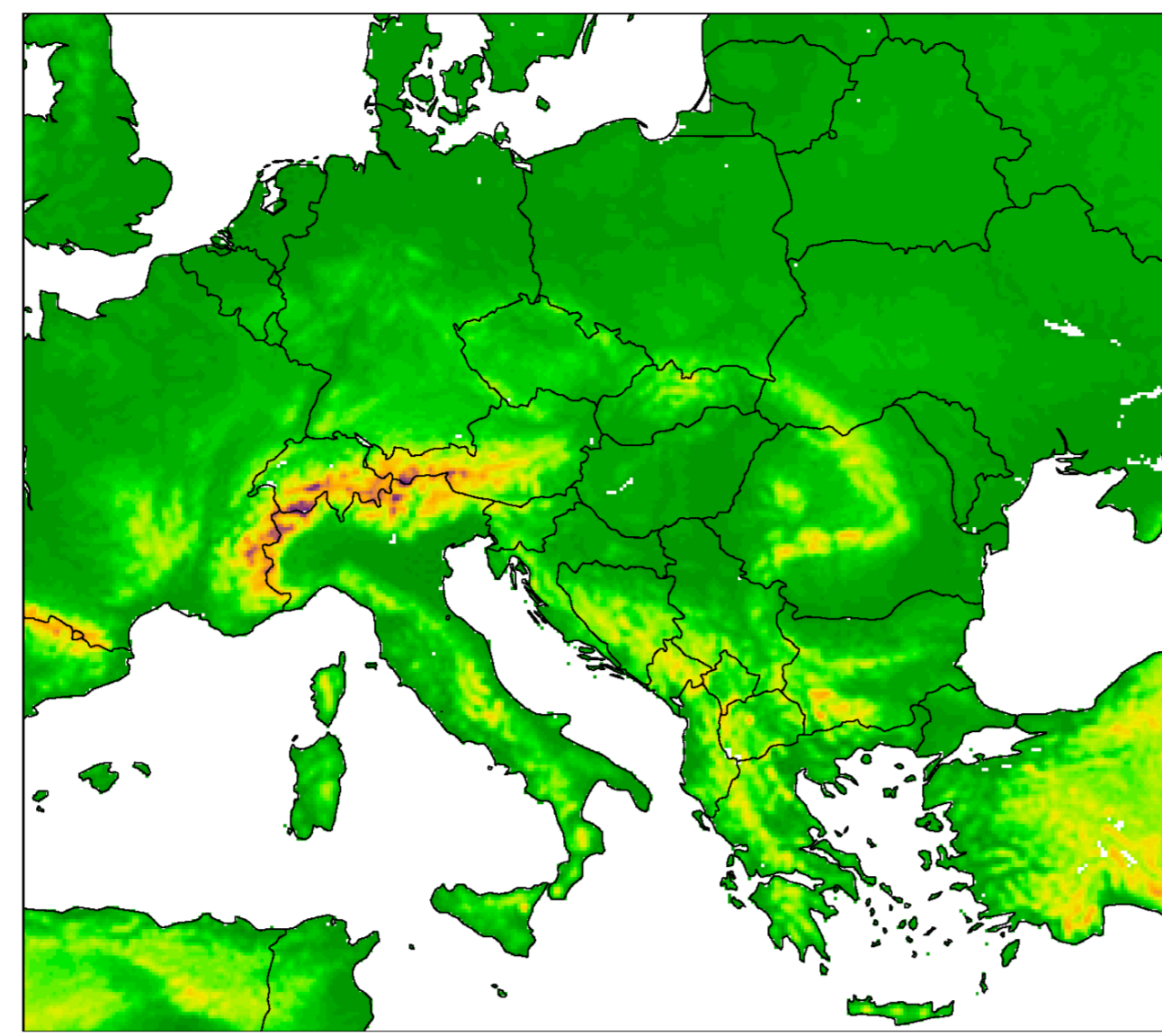


Operational configurations

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

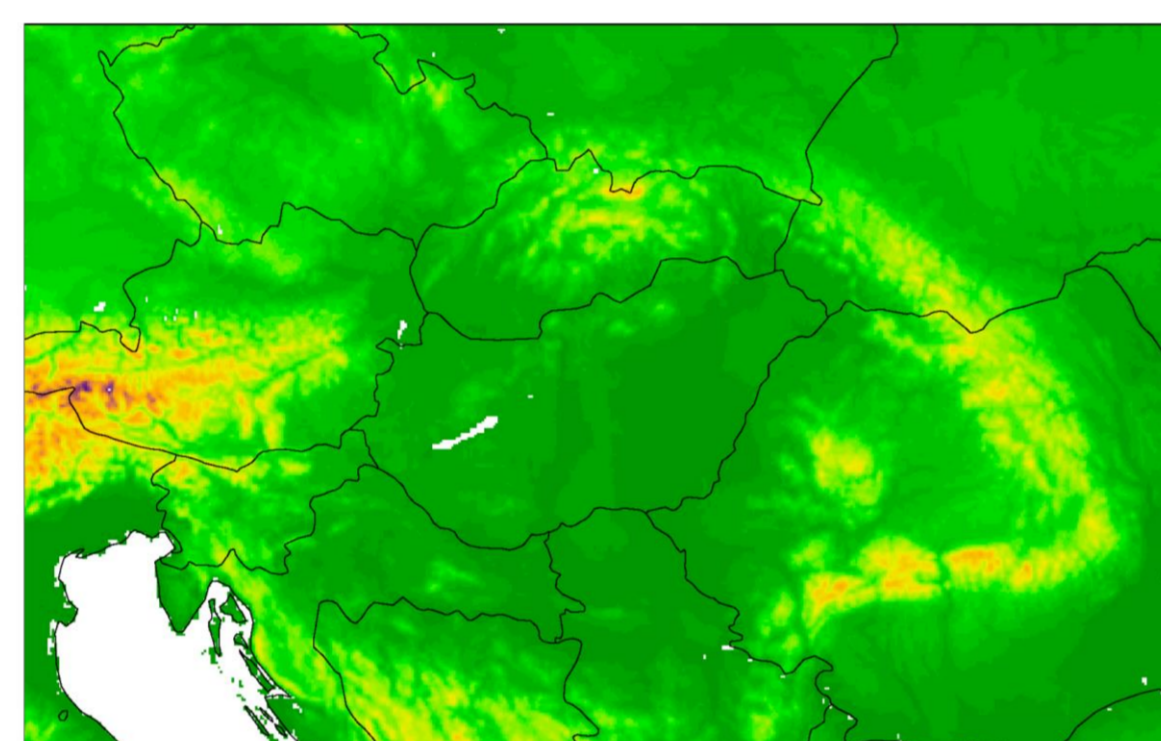


ALADIN/HU model domain

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 (u, v, T, RH, z, snow)
• SYNOP-SHIP (u, v, T, RH, z)	• TEMP (u, v, T, q)
• TEMP (u, v, T, q)	• AMDAR (u, v, T, q)
• AMDAR (u, v, T)	• Slovenian & Czech Mode-S MRAR (u, v, T)
• ATOVS (AMSU, MHS radiances)	• GNSS ZTD (IWV)
• MSG/GEOWIND (AMV)	• AMV, HRWIND (u, v)
• MSG/SEVIRI (radiances)	



AROME/HU and AROME-EPS domain

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

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

AROME e-suite with assimilation of snow data

The operational AROME/HU initializes the snow field with the 3-hour first guess valid for the analysis time. Using this approach the snow often persists in the forecasts even for weeks after its falling without its significant melting.

An e-suite was running with assimilation of SYNOP snow depth measurements 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. 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 additional spatial check is not activated as it removed important SYNOP measurements (not only snow depth). The data with negative value (meaning not continuous or very thin snow cover) are assimilated as zero snow depth.

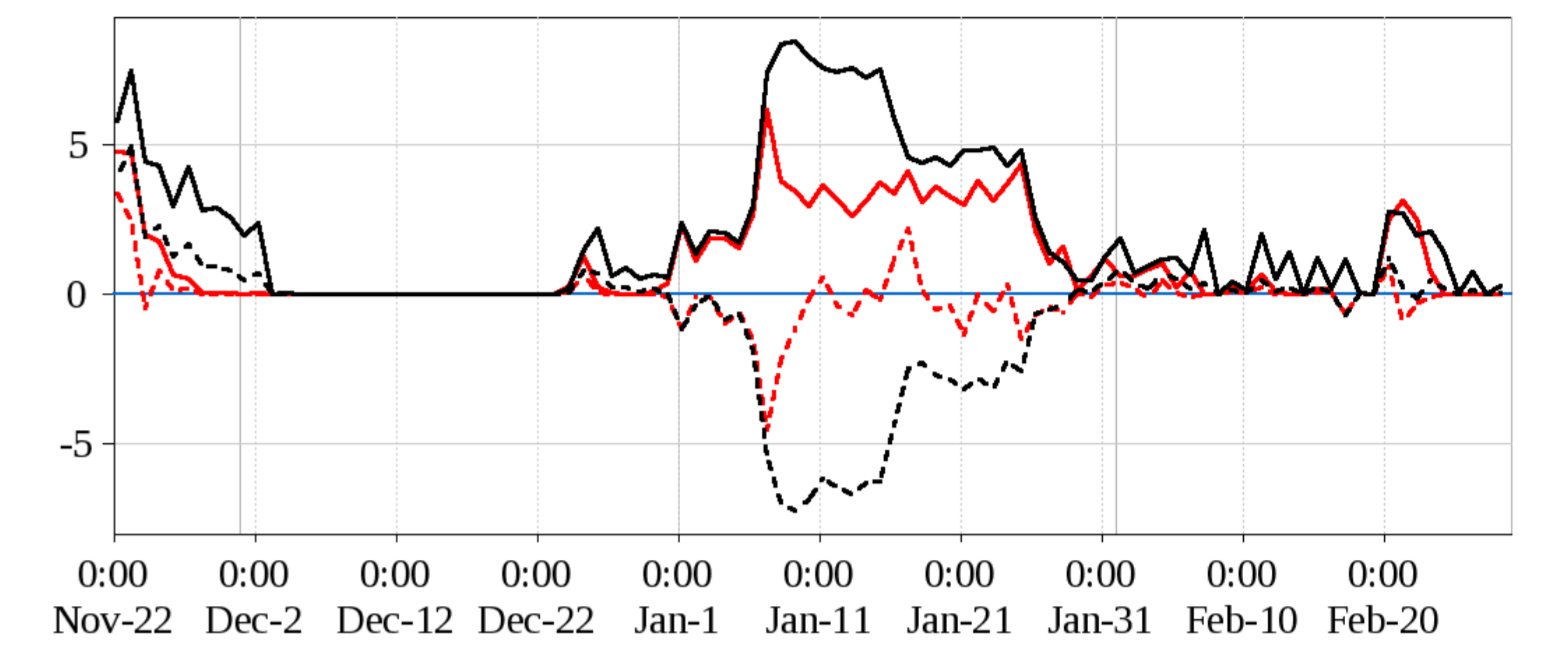
The e-suite was running from November 2025 to March 2026. Snow does not fall often in Hungary recently, but the test period was exceptional: several cases occurred this winter, sometimes even with 20-36 cm snow depths.

CANARI namelist parameters for the e-suite:

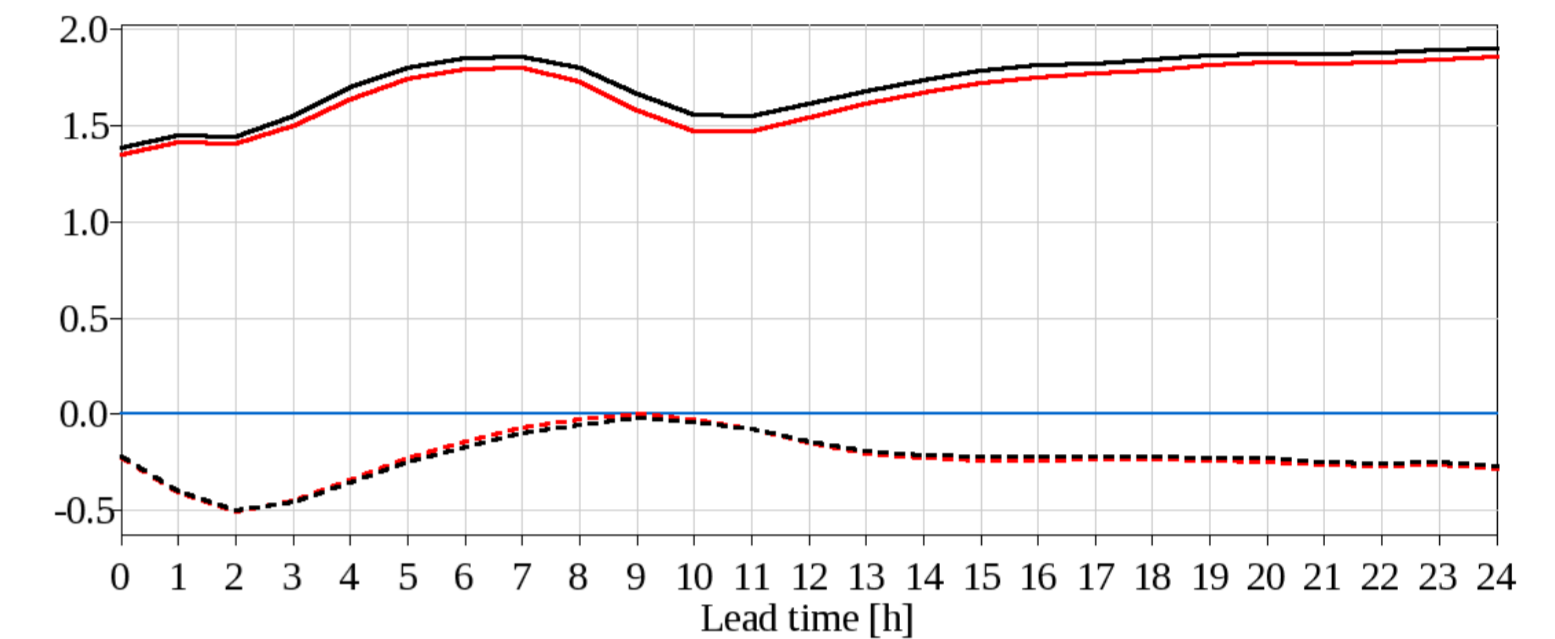
```

LAESNM = T # active snow assimilation
REF_S_SN = 5 # background error std dev, kg/m2
ECTERO(1,1,92,1) = 4 # observation error std dev, kg/m2
LAOROFLEXREJISN = T # altitude-dependent quality check
OROFLEXREJIS = 300.
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
    
```

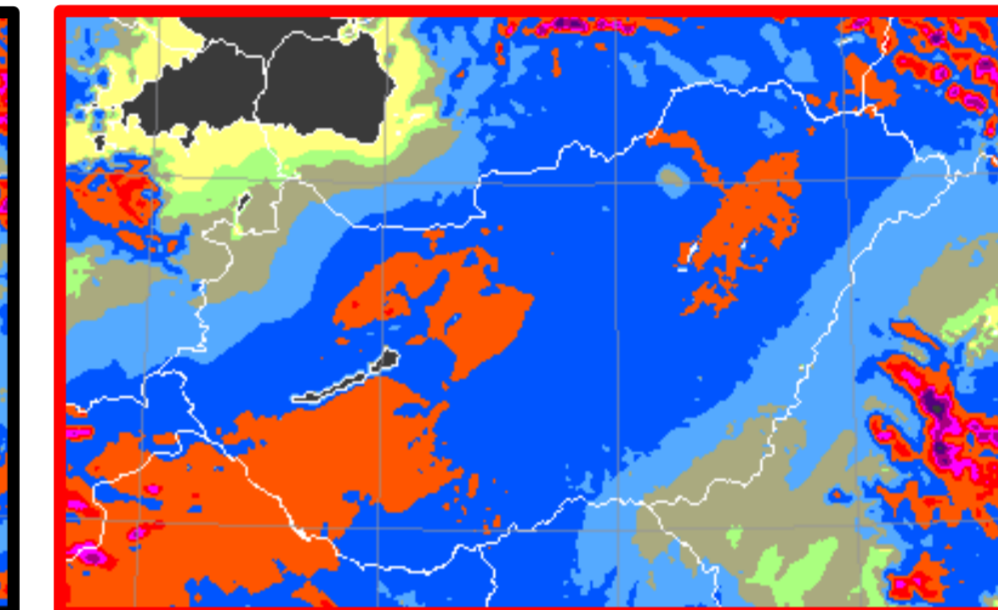
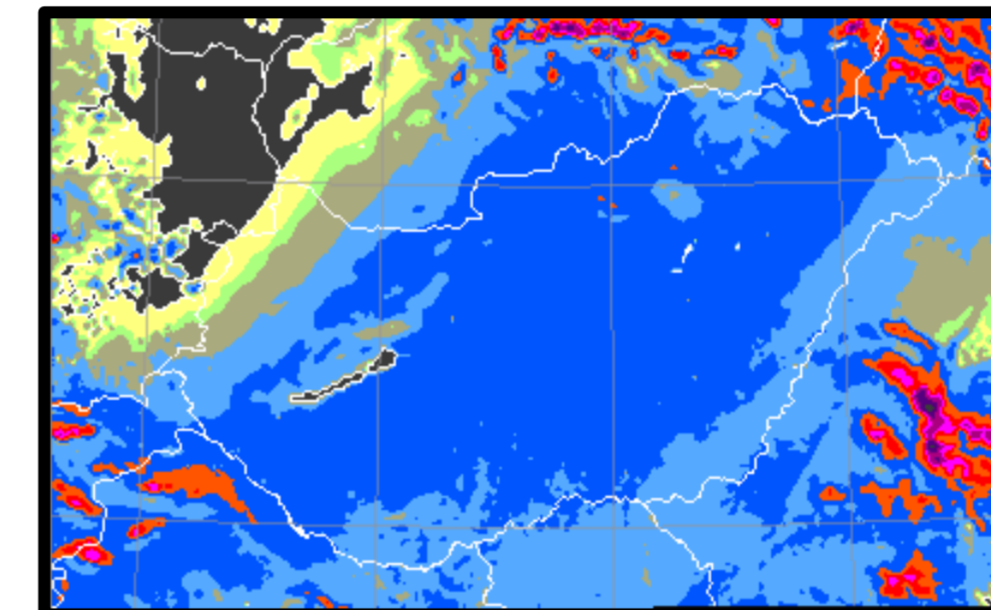
RMSE (-) and bias (-) of 6-hour snow depth forecasts [cm]
22 November 2025 – 28 February 2026, 0 UTC runs; Hungary



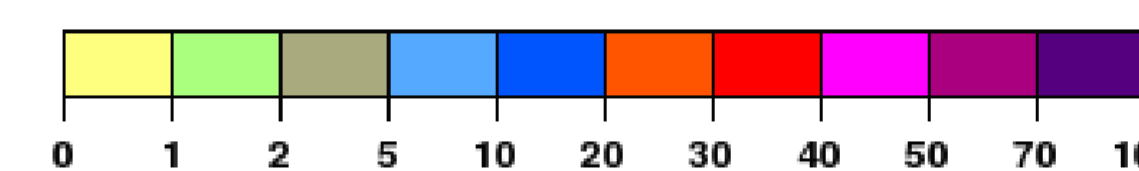
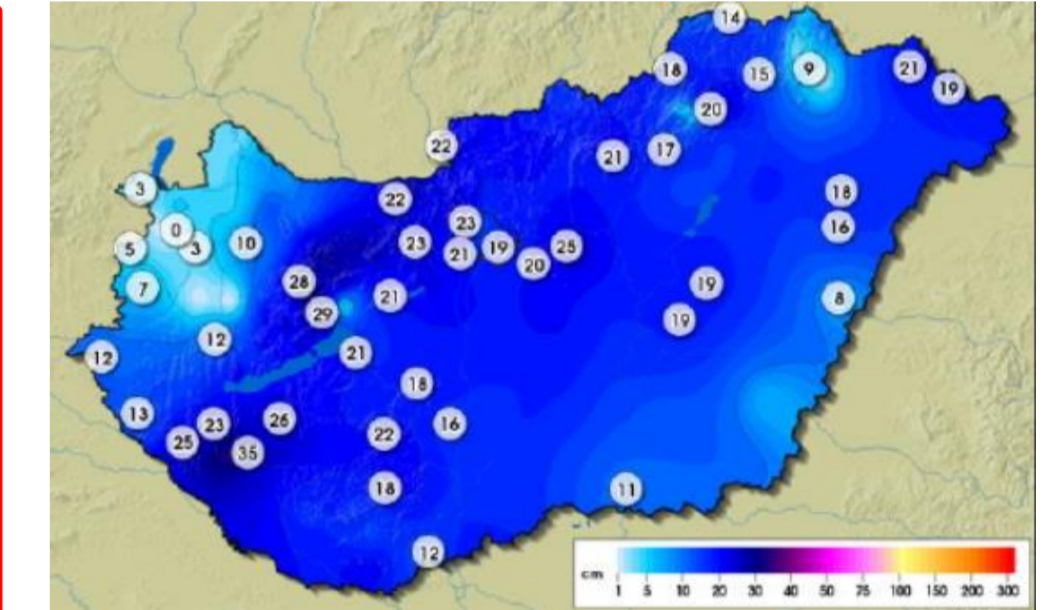
RMSE (-) and bias (-) of 2-meter temperature [°C]
22 November 2025 – 28 February 2026, 6 UTC runs, Hungary



Snow depth [cm] analyses at 6 UTC on 7 January 2026



Snow depth [cm] observations



The development improved both the analyses and the forecasts of snow depth. The impact was positive even in cases with high snow amounts usually overestimated by AROME/HU. Due to the more accurate snow initialization, the procedure of melting became more realistic (i.e. shorter).

Improvement was also gained in 2-meter temperature and dewpoint temperature forecasts with reduced over- and underestimations. The assimilation of SYNOP snow depth data was introduced into every (EPS, RUC etc.) configuration of AROME/HU in March.

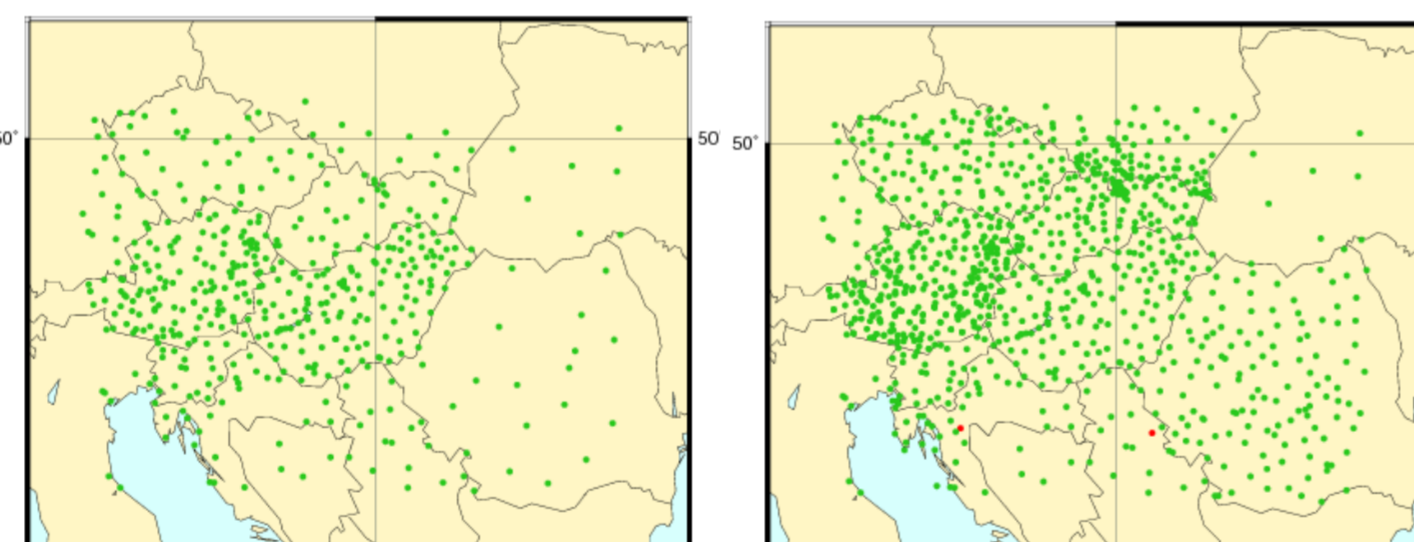
Testing assimilation of additional SYNOP data

In the last few years, the density of SYNOP station network enhanced a lot in Central and Eastern Europe. Not all the data are available in the GTS, but the member states of LACE share them with each other for assimilation and verification purpose. The data are pre-processed via OPLACE and ready for further use.

In Hungary, we started experiments to involve the extra SYNOP data in the 3D-Var system of AROME/HU. We carried out experiments at 2.5kmL60 and 1.3kmL90 resolutions with 3- and 1-hourly assimilation cycle, respectively. The study covered two periods: April 2025, from 22 October to 20 November 2025. Apart from the extra SYNOP data, the settings were the same as in the corresponding AROME/HU and AROME-RUC forecasts.

The number of the assimilated SYNOP data roughly doubled due to the extra input data. At the same time, the standard deviations of the OMG and OMA departures slightly increased.

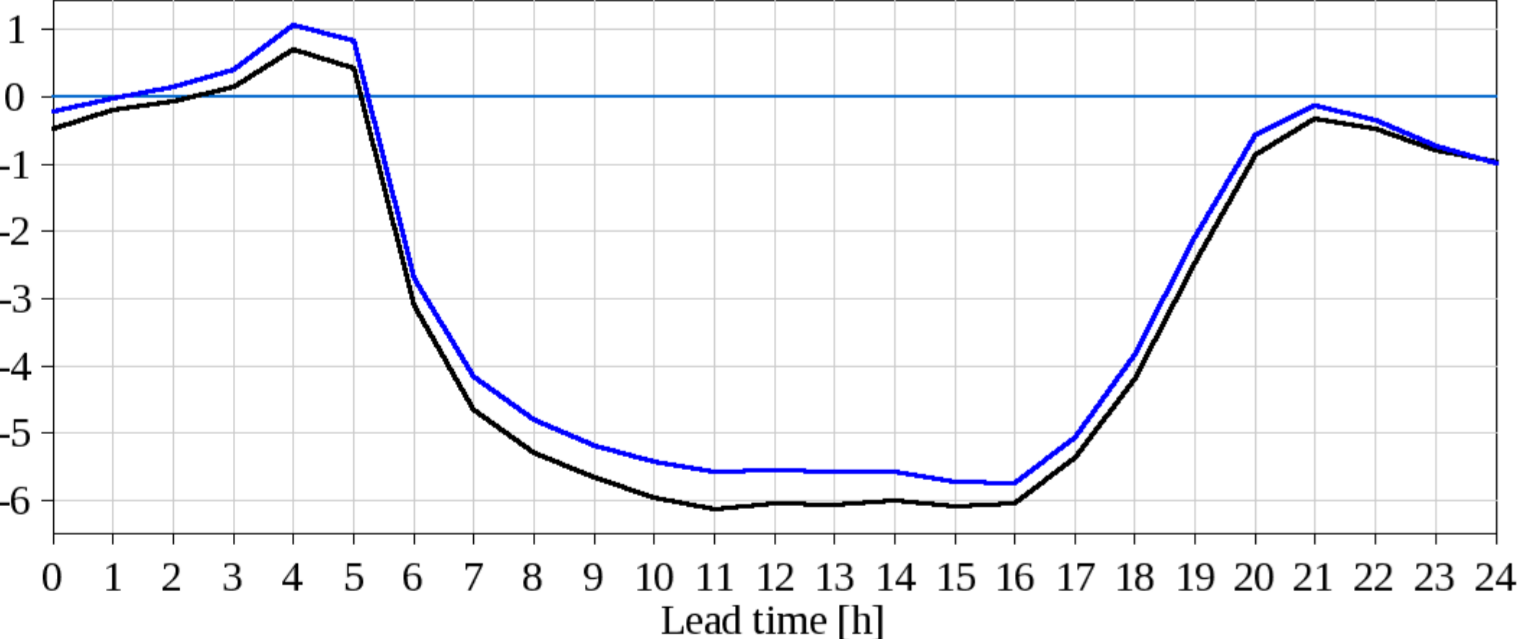
SYNOP 2-meter temperature data used in assimilation
Current system Experiment with extra data
9 April 2025, 12 UTC



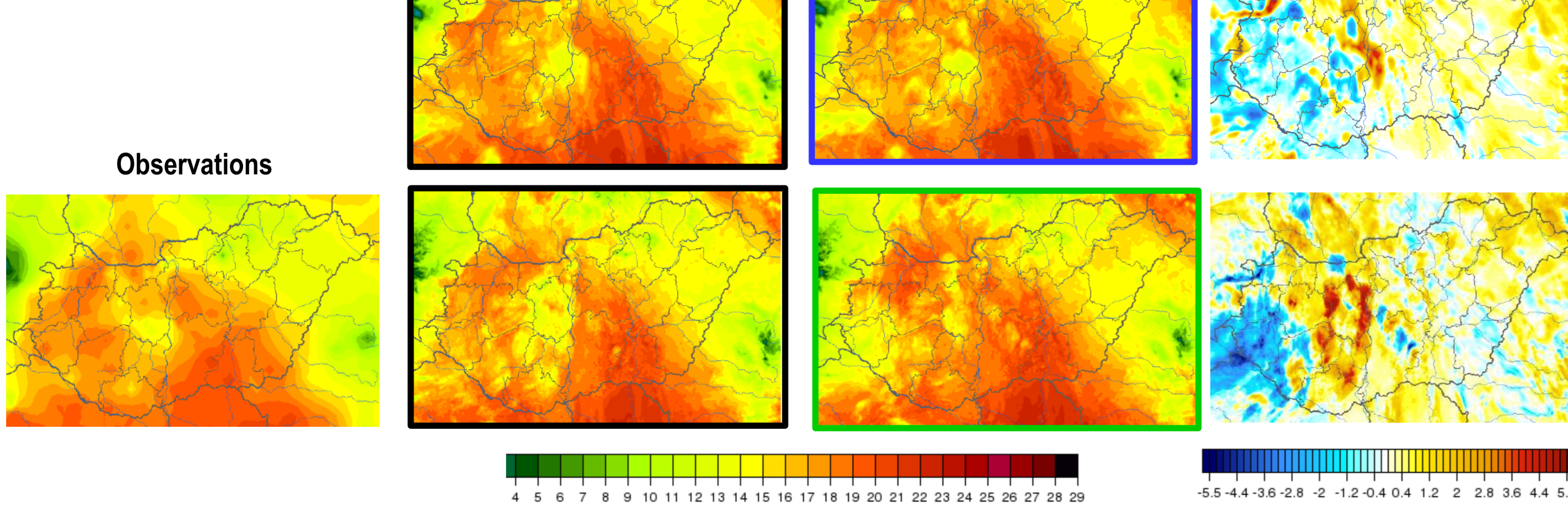
Based on the verification of surface parameters, the impact of extra SYNOP data varies between the experiments (resolution and assimilation cycle), the evaluation period (spring and autumn), the weather situations and the initialization times (0 and 12 UTC runs). In general, we concluded some neutral to positive impact at lower resolution, especially in autumn. Nevertheless, considerable degradation was also detected in many cases.

Bias of 2-meter relative humidity [%]

April 2025, 12 UTC runs AROME/HU domain



2-meter temperature [°C]
at 12 UTC on 18 April 2025

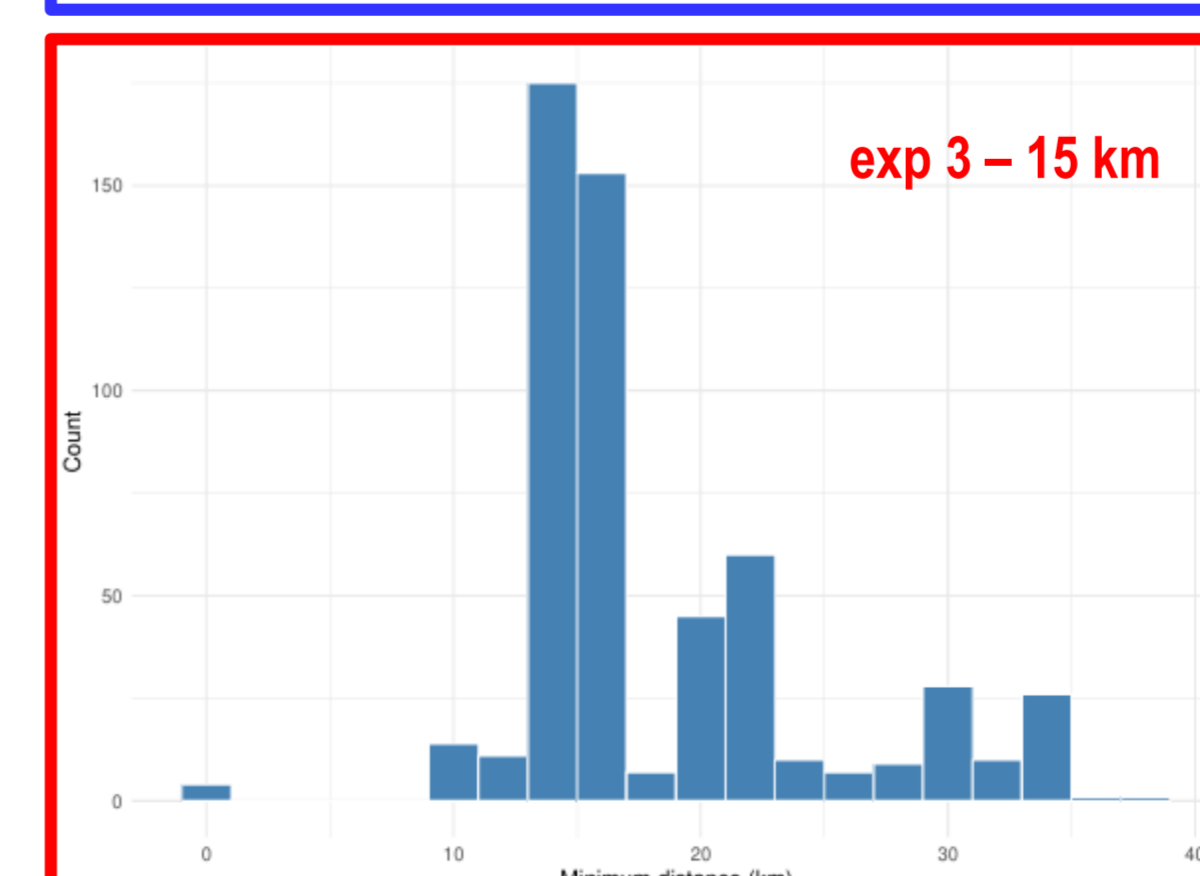
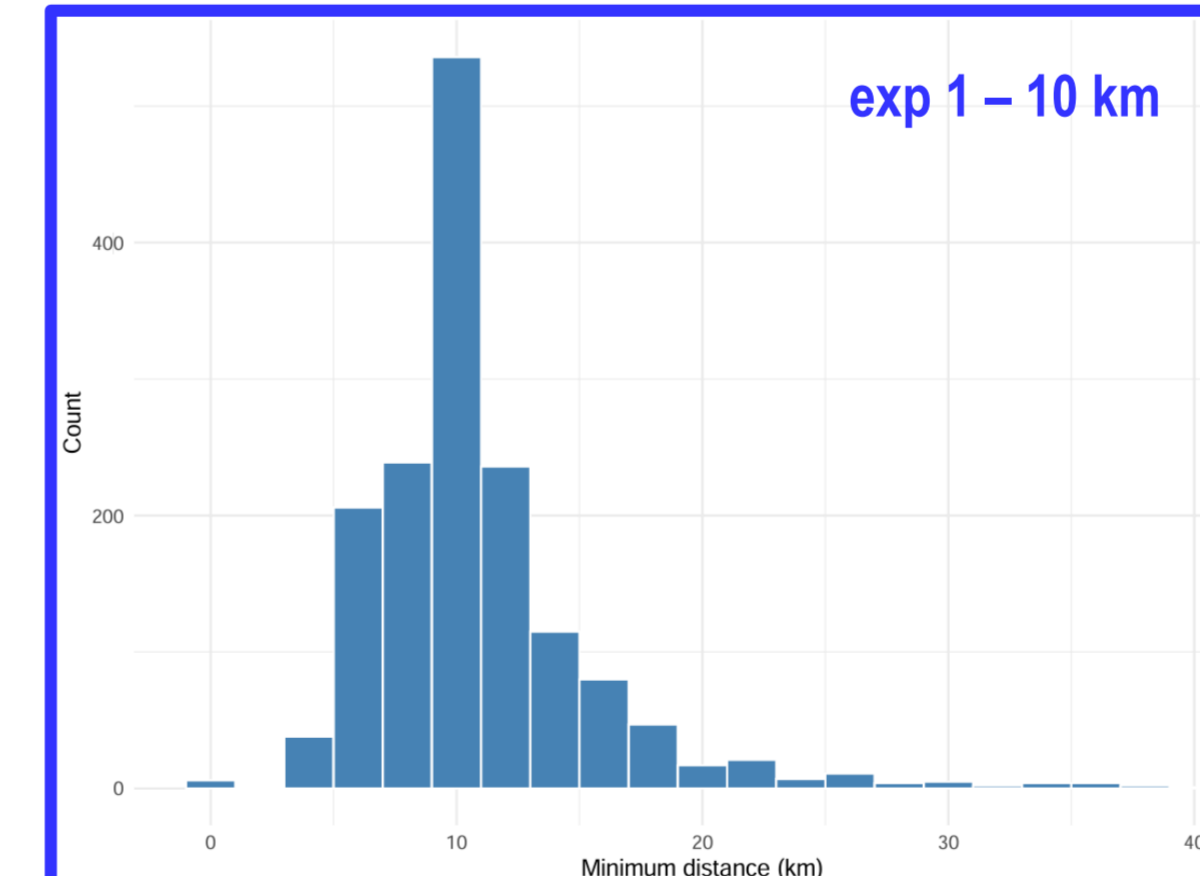


The current experiments were achieved without applying special blacklist for the additional data. We believe that more positive impact could be gained with reconsideration of these settings, thus we are going to continue the tests in this direction.

Testing assimilation of radar reflectivity in AROME

During a 4-week ACCORD/LACE stay at the CHMI in November, we worked on optimising the thinning method applied to radar reflectivity observations in ALARO/CZ. Radar data can be filtered at two stages during the assimilation: (1) right after reading them from the HDF5 files, in the BATOR module (via HODIM%Sample namelist parameter); (2) after the Bayesian inversion in the screening module (via RMIND_RADAR, RFIND_RADAR and XYSHIFT_THIBOX parameters). Based on the experiences, we ran the same experiments for optimisation of thinning for AROME/HU using only the data of 5 Hungarian radars.

Distribution of minimum distances between observations



The first verification results of the AROME runs show, that in summer the thinning settings have higher impact at the time of precipitation peak within the day, mostly between 13 and 17 UTC. In the case of the 12 UTC runs, this might interact with some spin-up effect amplifying both the bias and the RMSE values in the first forecast hours. Usually the reference experiment provides the best results and it is followed by the experiment with pre-thinning in BATOR.

The detailed results with ALARO/CZ are presented in ACCORD NL8.

Parameter	ref	exp 1	exp 2	exp 3
HODIM%Sample	5000	5000	5000	15000
Effective sampling distance [m]				
RMIND_RADAR	16275	10000	20000	16275
Grid size [m]				
RFIND_RADAR	16275	10000	20000	16275
Grid size [m]				
XYSHIFT_THIBOX(13)	0.5	0.5	0.5	0.5
Horizontal shift				

The optimal thinning distance was selected based on the 0.2 threshold for error correlation between neighbouring observations. However, the convergence to this value was less smooth in the AROME experiments, probably due to the lower number of radar data.

Sensitivity studies were conducted using different configurations (see Table) to assess their impact on verification scores. Even with a specific thinning distance set in the screening, it is not possible to prevent observations from falling closer than the target spacing. The largest counts in the distributions cluster around the respective target thinning distances, yet more than half of the observation pairs still appear below these. In contrast, the distribution for experiment 3 has a slightly different pattern, with observation separations shifted more towards higher values.

RMSE (-) and bias (-) of 3-hour precipitation amount [mm]
4 July – 4 August 2025, AROME/HU domain

