NWP at the Hungarian Meteorological Service

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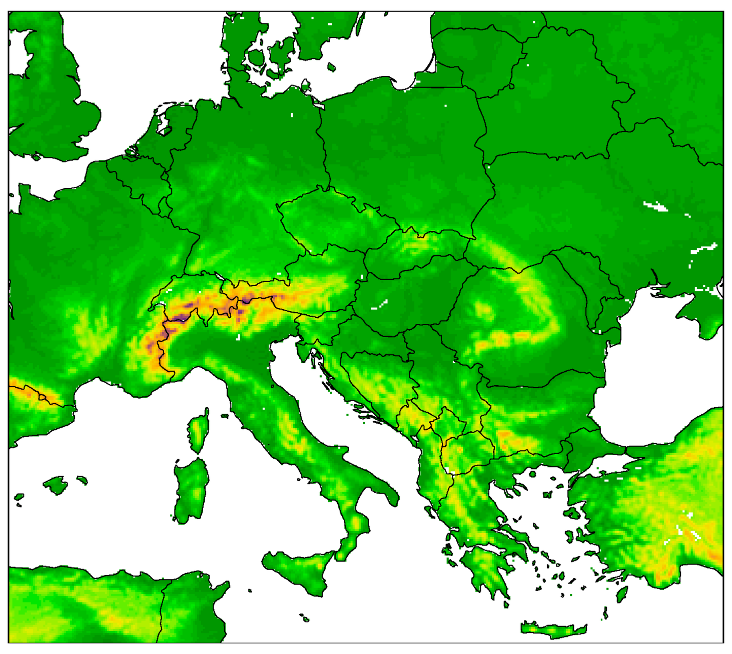
Operational configurations

ALADIN/HU

- Model version: cy40t1 (ALARO-v1b physics)
- 8 km horizontal resolution, 49 vertical levels
- Local data assimilation:
  - 3D-Var (upper air), optimal interpolation (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

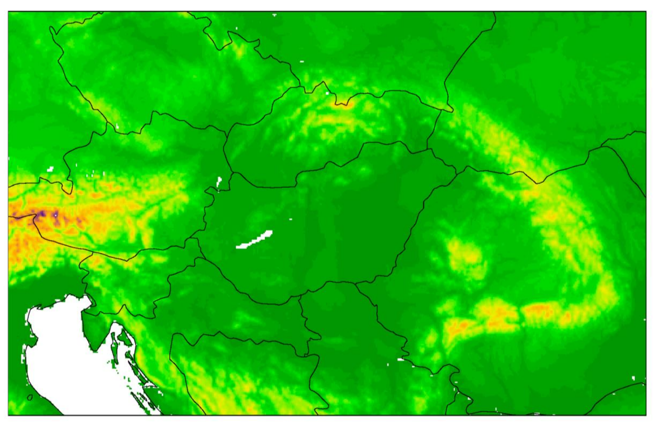


ALADIN/HU model domain

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

- Model version: cy43t2_bf11
- 2.5 km horizontal resolution, 60 vertical levels
- Local data assimilation:
  - 3D-Var (upper air), OI-main (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 fields
- Hourly outputs for forecasters, special outputs in every 15 minutes for commercial users & the hail prevention system



AROME/HU and AROME-EPS domain

Convection-permitting ensemble system

- 11 ensemble members using AROME
- Atmospheric initial conditions and hourly LBCs from 18 UTC ECMWF EPS, surface initial condition from 0 UTC AROME/HU
- Downscaling, no local perturbations
- One run a day, from 0 UTC up to 48 hours
- 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

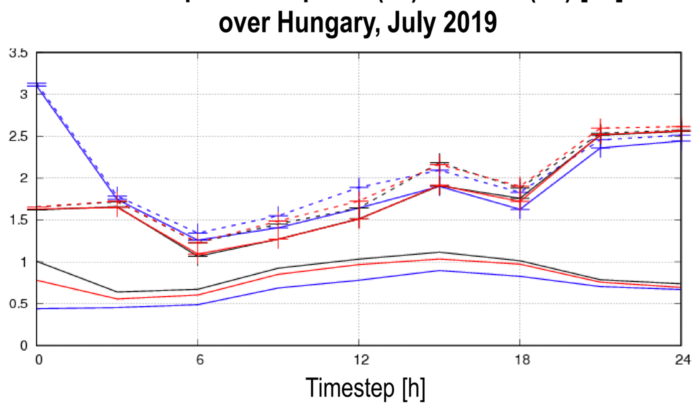
Assimilation in convection-permitting AROME ensemble forecasts

AROME-EPS is operational since February 2020. The verification proved that it outperforms its predecessor, ALARO-EPS. At the same time, AROME/HU provides better forecast in some weather situations which underlines the need of local data assimilation as well as local perturbations in AROME-EPS.

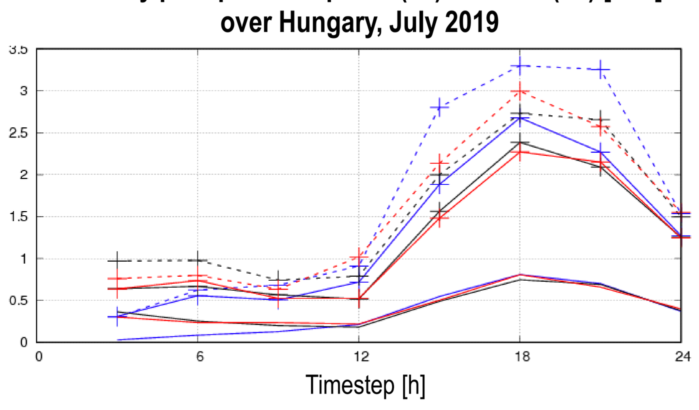
We set up ensemble data assimilation (EDA) experiments with the following characteristics:

- 3 hourly assimilation cycle identically to the operational AROME/HU, using OI for surface and 3D-Var for upper air;
- Same conventional and GNSS ZTD measurements as in AROME/HU;
- 3 hourly coupling to 11 members of ECMWF ENS;
- Operational AROME-EPS domain with 2.5 km resolution and 60 vertical levels;
- Model version: cy40t1;
- Offline perturbation of observations before surface assimilation and after screening, by routine PERTCMA;
- Perturbation scaling with factor of 1.0 and 1.4.

2 m temperature spread (—) & RMSE (++) [°C] over Hungary, July 2019



3-hourly precipitation spread (—) & RMSE (++) [mm] over Hungary, July 2019

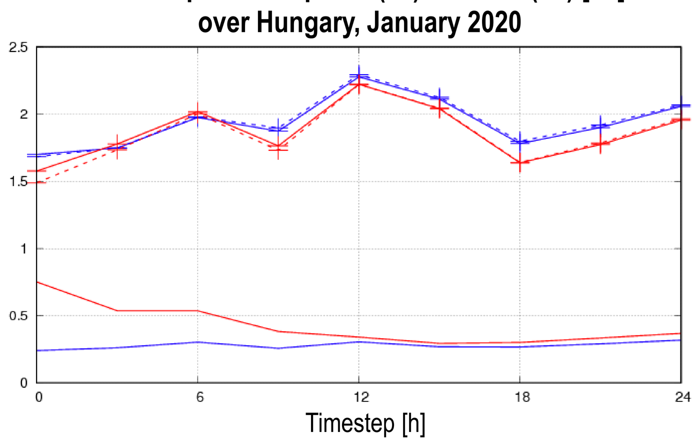


– Operational AROME-EPS
– AROME-EPS with EDA and scaling factor of 1.0
– AROME-EPS with EDA and scaling factor of 1.4
– – RMSE of control member if any EPS

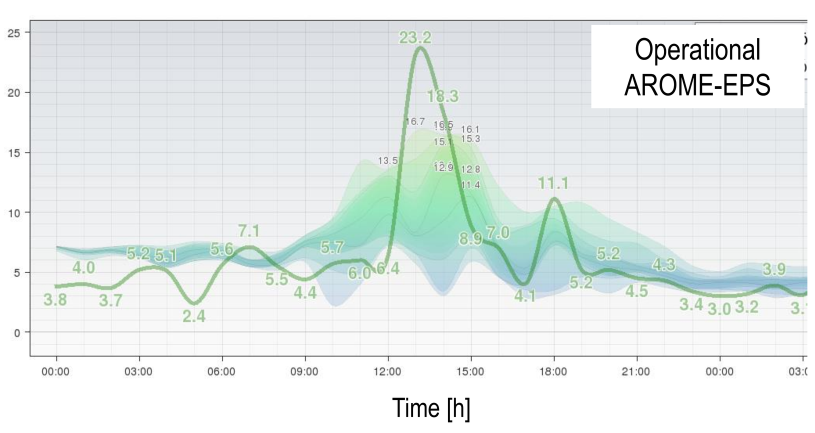
EDA was tested first in the convective season for July 2019. For temperature and MSLP, the initial state is much closer to the measured values in EDA run, and its effect lasts to 9-15 hours. The assimilation seems to degrade the quality of wind speed and humidity (not shown) at the beginning of the forecast. Afternoon precipitation gets better with EDA, which is an important advantage. Some very little additional improvement can be gained with **inflated** perturbation in humidity, wind and cloudiness (not shown).

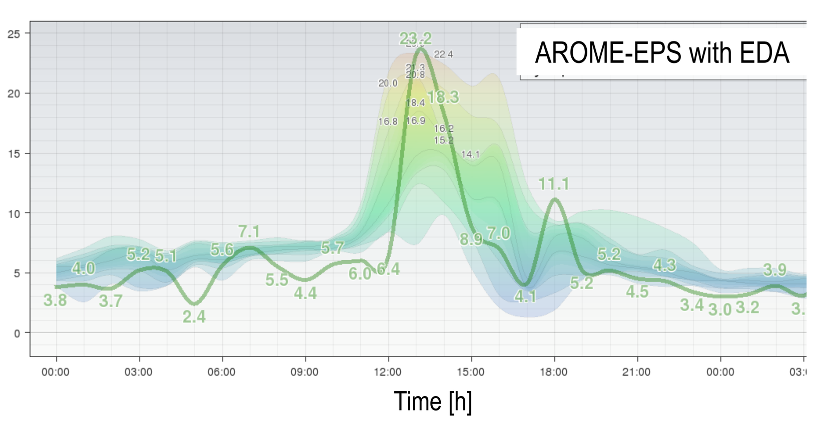
A winter period was also chosen: January 2020, a dry month with average daily temperature around 0 °C and clouds in half of the month. The verification results are similar to summer ones.

2 m temperature spread (—) & RMSE (++) [°C] over Hungary, January 2020

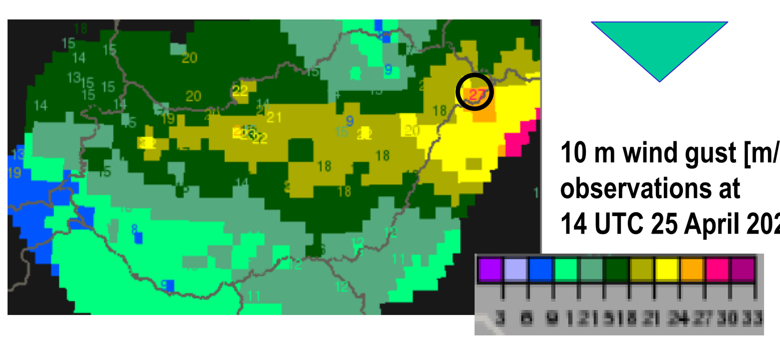


10 m wind gust [m/s] forecasts and observation (—)
Location: Vásárosnamény; forecast initialization: 0 UTC 25 April 2020





On 25 April 2020, a cold front passed over Hungary accompanied by robust upper-air flow. Due to downward mixing of strong wind, there was some precipitation over the northeastern part of the country in the afternoon. AROME/HU slightly underestimated the maximum wind gust, which was even lower in the AROME-EPS members. With EDA, we gained not only more accurate analyses, but also enhancement of wind gust forecast in all EPS members over the area of interest. (The meteograms are prepared for the location indicated by circle on the map.)



10 m wind gust [m/s] observations at 14 UTC 25 April 2020

Tuning experiments with B-matrix for 90 vertical levels

Preparing for a resolution upgrade of AROME/HU, a new B-matrix was constructed using EDA at 90 vertical levels. The first forecast results with it were not satisfying, so we accomplished further experiments tuning the scaling factors for observation and background error statistics and switching the canopy scheme (Table). Besides the 60-level reference run, a **dynamical adaptation** at 90 levels was also carried out. The experiment covered the period from 9 to 31 July 2020 (with many showers and thunderstorms).

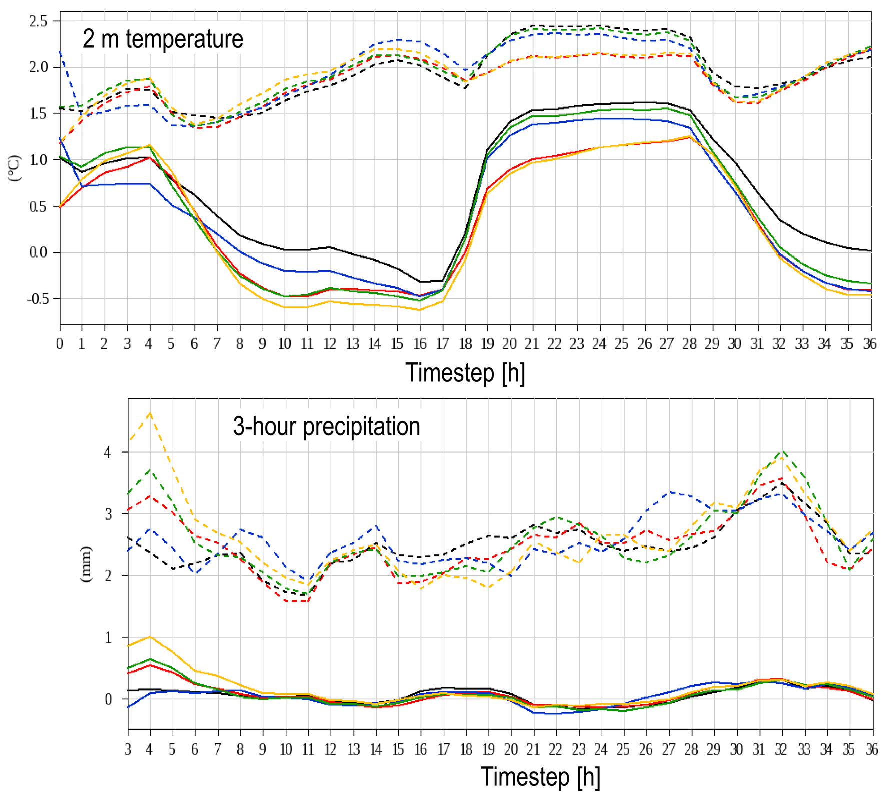
Replacing the default weights for background and observation errors with the **Desroziers values** (EXP1), the nighttime temperature improved, meanwhile the precipitation and humidity degraded in the first 3 hours.

For this reason, the B and R scaling was set back to the default values but with **higher B scaling for humidity**. With this setting (EXP2), the precipitation forecasts improved in the first hours. In addition, the **canopy scheme was deactivated** (EXP3) resulting in a significantly better analysis and nighttime forecast of 2-metre temperature.

Overall, the finer vertical resolution shows positive impact in most surface parameters and mainly neutral impact in the upper-air. We plan to study a winter period applying the same settings as in EXP3.

Experiment	REF	DA	EXP1	EXP2	EXP3
Number of vertical levels	60	90	90	90	90
Canopy	on	on	off	on	off
REDNMC	1.2	-	1.26	1.2	1.2
SIGMAO_COEF	0.9	-	0.71	0.9	0.9
REDNMC_Q	-	-	-	1.67	1.67

Bias (—) & RMSE (– –) over Hungary in 0 UTC runs



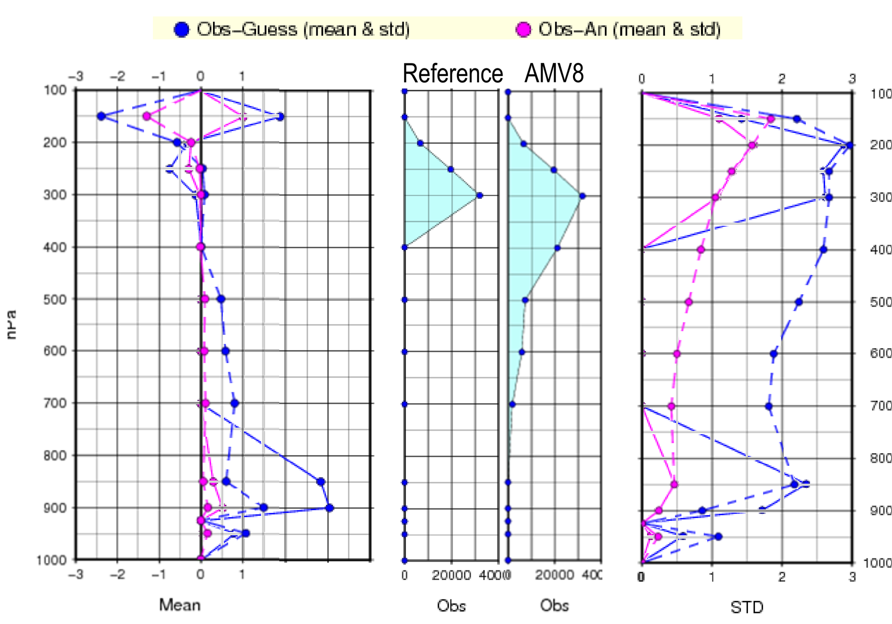
Impact study for assimilation of EUMETSAT AMV & NWCSAF HRW data

Geowind and hrwind data was assimilated from 5 July to 7 August 2019. The used AMVs were generated from IR, VIS and WV channels. For thinning and blacklisting we applied the ALADIN/HU settings (reference in Table)

We concluded mostly neutral impact of AMV data on forecasts, with a slight positive effect for wind gust and precipitation. Further experiment with the same settings was made from 1 to 18 December 2019, which also showed neutral impact.

Setting	Reference	AMV8	AMVA
Quality index < 85 %	inactive	inactive	inactive
Data where p>700 hPa over land	inactive	inactive	active
Data where p<700 hPa for VIS	inactive	inactive	active
Data between 300 and 850 hPa	inactive	active	active
Data where p>400 hPa for WV	inactive	inactive	active

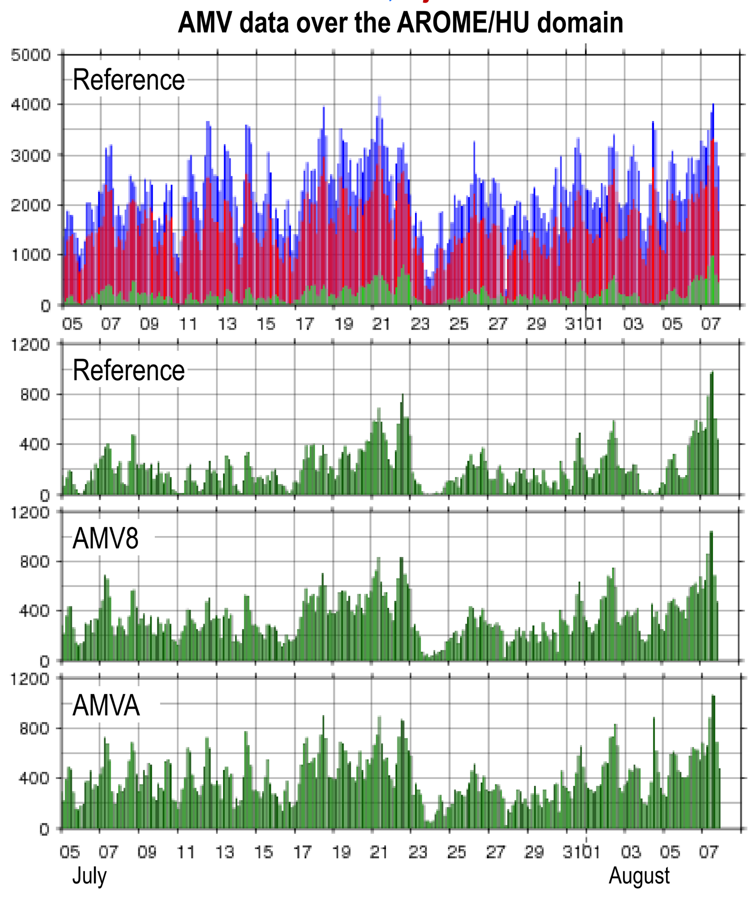
Vertical distribution of active observations, O–B & O–A statistics
—— reference, – – – AMV8 experiment



Using the reference settings, many observations were blacklisted, **active** wind vectors were located between 300 and 250 hPa and a few between 1000 and 850 hPa. To increase the number of active AMVs, we made an experiment (AMV8 in Table) adding observations between 800 and 350 hPa and an other one (AMVA) using all AMVs where the quality index reached 85%.

The number of active observations noticeably increased with the new settings and similar in AMV8 and AMVA experiments. The O–B (observation minus background) statistics between 800 and 350 hPa seem also reliable. We will continue the impact studies with AMV8 settings.

Number of total, rejected & active AMV data over the AROME/HU domain



Surface assimilation experiments with SEKF

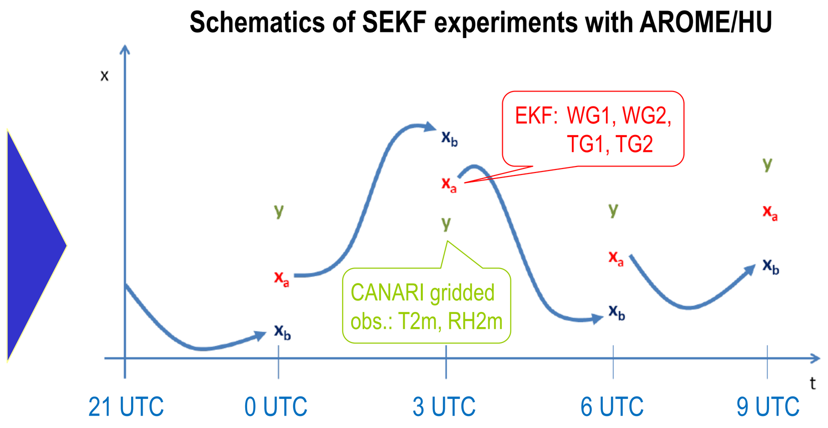
Simplified Extended Kalman Filter (SEKF) surface data assimilation method was validated and tested further over Hungary with AROME cy43t2 and SURFEX 8.0+.

Experimental set-up:

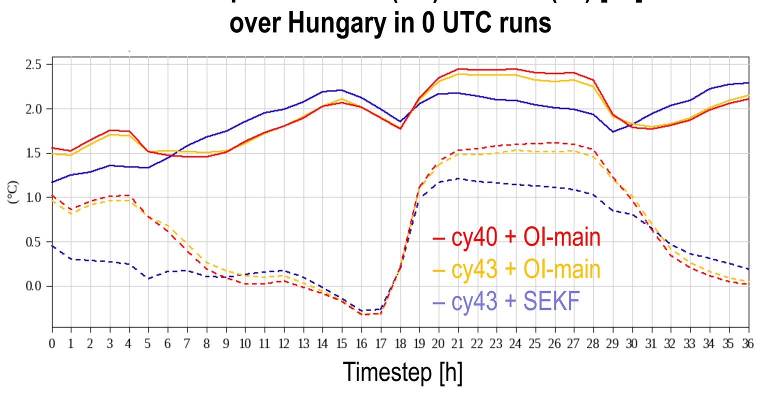
- Period: 9 to 31 July 2020 after 2-week spin-up (mostly warm and rainy weather);
- 3-hourly assimilation cycle;
- Forcings to offline SURFEX run from AROME inline forecasts at 9 m.

The night temperature shows a slight improvement in **cy43** with respect to **cy40**, while a substantial bias reduction is resulted by **SEKF** in comparison to the operational **OI-MAIN**. SEKF largely improved the 2 m temperature analysis, however its daytime forecasts over Hungary do not differ spectacularly from the OI-MAIN ones.

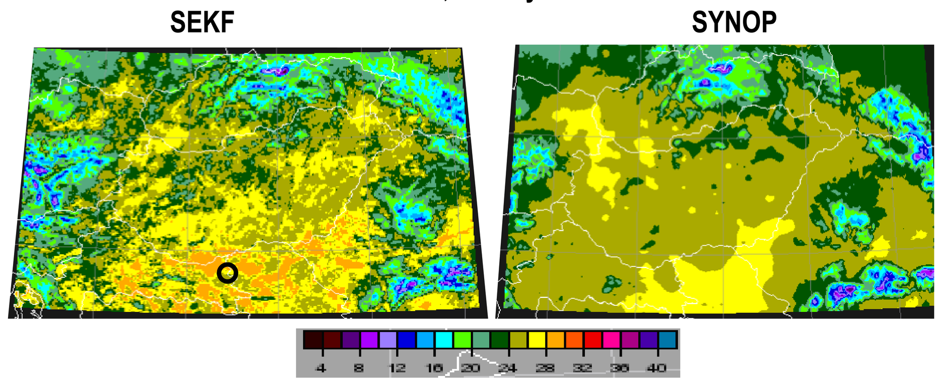
Schematics of SEKF experiments with AROME/HU



2 m temperature bias (– –) & RMSE (—) [°C] over Hungary in 0 UTC runs

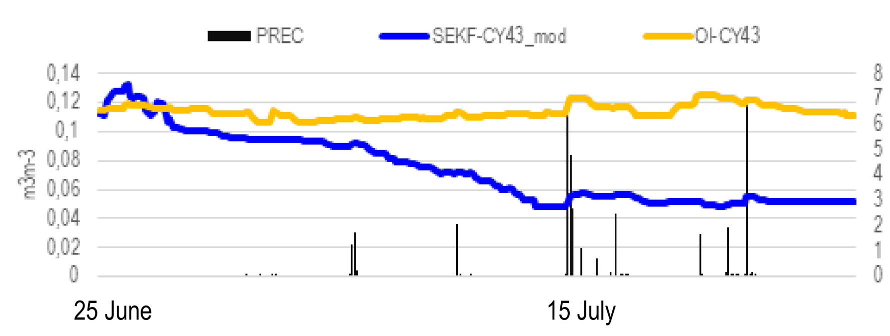


12-hour 2 m temperature forecast & observation [°C]
12 UTC, 15 July 2020



Overestimation of the minimum temperature and underestimation of the maximum temperature are typical in dry and warm anticyclonic periods in AROME/HU. The case study for 15 July 2020 indicates that SEKF improved the 2 m temperature analysis (not shown). At the same time, the 12-hour forecast was unrealistically warm over south.

Evolution of soil moisture (WG2) [m³/m³] & precipitation [mm]



Focusing on a single point from here (circle on the map), the soil moisture content decreased rapidly using **SEKF**, but **OI-MAIN** did not change it drastically. The main soil texture is sand (73%) in this area, so the soil moisture reflects quickly the precipitation variability.