NWP activities at the Hungarian Meteorological Service

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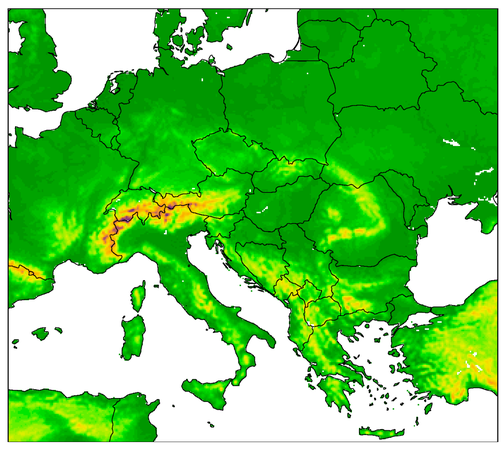
Operational configurations

ALADIN/HU

- Model version: cy40t1 (ALARO-v1b physics)
- 8 km horizontal resolution, 49 vertical levels
- Local data assimilation:
  - 3D-Var in upper air, optimal interpolation at surface
  - 6-hour assimilation cycle
  - Short cut-off analysis for the production runs
  - Downscaled ensemble background error covariances
- Digital filter initialization
- 4 runs a day:
  00 UTC (60h); 06 UTC (48h); 12 UTC (60h); 18 UTC (36h)
- 3 hourly lateral boundary conditions from ECMWF-HRES
- Hourly outputs

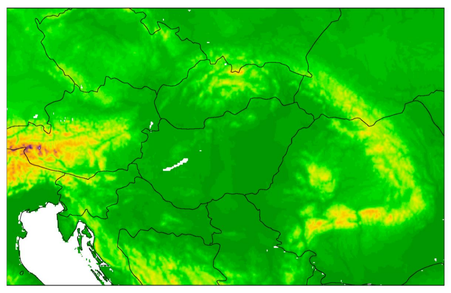


ALADIN/HU model domain

AROME/HU

- Model version: cy43t2_bf11
- 2.5 km horizontal resolution, 60 vertical levels
- Local data assimilation:
  - 3D-Var in upper air, **SEKF (from June)** at surface
  - 3-hour assimilation cycle
  - Lake temperature initialized from measurements at Lake Balaton
  - Hydrometeors & snow cycled through assimilation cycle
- Initialization: space-consistent coupling (no DFI)
- 8 runs a day:
  00 UTC (48h); 03 UTC (36h); 06 UTC (48h); 09 UTC (36h);
  12 UTC (48h); 15 UTC (36h); 18 UTC (48h); 21 UTC (36h)
- LBCs from ECMWF-HRES with 1h coupling frequency
- SBL scheme over nature & sea to calculate the screen level variables
- Hourly outputs for forecasters, special outputs in every 15 minutes for commercial users & hail prevention system

Assimilated observations (via OPLACE)	
ALADIN/HU	AROME/HU
• SYNOP (u, v, T, RH, z) • SYNOP-SHIP (u, v, T, RH, z) • TEMP (u, v, T, q) • AMDAR (u, v, T) • ATOVS (AMSU, MHS radiances) • MSG/GEOWIND (AMV) • MSG (SEVIRI radiances)	• SYNOP (u, v, T, RH, z) • TEMP (u, v, T, q) • AMDAR (u, v, T, q) • Slovenian and Czech Mode-S MRAR (u, v, T) • GNSS ZTD



AROME/HU and AROME-EPS domain

Convection-permitting ensemble system

- 11 ensemble members using AROME
- 2 runs a day, from 0 and **12 UTC (from April)** up to 48 hours
- Atmospheric initial conditions ad& hourly LBCs from 18/6 UTC ECMWF-ENS, surface initial condition from 0/12 UTC AROME/HU
- Downscaling, no local perturbations
- Resolution, physics etc. as in AROME/HU (cy43t2)

Computer system

- HPE Apollo 6000 server
- 12 nodes x 2 CPU x 20 cores, 2.2 GHz Intel XeonE5-2698 processors
- 128 GB RAM/node
- Transfer of IFS LBCs from ECMWF via Internet, backup ARPEGE LBCs from Météo-France via Internet & ECMWF re-routing

Operational implementation of SEKF

AROME-TEST ran in parallel to the operational AROME/HU forecasts between November 2021 and June 2022. The operational model used the optimum interpolation (**OI-main**) method for surface data assimilation, while simplified extended Kalman filter (**SEKF**) was applied in the e-suite with the following settings:

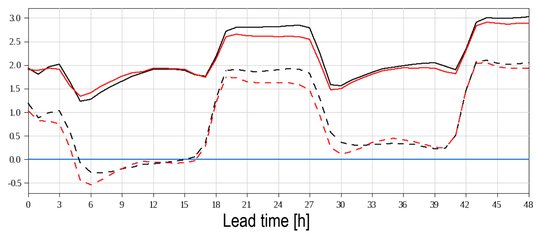
- XERROBS (T2M,HU2M) = 1.0,0.07
- XSIGMA (WG2,WG1,TG2,TG1) = 0.15,0.1,2.0,2.0
- XTPRT (WG2,WG1,TG2,TG1) = 10^{-4},10^{-4},10^{-5},10^{-5}

In addition to pointwise and SAL verifications, some subjective evaluations were carried out by forecasters and model developers in interesting weather situations between 4 May and 1 June 2022. In this month, less than average precipitation fell, in form of showers and thunderstorms, sometimes with intense hail and winds.

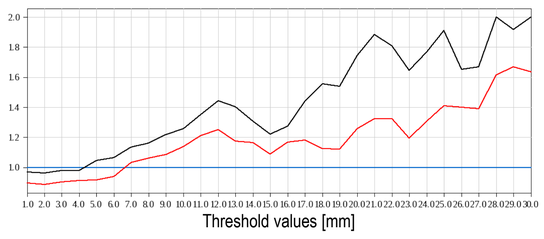
The two runs performed similarly for 2-meter temperature and dewpoint during daytime, while SEKF improved the nocturnal forecast errors. Events with daily precipitation exceeding 7 mm were overpredicted by operational AROME/HU and this improved in the test run. Less false alarms occurred with SEKF for almost all thresholds, and overestimation of the intensity was reduced.

SEKF was introduced in the operational AROME/HU in June.

2-meter temperature bias (- -) & RMSE (--) [°C]
4 May–1 June 2022, 0 UTC runs
AROME/HU with OI-main, AROME-TEST with SEKF

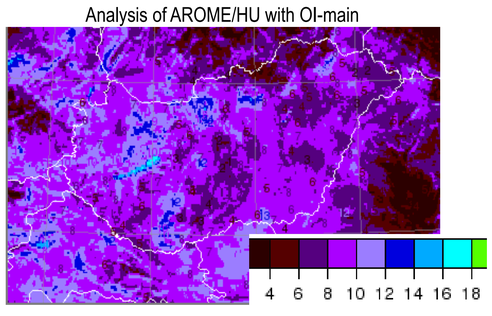


Frequency bias of 24-hour precipitation amount
4 May–1 June 2022, 0 UTC runs, 30-hour forecasts
AROME/HU with OI-main, AROME-TEST with SEKF

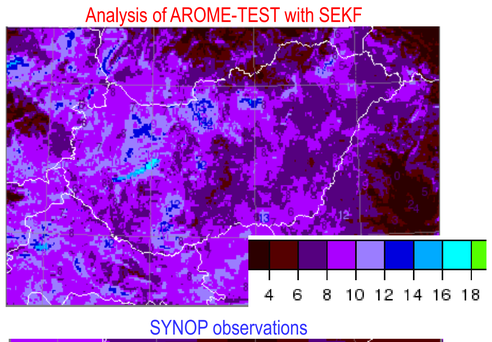


2-meter temperature [°C] at 0 UTC, 19 May 2022

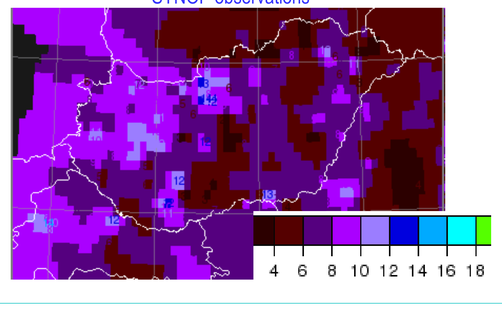
Analysis of AROME/HU with OI-main



Analysis of AROME-TEST with SEKF

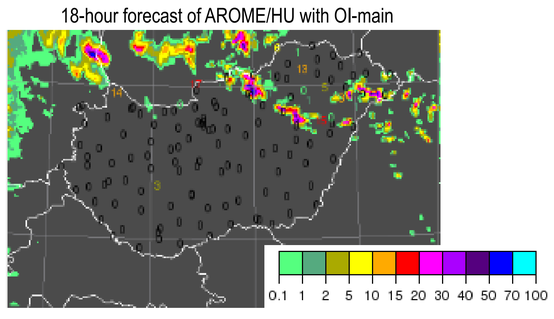


SYNOP observations

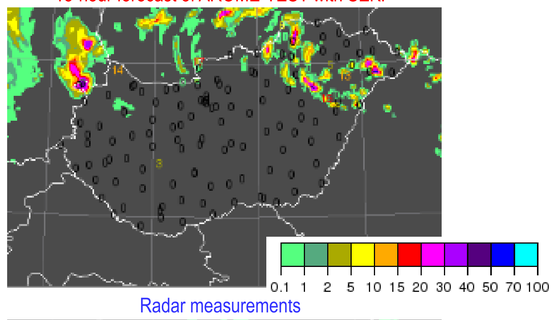


3-hour precipitation [mm] at 18 UTC, 7 May 2022

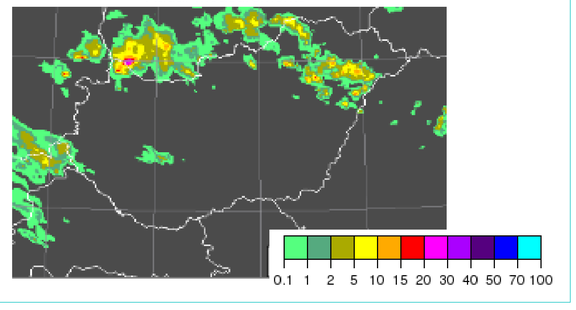
18-hour forecast of AROME/HU with OI-main



18-hour forecast of AROME-TEST with SEKF



Radar measurements



Supervisor: Benedikt Strajnar

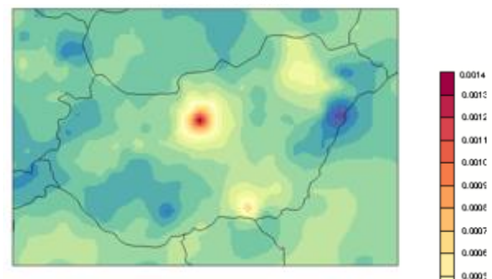
Experimental assimilation of OPERA reflectivity

Radar reflectivity data was tested in assimilation over a period between 27 June and 31 July 2021 when several precipitation events occurred, sometimes with high amount at night. HOOF 2.0 (Homogenization of OPERA Files) was used to homogenize the radar data. Due to memory issues, data of 4 Hungarian and 2 Slovenian radars were taken.

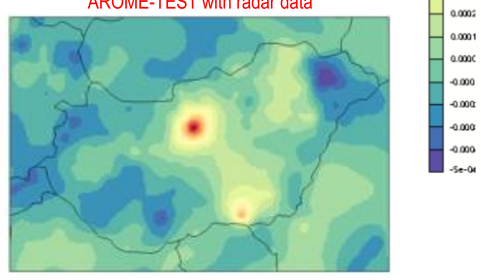
Some positive impact is concluded for parameters related to the reflectivity, such as precipitation, relative humidity, cloud cover. The improvement in cloud forecasts is likely linked to the drying effect caused by the assimilation of reflectivity that was experienced by e.g. Panežić (2021).

The verification results show from slight negative to neutral impact for 2-meter temperature, 10-meter wind speed and gust. In the upper air, there is an improvement in relative humidity forecasts, while the impact is mostly neutral for temperature and wind speed.

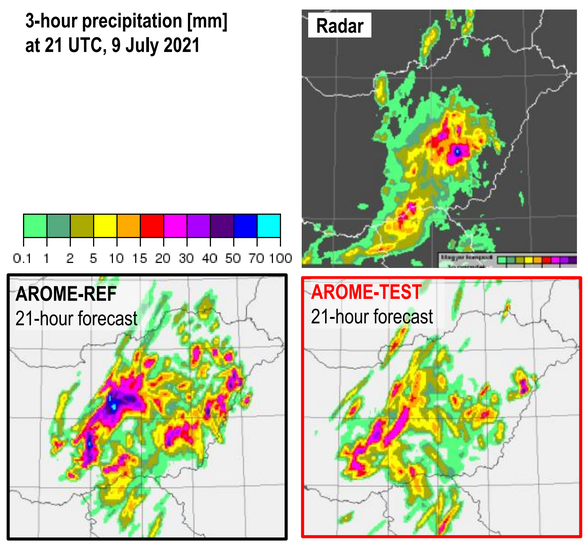
Analysis increment for relative humidity at 925 hPa
AROME-REF without radar data



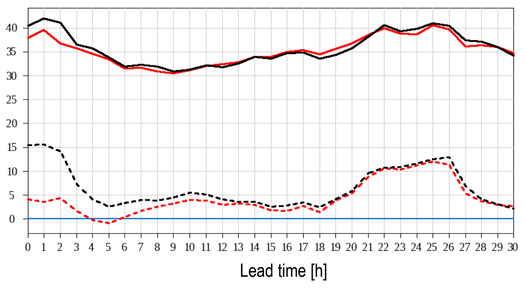
Analysis increment for relative humidity at 925 hPa
AROME-TEST with radar data



3-hour precipitation [mm]
at 21 UTC, 9 July 2021



Total cloud cover bias (- -) & RMSE (--) [%]
0 UTC runs, 2021/7/1–31
AROME-REF without radar data, AROME-TEST with radar data

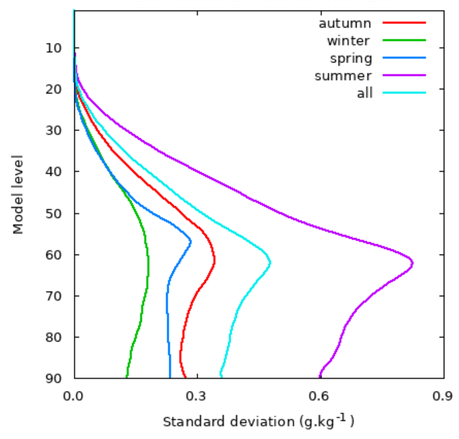


Computation of new B-matrix at 1.3kmL90 resolution

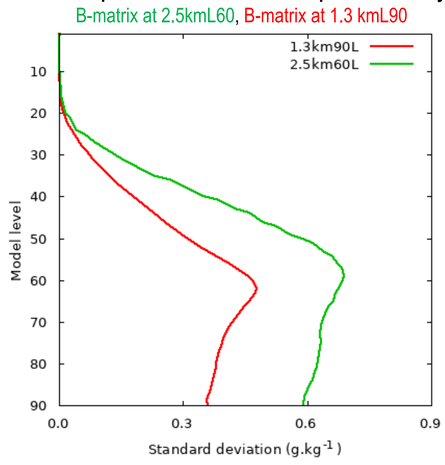
We are testing AROME at 1.3 km resolution and with 90 vertical levels as well as with hourly assimilation cycle. This requires a reconsideration of the assimilation system, e.g. the B-matrix. We use the ensemble data assimilation (EDA) technique to compute the background error statistics. The downscaled B-matrix has been completed so far. We selected four 10-day periods from each season during which 4 ensemble members of AROME have been initialized at both 0 UTC and 12 UTC.

The B-matrix was calculated using the difference of 4 members (i.e. RUN1-RUN2, RUN1-RUN3, RUN1-RUN4, where RUN1 is the control member, RUN2,3,4 are the perturbed members). The biggest difference between the seasons is in the standard deviation for summer humidity, which has a big impact for the overall B-matrix as well. The smallest seasonal difference is observed for temperature. The standard deviations of temperature, humidity, vorticity and divergence is smaller for the **90 level B-matrix** than for the **60 level B-matrix**.

Vertical profile of std. deviation of specific humidity
Downscaled B-matrix at 1.3 kmL90



Vertical profile of std. deviation of specific humidity
B-matrix at 2.5kmL60, B-matrix at 1.3 kmL90

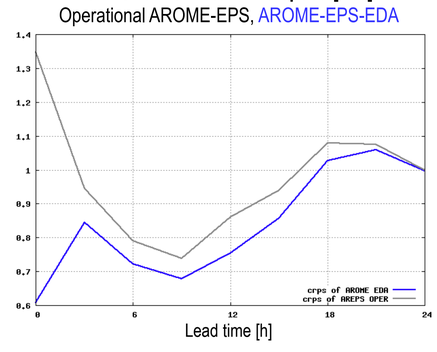


Experiments for EDA in AROME-EPS

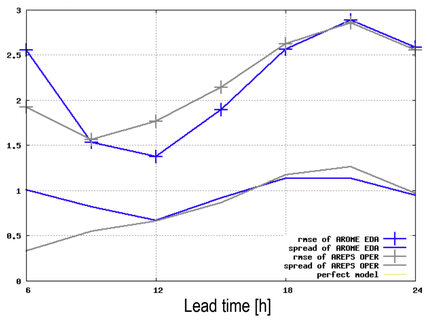
Operational AROME-EPS is downscaling of the first 11 members of ECMWF-ENS. Experiments to introduce local perturbations were started with CY43T2 using **EDA** technique over July 2021 with the following setup:

- 3 hourly assimilation cycle, using OI-main for surface and 3D-Var for upper-air analysis;
- The same conventional and GNSS ZTD measurements as in AROME/HU;
- Offline perturbation of observations before surface assimilation and after screening;
- Forecasts initialized at 0 UTC.

CRPS for 10-meter wind speed [m/s]
Operational AROME-EPS, AROME-EPS-EDA



RMSE & spread for 6-hour precipitation [mm]
Operational AROME-EPS, AROME-EPS-EDA

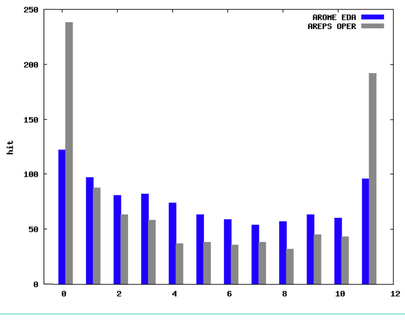


EDA led to an improvement in 10-meter wind speed and gust, 2-meter temperature and relative humidity forecasts in the first hours (in CRPS, bias and RMSE of the ensemble mean) and increased the overall spread.

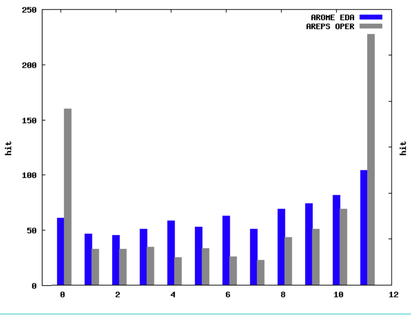
Precipitation results are variable: both RMSE and spread is increasing during the first few hours, while the impact is almost neutral later.

In upper air, considerable positive impact is seen in the analysis time and up to 6-12 hours for wind speed, temperature and relative humidity.

Talagrand diagram
2-meter temperature, time step: t+9h
Operational AROME-EPS, AROME-EPS-EDA



Talagrand diagram
2-meter relative humidity, time step: t+9h
Operational AROME-EPS, AROME-EPS-EDA



Talagrand diagram
3-hour precipitation, time step: t+9h
Operational AROME-EPS, AROME-EPS-EDA