NWP activities at the Hungarian Meteorological Service

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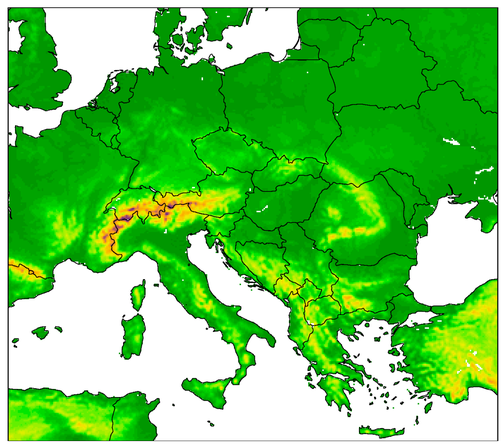
Operational configurations

ALADIN/HU

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

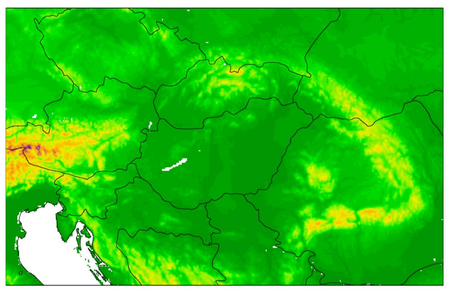


ALADIN/HU model domain

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-ENS, 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

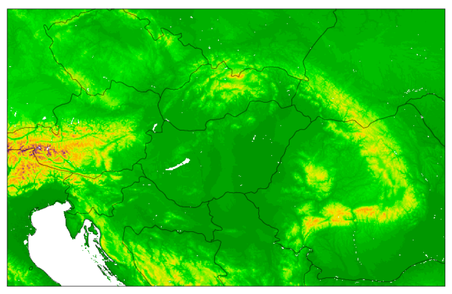
- HPE Apollo 6000 server
- 12 nodes x 2 CPU x 20 cores, 2.2 GHz Intel XeonE5-2698 processors
- 128 GB RAM/node
- Transfer of IFS LBCs from ECMWF via Internet, backup ARPEGE LBCs from Météo-France via Internet & ECMWF re-routing

High-resolution experiments with AROME

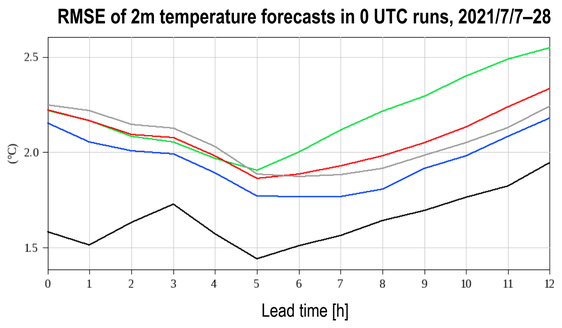
AROME is being tested over the area covering AROME/HU domain with 1.3 km horizontal resolution and 90 levels. Data assimilation is not included yet. The first experiment is achieved from 7 to 28 July 2021 adopting AROME-France settings and tuning a parameter related to the new cloud diagnostics.

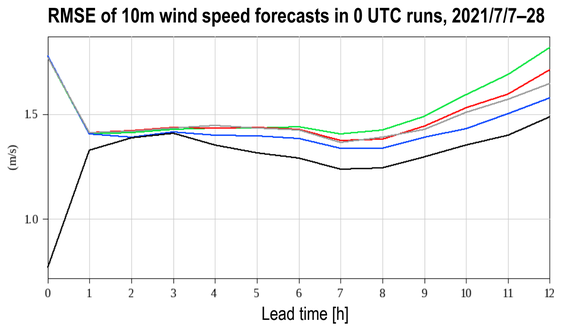
The preliminary results show some degradation in the forecast performance for 2m temperature and 10m wind, partly due to changes in microphysics and partly due to lack of assimilation. **Tuning VSIGQSAT** helped to eliminate the degradation associated with the new cloud diagnostics resulting in precipitation forecasts outperforming AROME/HU.

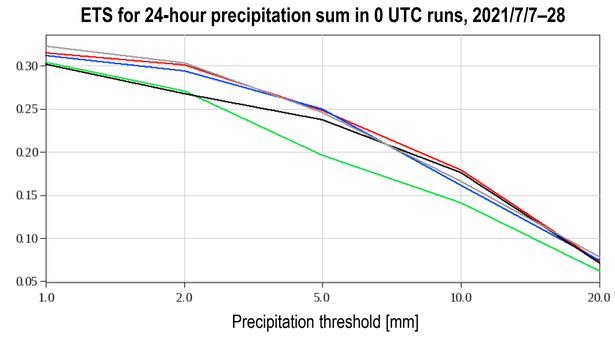
Experiments	OPER	DYNA	LOSIGF	VSIG2	VSIG6
Horizontal resolution (km)	2.5	2.5	1.3	1.3	1.3
Number of vertical levels	60	90	90	90	90
Data assimilation	+	–	–	–	–
LOSIGMAS	F	F	F	T	T
VSIGQSAT	–	–	–	0.02	0.06



Domain and orography of 1.3 km resolution AROME







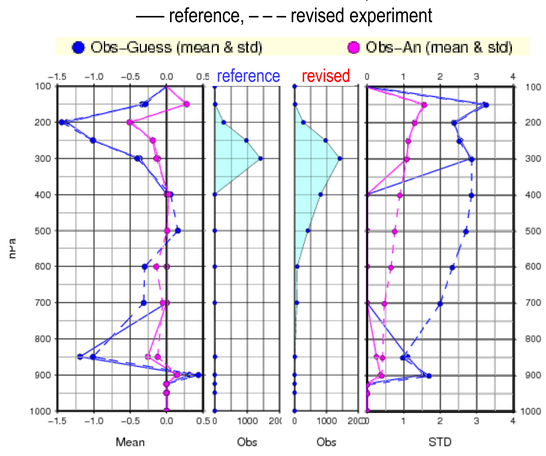
Revised blacklisting settings for assimilation of AMV data

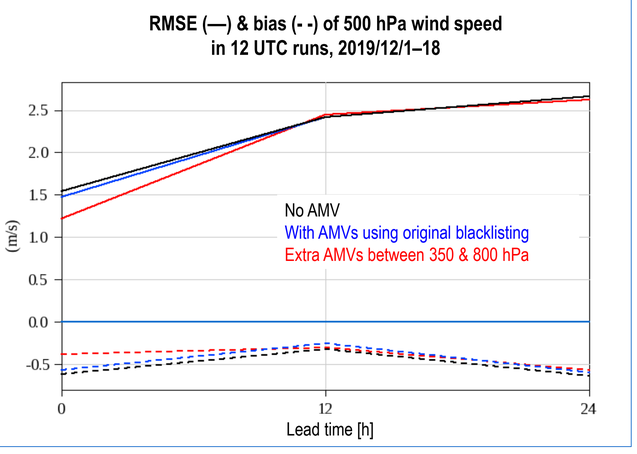
Geowind and hrwind data were assimilated from 1 to 18 December 2019. For thinning and blacklisting of AMV data, we applied the ALADIN/HU settings first (**reference** in Table). But many observations were blacklisted with this setup: active wind vectors were mostly located between 300 and 250 hPa.

To increase the number of assimilated AMVs, we added extra observations between 800 and 350 hPa (**revised** in Table). The corresponding O–B (observation minus background) statistics seem reliable between 800 and 350 hPa.

Setting	Reference	Revised
Quality index < 85 %	inactive	inactive
Data where p>700 hPa over land	inactive	inactive
Data where p<700 hPa for VIS	inactive	inactive
Data between 350 and 800 hPa	inactive	active
Data where p>400 hPa for WV	inactive	inactive

Using more data showed very small, almost no impact for surface parameters. The impact is mostly neutral also in the upper levels, although some improvement can be detected: the **extra wind data** reduce the bias and RMSE for the wind speed at 500 hPa in the early forecast hours.



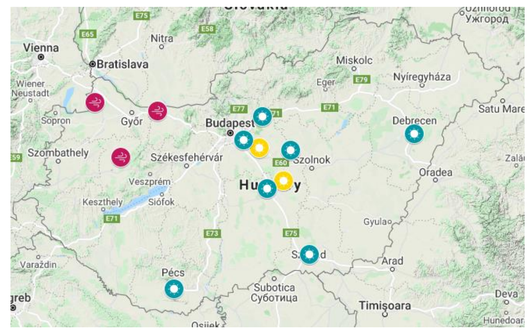


Post-processing of model outputs using machine learning

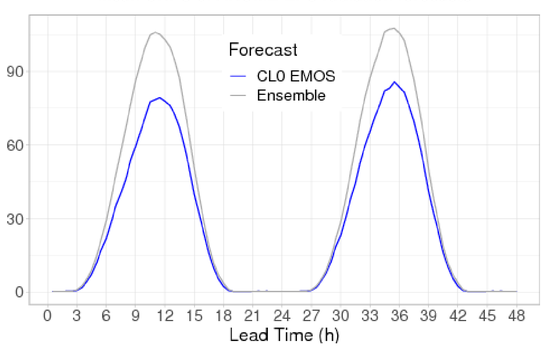
In cooperation with some wind and solar energy farms, studies are started to post-process the raw forecasts supplying input for estimation of short-term energy production. The focus is on improvement of global radiation and 100-meter wind speed forecasts of AROME/HU and AROME-EPS.

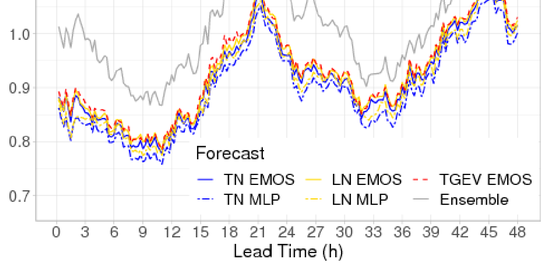
Several methods for ensemble model output statistics (EMOS) are tested on AROME-EPS 100m wind speed forecasts based on **truncated normal (TN)**, **lognormal (LN)** and **truncated generalized extreme value (TGEV)** distributions. In addition to the forecasts, corresponding 100m observations from the partners' sites are used to train the models with a 51-day training period rolling over a year from July 2020. The best result, 12 % reduction in CRPS, is obtained with truncated normal distribution supported with **multilayer perceptron method (TN MLP)**.

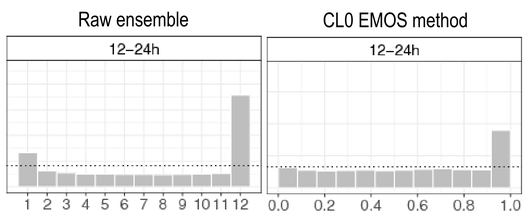
A **censored logistic (CL0)** probability distribution is applied to calibrate ensemble forecasts for radiation fitting better to its diurnal characteristics. On top of the partner observations, SYNOP measurements are used to train the model over a year with a 31-day rolling training period. The method decreases the CRPS with 23 %, increases the ensemble spread reducing the radiation underestimation.



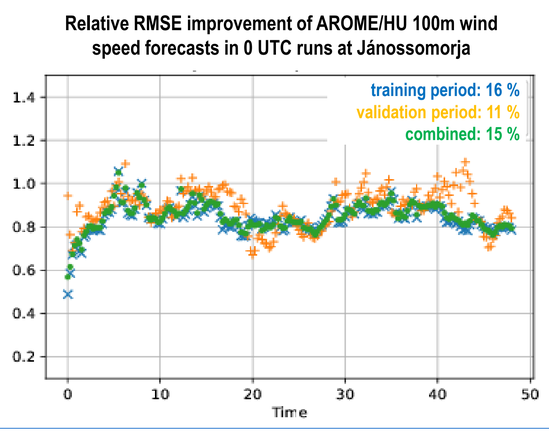
Observations used in post-processing:
100-meter wind speed from windfarms, global radiation from solar energy farms and SYNOP observations

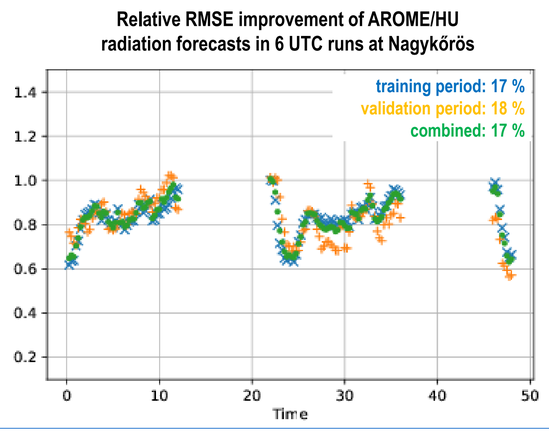






Multiple algorithms are tested on AROME/HU forecasts: combined convolutional and artificial/feedforward neural networks to improve the forecasts in every 15 minutes up to 48 hours; convolution autoencoder to improve the forecasts over the whole range. In addition to the partners' observations, forecasts and SYNOP measurements are used over the selected area, also for temperature and surface pressure. RMSE is reduced at least by 10 % for 100m wind speed and by 9–18 % for radiation depending on method, forecast initial time and length of the validation period. The algorithm to be implemented into operational applications will be a combination of different methods.





Case study for dew-point with SEKF

Our forecasters indicated a known deficiency of AROME forecasts: too high and unrealistic dew-point values usually happening on sunny days with weak wind.

Looking at the case on 24 April 2021, the moisture flux in the planetary boundary layer was exaggerated by AROME resulting in an overestimated dew-point over the western and northeastern parts of Hungary. AROME-EPS produced similar forecasts suggesting that this feature is mainly associated with the surface conditions. (Note that AROME and AROME-EPS share the same initial conditions on the surface, but not in the atmosphere.) Soil moisture was indeed too high in these regions.

A test experiment was conducted using Simplified Extended Kalman Filter (SEKF) surface data assimilation with 2-week spin-up and 3-hourly cycling of AROME and SURFEX 8.0+.

The **Kalman Filter** dried the soil in the critical regions. This largely improved the dew-point forecast in comparison with the **operational forecast**, however, some overestimation still remained over West.