NWP related activities @SHMU

3rd ACCORD All Staff Workshop, 27.3.-31.3.2023, Tallin, Estonia

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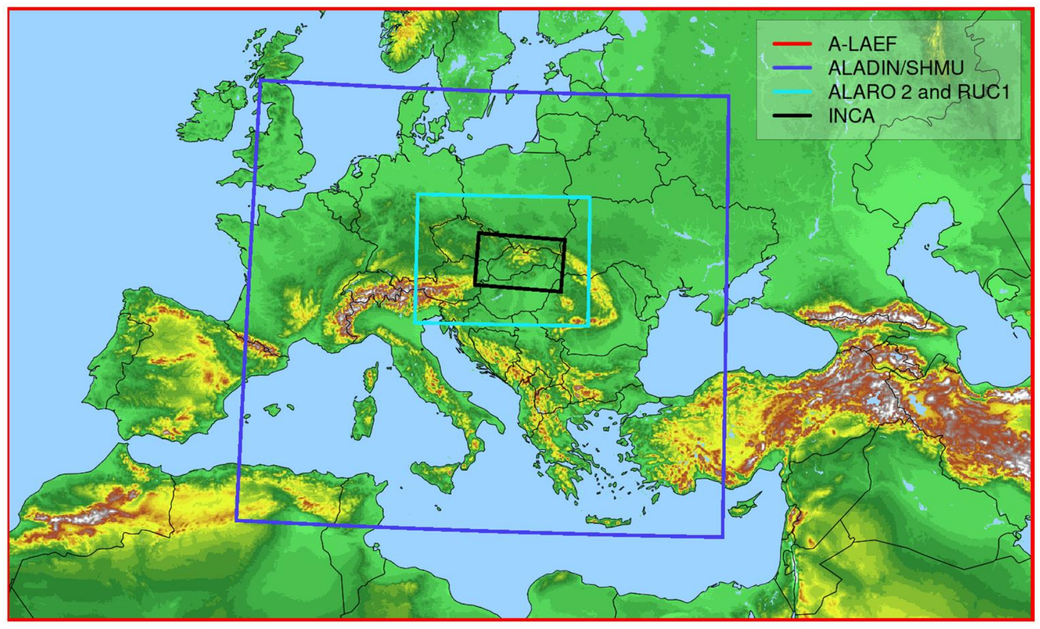
In cooperation with the Department of Air Quality Monitoring: Dušan Štefánik and Department of Hydrological Forecasts and Warnings: Zinaw Dingetu Shenga

ALADIN (ALARO) systems at SHMU

CMC	**ALADIN/SHMU**	**A-LAEF**	**ALA2e**	**RUC1**
status	operational	operational (common RC LACE)	test mode	test mode
code version	CY43T2bf11	CY40T1bf07+	CY43T2bf11	CY43T2bf11
physics	ALARO-1vB	ALARO-1vB (multi-physics + surface SPPT)	ALARO-1vB	ALARO-1vB
dx	4.5 km	4.8 km	2.0 km	1.0 km
points	625 x 576	1250 x 750	512 x 384	1024 x 768
vertical levels	63	60	87	63 (87 tested)
tstep	180 s	180 s	120 s	30 s
forecast ranges	78/72/72/60 (a' 1h)	72/-/72/- (a' 1h)	81/-/81/- (a' 1h)	Run hourly, up to +24h (a' 1h)
coupling model	ARPEGE (long- & short cut off), 3h	ECMWF ENS (c903@cy48t2), 6h	ECMWF, 3h	ARPEGE, 1h (time-lagged LBC)
assimilation	upper air spectral blending by DFI CANARI surface assimilation	ensemble surface data assimilation (ESDA) by CANARI for 16+1 members, upper-air spectral blending by DFI	A-LAEF control member init downscaling	CANARI+3DVAR, 1 hour cycling
initialization	no initialization	no initialization	DFI	None (DFI tested)
HPC	NEC HPC – 240 nodes, 6230 Intel Xeon Gold Scalable Processors (Cascade Lake), Omni-Path, Linux	Atos Sequana XH2000 AMD (ECMWF) (Bologna since 10/2022)	NEC HPC – 240 nodes, 6230 Intel Xeon Gold Scalable Processors (Cascade Lake), Omni-Path, Linux	
nodes	40	85	80 (only 25% of each)	40



Highlights of the research and development

Dynamics: RUC1 and VHR stability tests (DFI, echkevo, time-step sensitivity, etc.)

Data assimilation: New B-matrix for BlendVar

RUC: RUC development, transition to 87 levels, case studies

EPS: A-LAEF development and migration to Atos HPCF in Bologna, new products (meteograms, etc.), a feature article published in ECMWF Newsletter No. 172 - Summer 2022

Physics and diagnostics: Wet snow and maximum subgrid wind parameterizations coded in cy46t1

Verification: The harpSpatial package implemented and tested, offline SURFEX validation package developed and tested

Near future plans

Optimization of the RUC, HR modelling & DE_330 project participation, upgrade to cy46t1, development of convection-permitting EPS coupled to A-LAEF system

A-LAEF:

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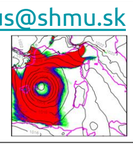
Please, see the A-LAEF dedicated poster:
A-LAEF migration to Bologna and extreme weather forecasts



New B-matrix for BlendVar suite:

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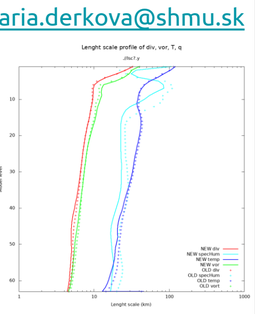
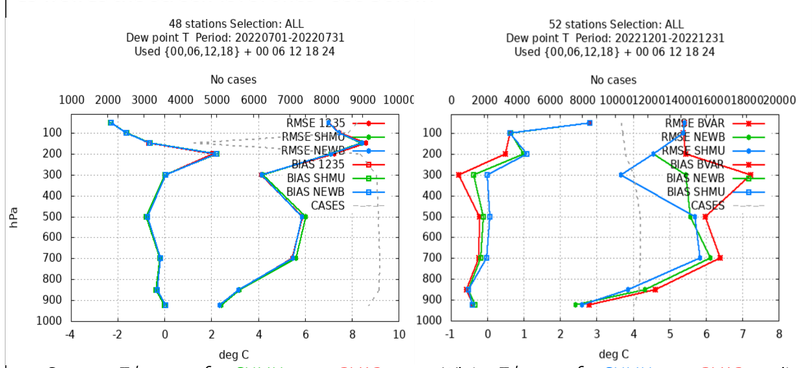
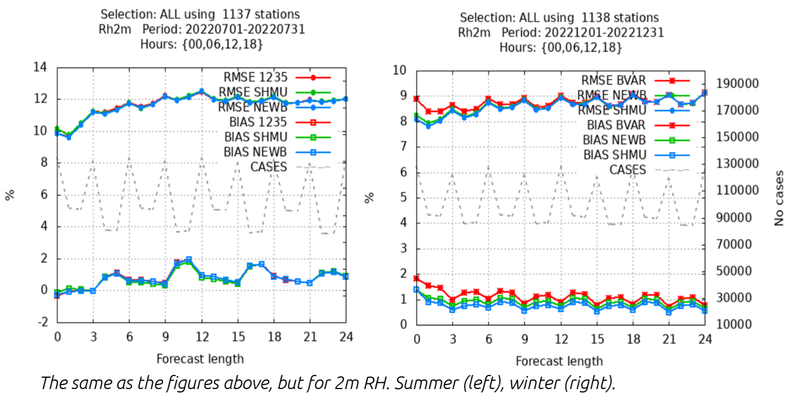
Evaluation of the BlendVar e-suite revealed issues in winter period with i) Td scores ~jet stream level, ii) 2m T, RH; that were not observed in the summer. New Bmatrix has been prepared and tested with positive impact on the problematic scores. Bmatrix was computed from the Arpege ENS DA LBCs downscaled. Six members from two two-weeks periods (July 2022 and January 2023) were utilized. The length scale profiles of spec. humidity (fig. right) are shorter in newB that helped to improve the Td upper air scores as well as the screen level ones - see below.





Summer Td scores for SHMU oper, BVAR e-suite and test with new B matrix (NEWB)

Winter Td scores for SHMU oper, BVAR e-suite and test with new B matrix (NEWB)



The same as the figures above, but for 2m RH. Summer (left), winter (right).

HEC-HMS model

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Applications: Hydrology

Based on the HEC-HMS model, SHMU products from INCA, QPrec and ALADIN/SHMU models are used to forecast flooding at more than 100 gauging stations. Daily, the HEC-HMS model runs at 03, 09, 15 and 21:00. A simulation, which is used as an initial conditions, is carried out using INCA T2m and qprec precipitation analyses, and forecasting is performed with ALADIN/SHMU outputs with a lead time up to 72 hours. The general scheme of operational flood forecasting and model output (at Velke Kapusany gauging station) are shown in the figures below.

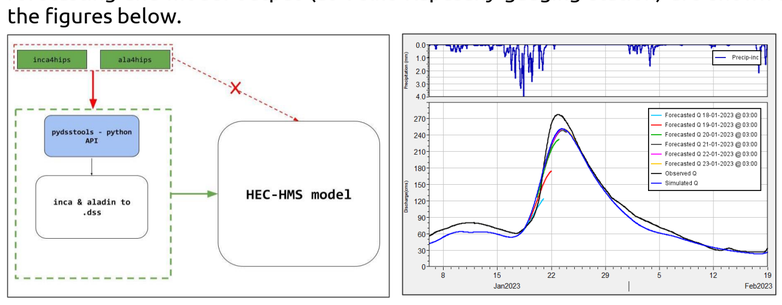

Figure on the left shows the scheme of operational flood forecasting. INCA and ALADIN model data is post-processed to CSV format, and finally converted to model-supported database (.dss) using Python pydsstools API. With precipitation and temperature as input data, rainfall-runoff simulations/forecast are carried out using HEC-HMS software. Figure on the right shows observed precipitation (blue line, figure on the top), observed flow (black line), simulated flow (blue line) and forecasted flow (other colors) at Velke Kapusany gauging station, Latorica River.

DFI tests in 1 km RUC

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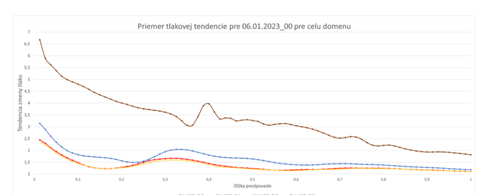
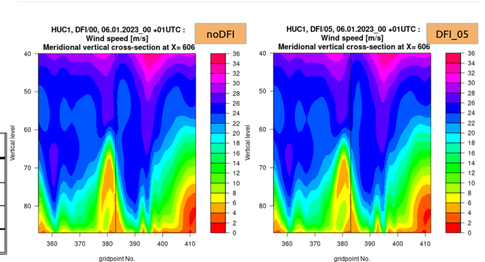
Digital filter initialisation is being tested in RUC1 setup with 3DVAR. A case study of 06/01/2023 with strong wind on the lee side of Low Tatras with reported damage in a local village has been performed. With DFI settings as in table below the spin-up ~ noise in Ps was reduced (fig. top right) and the high wind speed was still well captured.





nastaveni	NSTDFI	RTDFI	TAUS
00	-	-	-
01	7	45	720
03	10	45	1080
05	7	60	1080

RUC1 case studies

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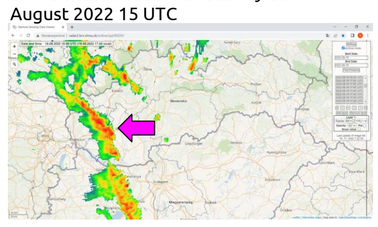
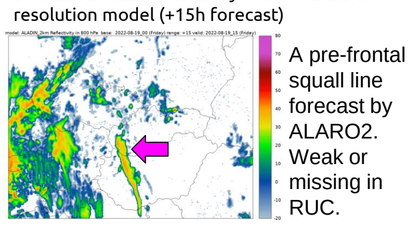
RUC1 outputs are continuously generated since June 2022. Cases with deep convection indicated a long spin-up (several hours) for forecasts of simulated reflectivity and precipitation. But some features were at least partially forecast.

SHMU mosaic radar reflectivity on 19 August 2022 15 UTC

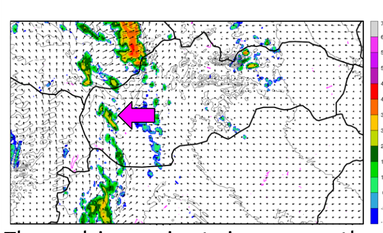


Simulated radar reflectivity of the ALA2e 2 km resolution model (+15h forecast)

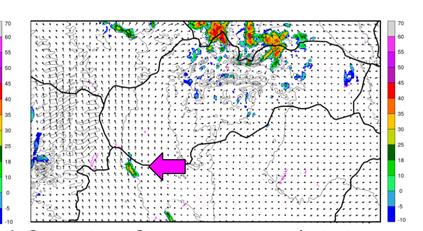


A pre-frontal squall line forecast by ALARO2. Weak or missing in RUC.

Simulated radar reflectivity of RUC1 (+5h forecast)



Simulated radar reflectivity of RUC1 (+2h forecast)



The work is ongoing to improve on the deficiencies of current system (missing cycling of hydrometeors) and lack of upper-air observations.

VHR tests (250 m resolution)

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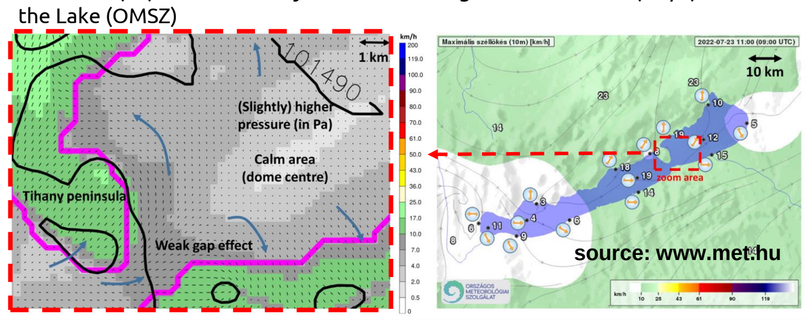
A test with experimental ALARO-1 to simulate "cold-dome" effects at the Lake Balaton (Hungary) in case with cold water surface and weak divergent winds.

Left: ALADIN/B25A 3h forecast of 10m wind gust (shades, km/h) wind (arrows) and MSLP (Pa) valid to 23 July 2022 09 UTC. Right: Observations (km/h) around the Lake (OMSZ)



ANA1/RUC1/ALA1

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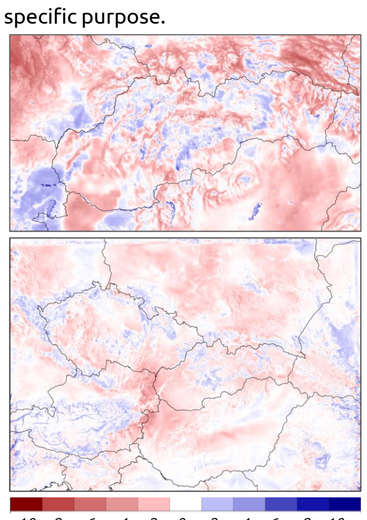
The concept of three 1km nwp models is under development. Each for a specific purpose.



T2m difference between ANA1 and INCA (top), and between ALA1 and RUC1 (bottom) [F+01] .

ANA1: Quickly available analysis for forecasters, road maintenance and hydrology. 3DVAR and only very short period of integration is available within 10 minutes after the full hour.

RUC1: Nowcasting purpose ALARO-1 NWP model in main terms (00, 06, 12, 18 UTC) F+24h and in minor terms F+12h. Start 30 min after full hour. On 40 nodes it takes 60 min. Lagged LBC from ARPEGE are used.

ALA1: NWP model with full set of observations and LBC as ALADIN/SHMU model. Now F+24h (plan F+48). ARPEGE LBC for 00 UTC are available at 3:15 UTC (F+48).

Offline SURFEX validation package

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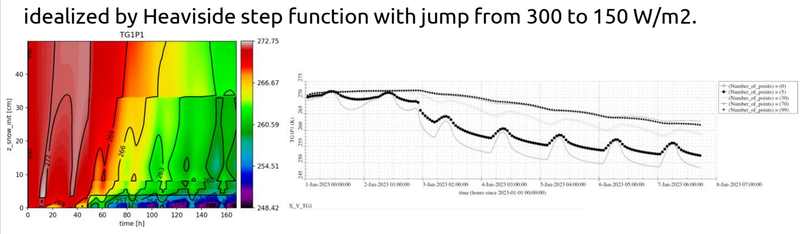
A new python based validation package for offline SURFEX has been developed which will aid development of existing numerical schemes. Package is based upon our earlier "fake grid" idea using the single-column setup. We have performed a few demonstrative numerical experiments. Here we show response of ground surface temperature on sudden decrease of downward atmospheric thermal IR radiation for varied snowpack thickness. Such decrease often occur due to sudden transition from overcast to clear-sky condition and can be enhanced by cold advection in atmosphere. During stable nocturnal conditions this often results in very low 2m temperatures. We used idealized atmospheric forcing with sudden decrease of downward thermal IR flux idealized by Heaviside step function with jump from 300 to 150 W/m2.



Left figure is heatmap plot of topmost ISBA-DIF layer temperature which is in contact with snowpack. X-axis is time in hours and y-axis represents varying initial snowpack thickness from 0 to 50 cm. Curves on right are slices along time axis where insulation effect of snowpack with different thickness can be compared. Snowpack density is ~150 kg/m3. In this experiment we used 12 layer explicit snow scheme and 14 layer ISBA DIF scheme for soil.

Applications: Air quality modeling

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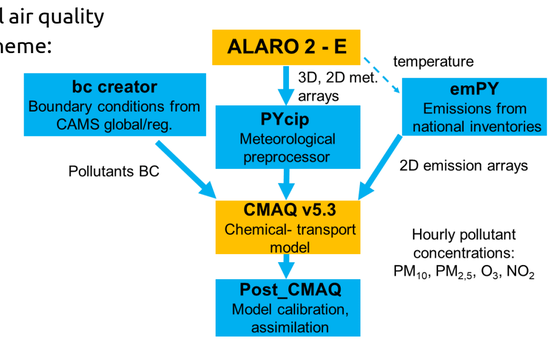
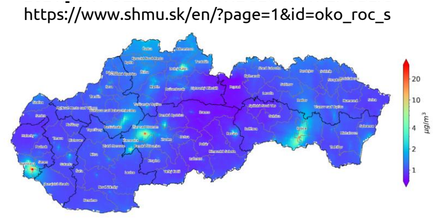
Operational air quality forecast scheme:



Products:

1. Air quality assessment

SO_2 annual mean concentrations in Annual Report 2021: AIR POLLUTION IN THE SLOVAK REPUBLIC https://www.shmu.sk/en/?page=1&id=oko_roc_s



2. Air quality forecast

$PM_{2,5}$ concentrations 11.01.2021 at 22:00