

*Regional Cooperation for
Limited Area Modeling in Central Europe*



LACE verification activities

Authors: Doina-Simona Taşcu with contributions of LACE partners



ARSO METEO
Slovenia

Verification of 10-m wind speed and direction for HR20 and HRAN systems (Croatia)

- ❖ based on the usage of ten-minute wind speed and direction at 10 m height from stations from Croatia from 2023
- ❖ five stations in the central and southern Adriatic are selected as focus group, stations characterized by a relatively high frequency of strong Bora and strong Sirocco winds:
 - this group of stations exhibits a wide distribution of wind speeds; a small proportion of calm conditions and the most frequent wind strength corresponding to 2 Beaufort

Verification of 10-m wind speed and direction for HR20 and HRAN systems (Croatia)

- ❖ the most frequent direction is southeast (Sirocco), often reaching storm force (Beaufort 10)
- ❖ while strong northeasterly (Bora) and northwesterly (Maestral) winds are also common
- ❖ for comparison, five weak-wind stations were chosen, where calm conditions exceed 10% and Beaufort 1 winds dominate (>50%), with mainly northeasterly and southwesterly winds of generally low intensity

Verification of 10-m wind speed for HR20 and HRAN systems (Croatia)

- ❖ assess verification measures for rare and frequent events
- ❖ data from ALADIN-HR20 at 2 km and ALADIN-HR40 at 4 km
- ❖ verification scores: POD, SR, TS, ETS, EDS, SEDS, EDI, and SEDI
- ❖ Best Performing Measure:
 - *Extremal Dependence Index (EDI)*
 - ✓ works well for all event frequencies
 - ✓ no strong bias
 - ✓ reflects true forecast quality

● *an article is under submission*

Validation of ALARO CMC at 1km resolution, Boris case (Czech Republic)

- ❖ a preliminary evaluation of ALARO at the resolution of 1 km → in the dynamical adaptation mode
- ❖ the operational 2.3 km version
- ❖ tests for the period of the Boris episode
- ❖ in contrast to the operational settings → the truncation quadratic, not linear any more
- ❖ time-step from 90 s to 60 s

- ❖ *the first evaluation → the difference in time-step length is already responsible for changes in tendencies from physical processes*
- ❖ *first scores*
 - *were neutral or slightly better, despite the dynamical adaptation mode*
 - *still old ISBA surface - already a good result*

Implementation of a direct method of FA reading to sqlite with EPYGRAM (Slovenia)

- ❖ a direct method of reading FA to sqlite ← EPYGRAM tool
 - for CLAEF verification
 - over the entire computational domain
 - no need for postprocessing to GRIB

Verification of wind hazard product (Hungary)

- ❖ *special attention* in case of damage reports and insurance inquiries related to stormy winds
- ❖ for geographical locations where observational data are not available
- ❖ the current product of HungaroMet is prepared considering station measurements for
 - daily maximum 10-meter wind gust
 - radar reflectivity
 - lightning images

⇒ *manual and strongly subjective method*

Verification of wind hazard product (Hungary)

- ❖ **Purpose:** development of an automatic and objective method

MISH (Meteorological Interpolation based on Surface Homogenized data basis) - Szentimrey and Bihari, 2007

- ❖ developed by the HungaroMet
- ❖ specifically designed for meteorological applications
- ❖ uses climatological and spatial structure information
 - the daily maximum wind gust for a given location is calculated by interpolation of station measurements onto a fine grid, enhanced with some background information

Verification of wind hazard product (Hungary)

Three automatic configurations were created:

1 MISH

- ❖ Pure interpolation of station measurements

2 MISH + AROME-RUC

- ❖ Includes high-resolution daily maximum wind gust forecasts
- ❖ AROME-RUC: hourly assimilation cycle

3 MISH + AROME-RUC + Stewart

- ❖ Adds thunderstorm-related gust estimation
- ❖ Based on Stewart (1991) method
- ❖ Designed to better capture convective gust events

Stewart, S.R., 1991: The prediction of pulse-type thunderstorm gusts using vertically integrated liquid water content (VIL) and the cloud top penetrative downdraft mechanism. <https://repository.library.noaa.gov/view/noaa/7204>

Verification of wind hazard product (Hungary)

- ❖ **Test period:** 25 May – 31 August 2025
- ❖ **Compared to:** operational manual product

Manual product

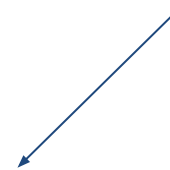
- ❖ systematic overestimation
- ❖ in several cases exceeded measured values
- ❖ large-area overprediction

Automatic products

- ❖ slight overall underestimation
- ❖ significantly closer to observations
- ❖ more spatially realistic structure

Automatic interpolation-based methods

- Reduce subjectivity
- Improve consistency
- Provide more reliable wind gust estimates

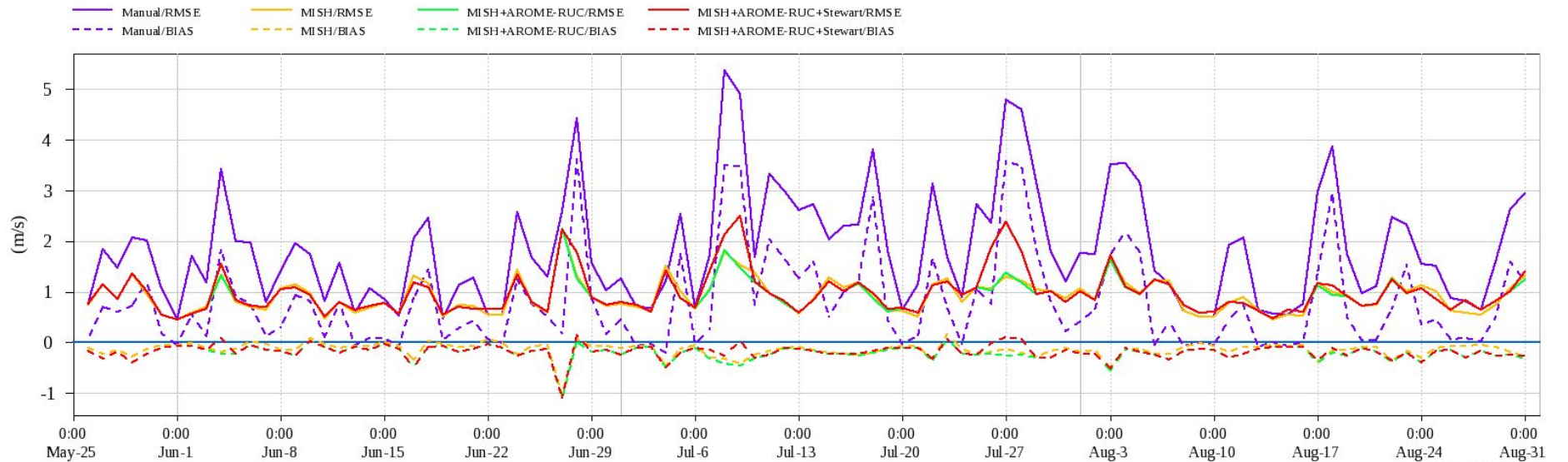


Verification of wind hazard product (Hungary)

RMSE (solid lines) and bias (dashed lines)

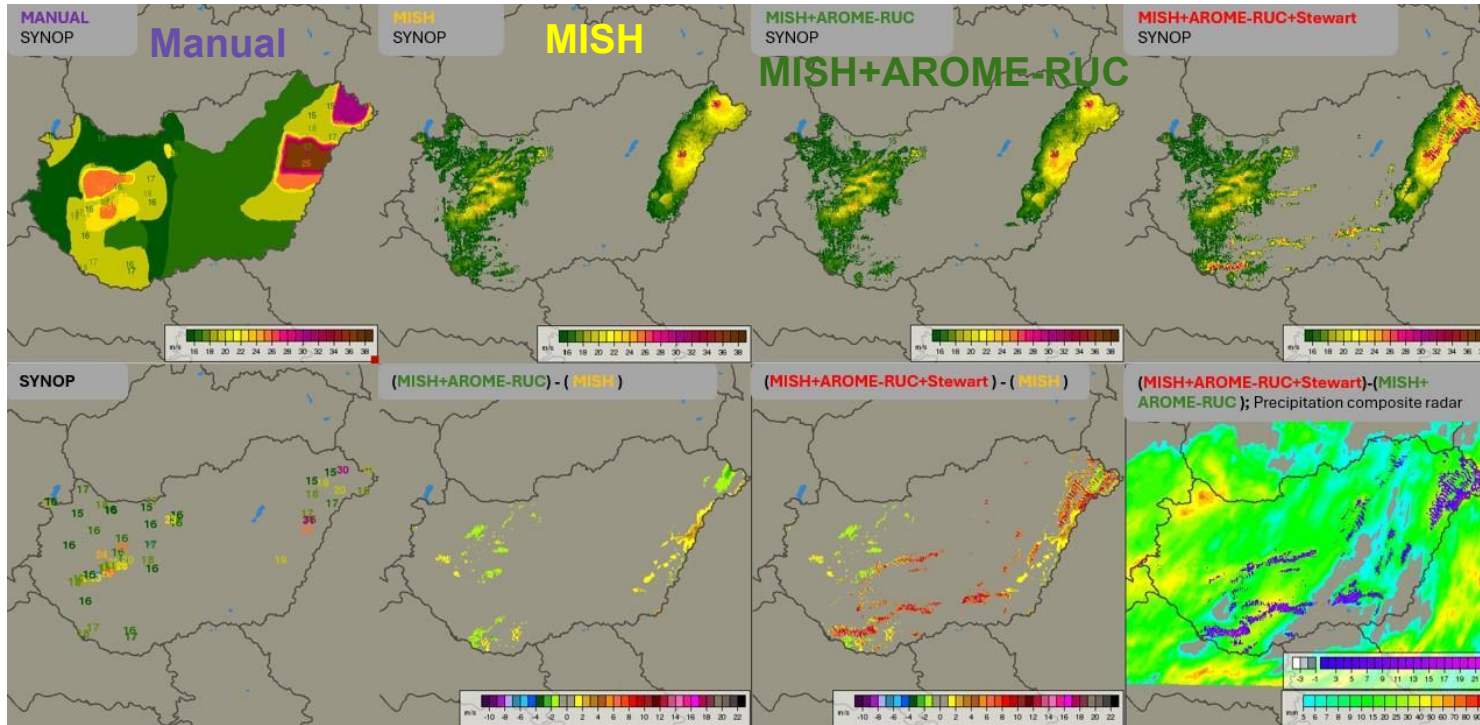
24-hour maximum wind gust [m/s]

25.05 - 31.08.2025

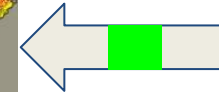


created by OVISYS with ploticus

◆ manual
 ◆ MISH
 ◆ MISH+AROME-RUC
 ◆ MISH+AROME-RUC+Stewart



**MISH+AROME-RUC
+Stewart**



**24-hour maximum wind gust
exceeding 15 m/s
9 June 2025, 00 UTC**

SYNOPSIS

differences:
MISH+AROME-RUC
and MISH

differences:
MISH+AROME-RUC+Stewart
and MISH

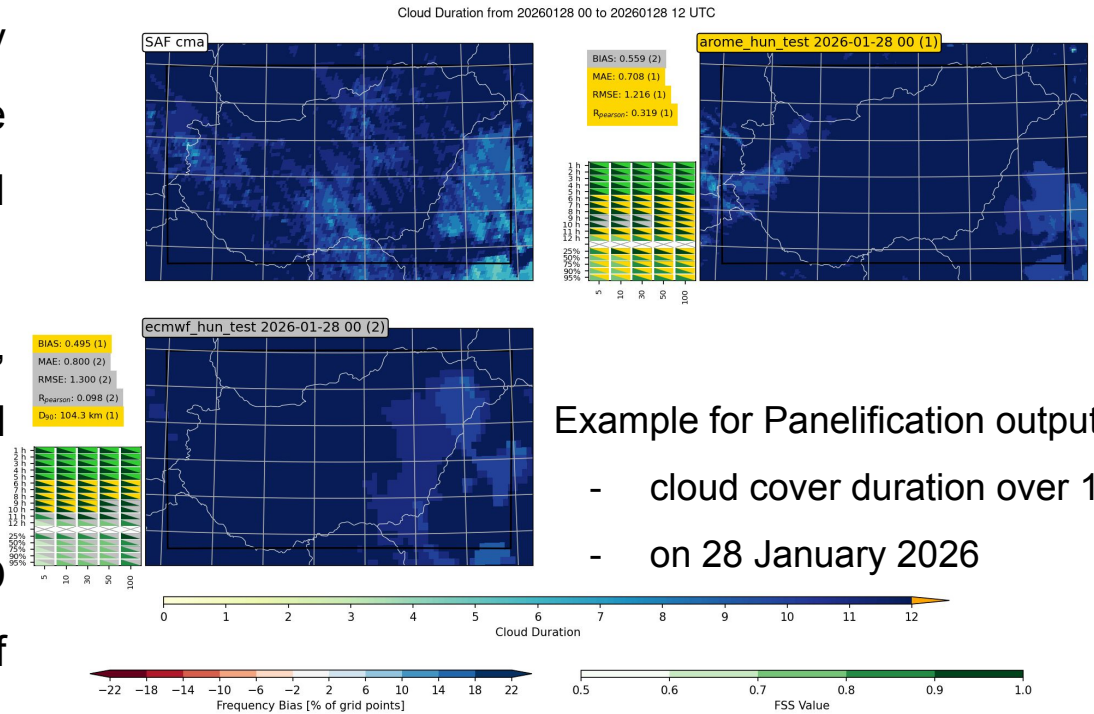
differences:
MISH+AROME-RUC+Stewart
and MISH+AROME-RUC
with composite radar image
for 24-hour precipitation sum

Progress in cloud verification based on satellite data (Hungary)

- ❖ work on extending GeoSphere Austria's Panelification program with cloud verification
- ❖ a few requirements for cloud data may be different
 - results in the development using NWC SAF binary cloud mask
- ❖ the binary cloud mask product offers two verification options:
 1. to verify either the instantaneous field of cloud cover in each hour - benefit for aviation
 2. calculated cloud cover duration field, measured in hours - for irradiance forecasts

Progress in cloud verification based on satellite data (Hungary)

- ❖ forecasts and SAF images are automatically matched by minimizing the relative time offset between the satellite imaging time and the round UTCs
- ❖ by increasing the duration value above 1, the program switches from hourly cloud cover to verify cloud cover duration
- ❖ Using data up to hourly breakdown in CCD also means ignoring the sub-hourly states of the sky



Example for Panelification output

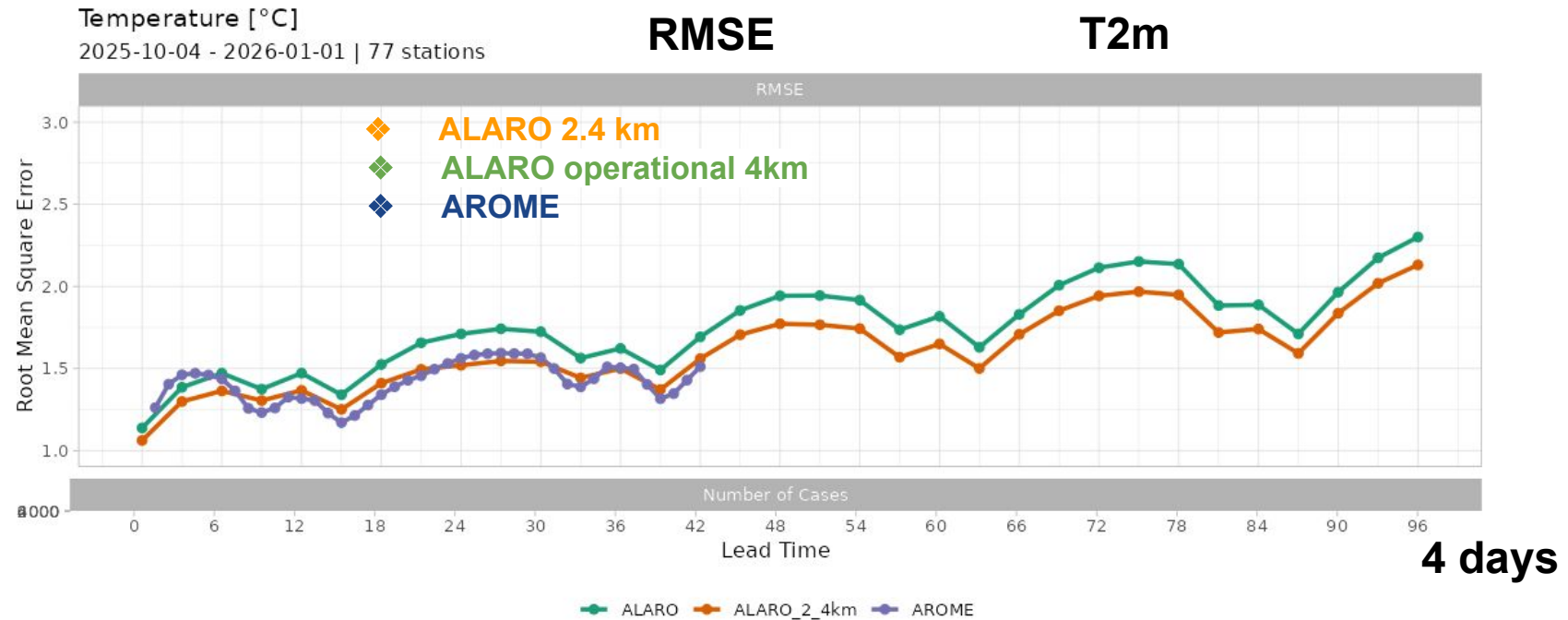
- cloud cover duration over 12h
- on 28 January 2026

Cloud verification requires multi-criterion evaluation

Verification scores for ALARO 2.4 km (Poland)

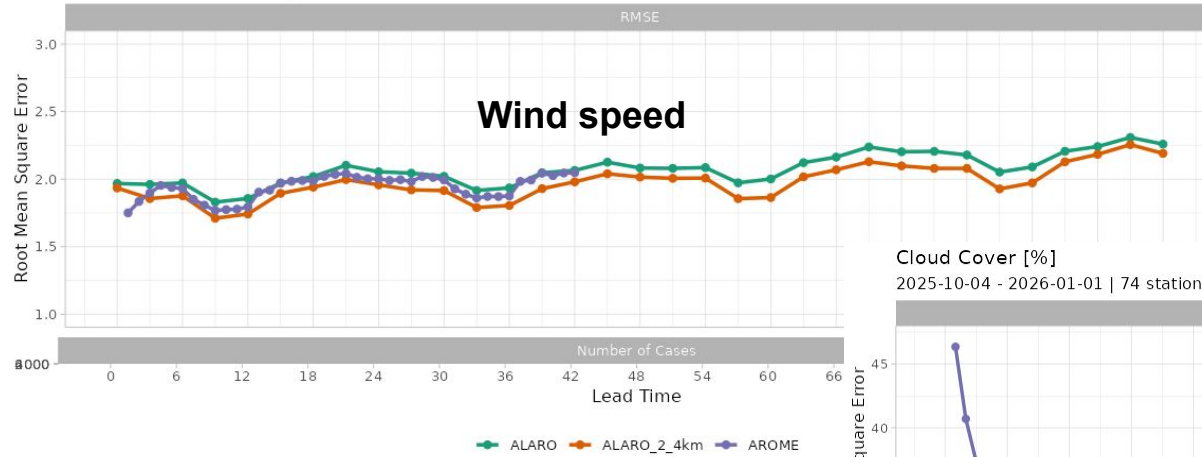
- ❖ from the middle of 2025 ACCORD Poland team runs pre-operationally ALARO at 2.45 km 90 s timestep, L70 (the configuration is consistent with the Czech team's one)
- ❖ verification for wind, pressure, RH2m, T2m, etc with HARP
- ❖ for October – December 2025 period

Verification scores for ALARO 2.4 km (Poland)



Verification scores for ALARO 2.4 km (Poland)

Wind Speed [m/s]
2025-10-04 - 2026-01-01 | 77 stations



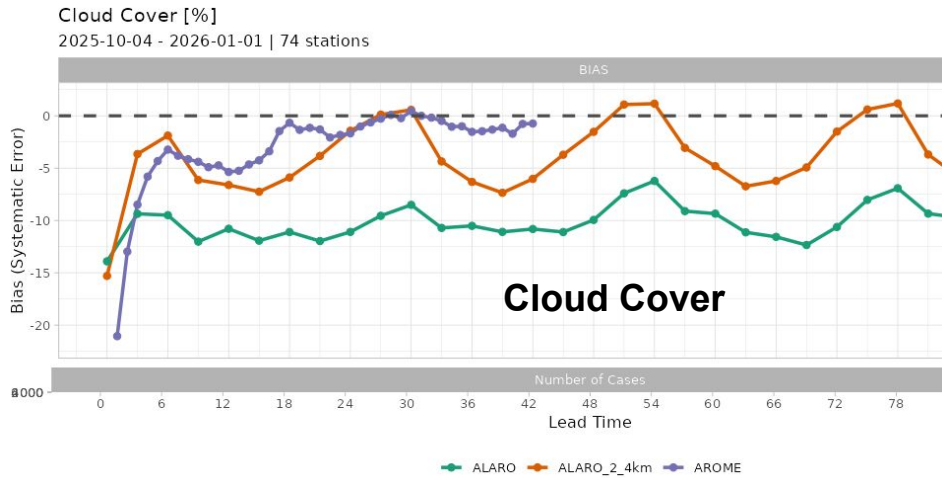
RMSE

Cloud Cover [%]
2025-10-04 - 2026-01-01 | 74 stations

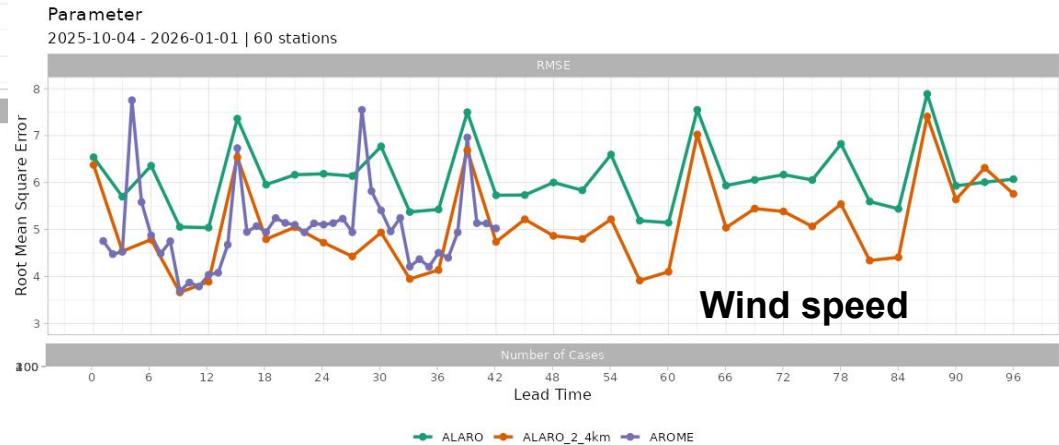


- ◆ ALARO 2.4 km
- ◆ ALARO operational 4km
- ◆ AROME

Verification scores for ALARO 2.4 km (Poland)



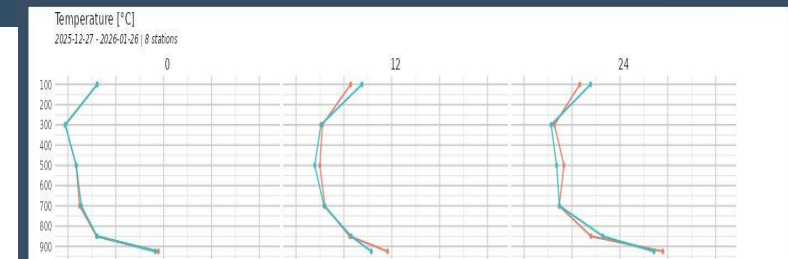
BIAS



- ◆ ALARO 2.4 km
- ◆ ALARO operational 4km
- ◆ AROME

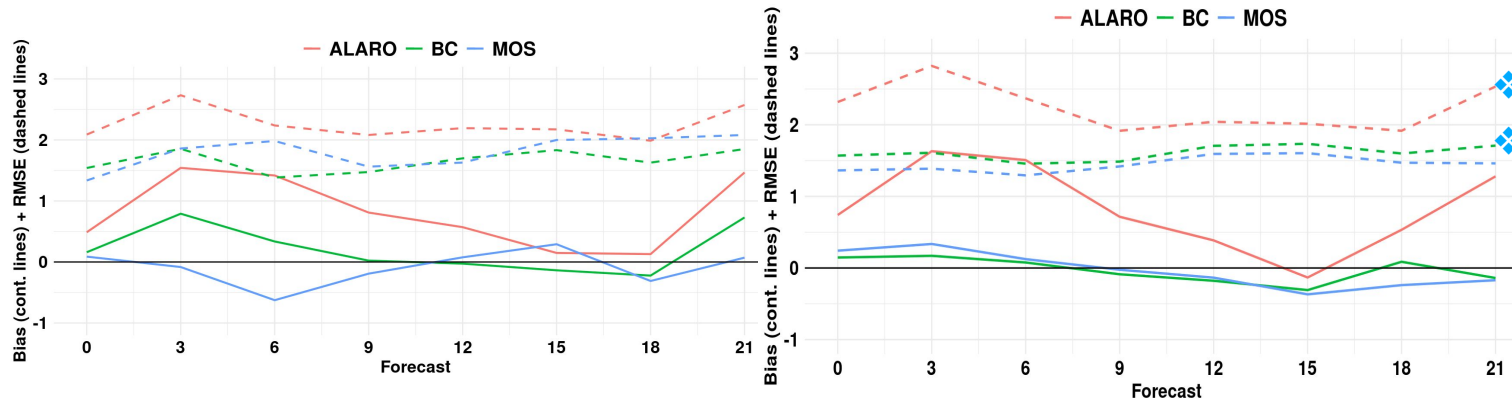
The HARP development (Poland)

- ❖ HARP v2.0
- ❖ for several models used in IMGW-PIB:
 - ALARO, AROME, COSMO and WRF
- ❖ can select the model, dates, stations and score, visualise it clearly, and compare model performance
- ❖ Diagrams/tables from the central part can be easily downloaded



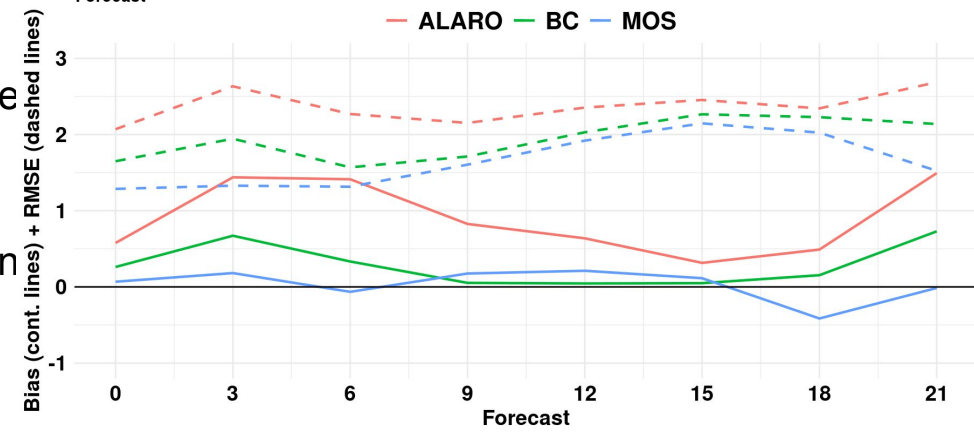
Verification of bias-correction for temperature (Romania)

period: June - August 2025
166 meteorological stations



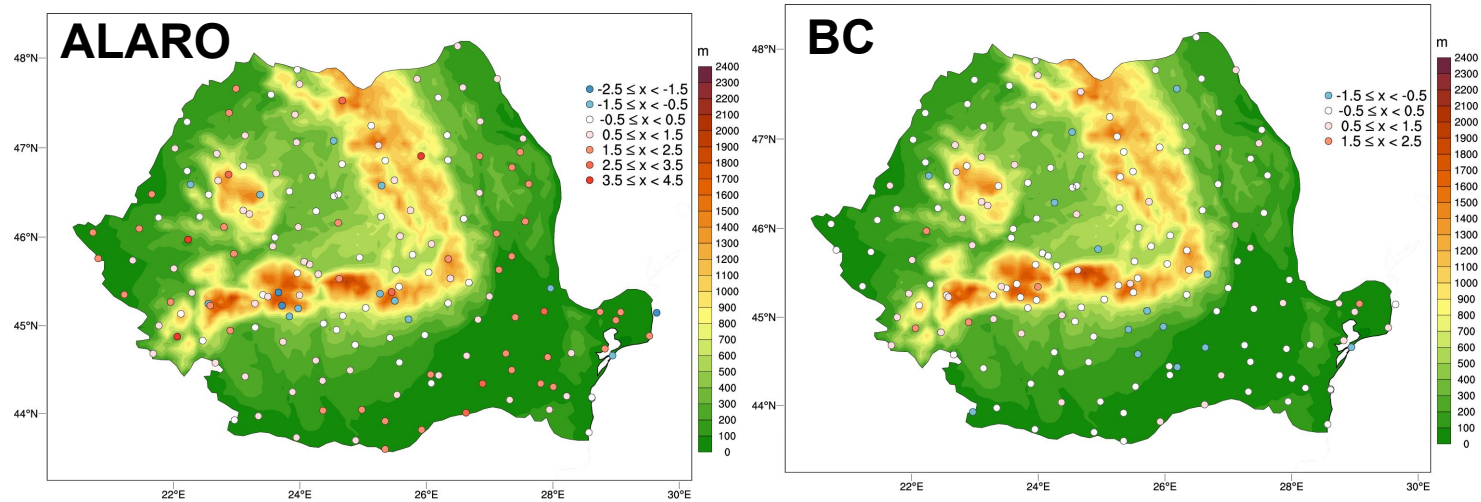
— Bias
- - - RMSE

- ❖ for the 2 m temperature forecast of ALARO 4km
- ❖ comparison with the forecast of raw ALARO and the MOS forecasts operationally
- ❖ the overestimation observed for ALARO is reduced in the corrected forecast
- ❖ the corrected forecast (BC) is comparable with MOS



Verification of bias-correction for temperature (Romania)

Monthly bias
June 2025

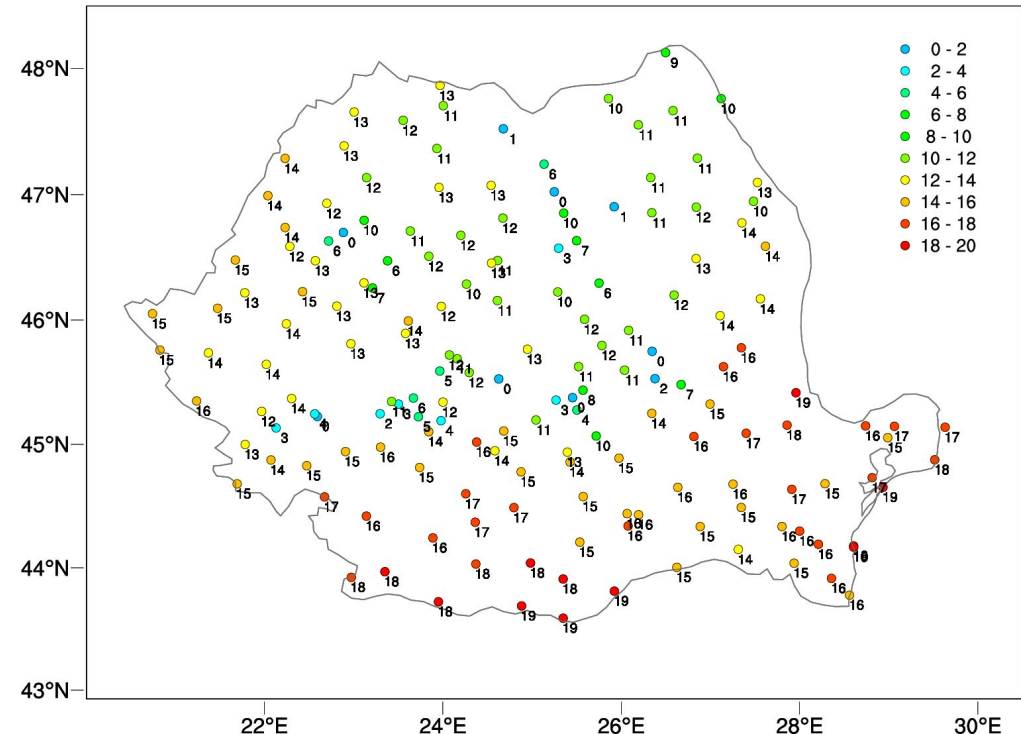


- ❖ for most stations in the East and South, the corrected forecast leads to more realistic values
- ❖ also, for some mountain stations the negative bias is reduced
- ❖ for July and August, the correction introduced some slight underestimation of real temperatures for some regions

Verification of bias-correction for temperature (Romania)

- ❖ => Example of **daily products** showing the corrected hourly 2 m temperature for ALARO
- ❖ the correction was applied for the maximum daily temperature as well

Valoarea temperaturii corectate pentru data: 30.09.2025, run 00 UTC, ora 12 UTC



Testing improvement possibilities of AROME-EPS EMOS postprocessing for radiation (Hungary)

- ❖ continuation of tuning the AROME-EPS EMOS postprocessing using data from groups of similar stations
 - ❖ extended previous work to a full year: **June 2024 – May 2025**
 - ❖ focus on **7 target stations** with different error characteristics
 - ❖ improvements of forecasts of **global radiation**
 - ❖ optimization based on **CRPS minimization**
- ❖ 35 HungaroMet stations
- ❖ 117 private stations (south-tilted pyranometers → recalculated to horizontal)
- ❖ 20 private stations (horizontal measurements)
- ❖ temporal resolution: **30 minutes**

Testing improvement possibilities of AROME-EPS EMOS postprocessing for radiation (Hungary)

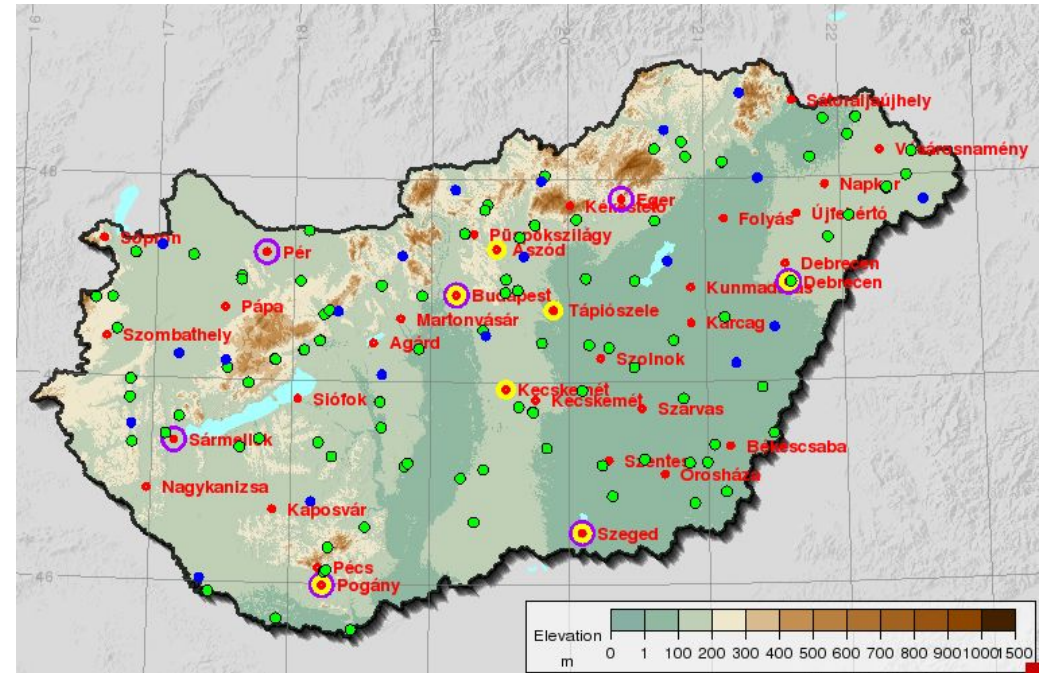
Stations grouped by similarity using:

- ❖ Bias
- ❖ CRPS (following Lerch & Baran, 2017)

Tested:

- ❖ Shorter training period (31 → 24 days)
- ❖ Larger regional groups (7 → 9 stations)

Locations of **HungaroMet** and partner (**tilted instruments** and **horizontal ones**) observation stations, **stations in operational run**.



Target stations of tests (also used together for run with different stations) are shown with purple circles.

Testing improvement possibilities of AROME-EPS EMOS postprocessing for radiation (Hungary)

Performance Improvement with Optimized EMOS

- ❖ Yearly average CRPS reduced to **~40 W/m²**
(for all target stations except Eger – mountainous region)
- ❖ Improvement:
 - **1–3%** vs. EMOS with different station groups
 - **10–20%** vs. raw EPS
- ❖ **Sensitivity Tests**
 - Increasing the number of stations → slight improvement
 - Shortening the training period → no clear benefit
 - Overall impact small (~0.1 W/m² in CRPS)

Key Finding

- Including converted tilted measurements can improve performance → *denser observation networks are beneficial*

Testing improvement possibilities of AROME-EPS EMOS postprocessing for radiation (Hungary)

- ❖ similar-station EMOS adds most value in **spring & summer**
- ❖ in **winter**, different-station groups yield best CRPS
- ❖ complex terrain stations show strongest improvement (also reflected in reduced RMSE of ensemble mean)

Station Pogány (Day 1 Forecast)

- ❖ best-performing group includes nearby HungaroMet stations
 - two geographically close tilted stations
- ❖ clear improvement:
 - After **09 UTC** and for most lead times in **winter & summer**
- ❖ weaker performance:
 - between sunrise and 09 UTC in **autumn & spring**

Testing improvement possibilities of AROME-EPS EMOS postprocessing for radiation (Hungary)

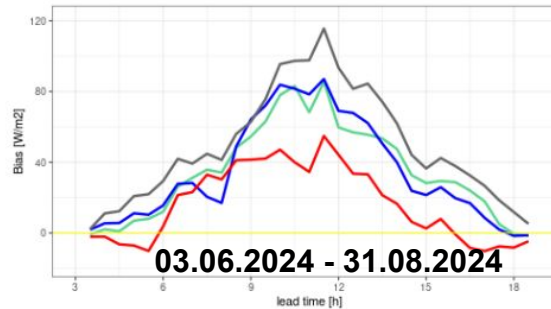
Pogány station

Seasonal mean bias of radiation (W/m^2) for ensemble mean

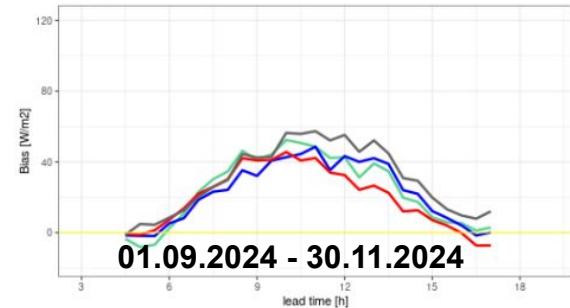
Comparison of:

- ◆ raw EPS
- ◆ **postprocessed versions**
- ◆ **different stations** (blue line, stations circled with purple)
- ◆ **the operational** (green line, with stations marked in yellow)

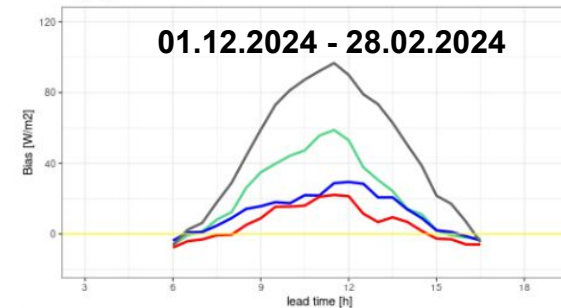
Pogány, 2024-06-03_2024-08-31



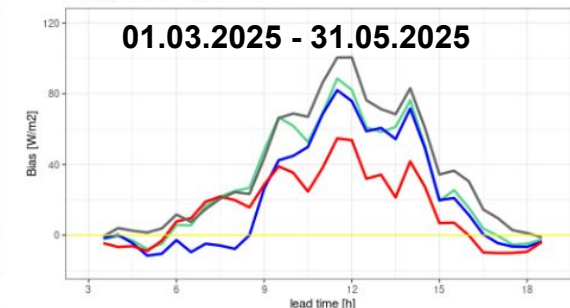
Pogány, 2024-09-01_2024-11-30



Pogány, 2024-12-01_2025-02-28



Pogány, 2025-03-01_2025-05-31



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Thank you for your attention.

