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NWP in Poland

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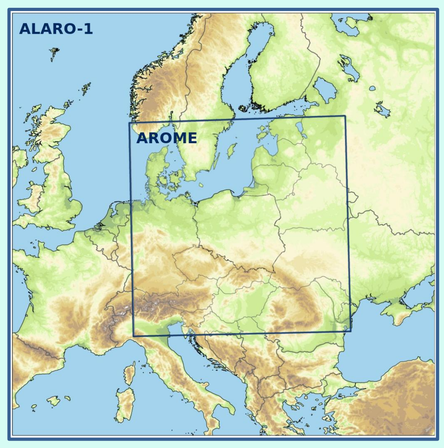
Operational

ALARO-v1B NH (CY43T2) operational domain:

4km horizontal resolution, **789x789** grid points,
70 vertical model levels, on a Lambert projection with **3h** coupling frequency and **1h** output, coupling zone 16 points; Runs 4 times per day (00,06,12 and 18) with **102** hours forecast range; LBC from ARPEGE with 9.4km horizontal resolution; Time step 150s. In pre-operational mode CANARI surface assimilation with 6h cycling.

AROME (CY43T2) operational domain:

2km horizontal resolution, **799x799** grid points, **70** vertical model levels on a Lambert projection with **3h** coupling frequency and **1h** output. **4** runs per day (00, 06, 12 and 18UTC) with **42** hours forecast range; LBC from ALARO-1 4km; output every 1h – for LEADS system; Time step 50 s; 10min output for INCA Nowcasting System.



Computational domains of ALARO-1 (4.0km horizontal resolution) and AROME (2.0km horizontal resolution) nested models.

New operational machines - characteristics

SAWA (located in Warsaw) – 180 Dell R660 CPUs, 1 Pflop in total, each core 512 GB RAM, OS Rocky Linux, Debian, CentOS; **KRAK** (Kraków) – 45 Dell R660 CPU (250 Tflops), 3 Dell XE9680 GPU (750 Tflops). Each GPU core contains eight NVIDIA H100 cards.

Testing ALARO CY46T1

Preoperational tests with CY46T1 export version runs daily for ALARO CMC with **horizontal resolution 2.45km**. The four packages of code changes developed by Czech LACE team in Prague were included in the local model version.
Timestep **90s**, **70** vertical levels (later maybe more).
Climatological files were prepared according to the procedure described in Jan Masek's report. Initially, model dynamics setup was set according to Petra Smolikova presentation, then some changes in namelists were introduced.

Computational domains of ALARO-1 2.45 km (blue) and 4.0 km (red)

Tuning of Dynamics in the ALARO 2.4 km

The ECTO program was used for diagnostics, as it enables the determination of the spectral of kinetic energy.

Initially, a configuration described in the report was used (Chapter 5, page 15; experiment E024 in Figure 1 and experiment REFERENCE in Figure 2):

https://www.rclace.eu/media/files/Dynamics_and_Coupling/2019/report_PSmolikova_Dynparam_2019.pdf

Preliminary tests indicated a potential issue with horizontal diffusion — the presence of a "bulge" (local maximum) in the tail of the spectrum (curve for E024). Since this "bulge" appears at higher levels, it suggests the use of so-called Reduced Spectral Diffusion (RSD).

The spectrum should be as flat as possible, with a slope transitioning from k^{-3} in the upper troposphere and stratosphere to $k^{-5/3}$ near the surface (two black lines in the figure).

To mitigate the potential issue, a series of tests was conducted for different model configurations. Adjustments to the RDAMP* and SLEVDH parameters in the &NAMDYN block of the model configuration were required.

The two parameters with the greatest impact on the shape of the kinetic energy spectrum were SLEVDH and RDAMPDIV. Selected configurations are presented in Figure 1.

E024_13: RDAMPDIV=4., SLEVDH=0.6,	**E024_14:** RDAMPDIV=4., SLEVDH=0.7,	**E024_16:** RDAMPDIV=3., RDAMPQ=15., RDAMPT=15., RDAMPVD=15., RDAMPVOR=4., SLEVDH=0.65,

Finally, the E024_16 configuration was selected.

The diffusion changes presented in Figure 1 are visible in the model fields of *pressure departure*. Results for vertical level 40 are shown below for both the default model version and the E024_16 configuration.

Comparing the results for level 40 (Figure 2), a reduction of noise is observed over the region northeast of Poland and over the North Sea in the new ALARO model configuration.

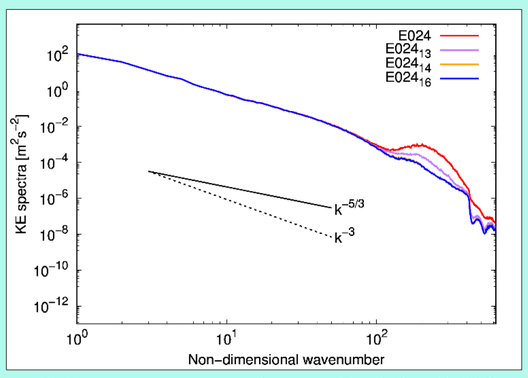


Figure 1. Kinetic energy spectrum for vertical level 40 at 12 UTC on 31/01/2024. ThKinetic energy spectrum for vertical level 40 at 12 UTC on 31/01/2024. The model uses 70 vertical levels, with level 70 being the closest to the ground at a height of ~10 me model uses 70 vertical levels, with level 70 being the closest to the ground at a height of ~10 m.

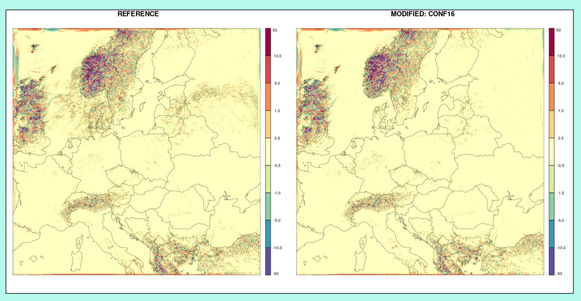


Figure 2. Comparison of pressure departure fields for vertical level 40 for the forecast initialized at 12 UTC on 31/01/2024

General Verification

The verification of the new ALARO CY46T1 model version (with a horizontal resolution of 2.4 km) has been conducted in operational mode since the beginning of 2026. Verification results for a one-month period (23/02/2026–24/03/2026) are summarized in Table 1.

Further and more detailed verification will be performed for total cloudiness. To find out the reason for its poor performance.

Parameter	RMSE	BIAS
Air temperature at 2m	Comparable results	Slight deterioration in results for ALARO CY46T1 2.4km
Relative humidity at 2m	Higher RMSE for ALARO CY46T1 2.4km	Higher positive bias for ALARO CY46T1 2.4km
Wind speed at 10m	Lower RMSE during daytime for ALARO CY46T1 2.4km	Slightly positive bias
Wind direction at 10m	Comparable results	Comparable results
Total cloudiness	Significantly worse results for ALARO CY46T1 2.4km	Positive bias for ALARO CY46T1 2.4km
Wind gusts	Comparable results	Comparable results
Mean sea level pressure	Comparable results	Higher bias

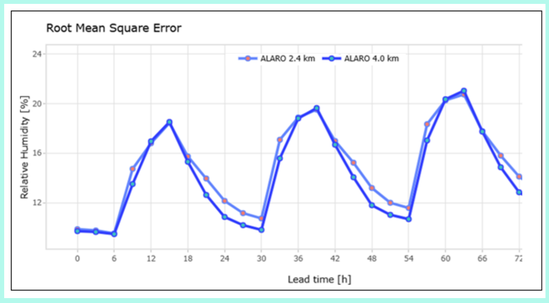


Figure 3. RMSE of relative humidity for ALARO CY46T1 2.4 km and ALARO 4km CY43T2

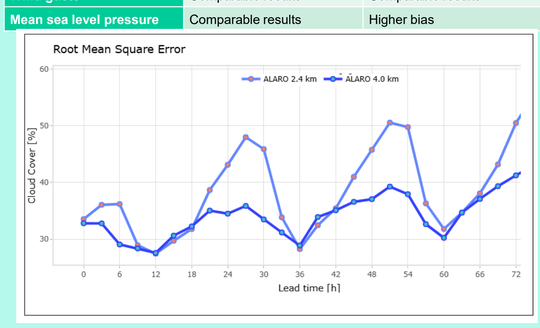


Figure 4. RMSE of total cloud cover for ALARO CY46T1 2.4 km and ALARO 4km CY43T2.

The implementation of the sweep interpolation in the semi-Lagrangian scheme of the ACCORD system

Introduction

The sweep interpolation method is a semi-Lagrangian scheme that alternates backward and forward interpolation sweeps over consecutive time steps, effectively combining two lower-order schemes to improve accuracy. By doing this "sweeping" process, it achieves high (typically fourth-order) accuracy at the computational cost of lower-order (third-order) interpolation, reducing numerical errors such as dissipation and dispersion near sharp gradients while remaining efficient.

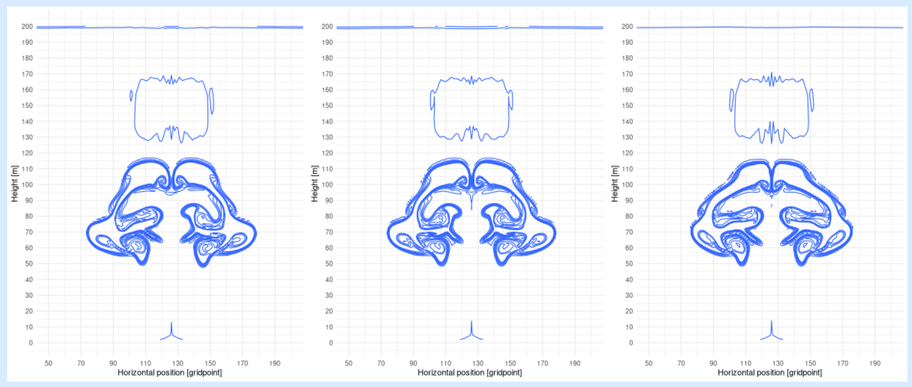


Figure 1. Bubble test: perturbation of potential temperature after 7 minutes – left to right: sweep interpolation, quadratic interpolation, and cubic interpolation.

Implementation and experiment

The method was implemented in the CY48t3mas LAM code. A new logical switch (LSWEEP) was introduced. The sweep interpolation was tested using the Robert's rising thermal bubble, which was defined to be a sharp edged 2D bubble with perturbed temperature: +1K in the centre of bubble and no advection in the field of constant potential temperature of 300K. The experiment was carried out on a domain of 256 gridpoints, 200 vertical levels with meridional grid spacing and vertical spacing of half levels both set to 10m.

Results

The results were compared against solutions obtained with quadratic and cubic interpolation schemes, as shown on Figure 1. The sweep interpolation produces solutions similar to both quadratic and cubic references. This indicates that the method accurately captures the essential dynamics of the rising thermal bubble. Thus the method is promising and additional testing across varying parameters and a 3-dimensional test cases is necessary to further validate the sweep interpolation method for atmospheric modelling applications.

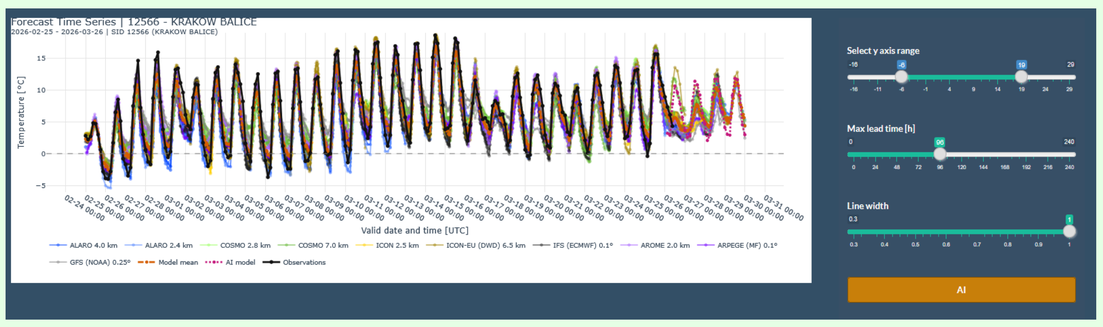
Local implementation of HARP2 package

Hirlam-Aladin R Package version 2.0 is used for verification of several models used in IMGW-PIB: ALARO, AROME, COSMO and WRF.

One can select the model, dates, stations and score, visualise it clearly, and compare models performance.

Diagrams/tables from central part can be easily downloaded. An additional menu on the right hand side appears which allows adjustment of axis ranges, background color and inclusion of Y=0 line.

Additional features were added lately, with possibility to check scores and point forecasts for selected station, interactive plots with plotly with possibility to download selected data in a form of html file to local computer.



When longer period of data is selected it is possible to train simple Random Forest model on it and produce new AI model based on the knowledge how models are performing so far.

There is also a view with verification scores on the map with stations. Additional features are under development, such as: ensemble forecasts verification, spatial verification with SAL.

SAL (Structure-Amplitude-Location) is verification score used for high resolution models (e.g. ALARO 2.4 km). Its ideal values are S = 0, A = 0 and L = 0. It is sensitive to the structure of the precipitation field and reduces pointlike error in high resolution NWP forecast and nowcasting.