NWP related activities in 2023-2024 @SHMU

4th ACCORD All Staff Workshop, 15.4.-19.4.2024, Norrköping, Sweden

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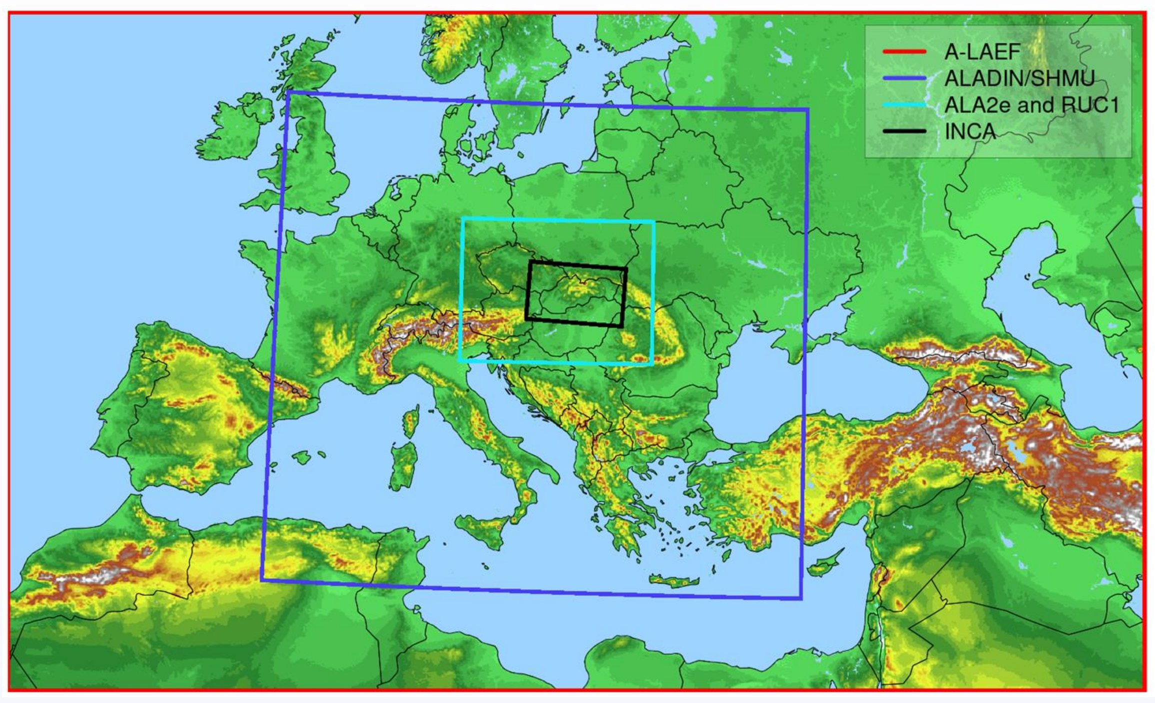
ALADIN (ALARO) systems at SHMU

CSC	A-LAEF	ALADIN/SHMU	ALA2e	RUC1/ALA1
status	operational (common RC LACE)	operational		test mode
code version	CY40T1bf07+	CY46T1bf07	CY43T2bf11	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 (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	40



Highlights of the research and development

Dynamics: DFI and IAU tests, hectometric scale (~ 250m resolution) experiments

DA: BlendVar CY46T1 operational, Slant Total Delays assimilation in CY49T1

RUC: CY46T1 and 87 levels, SCC, case studies, CANARI deep soil wetness tests

EPS: A-LAEF upgrade to CY46T1, new ALARO multiphysics (EL0, EL1, prognostic graupel, etc.), new diagnostic fields and products, inputs for hydrology, climatology and air quality departments (models), hindcasts to feed AI/ML (commerce), case studies

ALA2e: tests with CY48T3, new convective parameters and graupels, evaluation of lagged coupling

Climatological modelling: downscaling of ERA 5 reanalyses

Physics and diagnostics: Parameterization of wet snow and ice accretion on wires in CY49T1 (Arpege and ALARO), graupel parameterization tested in CY48T3

Quality control: implementation of new methods for quality checks at stations

DE_330_MF (DEODE) project: simulations on HR (ALA2) and hectometric (D75A) domains provided to partners in hydrology and air quality monitoring

Operational highlights

Upgrade of ALADIN/SHMU and RUC1 to CY46T1

Near future plans

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

A-LAEF development

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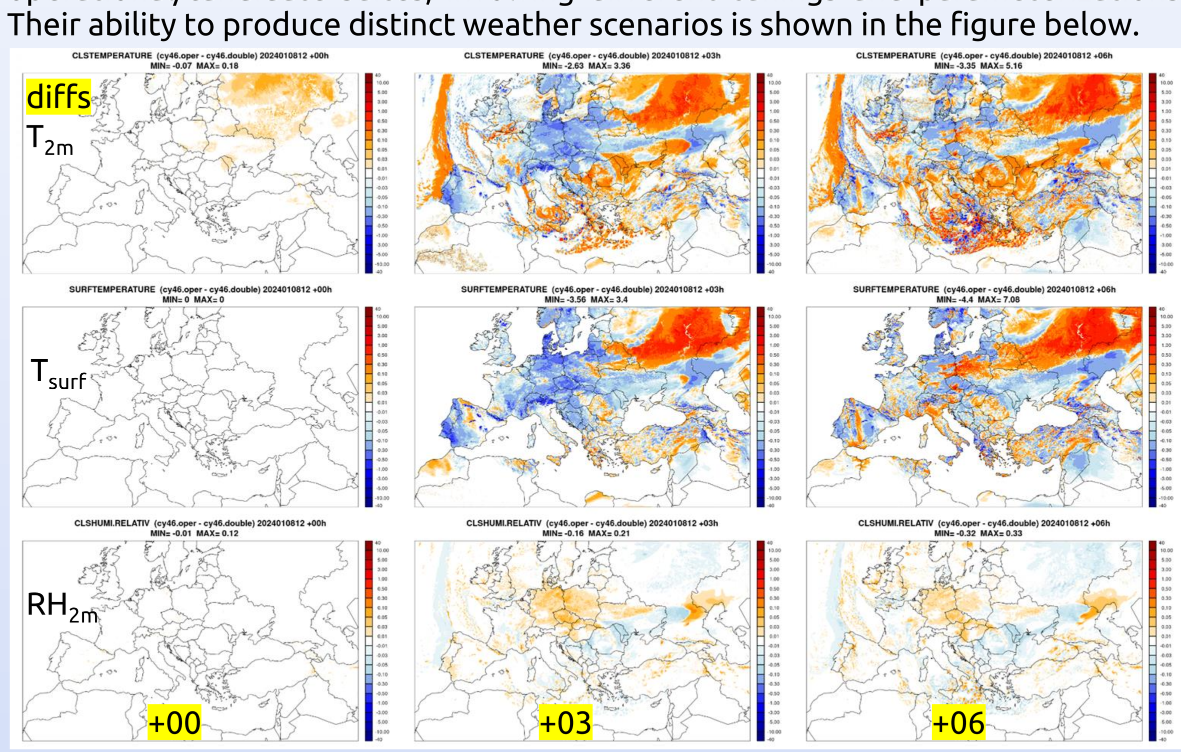
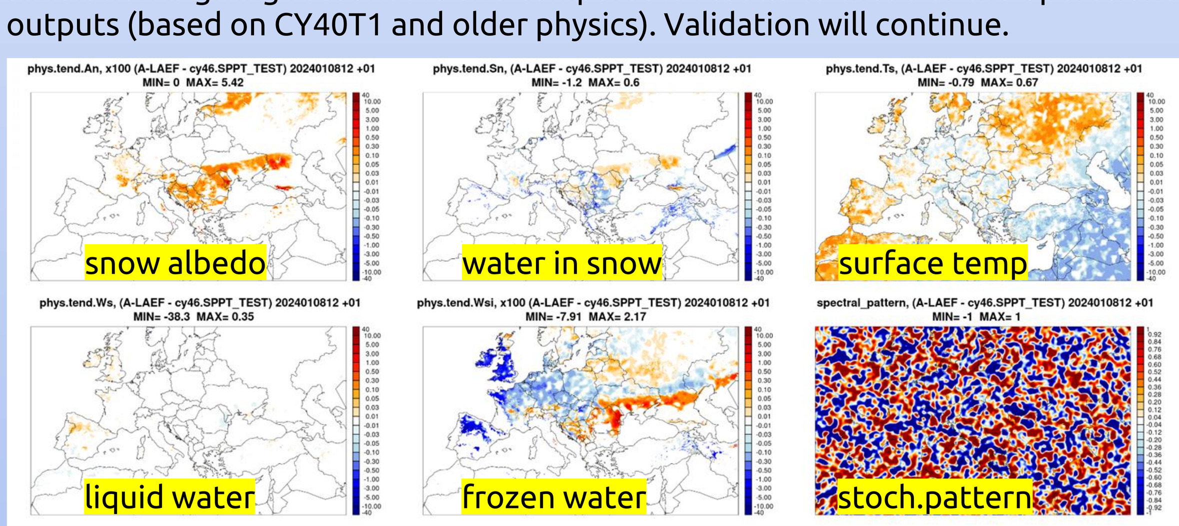
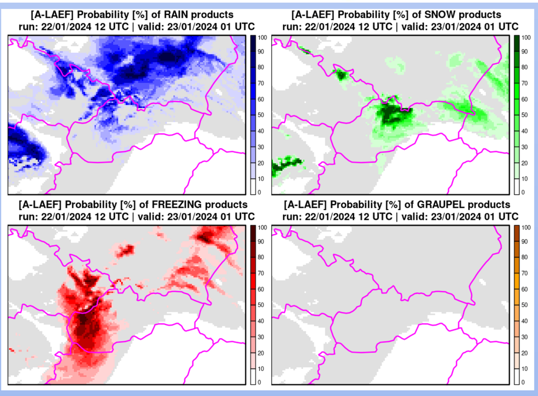
The whole A-LAEF system is being upgraded to CY46T1 version of the code. Together with that change comes also new multiphysics based on the latest ALARO development (special thanks to Jan Mašek for providing the source codes and supervision). The two main physics clusters were derived from the CZ operational/candidate suites, involving different tunings and parameterizations. Their ability to produce distinct weather scenarios is shown in the figure below.



Another physics variations were prepared combining (with the above) the two different mixing length computations - EL0 (Geleyn-Cedilnik) and EL1 (revised Bougeault-Lacarrère with the inclusion of a shear member). They are tied with the PBL height calculations using weak capping inversion method versus the TKE-based method, respectively. In order to enhance the model uncertainty simulation even further, the stochastic perturbation of ISBA surface prognostic fields was phased into CY46T1 and validated (see figure below). New model uncertainty simulation is giving reasonable and comparable results to those of the operational outputs (based on CY40T1 and older physics). Validation will continue.





The ongoing upgrade of A-LAEF system together with the ALARO physics will bring (among the other improvements) also some new prognostic and diagnostic fields. On the left is an example of successful prediction of newly implemented precipitation types during the glaze event in SW Slovakia. Frozen rain on sidewalks/streets complicated commuting on January 23.

ALA2e coupling experiments

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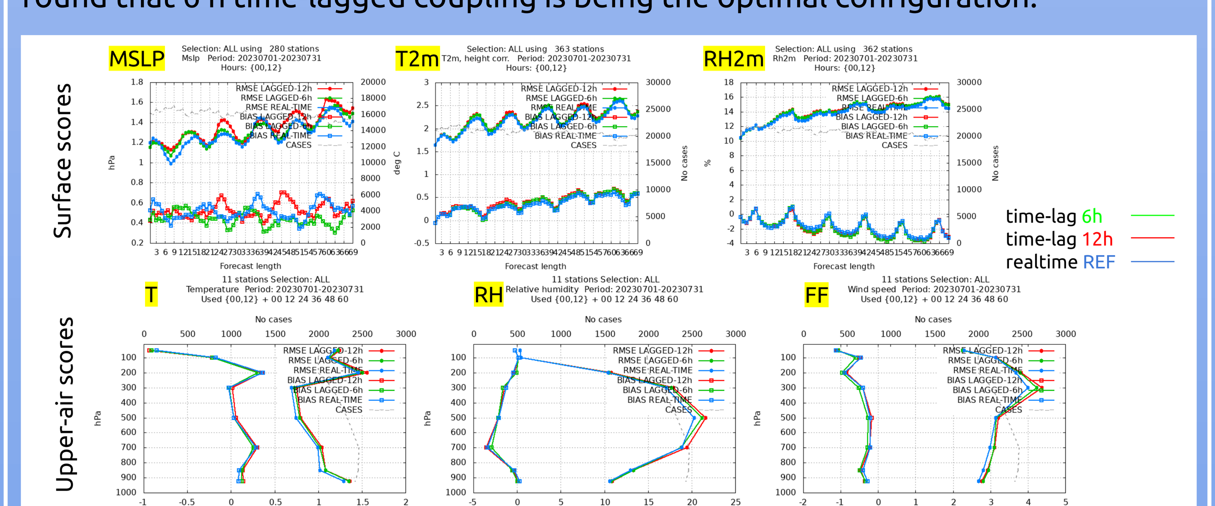
ALARO 2 km / 87 lev NH model is being initialized by A-LAEF unperturbed analysis and coupled to the ECMWF HRES global model. It runs for 00 and 12 UTC network times, with a 3-day lead time. Its main purpose is feeding the air-quality's chemical-transport model CMAQ with the surface and upper-air meteorological fields. It serves as a high-resolution NH input for SHMU forecasters too. To improve its time availability, time-lagged vs real-time coupling was tested. It was found that 6 h time-lagged coupling is being the optimal configuration.



Harp OBSOUL implementation

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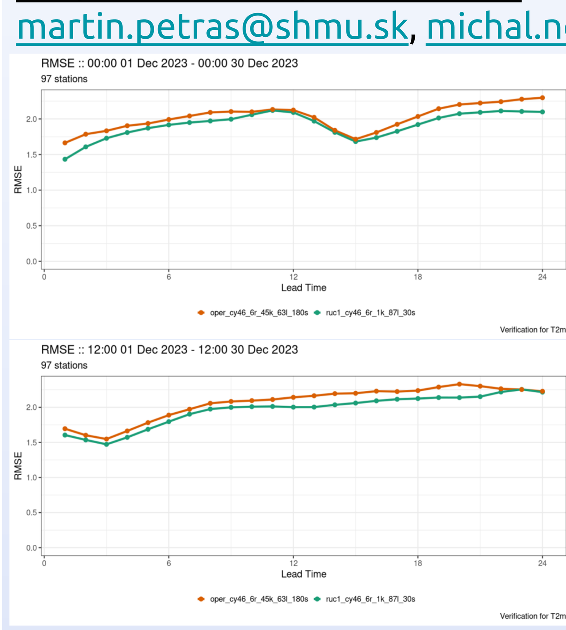

Initially, to verify NWP models with HARP at SHMU, observation data were read directly from local MySQL DB. Our goal was not only to replace direct reading from DB with obsoul files, but to use identical input data set as is utilized in operational data assimilation for SHMU NWP systems.

Fig. T2m Verification score (rmse) of SHMU OPER [orange] (4.5 km ALARO-1 CY46T1) vs SHMU RUC [green] (1 km ALARO-1 CY46T1) for period 2023-12 (00 UTC top, 12 UTC bottom).

Implementing HEC-HMS: Hydrological Modelling at SHMU

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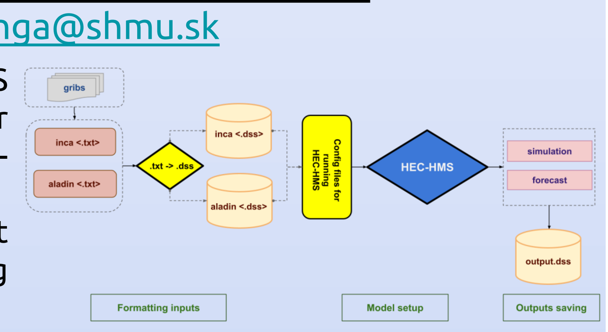
Development of a robust HEC-HMS hydrological modeling framework for forecasting floods across several sub-basins using ALADIN and INCA data. Utilizing Python scripting to implement automated procedures for executing HEC-HMS models four times a day.



Investigation of numerical oscillations in offline SURFEX experiments

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Numerical oscillations were observed in some idealized single column offline SURFEX experiments using Explicit snow or Crocus schemes. They could be seen in snow, ground and screen level variables and also in surface fluxes (Fig. 1). It was found that oscillations originate in snow surface layer penetrating into deeper snow eventually ground layers (Fig. 4). A standalone simulation package was developed for investigating numerical oscillations in a more controlled environment. It was found that oscillations are due to numerical treatment of nonlinear turbulent heat transfer terms H and LE in surface heat balance equation. Linear stability analysis (Figs. 5,6) reveals that only H and LE components can turn numerical solution oscillating but only LE component can lead into unstable oscillatory solution. Numerical oscillations tend to be quickly damped away if they come from H term (Fig. 3) while they can persist over much longer time periods if they come from LE term (Fig. 2).

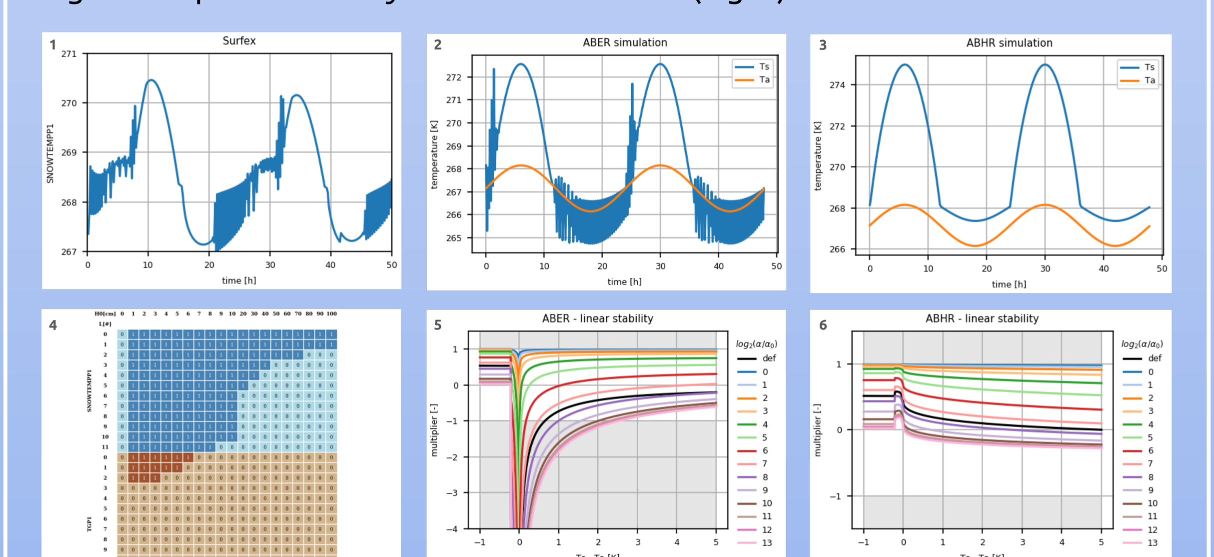

Fig. 1: Surface snow surface temperature time evolution for ~50 cm deep snowpack. Fig. 4: Presence (1/0) of numerical oscillations in each Surfex layer temperature (rows) for various initial snowpack depths in cm (columns). Figs. 2,3: Simulated surface temperature time evolution for two model variants. Figs 5,6: linear multipliers as a function of surface to forcing temperature difference for various values of universal parameter *dt/(Cs*dz)*.

Implementation of CY46T1 in BLENDVar to ALADIN/SHMU

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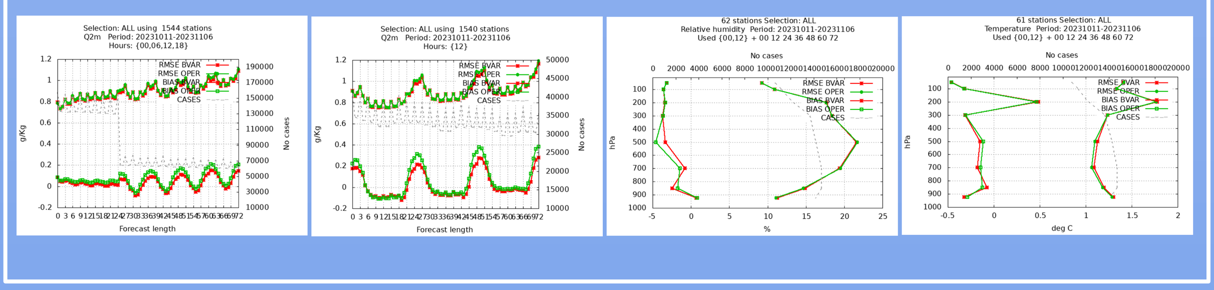
Operational NWP model ALADIN/SHMU was successfully upgraded to CY46T1. The complete upgrade of all configurations (927, 701, Blending, 002, 131, 001) was done in November 2023. The old operational NWP model CY43T2 is labeled as OPER, the new NWP model CY46T1 is labeled as BVAR.



RUC1 tests

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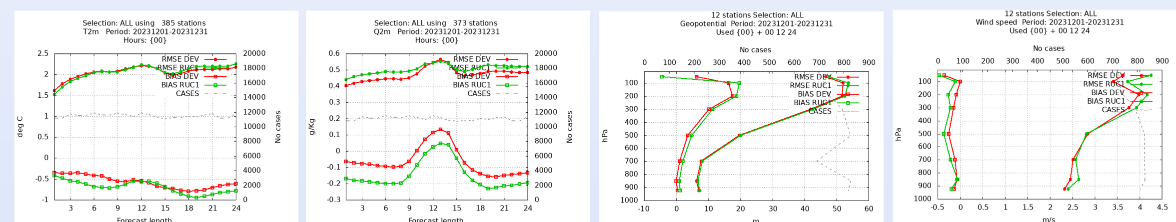
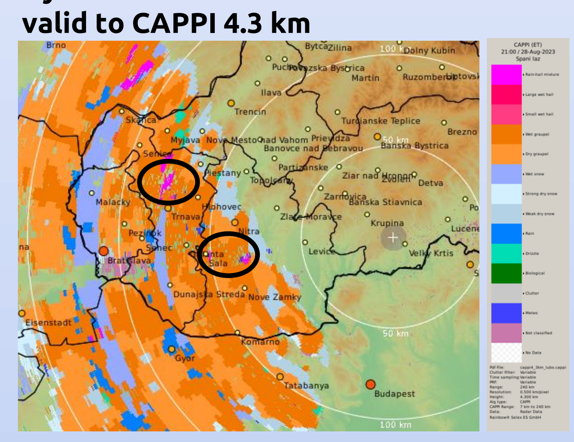
The RUC1 prototype was switched to cycle 46T1 and 87 levels using Space Consistent Coupling (SCC) instead of the time consistent one of the previous version. Overall improvement could be seen in the verification results for the period in December 2023. Case studies also indicated better results in situation with intense convection and convective outflow if higher cycle (CY46 or CY48) and if parameterization of graupels was utilized. We also started to investigate the variations in deep soil wetness (PROFRESERVE.EAU) with the aid of colleagues from CHMI.

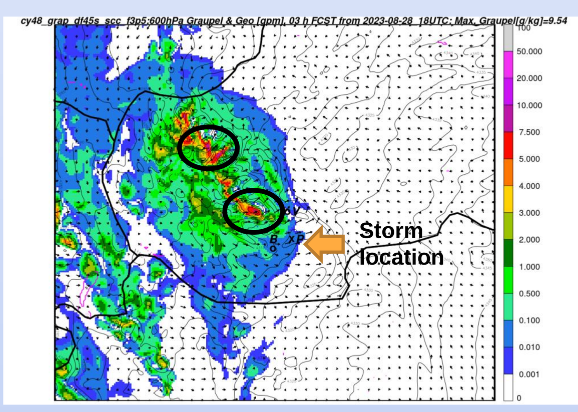


Scores of respective parameters (T2, Q2, geopotential, wind speed) for RUC1 (CY43T2, 63L) and RUC1 DEVelopment (CY46T1,87L) for December 2023.

Hydrometeors classification from radar valid to CAPPI 4.3 km



RUC CY48T3: 600 hPa Graupel mixing ratio



The numerical simulation of the 28 August 2023 windstorm indicated high concentration of graupels, which was also indicated by radar detection

DE_330_MF project: case studies at high (up to 250 m) resolution

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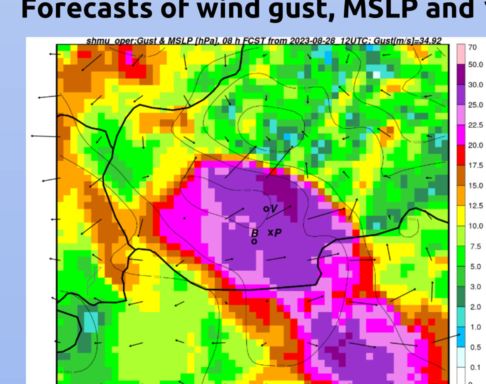
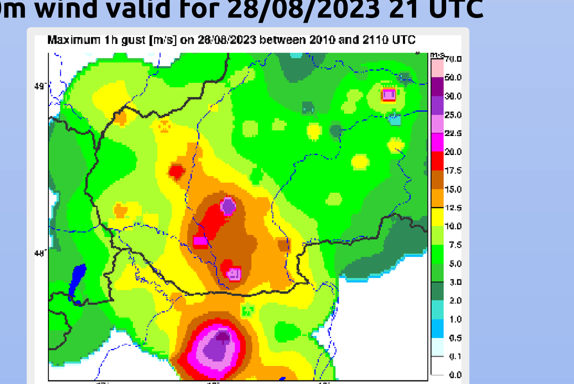
The 28 August 2023 windstorm was studied at several resolutions (4.5 km, 2.0 km, 1.0 km, 250 m) using several kinds of setups (both hydrostatic and non-hydrostatic runs predicted the storm). The 1 km resolution run exhibits finer and more realistic structures in the wind and gust field compared to the 4.5 km ALADIN/SHMU run. Hectometric runs increase the speed of gusts but at the cost of worse spatial accuracy.

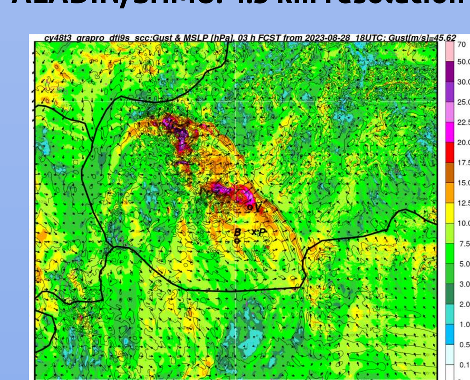
Forecasts of wind gust, MSLP and 10m wind valid for 28/08/2023 21 UTC



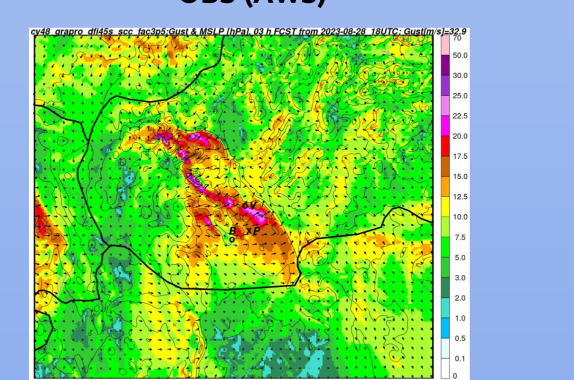
ALADIN/SHMU: 4.5 km resolution



OBS (AWS)



M25A: 0.25 km resolution



RUC1/SHMU: 1.0 km resolution

"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."

Increasing the number of vertical levels in ALADIN/SHMU

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The increase of the number of vertical levels in ALADIN/SHMU from 63 to 87 is in experimental phase. This development and tuning of cloud parameterization was done in collaboration with CHMI.

The new visualisation of verification in the form of scorecards shows scores for various parameters at various levels and forecasts ranges of new 87L configuration (labeled as DEV) in comparison with operational ALADIN/SHMU 63L (labeled as OPER) for February 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. The intensity of color represents the relative significance of change of parameter.

Another long term experiment will be performed in summer period, to conduct more robust verification of increase of vertical levels number.

The surface scorecard

The upper air scorecard

New interactive (json-based) EPSGRAMS at the SHMU website

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New visualisation of the A-LAEF, ALADIN/SHMU and ECMWF products was prepared. Based on JSON data, the highcharts enable to read values of meteorological parameters with the use of the mouse pointer. The EPSGRAMS are generated for over 1000 settlements in Slovakia, showing the spread (quartiles), maxima and minima and EPS median values, as well as the deterministic forecast of ALADIN/SHMU (in pink).

https://www.shmu.sk/en/?page=2673&nwp_mesto=31357#alaef