Applications and Verification
Report

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Period:	2024
Date:	September 2024

Summary

The primary goal is to develop and adapt/use different specific applications into user-friendly mode. Many tools and software products were developed along the years for meteorological parameters. These days, it is imperative to have easy to use applications, maybe to find and to identify the operational activities, to make a common way for saving time and manpower resources. Nowadays, it is important to make the applications easy to implement without too much cost and to make a common way for saving time, computer costs and manpower. It is a big challenge to identify and to merge all the beneficial technical approaches and applications for all countries.

The report summarizes the Applications and Verification activities of the first 6 months of the year 2024:

- The work of Polly Schmederer at DMI (in an ACCORD stay) is related to the generalising spatial verification based on panelification harp panel tool.
- The results obtained by Martin Petráš, during his stay in Prague, in collaboration and supervised by Alena Trojáková, on extending harpIO to enhance its functionality for upper air verification within the OBSOUL framework.
- In Croatia, the work of Iris Odak Plenkovic in the development of a simple way to present wind scores, taking into account wind direction.
- The continuous work, in Austria, on the development of panelification and an important upgrade for hail and lightning verification and migrated to the newest version.
- The report provided by Hungary is based on 3 important aspects: the verification tool HARP was upgraded to version 2.0 and it was completed the operational scripts for monthly verification of AROME-EPS; were provided internal HARP training courses for HungaroMet colleagues and also a mentoring for a BSc student was mentored in order to perform the surface point verification of the 11-member AROME-EPS compared to the 51-member ECMWF ENS using HARP, for an early summer one-month-long period in 2024 when several convective events happened.
- Also in Hungary, the input data for the EMOS post processing for radiation runs daily are used the 11-member forecasts of AROME-EPS as well as measurements at 7 stations.
- For a more flexible mode for the evaluation of the operational model, the standard verification was extended in Croatia, in this way the scripts based on the verif module were written/modified in order to make them compatible when trying to calculate a vertical profile of some basic verification scores. Also, it was added the possibility to calculate scores in Python for EPS.
- Another topic in Croatia is the usage of an analog post-processinf method for wind for the general public.
- In Czech Republic, it was prepared the code in order to have new outputs for aeronautical forecasts to the ALARO CMC.

- In Poland, it was performed the following validation for different experiments: ALARO cy43t2 with assimilation, ALARO cy46 – with modifications from colleagues from Prague, new LBC with 1h frequency and snow scheme in SURFEX – only for winter period.
- Another approach in Poland is the d-dimensional copula is a multivariate distribution function with uniformly distributed marginals. Sklar’s Theorem. The goal is the error mitigation of the temperature forecast given by the ALARO model.
- In Romania, the HARP tool was used in order to perform verification for the 10 m wind gust, for experiments done in order to tune the parameter FACRAF. Another verification was performed for comparison between model versions cy43bf10 and cy43bf11, in order to be able to use cy43bf11 for the operational configuration.

Action/Subject/Deliverable: Development of HARP [MQA1]

Description and objectives:

Two important stays were done: the stay of Polly Schmederer at DMI in the frame of ACCORD and one of Martin Petráš at CHMI in collaboration with Alena Trojáková.

The report of Polly Schmederer is related to the generalising spatial verification based on panelification harp panel tool. The used observations were DMI's radar precipitation product: Surface Quantitative Precipitation Estimation (SQPE) using both rain gauge and radar data EUMETSAT SEVIRI data. The model outputs are the grib files generated in the DEODE workflow running HARMONIE cy46h1 (total precipitation and FULL POS simulated radiances channels WV_062 & IR_108). The work was done on ATOS.

The report of Martin Petráš, during his stay in Prague, in collaboration and supervised by Alena Trojáková, shows the work on extending harpIO to enhance its functionality for upper air verification within the OBSOUL framework. Their main purpose was to improve the accuracy and efficiency of processing and analyzing upper air observation data.

***Generalising spatial verification* (Austria)**

The developments done during Polly Schmederer's ACCORD VS at DMI.

Topics of VS

1) Generalising spatial verification:

- use of reticulate package to interface R with Python
- generalise/ apply harp panel tool ("panelification")
- this is a harp and R based version of the originally python based panelification
- provide R scripting examples for reading, verification, harp panel tool usage

2) Data used for spatial verification

- Observations:
  - DMI's radar precipitation product: Surface Quantitative Precipitation Estimation (SQPE) using both rain gauge and radar data
  - EUMETSAT SEVIRI data (https://api.eumetsat.int/data/browse/collections): High Rate SEVIRI Level 1.5 Image Data - MSG - 0 degree (native), e.g. MSG3-SEVI-MSG15-0100-NA-20240102235743.693000000Z-NA.nat
- NWP:
  - Grib files output of the DEODE workflow running HARMONIE cy46h1 (total precipitation and FULL POS simulated radiances channels WV_062 & IR_108)
  - As part of the WP6 of the CERISE (Copernicus Climate Change Service Evolution) project, DMI is contributing to the spatial verification of snow cover using the harp verification package.

The development was done on ATOS (shared using accord group). More details about the installation instructions of how to install the libraries are on github: https://github.com/fbaordo/oper-harp-verif/blob/master/ACCORD_VS_202406/INSTALLATION.md.

Information displayed in the plot

In the first panel the observation field is displayed, there is one panel for each of the verified models:

- observations: obs title - name + valid observation time
- models: model title - left: model name, initialisation time + lead time, (average FSS rank); right: average rank of basic scores (this is the average of all non-FSS scores that are passed in the definition file) and ranking of the models according to this average rank
- top box: ranks of FSS (using thresholds); ranks of FSS (using percentiles); basic scores - displaying the actual values (rank according to the value)

For more information on what you see on a panel plot, check the interpretation help.

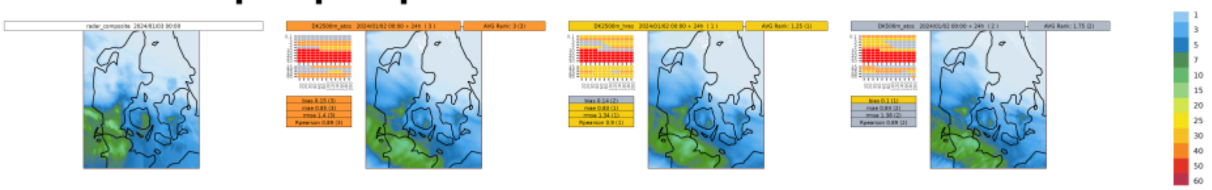
To add another model (panel) to panelification, a file with their definitions on how to read/verify must be added, which will then be added to the panelification.yml.

1. Know how to read the model that should be added. (An example on how the data may be read can be found in example_read_DataUsingReticulate.R).
2. Run verify_spatial, to see how the configurations must be passed to this function (see the examples example_verify_tp_deode.R, example_verify_sat_deode.R or example_verify_snow_cover.R).
3. Copy a definitions_* file (definitions_<new>.R) and change all parameters as needed to read/verify the data correctly.
4. Specify the new file in panel_configs/panelification.yml for model and parameter. (Define which config files to use > READING of the models/obs).

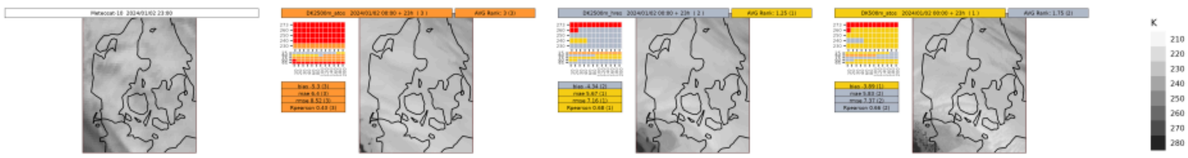
5. If a new parameter was added, also add a definition file for this parameter in panel_configs/panelification.yml (Define which config files to use > PLOTTING of the fields).

Some example plots

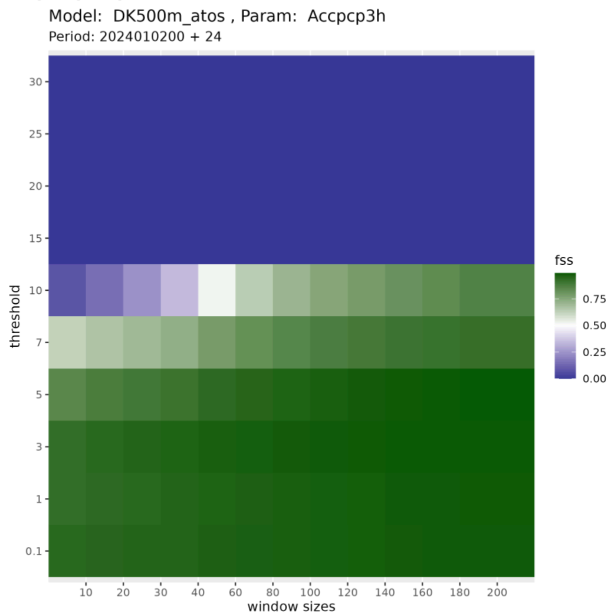
Panelification plot precipitation



Panelification plot IR 108



FSS plot precipitation



More details can be found on her report stay at DMI (www.rclace.eu).

Contributors, estimated efforts: Polly Schmederer (1 pm)

Extending harpIO to enhance its functionality for upper air verification within the OBSOUL framework ***(Slovakia and Czech Republic)***

1) Martin Petras, during his stay in Prague, with Alena helping, worked on extending harpIO to enhance its functionality for upper air verification within the OBSOUL framework. This upgrade aims to improve the accuracy and efficiency of processing and analyzing upper air observation data. The improvements focus on optimizing data handling, processing, and analysis, ensuring more accurate and efficient verification processes for upper air observations The next phase will focus on implementing these updates into the Harp development version. The report from this stay is in its final stages (more details on www.rclace.eu).

Also, the plan is to integrate Harp into the LACE web - https://www.rclace.eu/extra/monitor/ (Figure 1), allowing us to generate two distinct outputs: one from Monitor and another from Harp. Harp's verification will utilize observations from OBSOUL, while Monitor will rely on observations from vobs. In Slovakia, are archived GRIB files for all LACE countries, allowing to run Harp interfaces and verification on our HPC. However, this is still a future plan. Our immediate focus is on resolving several key issues, including:

- Establishing web data interfaces (for sending verified data and visualizing verification scores)
- Ensuring data production for OPLACE upper air (confirming if we have this capability)
- Addressing issues with station SID (ID) names.

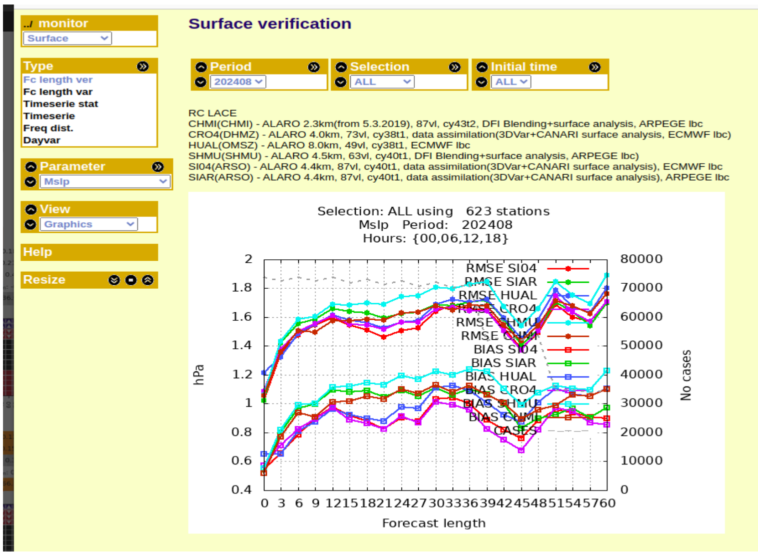


Figure 1. Example of verification on RC-LACE web page.

OBSOUL files, generated in ASCII format by the OULAN programme, are used as input to the NWP assimilation system. These files can contain data from a variety of sources, currently surface synoptic observation (SYNOP), radiosonde (TEMP) and aircraft data are provided by OPLACE. By incorporating TEMP data from

OBSOUL, we aim to improve the completeness of the verification datasets. TEMP data provides valuable insight into atmospheric conditions at different pressure levels, improving the overall quality of verification processes. Different observation types are represented by a corresponding number in the OBSOUL files, see the first column of Figure 2. Each of these types can contain different observation parameters represented by parameter numbers (Figure 3).

Observation type (obstype@hdr)	Data description
1	Land SYNOP and SHIP reports
2	Aircraft based measurements (AMDAR, EHS)
5	Radiosonde (TEMP) reports

Figure 2: Observation types are specified by the obstype@hdr column.

Observation parameter (varno@body)	Parameters description
1	geopotential [J/kg]
2	upper air temperature [K]
3	upper air u wind component [m/s]
4	upper air v wind component [m/s]
7	specific humidity (upper air and 2m)
29	upper air relative humidity [0-1]
39	2m temperature [K]
41	10m u wind component [m/s]
42	10m v wind component [m/s]
58	2m relative humidity [0-1]

Figure 3: Observed parameters specified by the number in the first column.

The parameter quality flag for TEMP can have four values depending on the pressure levels. It is set to **3680** in the case of the surface parameters, to **2560** for upper air parameters at standard levels and to **10304** or **10272** for significant and non-significant upper air levels depending on observed parameter.

The following example of a TEMP record is the same as for SYNOP, but other observations may have different structures:

23 5 10003035 70.93957 -8.66930 '01001' 20240401 90000 1.00000E+01 135 11111 0 1 1.02950E+05 1.70000E+38 9.80600E+01 3680 **39 1.02950E+05 1.70000E+38 2. 67970E+02 3680**

It contains two bodies, the first body has following elements:

- 1: observation parameter number of geopotential
- 1.02950E+05: vertical coordinate
- 1.70000E+38: fill value
- 9.80600E+01: observed value
- 3680: flag

and the second body following ones:

- 39: **observation parameter number of 2m temperature**
- 1.02950E+05: **vertical coordinate**
- 1.70000E+38: **fill value**
- 2.67970E+02: **observed value**
- 3680: **flag**

The header part contains:

- **23: number of items (n + header + bodies) for this record**
- **5: type of observation**
- **10003035: observation code (it is assigned by program OULAN)**
- **70.93957: latitude**

- **-8.66930: longitude**
- **'01001': identification of the station/flight**
- date
- time
- altitude
- number of bodies following the header
- observation quality flags (assigned by program OULAN)
- site dependant information (assigned by program OULAN)

This update to Harp version 0.2.2 expands its capabilities to read both SYNOP and TEMP data from OBSOUL files. While the SYNOP and TEMP OBSOUL formats have some structural similarities, the main difference is in the number of data columns. The TEMP data have additional vertical levels than the SYNOP data, with each level data stored in a separate column in the OBSOUL file. In some cases, the number of columns exceeds 2,000. To account for this difference, modifications were made to the read_obsoul function.

As is mentioned before a TEMP file can be populated with columns of any length. It was therefore necessary to make some changes in order to read such a long columned file. The reading of files in R can be accomplished using a variety of functions. In our case, read.table1 is used to read a file in R. In some cases, we faced that this function does not work properly. Some columns were not properly sorted, which caused the problem. There should be a single row for every record from the TEMP. It happened in some cases that one record was split into two rows, which wasn't supposed to happen.

The read_obsoul function plays a crucial role in Harp. It transforms raw data from OBSOUL files into a well-organized format, making it easier to analyze and visualize. This update focuses on significant changes made to this function to effectively handle TEMP data, which has a 1Reads a file in table format and creates a data frame from it, with cases corresponding to lines and variables to fields in the file 4 Regional Cooperation for Limited Area Modeling in Central Europe different structure compared to SYNOP data. SYNOP data only contains records for surface observations.

A series of comparative tests were conducted in order to verify the new interface for OBSOUL TEMP with respect to the VOBS data. These tests involved separately reading observations from each source. The forecast data used for comparison originated from CHMU's operational model, ALADIN CY46 (2.3km resolution). We will present the results of these tests, focusing on comparisons of data time distributions and verification scores.

A comparison of data count distributions for parameter T between Praha-Libus (Czech Republic) and Ganovce (Slovakia) is shown in Figure 4 and 5. It can be seen that the data distributions are different between the VOBS and OBSOUL files. Data from OBSOUL are available in term 00:00, while data from VOBS are available in term 23:00 and 01:00. The same thing happens in 12:00, only in term 06:00 we have data from both.

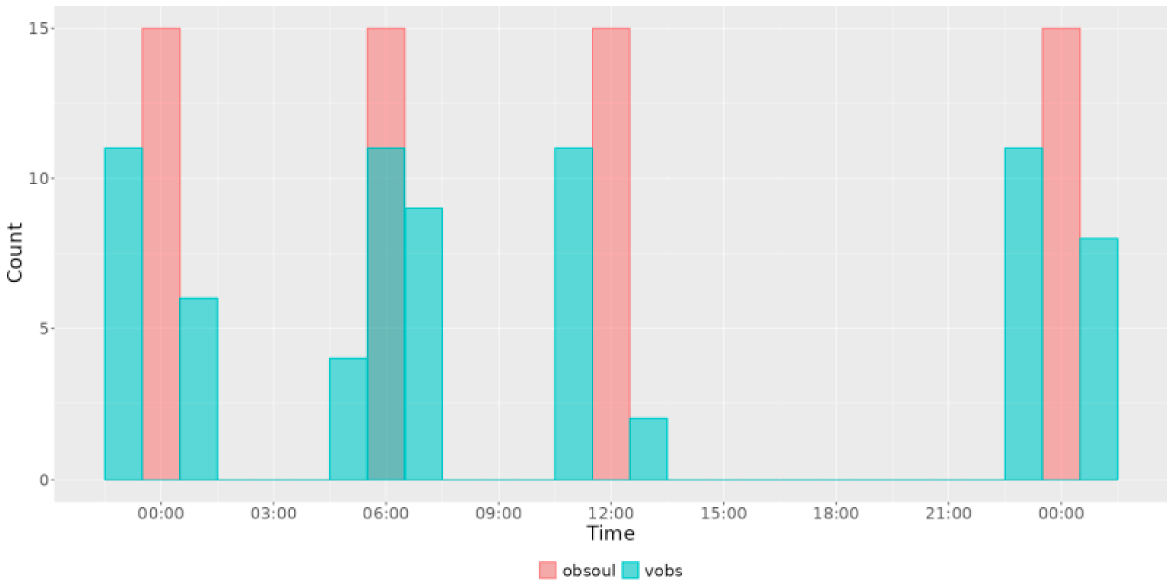


Figure 4: Parameter T time distribution station Praha-Libus [11520].

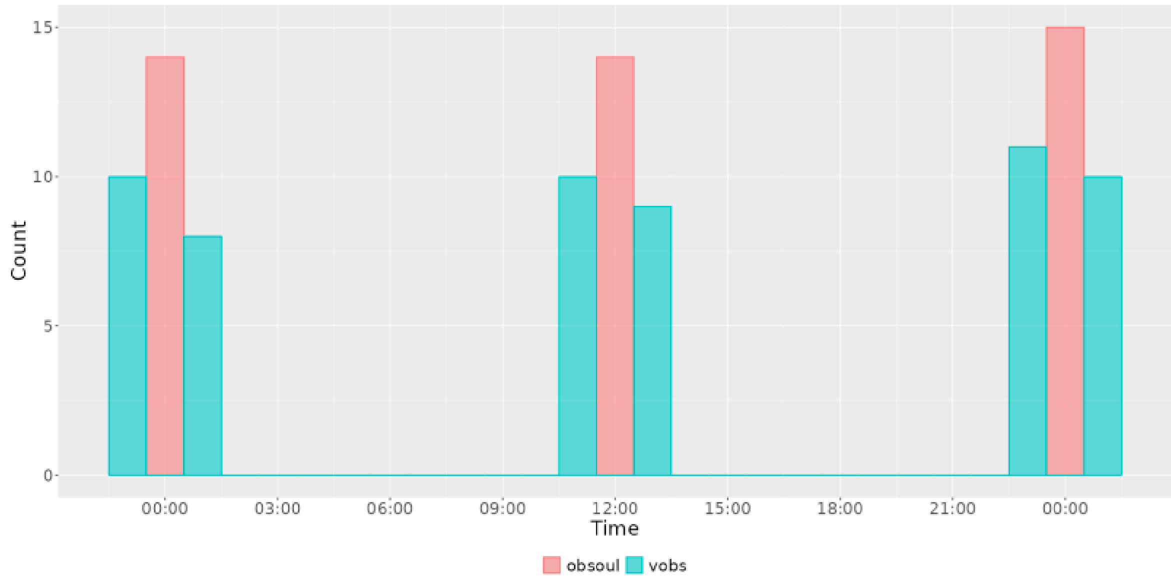


Figure 5: Parameter T time distribution, station Ganovce [11952].

The verification scores are shown for temperature (T), relative humidity (RH) and geopotential (Z). The scores compare observations from two sources: OBSOUL and VOBS. The verification period covers two days, from April 1, 2024, at 00:00 UTC to April 3, 2024, at 00:00 UTC.

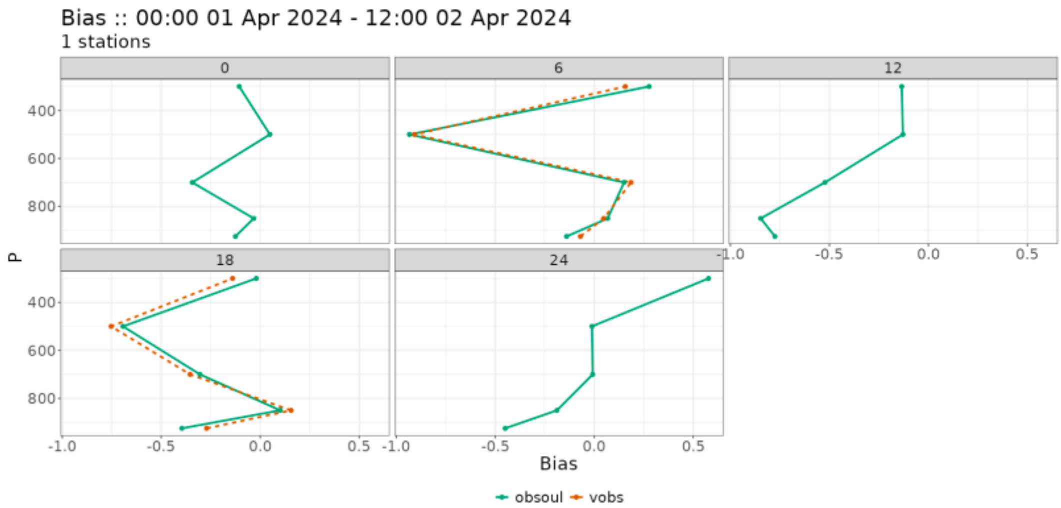


Figure 6: bias for station Praha-Libus [11520].

The findings confirm that some VOBS data is unavailable for lead times 00, 12, and 24, resulting in missing scores for these periods. BIAS scores are only comparable for lead times 06 and 18, and even then, the observed differences are minimal, likely attributable to rounding errors (Figure 6). This is further evident in Figure 7. Notably, VOBS offers only 4 observations per pressure level, whereas

OBSOUL provides 16. This disparity in data density can significantly impact verification scores, particularly when using an "all-in-one" verification approach that considers both forecast cycle and lead time. Figure 8 demonstrates that including data from other stations populates all time intervals. This confirms our expectation that the lack of data for certain time periods is specific to some stations, not a widespread issue.

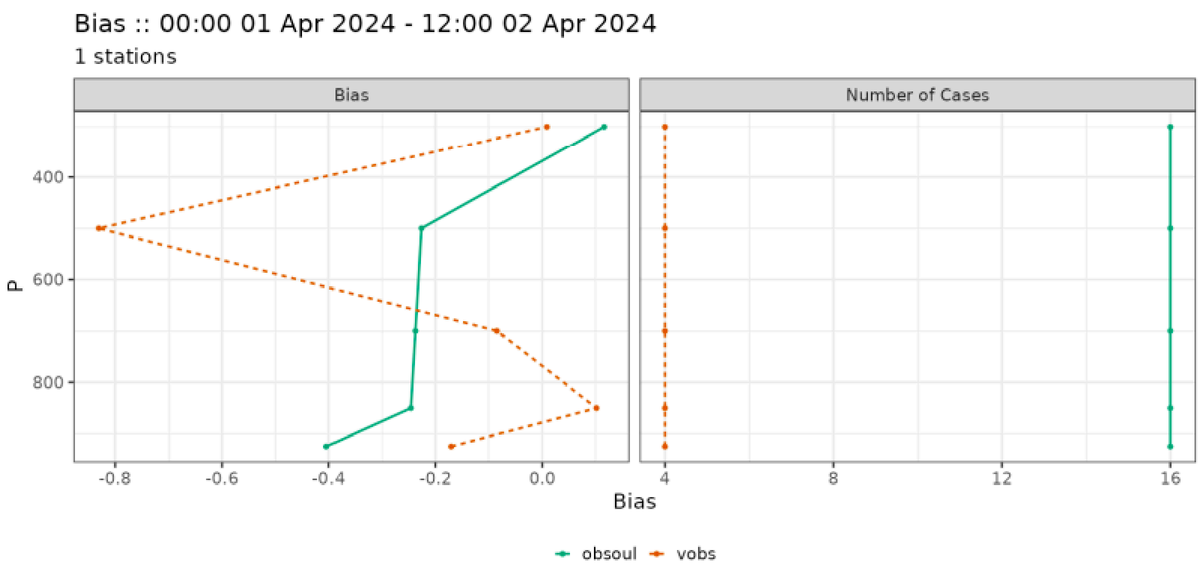


Figure 7: Number of cases for station Praha-Libus [11520].

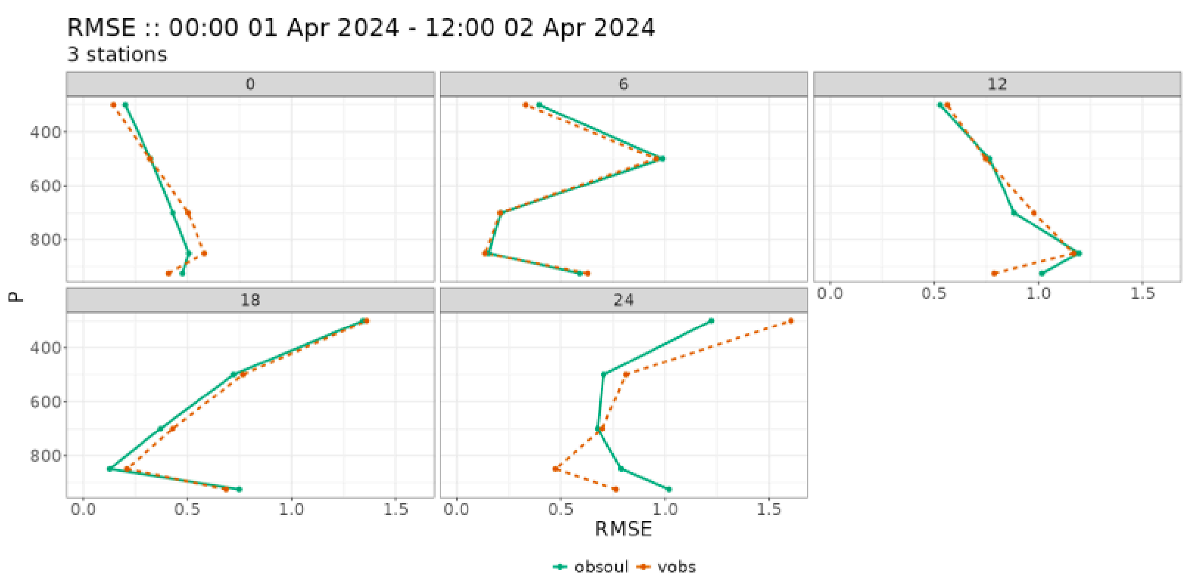


Figure 8: RMSE: Unique (same) station from VOBS and OBSOUL.

Contributors, estimated efforts: Martin Petras (5 pm), Alena Trojáková (0.75 pm)

Course participation at HARP Working week, 4-8 Mar 2024 in Dublin

- Piotr Sekula - ACCORD/RC-LACE funds
- Polly Schmederer, Phillip Scheffknecht and Martin Petras - RC-LACE funds

Contributors, estimated efforts: Piotr Sekula (0.25 pm), Polly Schmederer (0.25 pm), Phillip Scheffknecht (0.25 pm) and Martin Petras (0.25 pm)

MQA1 contributors, estimated efforts: Polly Schmederer (1 pm), Martin Petras (5 pm), Alena Trojáková (0.75 pm), Piotr Sekula (0.25 pm), Polly Schmederer (0.25 pm), Phillip Scheffknecht (0.25 pm) and Martin Petras (0.25 pm)
MQA1 total: 7.75 pm

Action/Subject/Deliverable: Development of new verification methods [MQA2]

Description and objectives:

In Croatia, one important topic was the starting work of Iris Odak Plenkovic in the development of a simple way to present wind scores, taking into account wind direction.

***Development of a simple way to present wind scores* (Croatia)**

It was started the development of a simple way to present wind scores, taking into account wind direction. At this point, RMSE or other scores are presented in a polar system that is ordered as a wind rose. Also, some investigation is done for a simplified version of M. Tesini's work, who used categorical verification using the wind rose fields. However, when this approach is tested and the users are asked, the answer is that they are overwhelmed since there are so many details. Thus, there is a need to verify both speed and direction but find the middle ground.

Contributors, estimated efforts: Iris Odak Plenkovic (0.5 pm)

MQA2 total: 0.5 pm

Action/Subject/Deliverable: Verification, evaluation and error attribution [MQA3]

Description and objectives:

The continuous work, in Austria, on the development of panelification and an important upgrade for hail and lightning verification and migrated to the newest version. The report provided by Hungary is based on 3 important aspects: the verification tool HARP was upgraded to version 2.0 and it was completed the operational scripts for monthly verification of AROME-EPS; were provided internal HARP training courses for HungaroMet colleagues and also a mentoring for a BSc student was mentored in order to perform the surface point verification of the 11-member AROME-EPS compared to the 51-member ECMWF ENS using HARP, for an early summer one-month-long period in 2024 when several convective events happened. Also in Hungary, the input data for the EMOS post-processing for radiation runs daily are used the 11-member forecasts of AROME-EPS as well as measurements at 7 stations. For a more flexible mode for the evaluation of the operational model, the standard verification was extended in Croatia, in this way the scripts based on verif module were written/modified in order to make them compatible when trying to calculate a vertical profile of some basic verification scores. Also, it was added the possibility to calculate scores in Python for EPS. Another topic in Croatia is the usage of an analog post-processing method for wind for the general public. In *Czech Republic, it was prepared the code in order to have new outputs for aeronautical forecast to the ALARO CMC. In Poland, w*ere performed the following validation for different experiments: ALARO cy43t2 with assimilation, ALARO cy46 – with modifications from colleagues from Prague, new LBC with 1h frequency and snow scheme in SURFEX – only for winter period. Another approach is the *d*-dimensional copula is a multivariate distribution function on with uniformly distributed marginals. Sklar's Theorem*. The goal is the* error mitigation of the temperature forecast given by the ALARO model. In Romania, the HARP tool was used in order to perform verification for the 10 m wind gust, for experiments done in order to tune the parameter FACRAF. Another verification was performed for comparison between model versions cy43bf10 and cy43bf11, in order to be able to use cy43bf11 for the operational configuration.

***Paneification* (Austria)**

The work of Phillip on the development of panelification:

- Fixed a long standing contouring bug which sometimes caused observations to be display wrongly. Higher contour level will no longer obscure all lower values.
- Upgraded hail and lightning verification and migrated to the newest version (Figure 9).

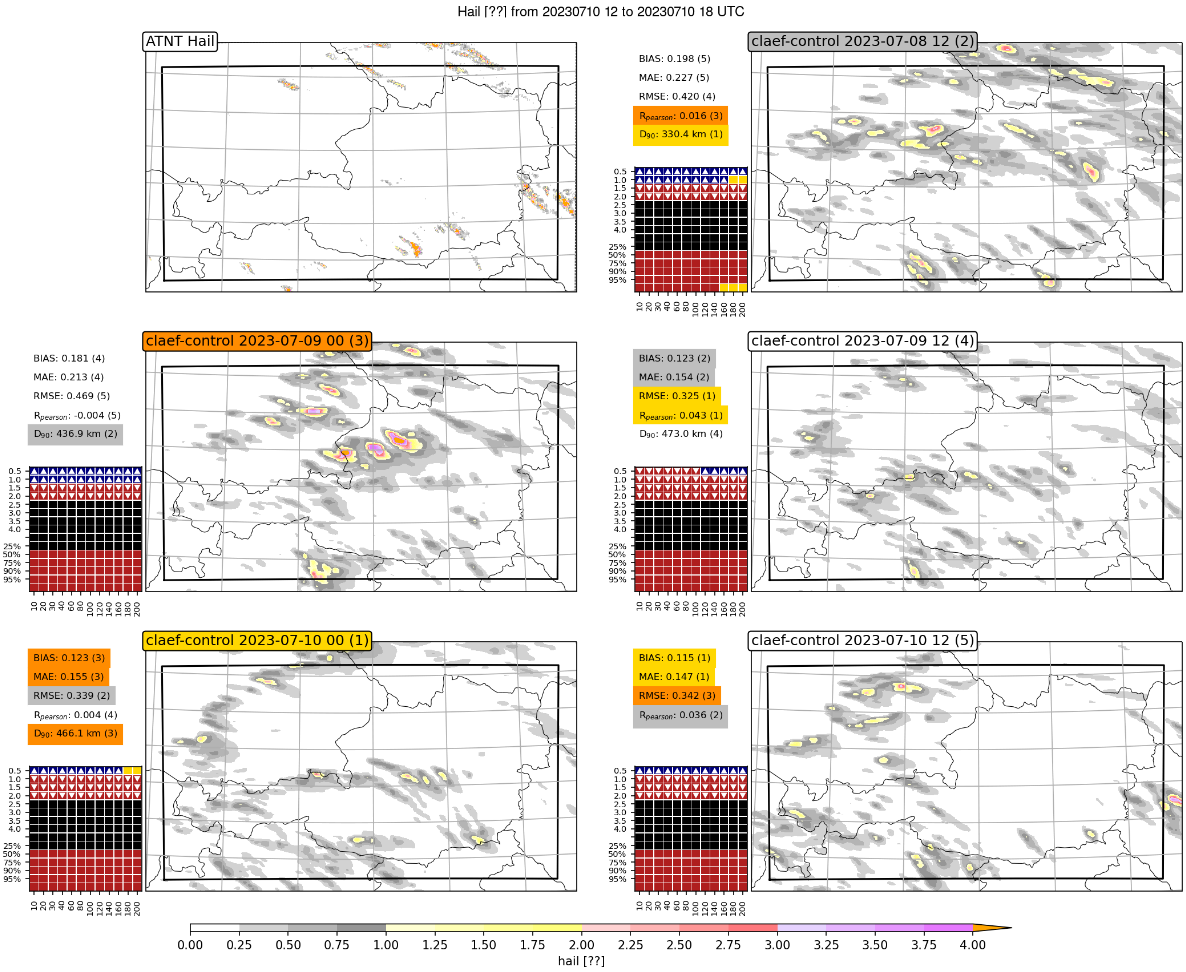


Figure 9. One example of hail from 10.07.2023, 12 UTC to 10.07.2023, 18 UTC.

Contributors, estimated efforts: Phillip Scheffknecht (0.5 pm)

Operational verification of AROME_EPS using HARP ***(Hungary)***

The report provided by Hungary is based on 3 important aspects:

a) The verification tool HARP was upgraded to version 2.0 and it was completed the operational scripts for monthly verification of AROME-EPS by using this tool. More details about the description of the work can be found in the report from February 2024. Pointwise verification is regularly done monthly for the last 1 and 3 months. For each case, two documents are produced: one for surface verification against SYNOP data, and another one for upper air verification against radiosonde data.

b) Internal HARP training courses were provided for HungaroMet colleagues.

c) A BSc student was mentored in order to performe the surface point verification of the 11-member AROME-EPS compared to the 51-member ECMWF ENS using HARP, for an early summer one-month-long period in 2024 when several convective events happened. Her practical lasted 6 weeks.

Contributors, estimated efforts: Katalin Jávorné Radnóczi (a - 1.25 pm), Dávid Tajti (a - 0.25 pm), Katalin Jávorné Radnóczi (c - 2 pm), Dávid Tajti (c - 1.5 pm), Boglárka Tóth (c - 1.5 pm)

Testing improvement possibilities of AROME-EPS EMOS post processing for radiation ***(Hungary)***

Operational EMOS post processing for radiation runs daily, as described in the February 2023 verification report. As input data are used the 11-member forecasts of AROME-EPS as well as measurements at 7 stations (Figure 10) from a running training period of 31 days. It is applied regional method, i.e. data from all stations are handled together to give an estimation for a few selected points. CRPS of the probabilistic forecasts was reduced by 15-17% with respect to the raw EPS for the first half of 2024, however, trying to improve the performance even further.

The main development idea comes from station-wise verification results: the scores of raw EPS (especially bias of ensemble mean), and consequently the performance of EMOS are much different at some stations, depending on their geographical conditions. Therefore, the stations were classified based on their characteristics to choose their optimal combination providing the highest improvement for the target station. For classification, the method of Lerch and Baran (2017) was adapted. The test period was chosen from 2 May to 31 August 2023 partly because there are a large number of radiation measurements from a private company for this period (though they were not used in this study).

It was evaluated the model error characteristics, the observation climatologies and the geographical distances among 34 HungaroMet stations. Then the EMOS postprocessing was ran for some new groups of stations. Experimental station-groups were determined by taking into account the lead-time dependent characteristics of each station, i.e. bias, median absolute error, CRPS and observation climatology in the test period. As the performance got worse with 31-day training period for most cases, some experiments were performed by increasing or decreasing length of training (in 4 days steps) inspired by e.g. Gneiting et al. (2005). The number of stations used in a group was tested.

In the best test run for Debrecen station, CRPS could be further improved only by 1.5% wrt. the raw EPS, however, for Pécs it was reached additional 9.5% when it was used data from stations from the same class (station groups are shown in Figure 10). This difference in improvement is caused by different characteristics of the two stations. Biases comparing operational and test setup with raw EPS scores for both stations are shown in Figure 11. The work is ongoing, tests involving more stations and for longer period are planned.

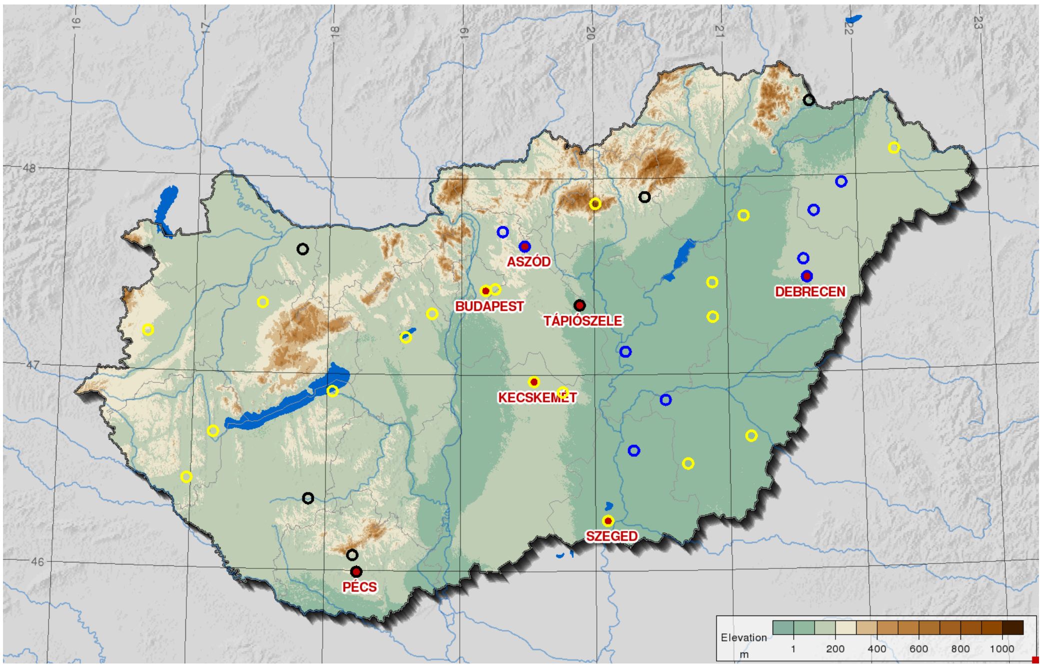


Figure 10: Stations used for operational AROME-EPS radiation postprocessing (red points and text), test runs for Debrecen (blue) and Pécs (black), unused stations in test runs (yellow)

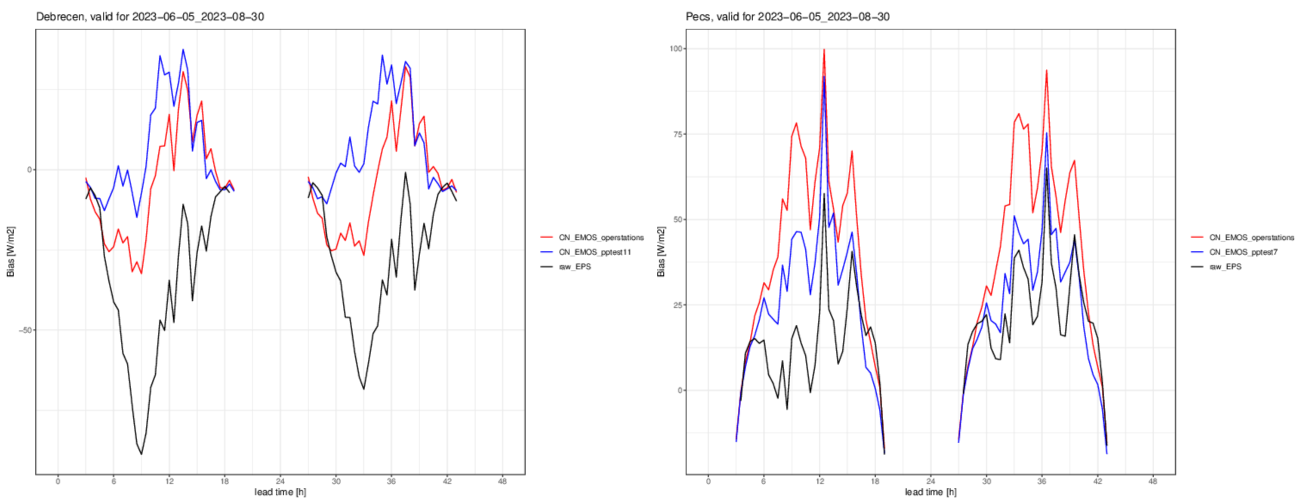


Figure 11: Radiation bias (W/m^2) for the operational selection of stations (red) and the best test selection of stations (blue) for the target of Debrecen (left) and Pécs (right) from 5 June to 30 August 2023, as a function of forecast lead time (h). Raw EPS scores are also shown in black.

Contributors, estimated efforts: *Katalin Jávorné Radnóczi (2 pm)*

References

Gneiting, T., Raftery, A. E., Westveld, A. H. and Goldman, T. (2005): Calibrated probabilistic forecasting using ensemble model output statistics and minimum CRPS estimation. Monthly Weath. Rev. 133, 1098–1118.

Lerch, S. and Baran, S. (2017): Similarity-based semilocal estimation of postprocessing models. Appl. Statist. 66, Part 1, 29–51.

Verification in Python ***(Croatia)***

In order to expand the standard verification procedure when evaluating the operational model, the scripts based on the verif module were written/modified in order to make them compatible when trying to calculate a vertical profile of some basic verification scores. Also, it was added the possibility to calculate scores in Python for EPS. The operational model was used in order to evaluate this tool.

Contributors, estimated efforts: Endi Keresturi and the other colleagues (1.5 pm)

The usage of an analog post-processinf method for wind for general public **(Croatia)**

This year a work was started related to the usage of an analog post-processing method for wind presented on meteograms for the general public (https://meteo.hr/prognoze_e.php?section=prognoze_model&param=3d). One example of how this meteograms show, it can be observed in the following figure 12.

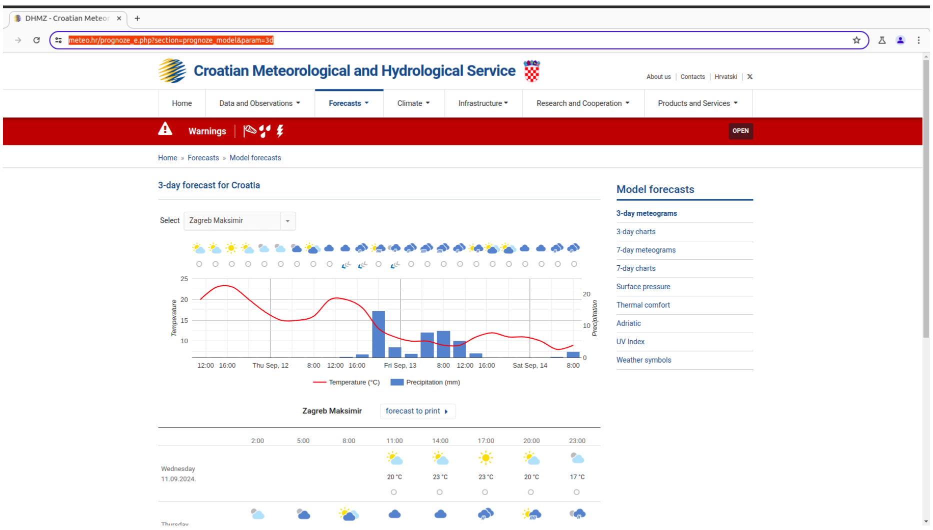


Figure 12: One example of how this meteograms.

Contributors, estimated efforts: Iris Odak Plenkovic and Ivan Vujec (0.5 pm)

New outputs for aeronautical forecast to the ALARO CMC ***(Czech Republic)***

- Determination of cloud base height either in meters or pressure;
- Calculation of Eddy Dissipation Rate (EDR), which depends on turbulence length-scale: there Mario helped me to see which length scale I should take in case of TOUCANS scheme;
- Calculation of inflight icing index (backphasing from CY48T1 cycle).

The preparation of the code to get these outputs was done and for the moment it was not done any validation.

Contributors, estimated efforts: Radmila Brožková (0.5 pm)

Verification activities in Poland ***(Poland)***

1. Regarding the operational/pseudo-operational verification, in Poland were performed the following validation:

- ALARO cy43t2 with assimilation
- ALARO cy46 – with modifications from colleauges from Prague
- New LBC with 1h frequency
- Snow scheme in SURFEX – only winter period

The operational models at IMGW-PIB:

- ICON (res. 2.8km)
- COSMO (res. 2.5km, 7km)
- WRF (res. 2km)
- ALARO (res. 4km)
- AROME (res. 2km)

The validation was done for the ALARO cycle 43t2 with assimilation compared with the operational version of ALARO for different meteorological parameters as follows: T2m, RH2m, wind speed, wind direction and atmospheric pressure. The verification period is 15.06.2024 – 15.07.2024. In Table 1, are specified the summarized results for all parameters. In figure 13 are shown the values of mean BIAS and RMSE for T2m – mean BIAS for the interval 15.06.2024 – 15.07.2024, in figure 14 the same scores for RH2m and in figure 15 the ones for PMSL.

Table 1: The resulrs of verification for the ALARO cycle 43t2 with assimilation compared with the operational version of ALARO for different meteorological parameters.

Parameter	BIAS	RMSE
T2m	Lower BIAS, higher amplitude	Lower RSME
RH2m	Positive BIAS	Reduction of RMSE at afternoon/night hours
Wind Speed	NO significant impact	NO significant impact
Wind Direction	NO significant impact	NO significant impact
Atm. Press.	Positive BIAS	NO significant impact

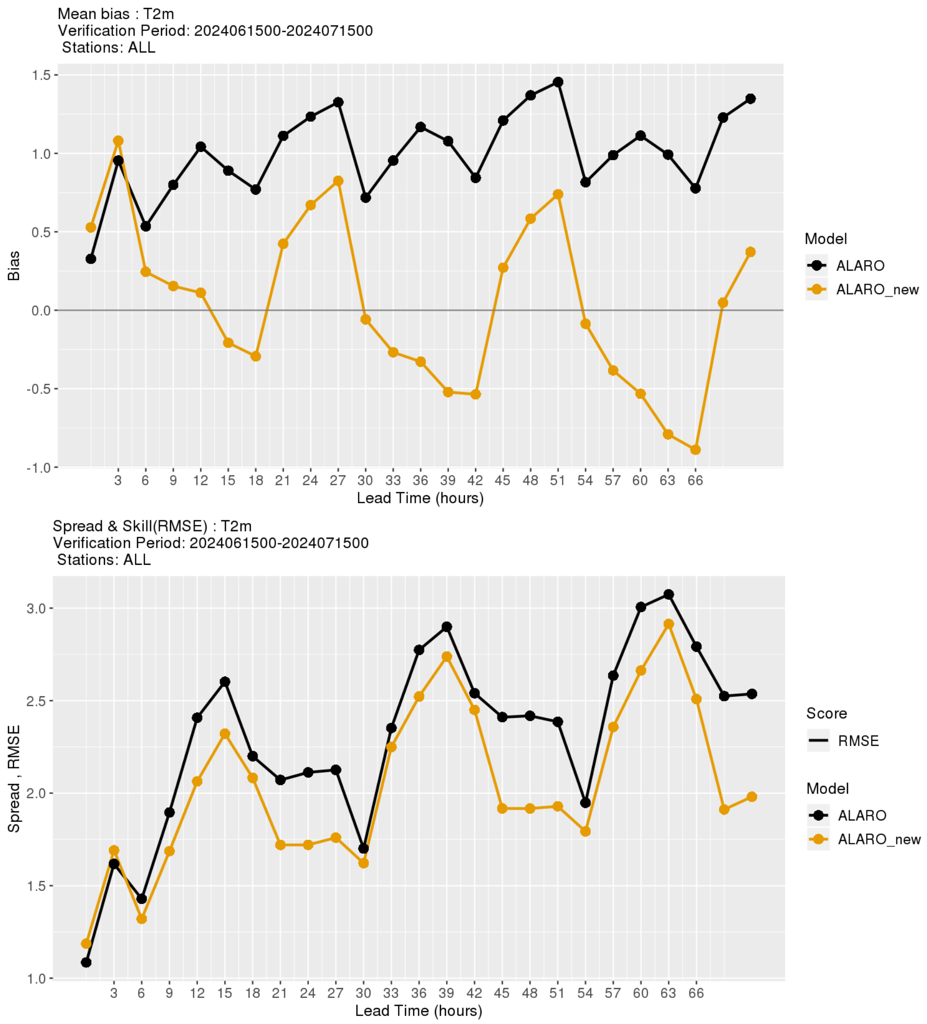


Figure 13: T2m – mean BIAS (top) and spread & skill (RMSE – bottom) for the interval 15.06.2024 – 15.07.2024 for ALARO with Assim – **ALARO_new** and operational version of ALARO – **ALARO.**

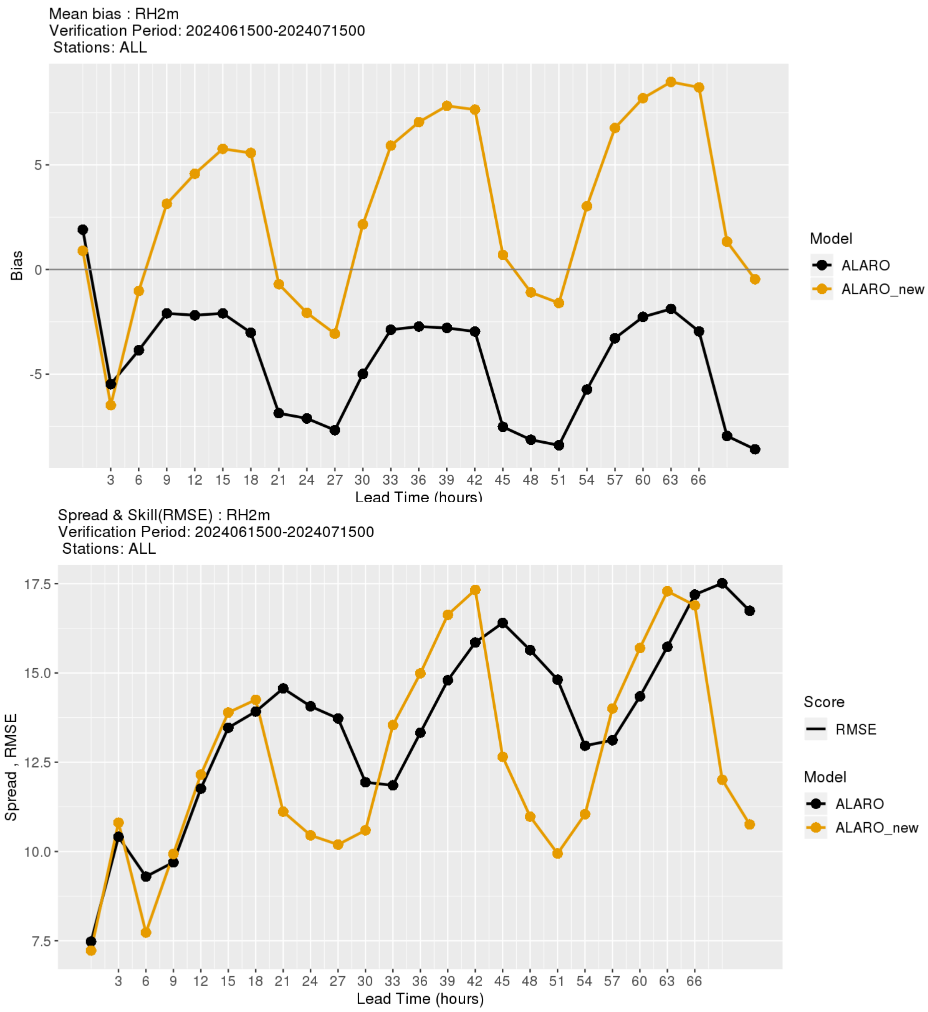
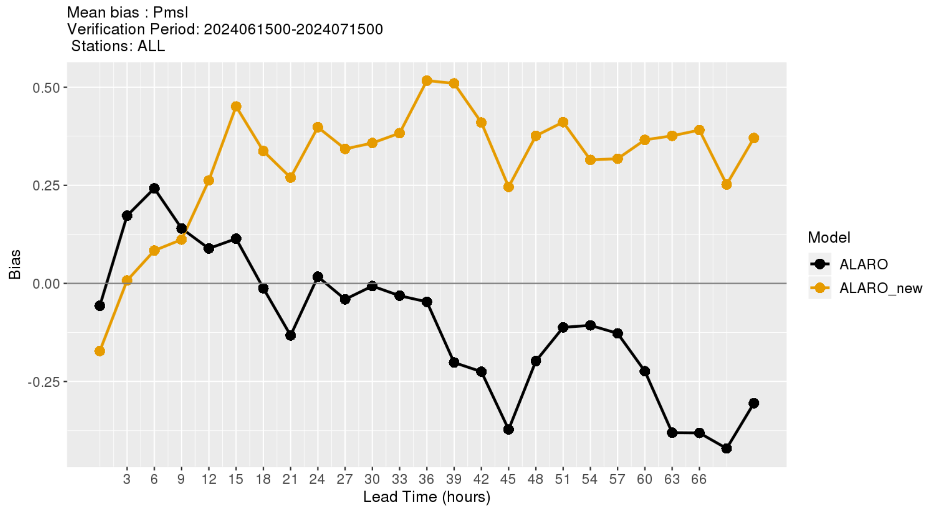


Figure 14: RH2m – mean BIAS (top) and spread & skill (RMSE – bottom) for the interval 15.06.2024 – 15.07.2024 for ALARO with Assim – ALARO_new and operational version of ALARO – **ALARO**.



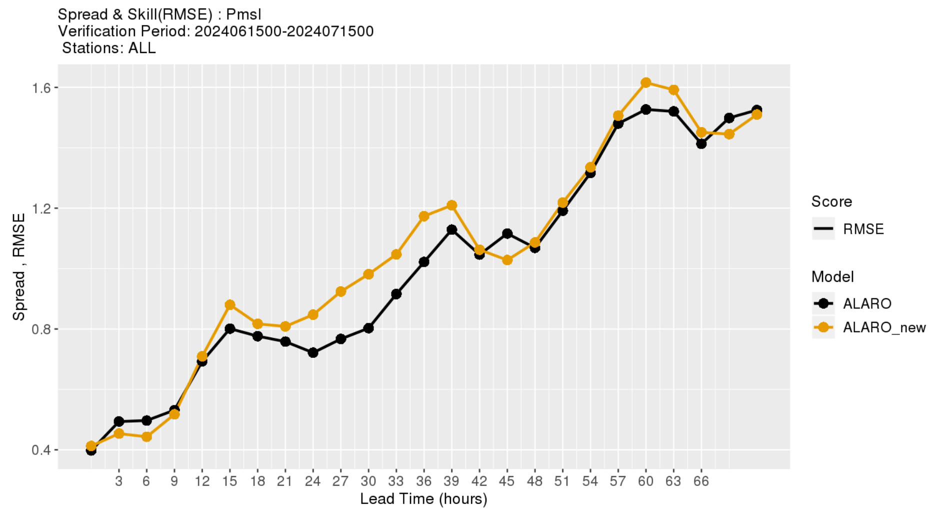


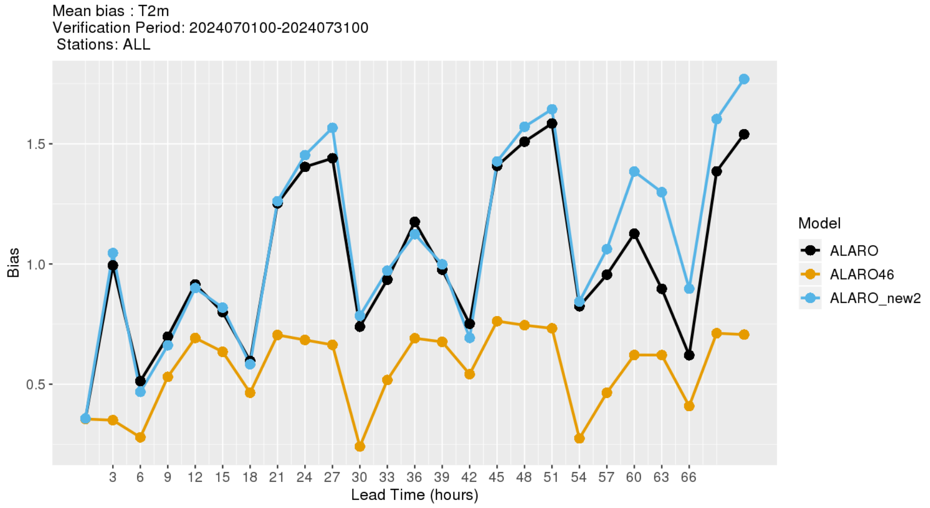
Figure 15: PMSL – mean BIAS (top) and spread & skill (RMSE – bottom) for the interval 15.06.2024 – 15.07.2024 for ALARO with Assim – ALARO_new and operational version of ALARO – **ALARO**.

2. ALARO cy46t1 & New LBC with 1h freq

In figure 16 are shown the results of BIAS and RMSE for the T2m, for the interval 01.07.2024 – 31.07.2024 by taking into consideration the following experiments:

- ALARO cy 46 with new settings from Prague – **ALARO46,**
- ALARO with 1 hour LBC – **ALARO_new2**
- operational version of ALARO with 3 hours LBC – **ALARO**

- By doing a comparison of LBC with one hour frequency with the operational settings at 3 hours frequency, there were no significant improvement for LBC with 1h.
- Better scores for ALARO cy46 with modifications from Prague and operational model (cy43t2).



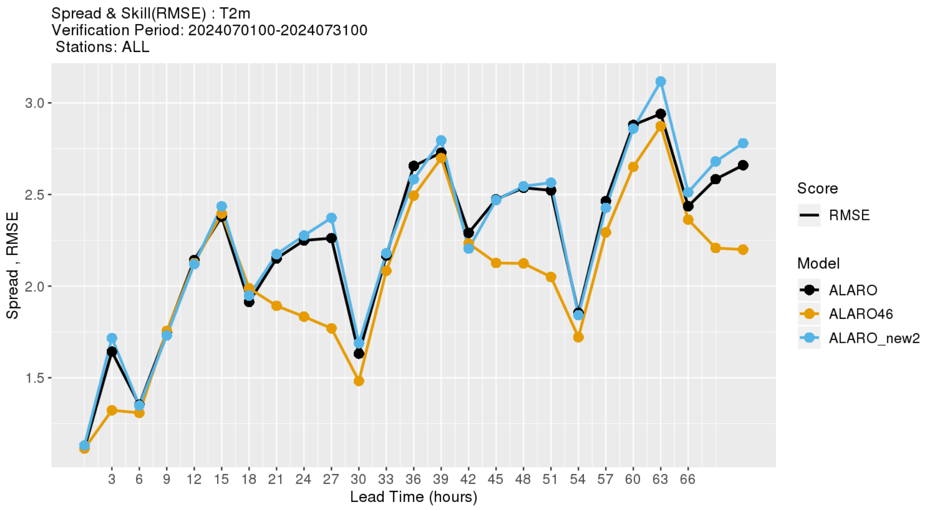


Figure 16: T2m – mean BIAS (top) and spread & skill (RMSE – bottom) for the interval 01.07.2024 – 31.07.2024 for ALARO cy 46 – ALARO46, ALARO with 1 h LBC – ALARO_new2 and operational version of ALARO – **ALARO**

3. Snow scheme verification

The verification was done for 2 m temperature, snow depth and snow water equivalent for season 2022/2023 for the high mountain station named Kasprowy

Wierch 1991 m a.s.l (Figure 17). Model AROME at 2x2 km for 24h forecast was used. The verification of air temperaturę from AROME model for mountain stations during winter season 2022/2023 can be noticed in Table 2.

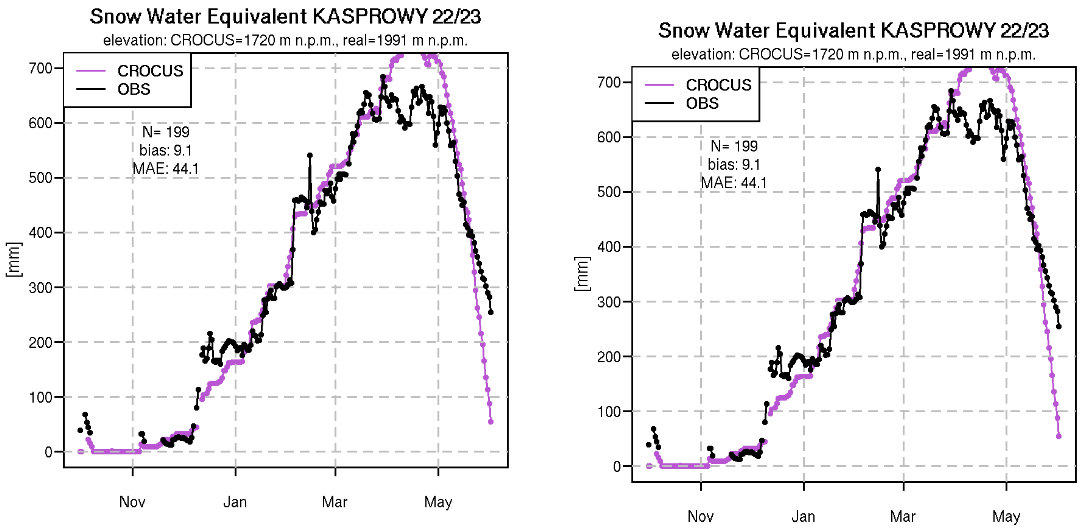


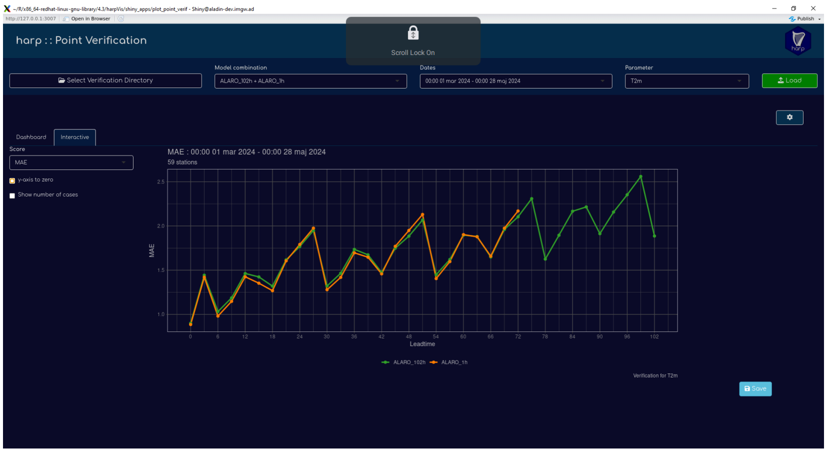
Figure 17. Snow depth (left) and snow water equivalent (right) for season 2022/2023 for the high mountain station named Kasprowy Wierch 1991 m a.s.l by using AROME at 2x2 km for 24h forecast.

Table 2. The verification of air temperaturę verification from AROME model for mountain stations during winter season 2022/2023.

Short name	elev_real [m n.p.m.]	elev_arome [m n.p.m.]	bias [°C]	RMSE [°C]
SBSL	1523	1643	-1,31	2,09
MOKO	1400	1698	-1,51	2,88
D5ST	1674	1681	-0,71	1,75
KASPROWY	1991	1522	2,34	3,33
DKOSC	1109	1391	-0,69	2,44
DCHOCH	1145	1345	-0,93	1,89
SNEZKA	1603	1156	2,92	3,6
PILSKO	1274	1193	0,84	1,79
MSZCZ	1180	1087	1,03	1,73
TURBACZ	1260	1098	1	1,97
PWETL	1230	902	0,91	1,99

4. New HARP version

- work in progres – operational in 2025
- verification of new LBC with frequency 1 and 3 hours (Figure 18)
- study period: 01.03.2024 – 28.05.2024



(Figure 17). Example for the new HARP version, study period 01.03.2024 – 28.05.2024

5. Current task: Upgrade HARP verification system – not yet operational

Contributors, estimated efforts: Marcin Kolonko (3 pm), Piotr Sekula (3.5 pm), Bogdan Bochenek, Małgorzata Szczęch-Gajewska, Marcin Kolonko, Jadwiga Róg, Piotr Sekuła, Gabriel Stachura, Natalia Szopa.

Vine copula application to ensemble postprocessing ***(Poland)***

Mathematical background **of the copula approach**

A *d*-dimensional **copula** is a multivariate distribution function on with **uniformly distributed marginals**. **Sklar's Theorem:** For a d-dimensional cumulative distribution function, there exists a copula, such that ,where F is a joint cumulative distribution function and are marginals. This theorem allows to separate univariate margins from the dependence structure.

Method

The goal is the error mitigation of the temperature forecast given by the ALARO model. It was construct a copula that contains both the information about the correlations between variables affecting the forecast error and their individual probability distributions. From a copula-given conditional probability distribution we can obtain a sample of pseudo-observations. We aim to check whether the choice of different conditioning variables has a significant effect on the correct fit of the model to pre-existing real data. We then calculate the average of these generated forecast errors, which we then add to the ALARO model's temperature forecast and check how much the corrected forecast is better than the original forecast using RMSE.

Data and results

- forecasts of air temperature values at 2m above ground level of NWP models at 12 UTC (forecast starting at 00 UTC) for 35 Polish synoptic stations
- training set: forecasts from 01.01.2019 – 31.12.2019
- test set: forecasts from 01.01.2020 – 31.12.2020
- results can be seen in figure 18

Indicators and the description of the conditioning variables:
a - AROME model forecast for the current day
b - COSMO model forecast for the current day
c - Forecast error of the ALARO model on the previous day
d - Value of observed temperature at 00 UTC
e - Forecast error of the AROME model on the previous day
f - Forecast error of the COSMO model on the previous day
g - Forecast error of the AROME model on the current day
h - Forecast error of the COSMO model on the current day
i - Difference between the forecast on the previous day and the current day of the ALARO model
j - Difference between the previous day's relative humidity forecast and the current day's ALARO model forecast

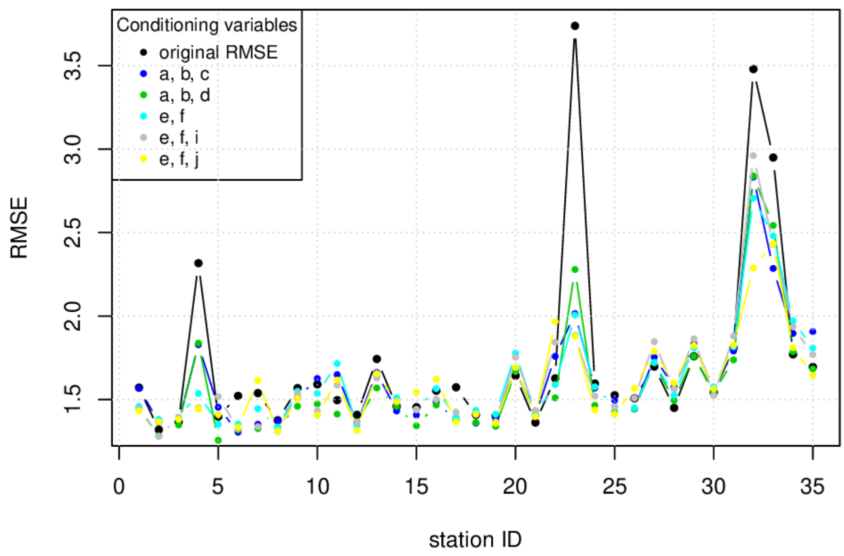


Figure 18. Root Mean Squared Error for various sets of conditioning variables for 35 meteorological stations.

Results

- The results are verified by checking the percentage change in the root mean squared error (RMSE) of the ALARO model's temperature prediction.
- A slight correction in the temperature prediction of the ALARO model is noted (figure 19).

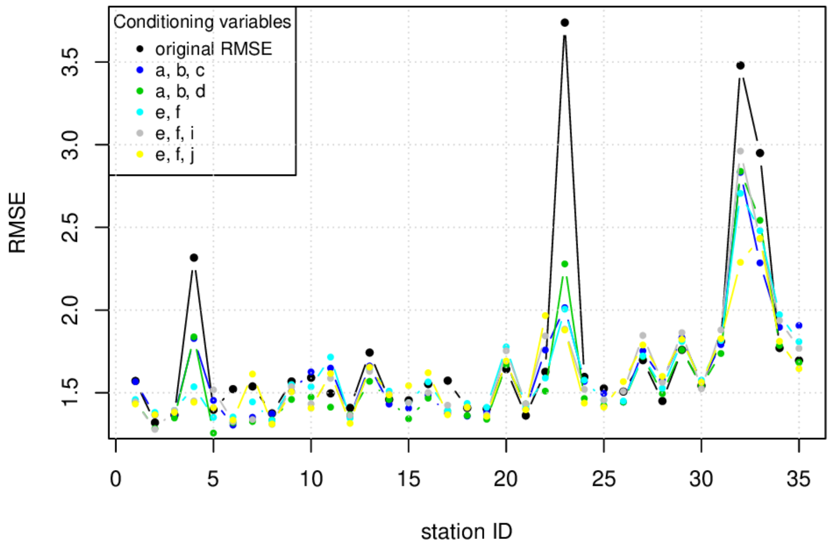


Figure 19. Root Mean Squared Error for various sets of conditioning variables for 35 meteorological stations.

Conclusions

The vine copula method allows reduction of systematic errors and generation of synthetic multi-dimensional data obtained by models in the hindcast. We can generate a sample from copula probability distribution and thus save CPU which is critical to ensemble forecasting.

Contributors, estimated efforts: Natalia Szpoza (4 pm)

***Using HARP for different experiments* (Romania)**

In Romania, during last month, after installing the HARP package in the operational user on our working machine, a script structure was built in order to facilitate the obtaining of verification score plots. A series of scripts was created, first to extract observation data from the local database, and then to process the output files in order to obtain the vobs files needed for the HARP package.

Also, a main script was created that allows the direct launch of the verification scripts without their previous editing. At this moment we are able to verify surface parameters like 2 m temperature, 2 m relative humidity, 10 m wind direction, 10 m wind speed, 10 m wind gust, precipitation cumulated in 1 h.

Using HARP, a verification was performed for the 10 m wind gust, for experiments done in order to tune the parameter FACRAF. They were obtained for the operational ALARO version at 4 km, bf11, for several values for FACRAF, using observation data from 151 stations, for July 2023. Several cases in July 2023 were selected when the operational ALARO led to significant overestimation of the wind gusts. Several values for FACRAF were tested: 3, 3.5, 4, 4.5, 5, 7, 7.5, 8. Value of FACRAF in the operational configuration is 10. The results are shown in the figures below from 20 to 25.

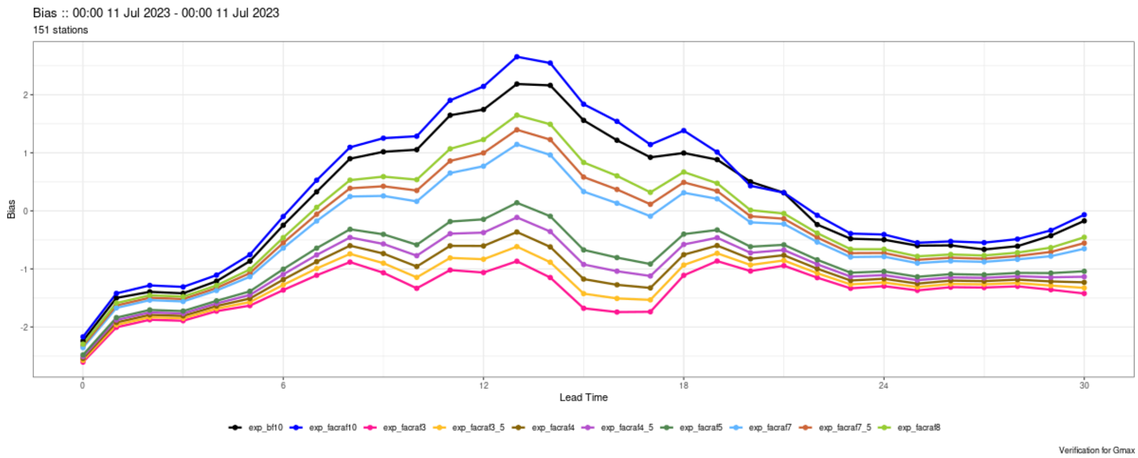


Figure 20. BIAS score for 11.07.2023, run 00, all tested values of FACRAF, for 30 h anticipation.

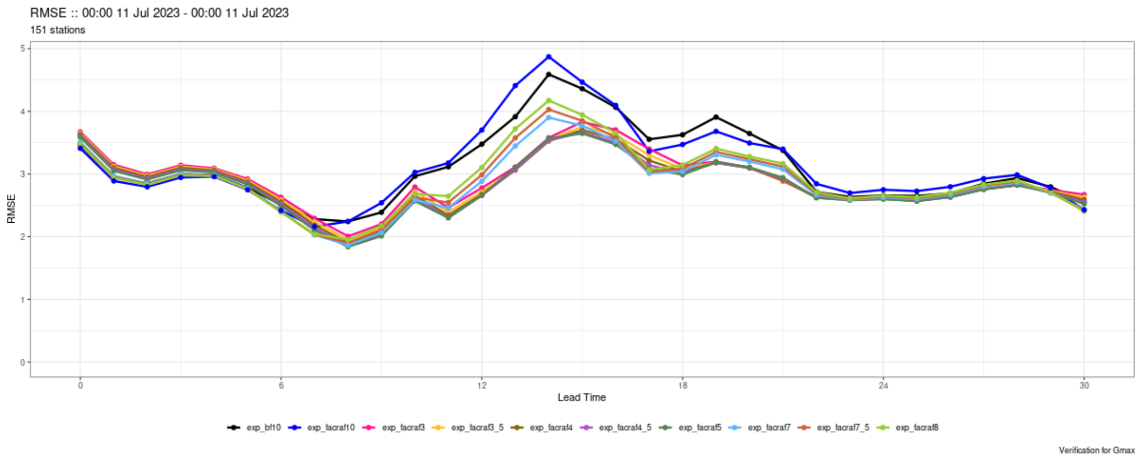


Figure 21. RMSE score for 11.07.2023, run 00, all tested values of FACRAF, for 30 h anticipation

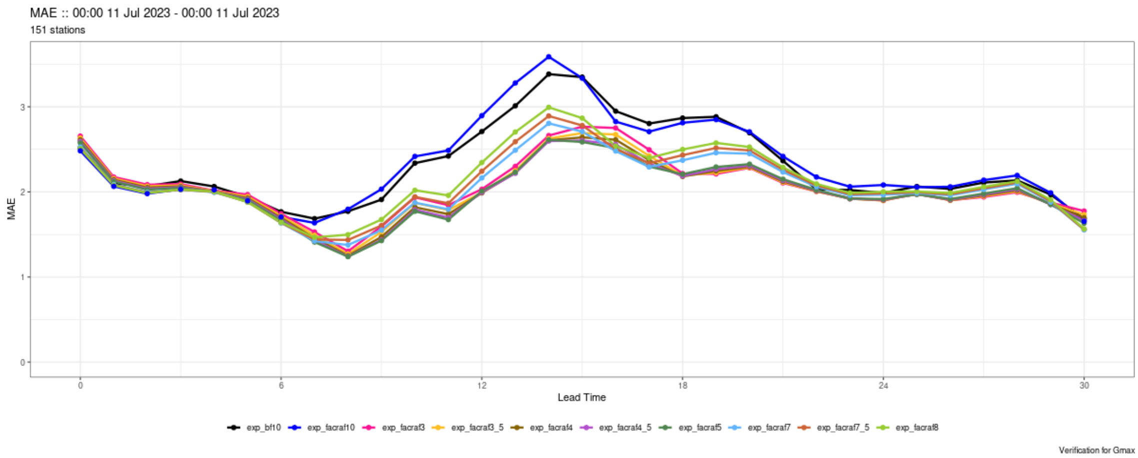


Figure 22. MAE score for 11.07.2023 period, run 00, all tested values of FACRAF , for 30 h anticipation

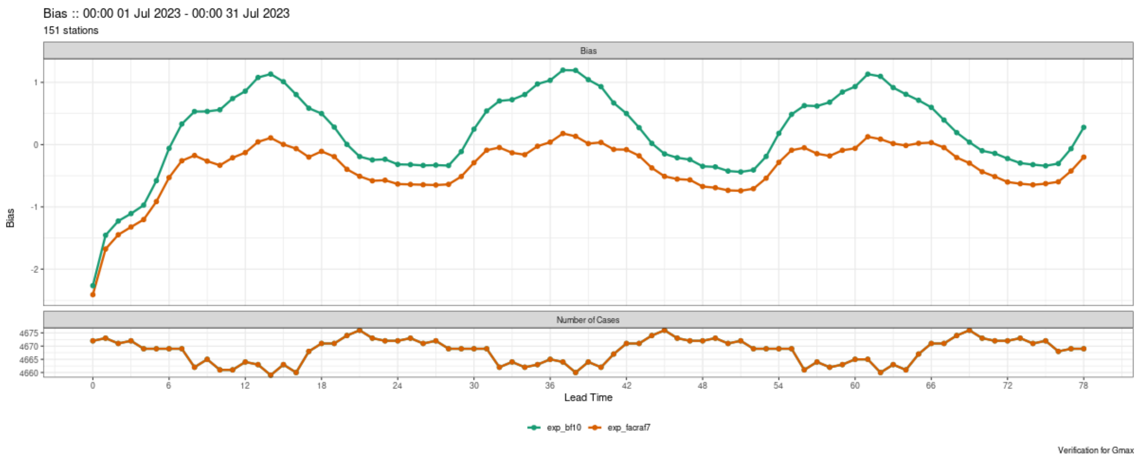


Figure 23. Monthly BIAS score for July 2023, run 00, for ALARO-oper version vs. ALARO_facraf7 version.

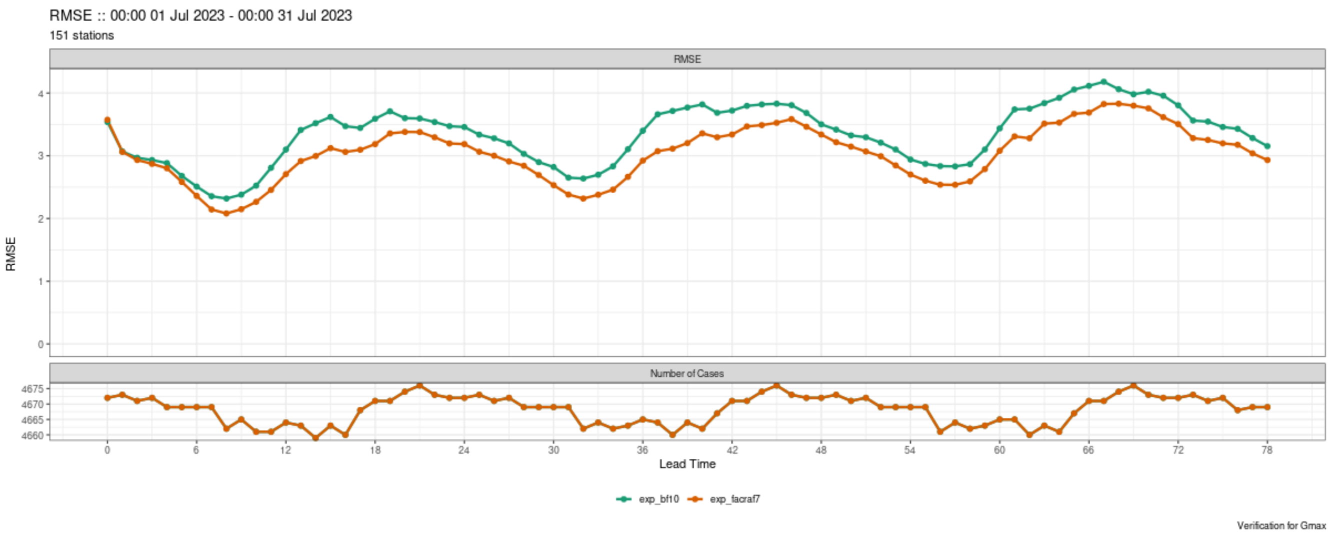


Figure 24. Monthly RMSE score for July 2023, run 00, for ALARO-oper version vs. ALARO_facraf7 version

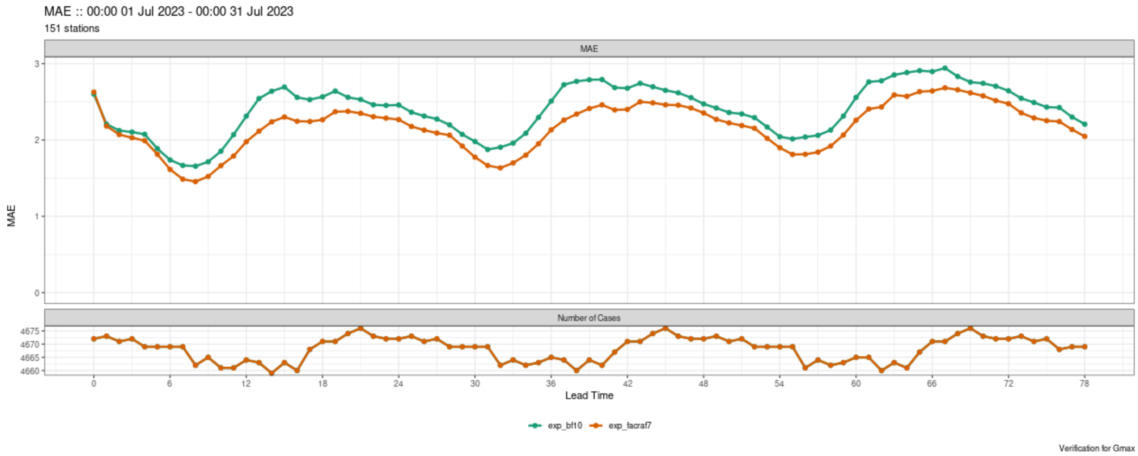


Figure 25. Monthly MAE score for July 2023, run 00, for ALARO-oper version vs. ALARO_facraf7 version

Close values of FACRAF lead to similar results. It was observed that the overestimation of the wind gust is reduced, for some hours, the bias is almost 0. There is an improvement in the scores over daytime, that is bigger than the underestimation introduced over nighttime. Overall in the monthly scores, the MAE score shows that the error is slightly smaller in all hours for FACRAF=7. This value could be a good candidate for the new operational setting.

Contributors, estimated efforts: Raluca Pomaga (2.75 pm)

Comparison between versions cy43bf10 and cy43bf11 (Romania)

Verification was performed for comparison between model versions cy43bf10 and cy43bf11, in order to be able to use cy43bf11 for the operational configuration. The scores are shown for the month of May 2024, for the following parameters: MSLP, 2 m temperature, 2 m relative humidity, 6 h Precipitations and 10 m wind speed (Figure 26). It was observed that the results are very similar.

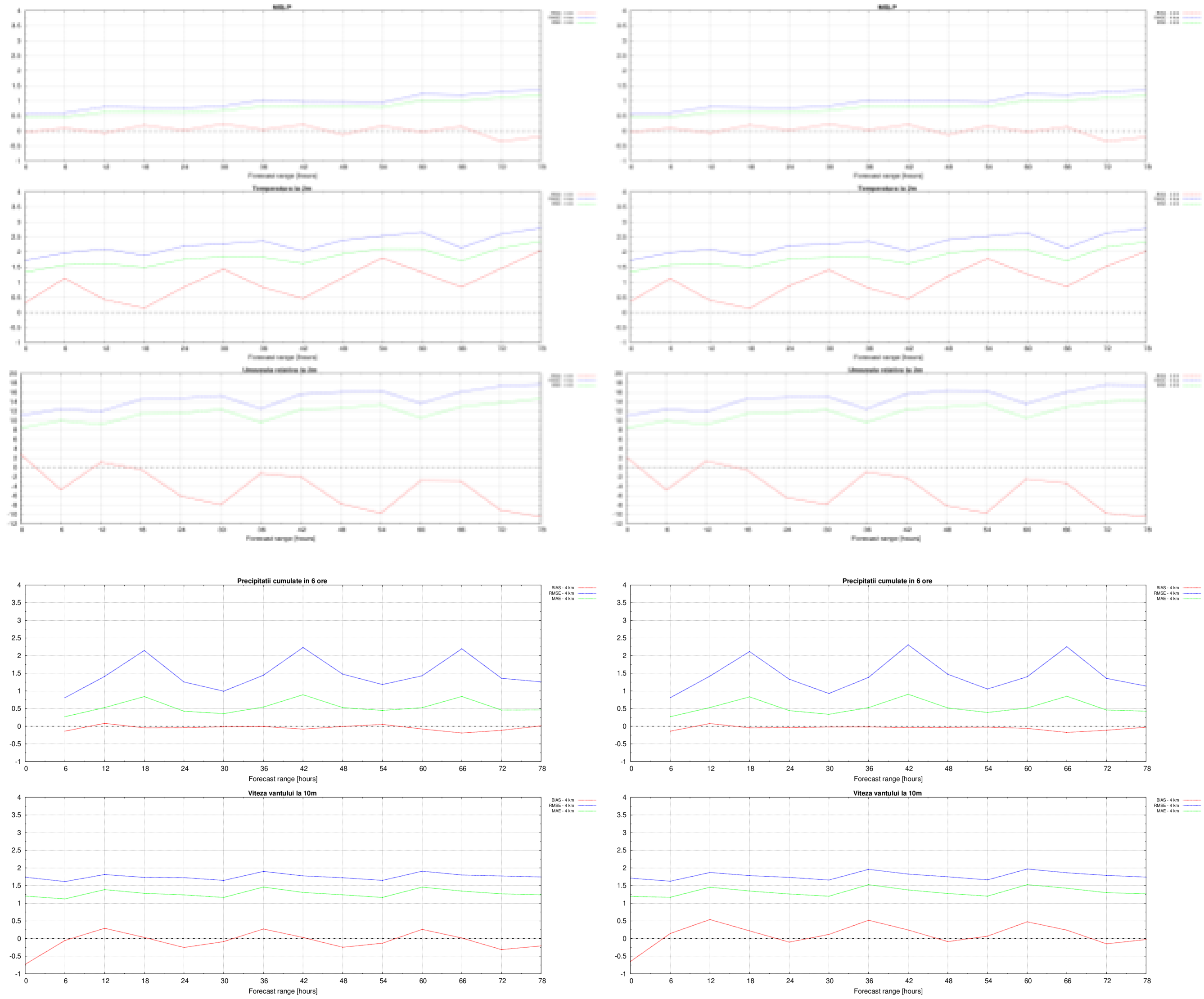


Figure 26. Monthly scores for cy43bf10 (left) and cy43bf11 (right) for MSLP, 2 m temperature, 2 m relative humidity, 6 h Precipitations and 10 m wind speed.

Contributors, estimated efforts: Alexandra Crăciun (0.5 pm)

MQA3 contributors, estimated efforts: Phillip Scheffknecht (0.5 pm)**,** Katalin Jávorné Radnóczi (a - 1.25 pm), Dávid Tajti (a - 0.25 pm), Katalin Jávorné Radnóczi (c - 2 pm), Dávid Tajti (c - 1.5 pm), Boglárka Tóth (c - 1.5 pm)***, Katalin Jávorné Radnóczi (2 pm),*** Endi Keresturi and the other colleagues (1.5 pm), Iris Odak Plenkovic and Ivan Vujec (0.5 pm), Radmila Brožková(0.5 pm), Marcin Kolonko (3 pm), Piotr Sekula, Bogdan Bochenek, Małgorzata Szczęch-Gajewska, Marcin Kolonko, Jadwiga Róg, Piotr Sekuła, Gabriel Stachura, Natalia Szopa (3.5 pm), Natalia Szpoza (4 pm), Raluca Pomaga (2.75 pm), Alexandra Crăciun (0.5 pm)
MQA3 total: 25.25 pm.

Summary of resources [PM]

Subject/Action	Resource (realized)	LACE stays
Development of HARP [MQA1]	7.75	1 pm
Development of new verification methods [MQA2]	0.5 pm	
Verification, evaluation and error attribution [MQA3]	25.25 pm	
Total	**33.5**	**1 pm**

Activities of management, coordination and communication

1. 42nd LACE Steering Committee meeting, 27-28 February 2024. Budapest, Hungary
2. 4th ACCORD All Staff Workshop 2024, 15 - 19 April 2024 (Norrköping), RC-LACE verification activities presented by Simona Tascu
3. 43rd LSC Meeting, 18-19 September 2024, Vienn