.simon@shmu.sk, martina.tudor76@gmail.com, neva.pristov@gov.si, jadwiga.rog@imgw.pl

Emergency:

In January 2026, the emergency of the A-LAEF LAM EPS system started to be gradually overtaken by dedicated RC LACE team of users (due to departure of Martin Belluš from SHMÚ, who was the main developer and manager of A-LAEF). Currently, representatives from 5 countries (CZ, HR, PL, SI, SK) participate and change weekly in duties. A presentation about A-LAEF system and its maintenance was prepared and held by Martin Belluš on 8 December 2025.

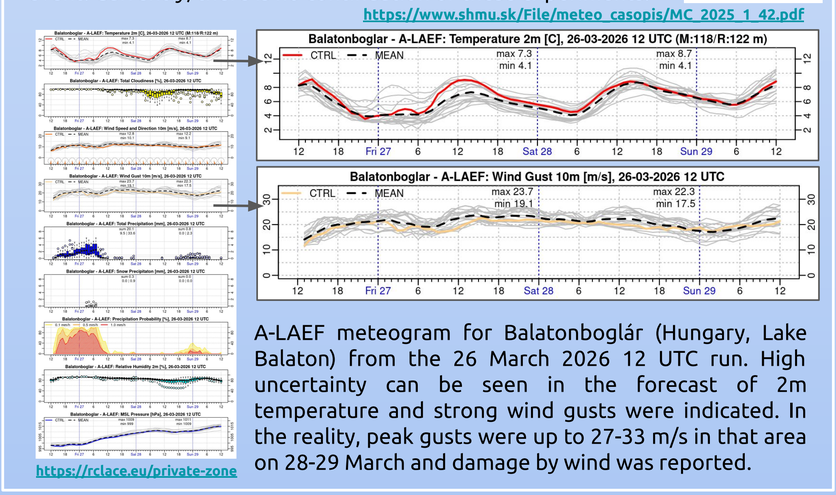
Expected upgrades:

A new e-suite has been prepared by Martin Belluš for CY46T1+, running from 12 June 2025 for the control member. It includes surface assimilation (ESDA) + upper-air spectral blending, integration (new multiphysics + stochastic physics), fullpos (inline with generation of GRIB2 outputs). Both validation and verification (HARP) were already provided. The operational implementation will be probably managed by the IMGW team.

Hectometric-scale EPS experiments:

A mini-EPS with 750m horizontal resolution was tested by Martin Belluš in the frame of the DE_330 experiments - see the publication of Šinger, Belluš and Méri in the Meteorological Journal of SHMU, containing the analysis of the "Boris" flood event. Currently, there is no continuation of these experiments.

https://www.shmu.sk/File/meteo_casopis/MC_2025_1_42.pdf



A-LAEF meteogram for Balatonboglár (Hungary, Lake Balaton) from the 26 March 2026 12 UTC run. High uncertainty can be seen in the forecast of 2m temperature and strong wind gusts were indicated. In the reality, peak gusts were up to 27-33 m/s in that area on 28-29 March and damage by wind was reported.

https://rclace.eu/private-zone

Radar DA - Comparison RUC1 vs ALA1 2026-03-28 12:00 UTC Bratislava

michal.nestiak@shmu.sk

The inclusion of data assimilation of OPERA radar reflectivity in the ALA1 introduces significant localized adjustments to the wind field compared to the RUC1. While the general northwesterly flow is maintained in both models, the ALA1 shows a distinct directional shift and increased gust intensity over the Bratislava City Center and Petržalka districts. In contrast, RUC1 exhibits a more uniform and geographically smoothed wind field, failing to capture the small-scale eddies and convergence zones induced by the radar-detected moisture and momentum. The RUC1 suite completes a 30-hour forecast in roughly 49 minutes on 60 nodes.

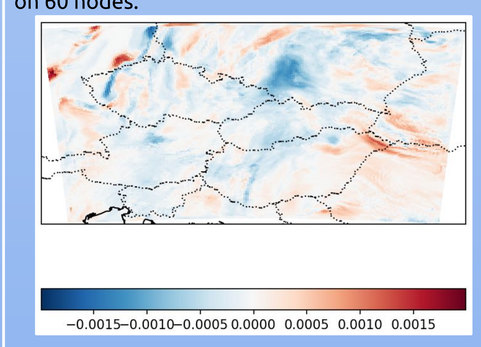
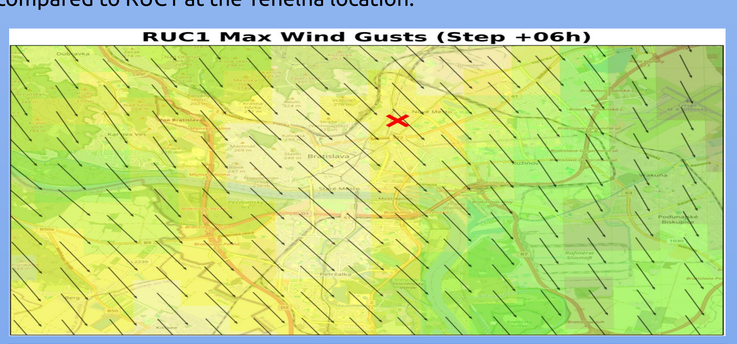
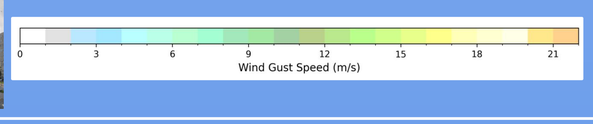


Figure (left): q difference RUC1 - ALA1 (Red: ALA1 is drier; Blue: ALA1 is wetter), (right): damage by wind in the western part of Bratislava

Figure (bottom): ALA1 produces a gust intensity surplus of more than 5 m/s compared to RUC1 at the Tehelná location.



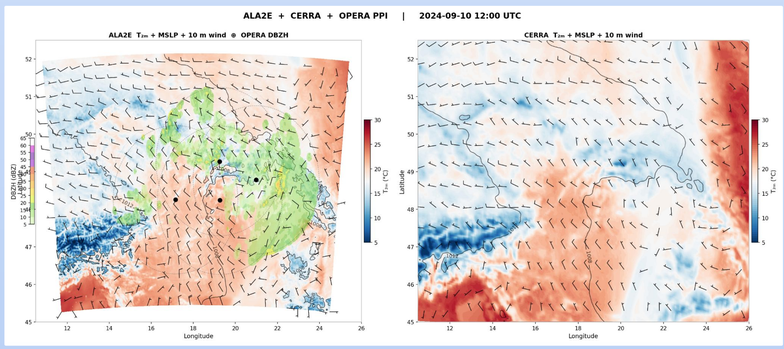


AI-ML nowcasting

martin.vozar@shmu.sk

This work is at a preliminary stage, focused on building data infrastructure and extending the knowledge base on the problem. ERA5 and CERRA datasets are meant to be utilized for pre-training, exploiting their extensive temporal range and options to explore spatial generalization. Fine-tuning on ALA2E or RUC1 NWP model outputs then targets performance at the increased resolution, with emphasis on convective scales and local extrema.

Two architectural families are under consideration. The primary candidates are GNNs, following the paradigm of BRIS (Met Norway) implemented via Anemoi framework. Another candidate are Computer Vision based architectures, which show great fidelity when generative approaches are utilized. Automatic weather station and OPERA radar observations are included as point-wise inputs in both approaches.

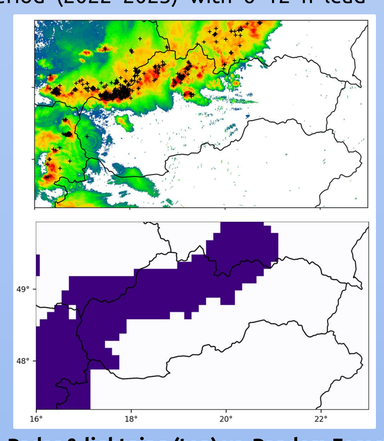


Machine Learning-Based Evaluation of Convective Predictors

petvas113@gmail.com

A multivariate machine learning approach for convective prediction was tested against traditional single-parameter predictors using 2014–2023 warm-season period over Slovakia. Storms were defined by combined radar reflectivity (≥30 dBZ) and lightning. Predictors, including CAPE, K-index, Showalter index, PWAT, and convective precipitation, were derived from ERA5 reanalysis and ALADIN/SHMU forecasts, interpolated to a 10 × 10 km, hourly grid. A Random Forest trained on ERA5 was applied to both reanalysis and a two-year independent ALADIN/SHMU forecast period (2022–2023) with 6–12 h lead times.

Continuous predictors were converted to binary forecasts using optimized thresholds by Heidke Skill Score, with Brier and Fractions Skill Scores incorporated in a composite metric. The multivariate model outperformed single predictors, improving HSS by ~20%, as well as other metrics. Instability and moisture were the main drivers of skill, while dynamical variables contributed less. Spatial verification showed that general convective patterns were captured, although limitations remain due to input data and simplified representation of physical processes.



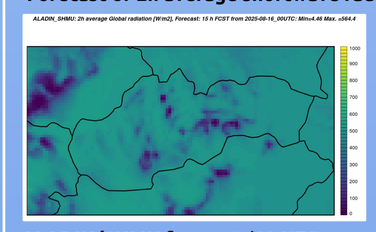
Radar & lightning (top) vs. Random Forest prediction (bottom, binary 0/1).

APVV project on global radiation nowcasting

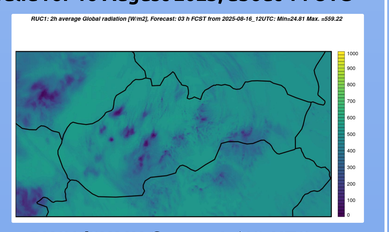
michal.nestiak@shmu.sk, andre.simon@shmu.sk

The aim of the ongoing research organized in cooperation between the Slovak Hydrometeorological Institute and the Faculty of Electrical Engineering and Informatics of the Slovak University of Technology (FEI STU, lead partner) is to develop a more accurate and computationally undemanding forecasting system aimed at small users. The system will predict changes in global radiation at a given location for several tens of minutes in advance, primarily based on a sequence of images from the All Sky camera (360-degree view of the sky). The project began in the late 2025. Besides observations (camera + AWS measurements + satellite images), the project expects also the use of NWP forecasts of parameters, relevant for cloudiness development (important during temperature inversions, etc.). The RUC1 system will be mainly adapted and used for this purpose.

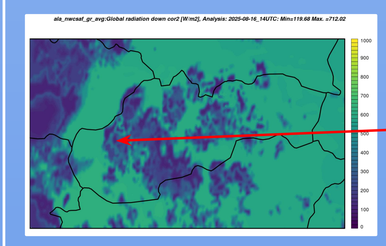
Forecast of 2h average shortwave radiation valid for 16 August 2025, about 14 UTC



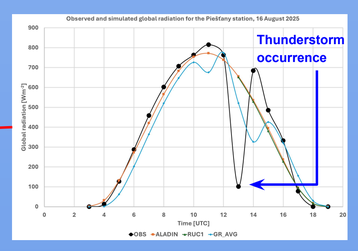
ALADIN/SHMU forecast (00 UTC run, valid for the 13-15 UTC period)



RUC1/SHMU forecast (12 UTC run, valid for the 13-15 UTC period)



Global radiation analysis from the gr_avg application, valid for 16 August 2025 14 UTC



Simulated and observed global radiation for the Piešťany station (SW Slovakia)

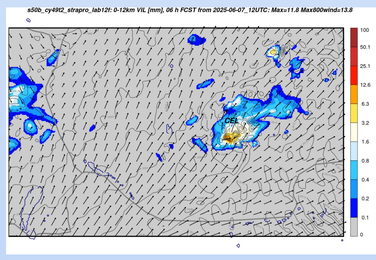
Authors declare that the research is supported from the project of the Slovak Research and Development Agency, APVV-24-0392, Short range prediction of solar radiation from sky observation and meteorological data.

Simulated Vertical Integrated Liquid (VIL)

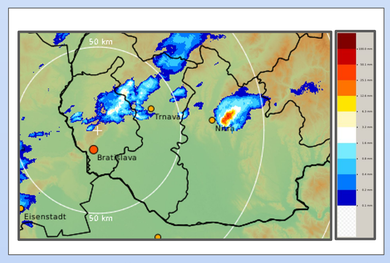
andre.simon@shmu.sk, luboslav.okon@shmu.sk

$$VIL = 0.001 \int_0^{12\ km} \left(\frac{Z_{mm6}}{C}\right)^{\frac{1}{D}} dz$$

VIL was defined by Greene and Clark (1972) to estimate the liquid water content of precipitating clouds on radar imagery. In the present form it is also used for detection of hail and severe storms. The NWP model outputs could also help to distinguish between ordinary and severe storms as the parameter is based on integral of simulated radar reflectivity (C, D are constants as defined in radar software) instead of single level information. The diagnostics was coded in the "adiab" part, in CY49t2 (bf_sfx). Results were tested on cases of severe storms (e.g. supercell over southwestern Slovakia on 7 June 2025).



ALARO, S50B experimental domain, +6h VIL forecast: explicit convection, 500m resolution, Marshall-Palmer scheme



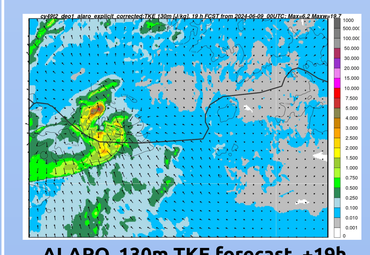
Corresponding VIL from SHMU radar observations (Malý Javorník site), on 07 June 2025 16:20 UTC

The peak forecast VIL in the high-resolution experiment was 11.8 mm. This is still much below observed values (several tens of mm) because the model is not capable to forecast hail, which has high radar reflectivity. Microphysics parameterization, e.g. the raindrop distribution schemes can have an important impact on the simulated thunderstorm intensity and VIL, e.g. the Abel and Boutle (2012) scheme (LAB12=.T.) predicted weaker storm and VIL of only 8.2 mm (not shown).

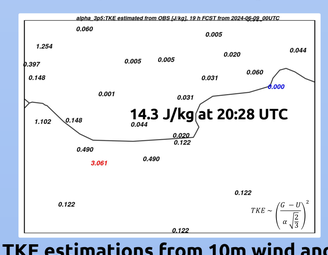
DE_330_MF project: Comparison of three CSC-s, a severe storm case

andre.simon@shmu.sk, nika.kastelec@gov.si

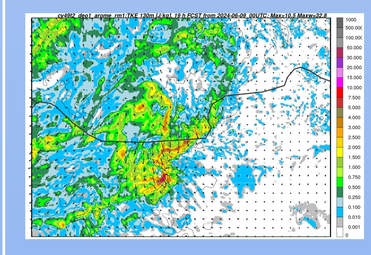
A unique comparison of three CSC-s (ALARO, AROME, HARMONIE-AROME) was done within the WP10 package of the DE_330 project, in the frame of the Working week in Brussels (29 September - 3 October 2025). The models were run on a same domain (1500 x 1500 points, 500m horizontal resolution), same IC and LBC and similar setup of dynamics. Several parameters were compared with available observations or estimations, (130m Turbulent Kinetic Energy comparison showed below). Among several cases, the environment of a severe thunderstorm event of 9 June 2024 over Central Europe was also analyzed.



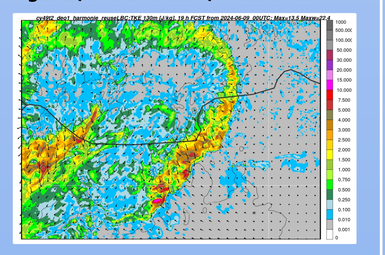
ALARO, 130m TKE forecast, +19h



TKE estimations from 10m wind and gusts, 09 June 2024, 19:00 UTC



AROME, 130m TKE forecast, +19h



HARMONIE-AROME, 130m TKE forecast, +19h

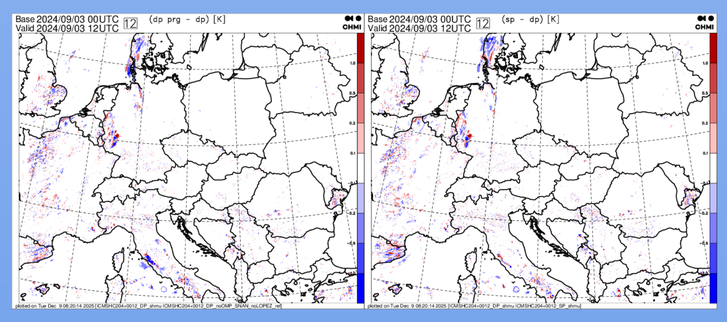
A thunderstorm outflow (region with high TKE, reaching 9-14 J/kg) is visible on the forecasts. This matched the TKE estimations from observed 10m wind and wind gusts (~ 14 J/kg during the gust front passage).

"This work is funded by the EU under agreement DE_330_MF between ECMWF and Météo-France. The on-demand capability proposed by the Météo-France led international partnership is a key component of the weather-induced extremes digital twin, which ECMWF will deliver in the first phase of Destination Earth, launched by the EC."

Single precision impact in CY49T2

oldrich.spaniel@shmu.sk, jan.masek@chmi.cz

Single precision code was optimalized in the cycle CY49T2 and comparisons were done with respect to double precision. Also sensitivity tests were run and 2m temperature differences were plotted for the CHMI and SHMU HPC, respectively (see below).



2m temperature differences [K] between the run at CHMU HPC (NEC, nfort) and SHMU HPC (NEC, ifort)

2m temperature differences [K] between the single and doble precision run

The comparison shows that the single-double precision difference is of similar order as if one would run the model on two, different HPC computers. Still, the use of single precision can save at about 50% of computational time (by fullpos offline).