NWP activities at the Hungarian Meteorological Service

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HungaroMet Hungarian Meteorological Service

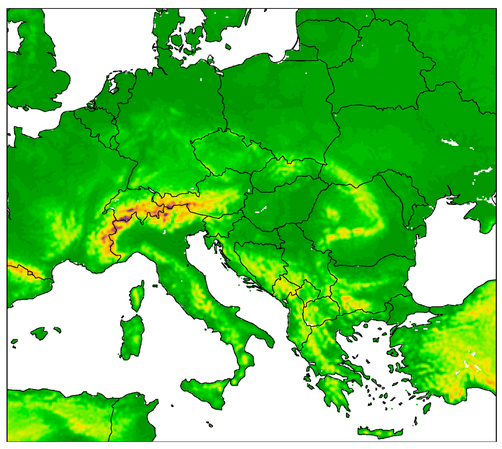
LACE nwp central europe

ACCORD A Consortium for COnvection-scale modelling Research and Development

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: at 00/06/12/18 UTC up to 60/48/60/36 h
- 3 hourly lateral boundary conditions from ECMWF-"HRES"
- Hourly outputs

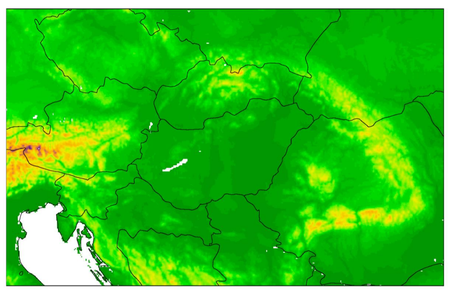


ALADIN/HU model domain

AROME/HU

- Model version: cy46t1_bf07
- 2.5 km horizontal resolution, 60 vertical levels
- Local data assimilation:
  - 3D-Var in upper air, SEKF at surface
  - 3-hour assimilation cycle
  - Lake temperature initialized from measurements at Lake Balaton
  - Hydrometeors & snow cycled in assimilation
- Initialization: space-consistent coupling (no DFI)
- 8 runs a day: 00/06/12/18 UTC up to 48h;
  03/09/15/21 UTC up to 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 &~~ Czech Mode-S MRAR (u, v, T) • GNSS ZTD (IWV) • AMV, HRWIND (u, v)



AROME/HU and AROME-EPS domain

AROME-EPS

- 10+1 ensemble members using AROME
- Local perturbations: 3 hourly ensemble data assimilation
- 2 forecast runs a day, at 0 and 12 UTC up to 48 hours
- Hourly LBCs from 18/6 UTC ECMWF-ENS
- Resolution, physics etc. as in AROME/HU

Computer system

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

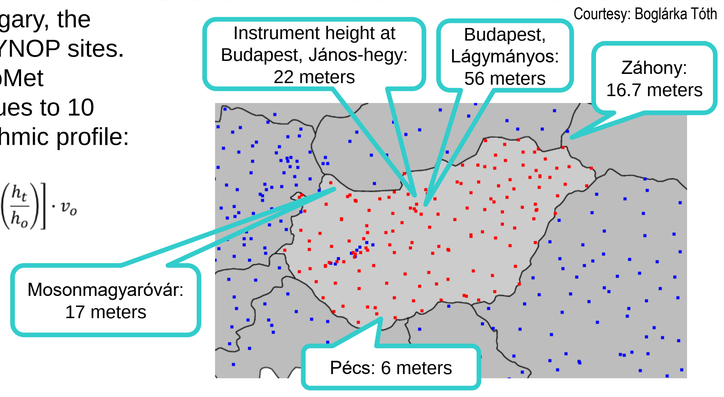
Impact of assimilating corrected 10-meter wind data

The instruments of wind measurements are not installed at 10 meters everywhere in Hungary, the height difference is significant at some SYNOP sites. The Unit of Climate Research at HungaroMet recomputed the wind speed and gust values to 10 meters using the raw data and the logarithmic profile:

$$v_t = \exp\left\{\gamma \cdot \ln\left[\frac{\ln\left(\frac{h_t}{r}\right)\cdot \ln\left(\frac{h_o}{0.1}\right)}{\ln\left(\frac{h_t}{0.1}\right)\cdot \ln\left(\frac{h_o}{r}\right)}\right]\right\} \cdot \exp\left[\alpha \cdot \ln\left(\frac{h_t}{h_o}\right)\right] \cdot v_o$$

h_o : original observation height
h_t : target height, e.g. 10 m
r : roughness length of observation site
v_o : wind speed in the height h_o
v_t : wind speed calculated for the height h_t
α, γ : parameters depending on season and variable

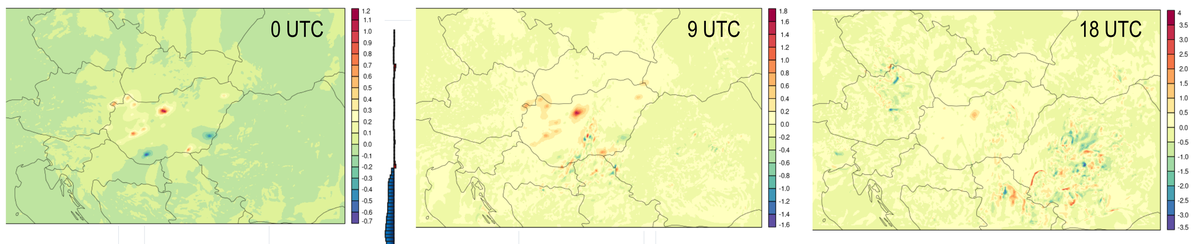
Location of corrected & untouched SYNOP wind measurements
Courtesy: Boglárka Tóth



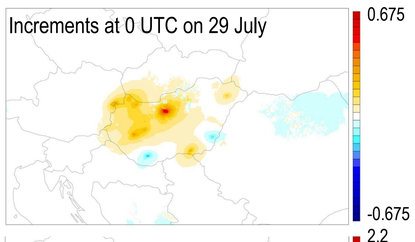
In addition to the original data, the corrected ones are available routinely since July 2025. We started to test the corrected data for 10-meter wind speed in the 3D-Var assimilation both at 2.5kmL60 resolution with 3-hourly assimilation cycle and 1.3kmL90 resolution with hourly cycle. After finalizing all the technical details which were necessary to merge the corrected data from Hungary and the raw data from the surrounding countries, we started an experiment at 0 UTC on 29 July which was a windy day in Hungary.

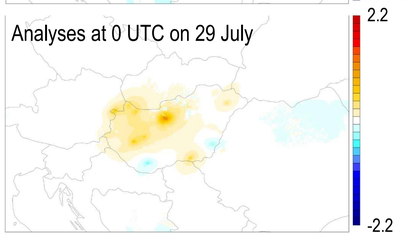
The increments and the analysis changed according to our expectations: mostly in the locations where the correction changed the measured wind speed. (It affected the other variables as well, like temperature, humidity.) The impact had a maximum around the screen-level and reduced with the height. These conclusions are valid both in the 2.5kmL60 and 1.3kmL90 versions.

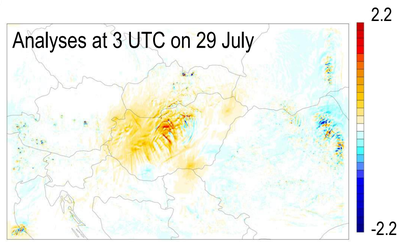
Difference in analysis of 10-meter wind speed [m/s]
between the 2.5kmL60 experiments using original and corrected SYNOP data, 29 July 2025

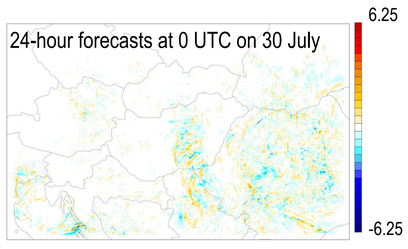


Difference of 10-meter wind speed [m/s]
between 1.3kmL90 experiments using original and corrected SYNOP data

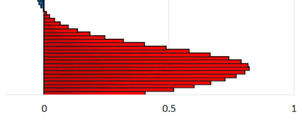








Analysis difference in wind speed [m/s] at model levels at Budapest
in the 1.3kmL90 experiments, 0 UTC 29 July 2025



Nevertheless, a definitely unexpected feature was a higher impact in the forecast after 12 hours over Hungary. Looking into the later analyses and the forecasts, the impact seems to travel to southeast (likely with the wind) and some spurious lateral boundary effect can also act. Some further inspection is needed.

Testing assimilation of snow data in AROME

Testing the assimilation of SYNOP snow depth observations is ongoing in AROME cy46t1. In Hungary, snow depth is measured only at 6 UTC. In the experiment, the 1-layer D95 snow scheme was used with 3 prognostic variables: snow-water equivalent, snow density and snow albedo.

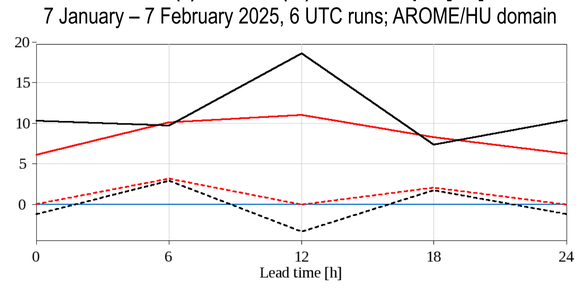
A bugfix released by A. Trojáková, J. Ševčík and F. Meier was implemented with some corrections of the CANARI assimilation flags in datum_anflag.final. Snow observations above 1500 meter a.s.l. are considered, and an altitude-dependent quality check for the departure from the first guess is built in the code (the higher a station, the higher the limit for the quality check). A new logical switch is applied to neglect the data with negative value (having special meaning).

Experiment was run from 7 January to 7 February 2025 with the next CANARI namelist parameters:

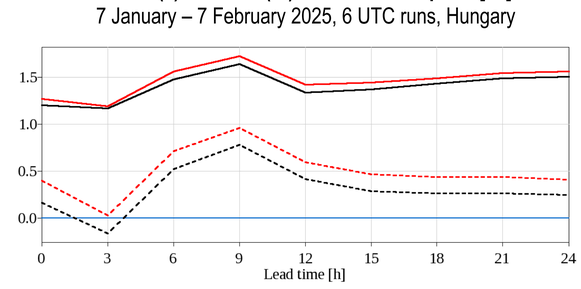
```
LAESNM = T              # active snow assimilation
REF_S_SN = 5            # background error std dev, kg/m2
REF_A_SN = 50000        # horizontal correlation length, m
REF_AP_SN = 0.05        # vertical correlation length, m
ECTERO(1,1,92,1) = 4    # observation error std dev, kg/m2
LAOROFLEXREJSN = T      # altitude-dependent quality check
OROFLEXREJS = 400.
LOBSNEG = T             # filter for negative values
ORODIF = 10000          # maximum altitude difference
                        between obs and model, m
OROLIM = 10000          # max altitude for surface obs, m
LAECHK = F              # spatial quality check
```

The assimilation of snow data improved both the analysis and the forecasts for snow depth over the AROME/HU domain. However, it introduces a positive bias in the 2-meter dewpoint.

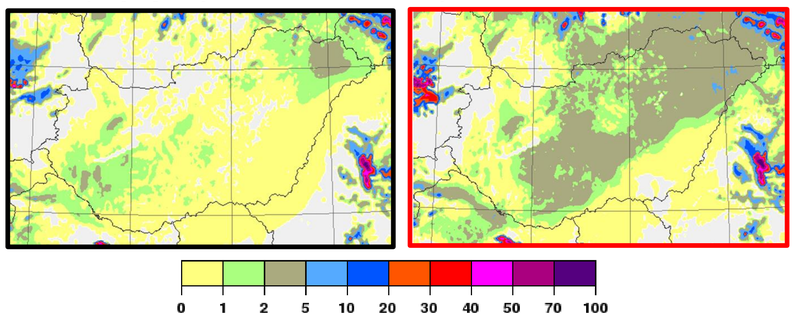
RMSE (–) and bias (- -) of snow depth [cm]
7 January – 7 February 2025, 6 UTC runs; AROME/HU domain



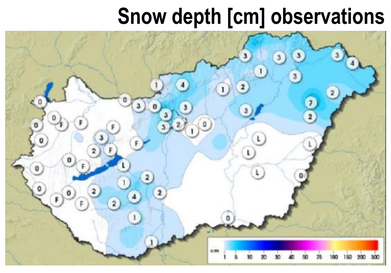
RMSE (–) and bias (- -) of 2-meter dewpoint [°C]
7 January – 7 February 2025, 6 UTC runs, Hungary



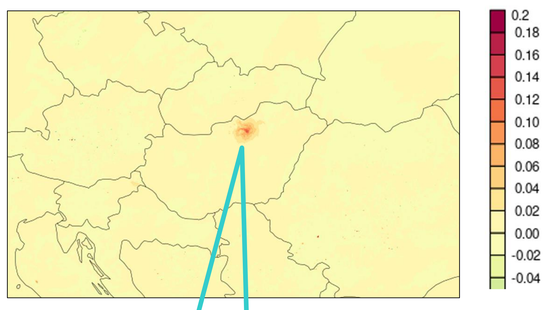
Snow depth [cm] analyses at 6 UTC on 16 January



Snow depth [cm] observations

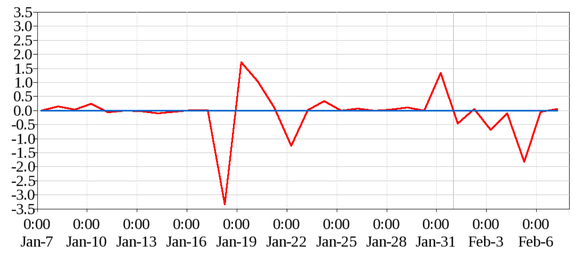


Difference in 2-meter relative humidity [ ]
between experiments with LAECHK=T and LAECHK=F



Activating the spatial quality check (LAECHK=T) and reducing ORODIF to 1500 m, affect only points with high elevation and it often has negative impact on near-surface humidity. We will continue to investigate this in detail to find the final setup.

Difference in 2-meter relative humidity [%] at Kékestető
between experiments with LAECHK=T and LAECHK=F



Experiments to assimilate descending radiosonde data in AROME

At the meteorological station of Budapest (12843), the erected radiosondes were equipped with parachutes during 2 measurement campaigns in 2023. We estimated the effect of involving these data into the 3D-Var and compared this impact with the one of the freely descending radiosondes.

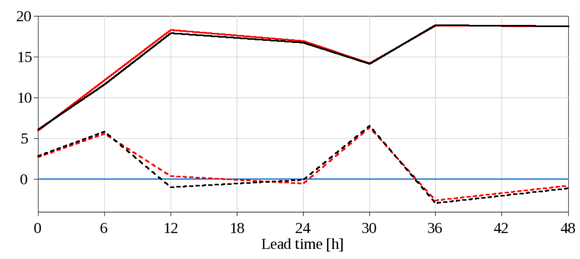
Three periods were selected from 2023:

1. 1–25 April, when the radiosondes were equipped with parachutes;
2. 2–24 August, when the radiosondes were equipped with parachutes;
3. 1–24 June, when the radiosondes descended freely (i.e. without parachutes).

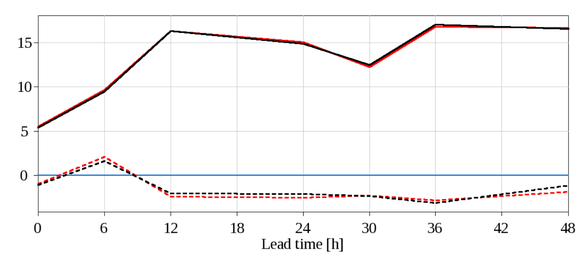
Two experiments were achieved for each period: **with** and **without assimilating data of the descending** radiosondes from Budapest. (There was not any other radiosonde station providing descending data over the model domain.) The first results do not show significant effect of the descending data with parachutes: mostly slight negative impact is detected in the higher atmosphere. The impact is even smaller when using data of freely descending instruments.

In our in-house verification system the verification for pressure level variables is achieved against TAC TEMP data, which allows the comparison only against observations of 1-5 stations. We will check the conclusions using HARP which handles BUFR TEMP data.

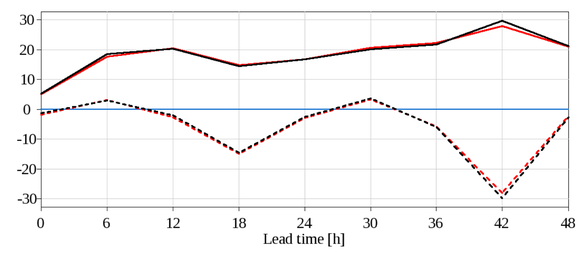
RMSE (–) and bias (- -) of relative humidity at 700 hPa [%]
1–25 April 2023, 0 UTC runs, AROME/HU domain



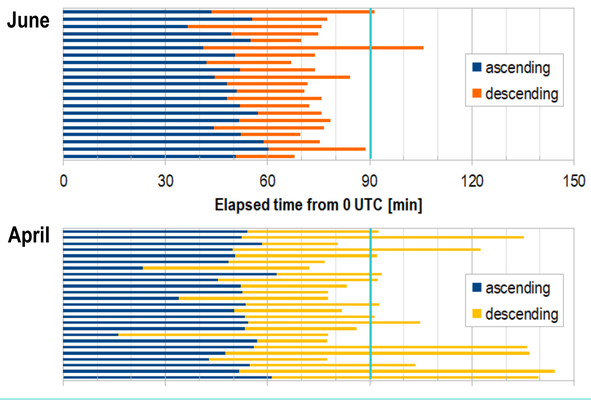
2–24 August 2023, 0 UTC runs, AROME/HU domain



1–24 June 2023, 0 UTC runs, AROME/HU domain



Radiosondes at 0 UTC at Budapest



Looking at the time of measurements deriving from different parts of the sonde trajectory, the data from the descending part quite often do not fall in the assimilation window (which is **-/+90 minutes** in AROME/HU) if the **radiosonde descends with parachute**. We will continue the experiments in the hourly updated AROME-RUC system.

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