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NWP in Poland

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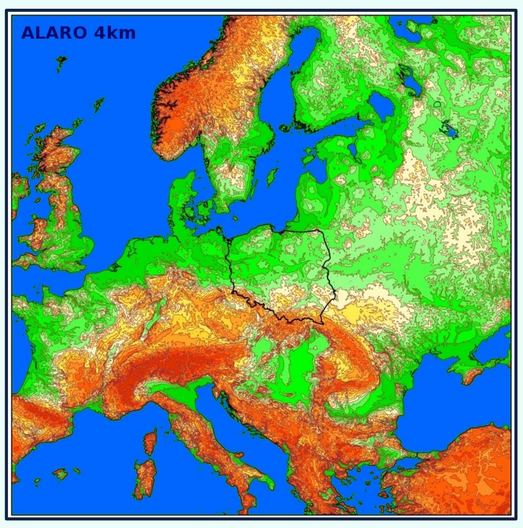
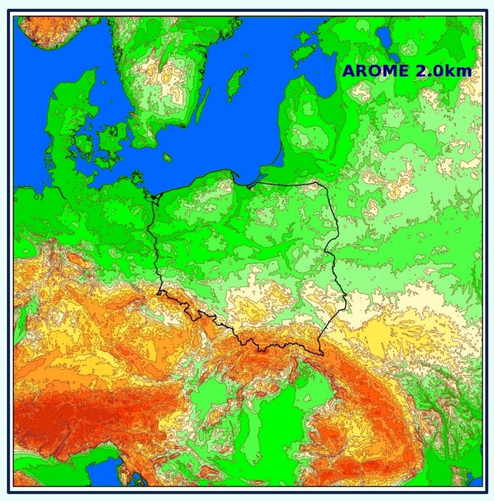
Operational

ALARO-v1B NH (CY43T2)

Operational Domain:

4.0 km horizontal resolution, 789x789 grid points, 70 vertical model levels on a Lambert projection with 3h coupling frequency and 1h output, coupling zone with 16 points; Runs 4 times per day (00,06,12 and 18) with 72 hours forecast range; LBC from ARPEGE with 9.4km horizontal resolution; Time step 150s.





AROME (CY43T2)

Operational Domain:

2.0km horizontal resolution, 799x799 grid points, 70 vertical model levels on a Lambert projection with 3h coupling frequency and 1 hour output 4 runs per day (00, 06, 12 and 18UTC) with 30 hours forecast range; Time step 50s; LBC from ALARO-1 4.0km; GRIB format, every 1h – for LEADS system; 10min output for INCA Nowcasting System.

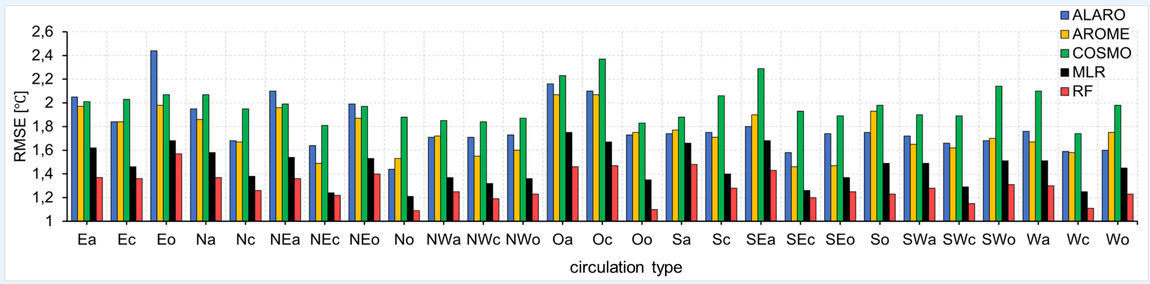
Operational machine characteristics

Cluster of HP BL460c_GEN8 servers connected with Infiniband network, OS Scientific Linux 6, Intel Xeon E5-2690 processors – with maximum 1552 cores (97 nodes with 16 cores each), each core RAM 128 GB, disc array – 64 TB**.**

Forecasts accuracy across different types of atmospheric circulation

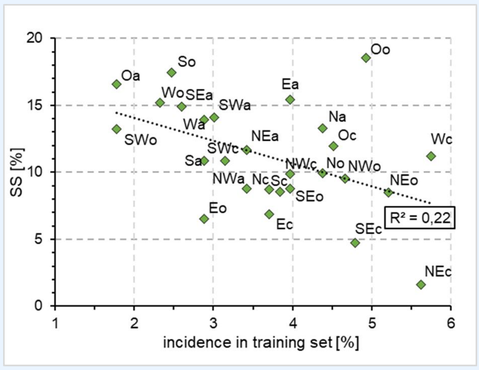
Forecast errors depend on various factors, e.g. forecast lead time or season of the year, but also on the direction of airflow and a pressure pattern over a studied area. Therefore, we compared RMSE of T2m forecasts from three NWP models: AROME (2 km), ALARO (4 km) and COSMO (7 km) as well as from two postprocessing methods: a linear one (MLR) and a machine-learning-based one (RF). A common forecast length used in this study was from 3 to 30h. The timeframe taken into consideration is 2020. A classification of atmoshperic circulation types proposed by Litynski and modified by Pianko-Kuczynska was used. Out of 27 types of circulation, there are 9 cyclonic, 9 antycyclonic and 9 gradientless types (subsripts *c* and *a* and *o,* respectively).

- **the largest values of RMSE for the NWP models occur for cyclonic and antyciclonic types with an undefined flow direction (Oc and Oa)**
- **relatively high errors are noticed also in case of eastern types (especially for ALARO)**
- **cyclonic types of circulation from the north-east (Nec), west (Wc)and south west (SWc) have the lowest RMSE**
- **the ML-based postprocessing method was the most accurate for every circulation type, achieving the greatest error for the gradientless type from the east (Eo) and antycyclonic from the south (Sa), whereas the lowest one – for gradientless type from the north (No) and from no defined direction (Oo)**



RMSE for different types of atmospheric circulation in 2020 for three NWP models (ALARO, AROME and COSMO) and two methods of postprocessing (MLR and RF).

To assess the skill of the ML-based postprocessing method, skill score (SS) was calculated in relation to the linear method. The greatest SS (18,8%) was obtained for the gradientless type from an undefined flow direction (Oo), while the lowest (only 1,6%) – for the cyclonic type from the north-east (Nec). Additionally, to adress the diverse incidence of the circulation types in the training set, the relation between SS and frequency of each circulation type in the training set was examined. Based on the relationship, a linear trend was drawn which is downward yet statistically insignificant. Thus, we can conclude that the incidence in the training set does not show clear impact on the SS.



Relationship between incidence in the training set and SS of RF against MLR for every circulation type. Linear regression was drawn with dotted line.

Urban boundary layer studies – project CoCO2

An important source of uncertainty in the estimation of the local and global carbon balance are urban areas. mainly due to the spatial and temporal variability of its emission and absorption sources. Kraków, located in the Vistula river valley, is an excellent location for such studies.

Between March 2021 and January 2022, 269 drone and passenger balloon flights were carried out up to 280m above ground level. They were grouped in eleven daily measurement campaigns (https://msip.um.krakow.pl/). During each flight continuous measurements of pressure, temperature and humidity were taken, as well as carbon dioxide (CO_2) and methane (CH_4) concentrations using a PicarroG-2311-f laser spectrometer.

The profiles collected during campaigns show the evolution of the boundary layer (PBL). During the day PBL it is mostly well mixed and at night an inversion forms, under which the concentration of CO_2 and CH_4 increases.

In winter, CO_2 concentrations are generally higher throughout the profile. However, due to inhibited respiration of vegetation in this season, at night in the ground layer this concentration is lower than in summer.

Biogenic methane emissions in summer contributes to a higher increase in its concentration in the nocturnal PBL compared to winter.

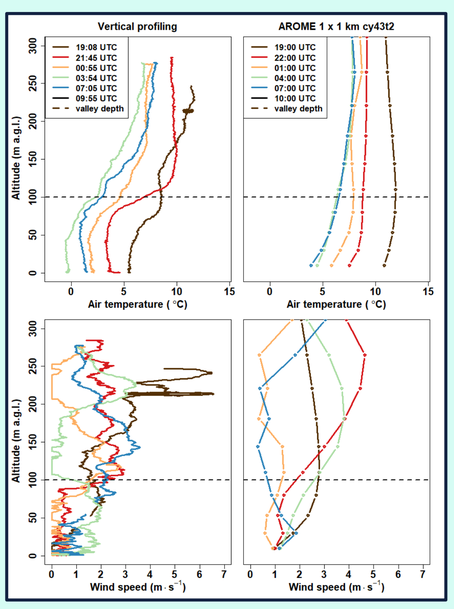
Vertical profiles are represenattive only for western part of the Kraków city, which is caused by complex topography. Visla river valley widens from 1 km in the western part to 10 km in the East.

Kraków city center. Location of vertical profile measurements (white arrow) with use of sightseeing balloon –scientific cooperation (https://balonwidokowy.pl)

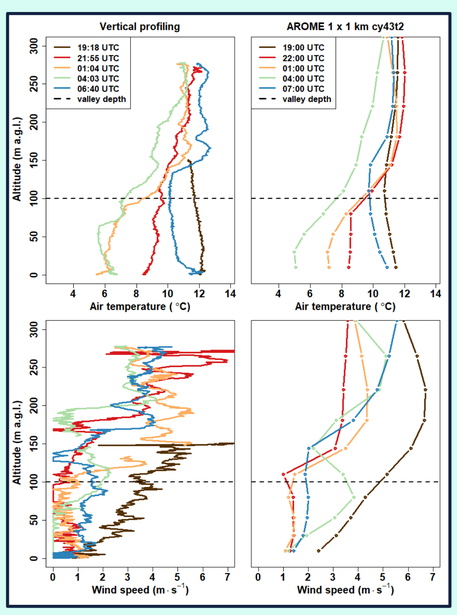
- **Too high temperature and too low relative humidity during the night.**
- **In the valley occured cold air pool which was not predicted by the model.**
- **Too strong wind predicted above the valey depth (above 100 m a.g.l.) - measurements from 22 and 4 UTC.**
- **Further studies with data assimilation are necessary.**

- **Nocturnal boudary layer was well represeted in the model – only in the Kraków developed humid cold pool (effect of topography).**

- **Above the valley depth ~100 m a.g.l. wind speed increases – also visible in the model forecast (measurements at 22 and 1 UTC).**



Vertical sounding (left column) and forecasted profiles (right column) of air temperature and wind speed from campaign in 25-26 Oct. 2021



Vertical sounding (left column) and forecasted profiles (right column) of air temperature and wind speed from campaign in 28-29 April 2021

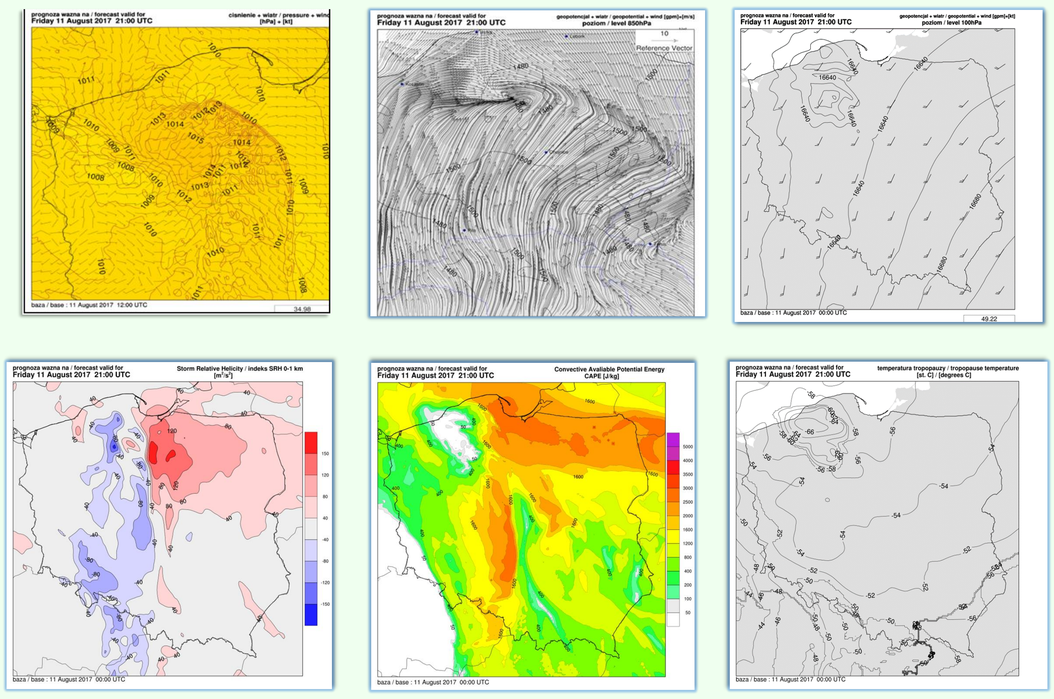
A study of the derecho case 11 Aug 2017 – AROME maps

A derecho case from Aug 11, 2017, killed 6 people and injured over 50. Around 80000 ha of forest was totally damaged. An extensive study of the ALARO and AROME model (their non-hydrostatic versions, not available at the time of cataclysm) forecast was performed and published.

The speed of wind gusts exceeded 42 m/s. A mesoscale convective system developed in western Poland and occurred in late afternoon/evening hours. We demonstrate a set of maps showing mesoscale convective vortex (MCV), middle and upper atmosphere fields as well as maps of storm indices – SRH or CAPE, relating to the mentioned situation.

3

The derecho phenomenon is more specific than bow echo and can be defined in several ways: there must be a compact area of surface damage, wind speed > 25.7 m/s and the size of damage swath length over 400 km. At least three reported F1 damage separated by at least 64 km and wind gusts over 33.4 m/s should occur. Time difference between them should be no more than 3 hours.



From top left to top right: AROME maps of the pressure, wind + geopotentiel at 850 hPa (with MCV) and 100 hPa. Bottom left: SRH 0-3 km, middle: CAPE, bottom right: ICAO tropopause temperature.

The reference to the associated paper: Kolonko, M., M. Szczęch-Gajewska, B. Bochenek, G. Stachura, and P. Sekuła, 2023: Using ALARO and AROME numerical weather prediction models for the derecho case on 11 August 2017. Meteorol. Hydrol. Water Manage., 10, 88–105, https://doi.org/10.26491/mhwm/156260.