Numerical Weather Prediction at IMGW-PIB

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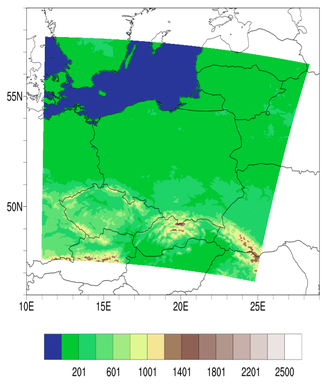
Status of the operational suite

COSMO-CE PL (COSMO-EULAG)

- 2.8 km mesh size
- Domain size [grid points]: 380 x 405
- 4 x per day up to +60 hours (00, 06 12,18 UTC)
- Time step: dt=20s
- LBCs: COSMO-PL 7, update interval 1h
- Nudging Assimilation scheme
- version 5.05

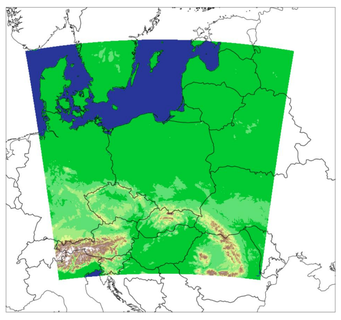
COSMO PL – TLE-MVE (ensemble)

- 20 members at 2.8 km mesh size
- Domain size [grid points]: 380 x 405
- 4 x per day up to +60 hours (00, 06 12,18 UTC)
- Time step: dt=20s
- LBCs: COSMO-PL 7, update interval 1h
- No data assimilation scheme
- version 5.05



ICON PL

- Equivalent Surface resolution ~2.5 km
- icon-2.6.2.2+icontools-2.4.12, R2B10,
- 14x14deg, NP -161.0, 38.0
- 65 vertical levels
- Time step dt=24s
- 4 x per day up to +48 hours (00, 06 12,18 UTC)
- Nested in R3B7 ICON Global (~13km equivalent)
- No data assimilation scheme
- 3h LBC update interval
- version 2.6.2.2



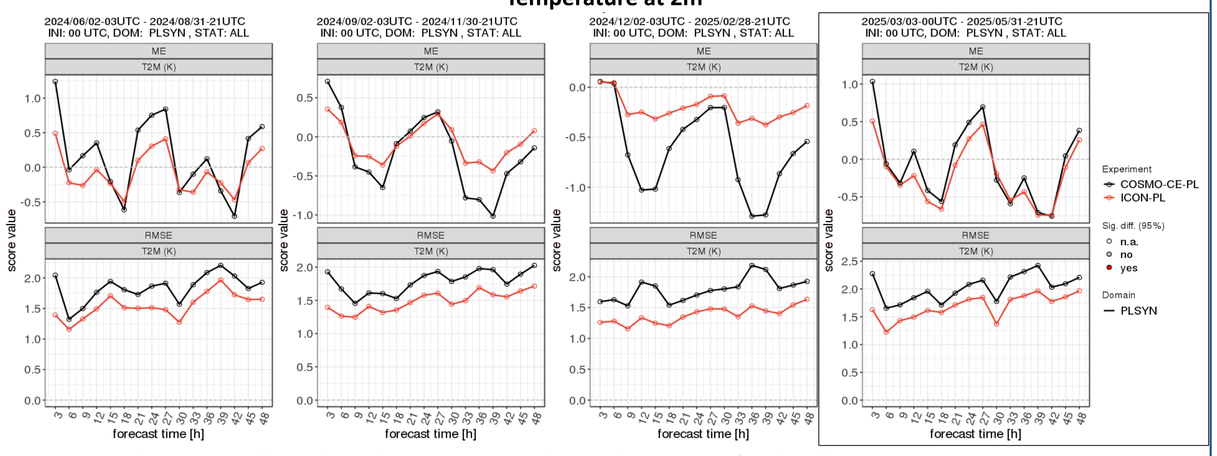
Input/output data for nowcasting forecasting systems

Products (forecasts)	Spatio-temporal resolution	Input to systems:
10-min precipitation sums (RUC mode)	10 min/2.8 km/upto 2 hrs	**SCENE**: nowcasting forecasts of precipitation field with high spatio-temporal resolution
Height of the 0°C isotherm	1 hour/2.8 km/upto 2 hrs	**HAIL**: hail detection (hail probability and size)
Vertical distributions of pressure, temperature & spec. humidity	1 hour/2.8 km/upto 2 hrs	**SPT** (Surface Precipitation Type): detection and nowcasting forecasts of precipitation type

Operational Comparison – ICON-PL vs. COSMO-CE-PL

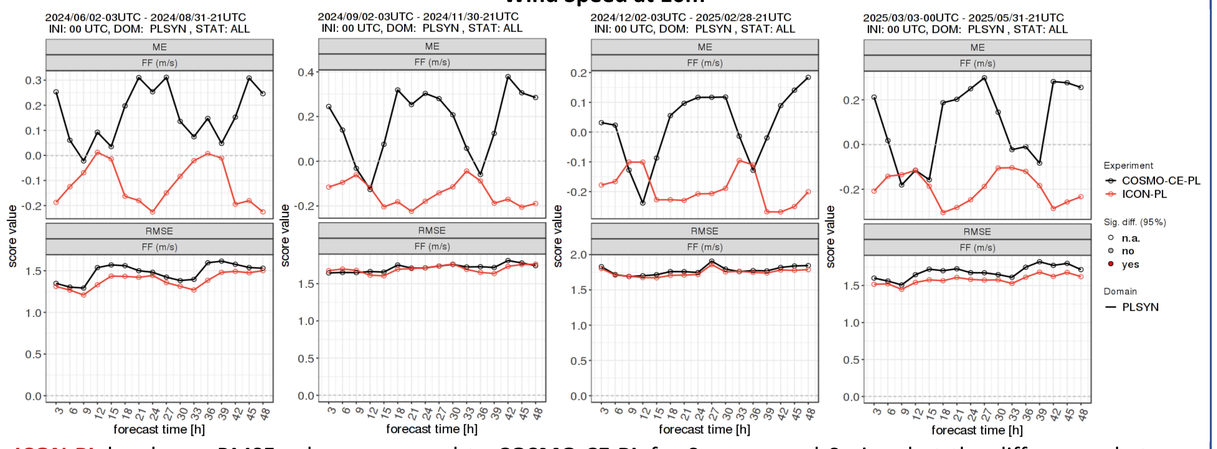
ICON-PL 2.6.2.2 (includes cp/cv bug fix, the RRTM radiation scheme) vs. **COSMO-CE-PL** v 6.01. Verification using MEC/Rfdbk. Verification period: JJA2024-MAM2025. Comparison with Polish SYNOP/TEMP stations.

Temperature at 2m



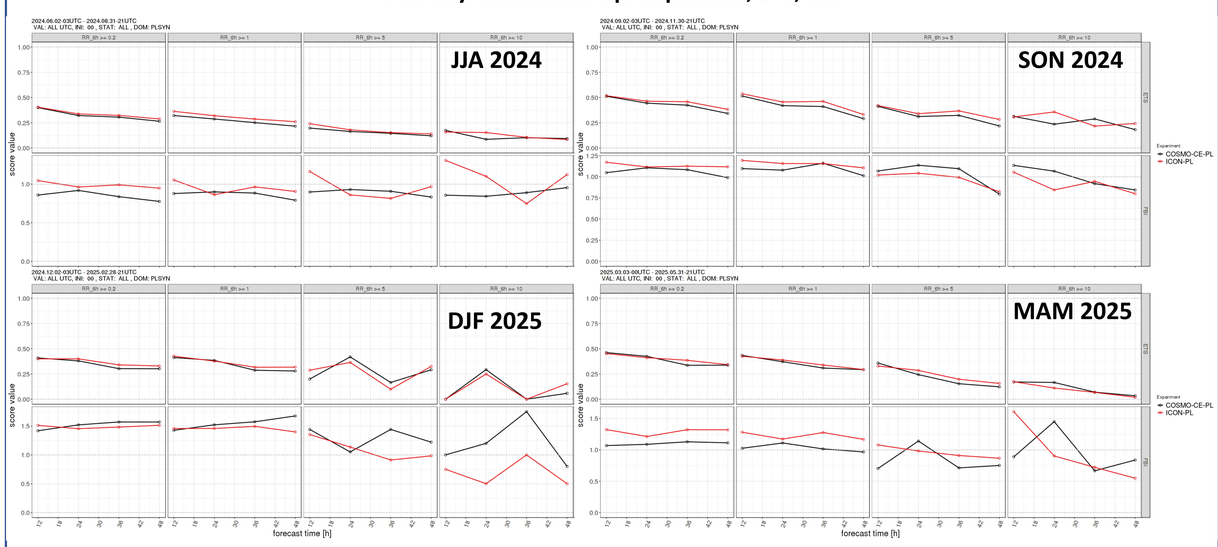
- **ICON-PL** is characterized by reduced RMSE compared to **COSMO-CE-PL** for the all seasons.
- **ICON-PL** is cooler than **COSMO-CE PL** for the most lead times in Autumn and Spring.
- **ICON-PL** is noticeably warmer than **COSMO-CE-PL** in Winter.
- **ICON-PL** forecasts reduce the cold bias, especially in Autumn and Winter during daytime.
- **ICON-PL** has a reduced bias in the diurnal cycle compared to **COSMO-CE PL,** except in Spring. The largest reduction occurs in Winter.

Wind Speed at 10m



- **ICON-PL** has lower RMSE values compared to **COSMO-CE-PL** for Summer and Spring, but the differences between both forecasts are rather small. For nighttime, both models are characterized by increasing biases in all seasons, with a positive bias for **COSMO-CE-PL** and negative bias for **ICON-PL**.
- **ICON-PL** has slightly stronger winds than **COSMO-CE-P**L in Winter and Spring for lead times in the range of 6 to 9 hrs.

6-hourly-accumulated precipitation, ETS, FBI



- Overall, **ICON-PL** has slightly better **ETS** scores than **COSMO-CE-PL**.
- **ICON-PL** usually produces more precipitation (higher **FBI**) than **COSMO-CE-PL** during warm period, and, *vice versa*, less rain (lower **FBI**) during cold period.

Conclusions

- In terms of surface parameters, **ICON-PL** performs better than **COSMO-CE-PL**. In all seasons and for all parameters and lead times (except for surface pressure in the first few hours of the forecast) **ICON-PL** has a reduced or similar RMSE compared to **COSMO-CE-PL**. The greatest relative reduction in RMSE was found for surface pressure at longer lead times (24-48h) in autumn, winter and spring (not presented in the above charts). 6-hourly precipitation is more skillful in **ICON-PL** at drizzle and light rain thresholds than **COSMO-CE-PL**. For the 10 mm threshold the results are less consistent.
- In terms of upper air verification (not shown in charts), **ICON-PL** overall performs better than **COSMO-CE-PL**. **ICON-PL** generally has a reduced or similar RMSE compared to **COSMO-CE-PL** for temperature, wind speed and relative humidity in all seasons. **ICON-PL** is generally less accurate than **COSMO-CE-PL** at the top of the atmosphere for relative humidity and wind speed, as well as for temperature at 100 hPa in winter and spring.

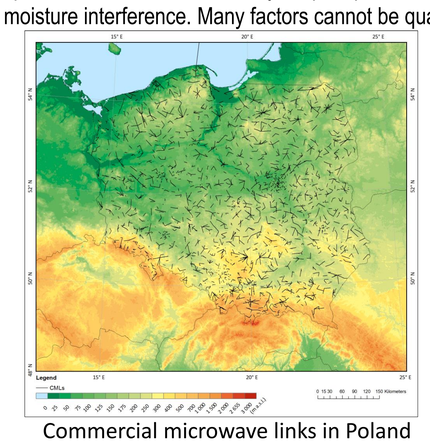
Research & Development

Application of Personal Weather Station and Opportunistic Sensor Data CrowdSourcing – APOCS Priority Project

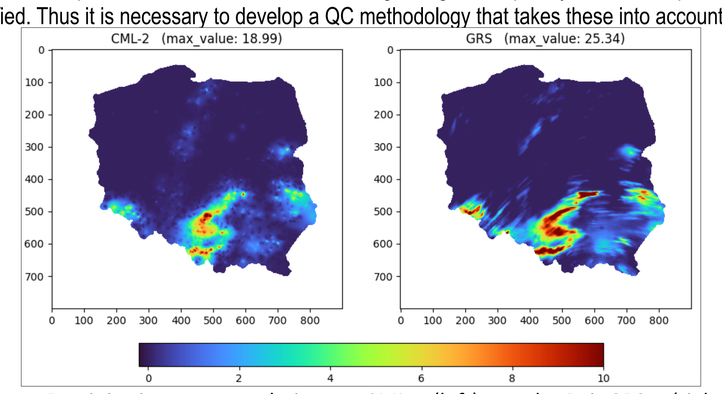
The aim of the work was to develop the results obtained in PT EPOCS - using many sources of meteorological measurement data, including the radar data from OPERA, data from Personal Weather Stations (PWS) and Opportunistic Sensors (OS).

Adaptation of the RainGaugeQC system to CML-based precipitation data

Precipitation based on CMLs has a spatial distribution and error structure that differs significantly from data from point rain gauges or spatial radars. The uncertainty of precipitation estimates depends on factors such as link length, signal frequency, and atmospheric moisture interference. Many factors cannot be quantified. Thus it is necessary to develop a QC methodology that takes these into account.



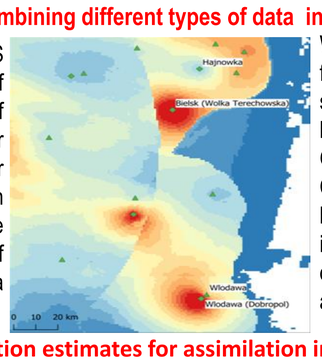
Commercial microwave links in Poland



Precipitation accumulations: CML (left) and RainGRS (right) during the flood Sep. 14th, 2024

Improving RainGRS+ precipitation estimates by combining different types of data in more efficient and seamless manner

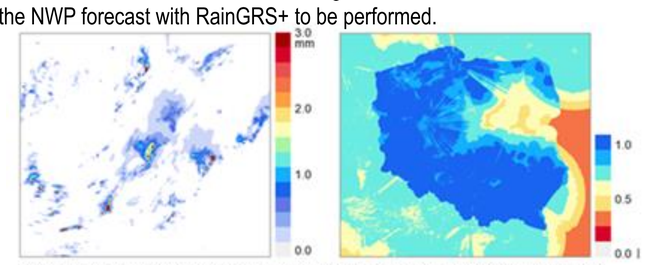
The RainGRS+ system, developed as part of the EPOCS project, requires improvements related to the specifics of the additional data included in the extended "+" version of the system, particularly the inclusion of OPERA radar composite maps. These data, in addition to their lower spatial resolution (~2km), have a different quality, which depends on the institutions providing their data and the QC algorithms they use. This requires the development of a technique to combine radar data of different origins for a seamless merging of POLRAD+ and OPERA data.



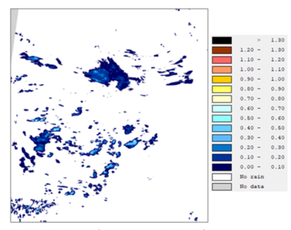
Work is underway to develop a technique for combining radar data from various sources to ensure a seamless connection between POLRAD+ and OPERA data. Once precipitation data from the PWS and CML networks are available, work will begin on developing a methodology for integrating them with RainGRS+. Data quality control algorithms (RainGaugeQC) are currently being adapted to this data.

Application of gridded RainGRS+ precipitation estimates for assimilation in NWP models (COSMO-RUC)

Very short-range precipitation forecasts with COSMO-RUC @IMGW-PIB at 2.8km and LHN data assimilation (DA). Currently DA utilizes radar OPERA SRI precipitation composites at 2km resolution and 15 min frequency. RainGRS+ composite developed in COSMO PT EPOCS includes PWS data at 1km resolution grid and 5-minute time intervals. The performance of new COSMO-RUC setup and the quality of the NWP forecast with RainGRS+ to be performed.



Merged precipitation (RainGRS) and quality index fields (13 June 2022, 12:00 UTC)



RainGRS+ (COSMO 2.8) domain

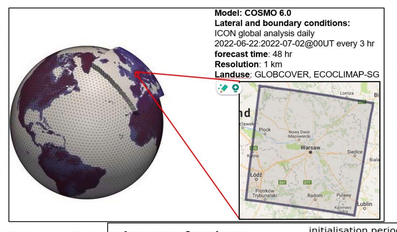
Application of PWS to NWP model verification in urban areas

The TERRA_URB implementation in the COSMO and ICON-LAM models - part of the COSMO PP-CITTA project. Local Climate Zones were incorporated into the TERRA_URB model based on ECOCLIMAP-SG land-use data. Better representation of urban heterogeneity in the NWP at high resolution requires a much denser observation network for model validation. COSMO and ICON-LAM simulations to be evaluated using measurements from PWS or other professional observation networks operated by independent agencies. Currently, three possible nested domains are being considered. Two of them are based on the operational ICON 2k5 IMWM forecasting system. The **Warsaw domain** was introduced in the PP CITTA project. It is also possible to create a high-resolution forecasting system for **Poland** with a **1-km** resolution based on ICON 2k5 or directly through ICON EU. The simulations will be performed using TERRA_URB, and in addition to PWS data, the RainGRS system will be used to verify the precipitation fields.

City Induced Temperature change Through Advanced modelling – CITTA Priority Project

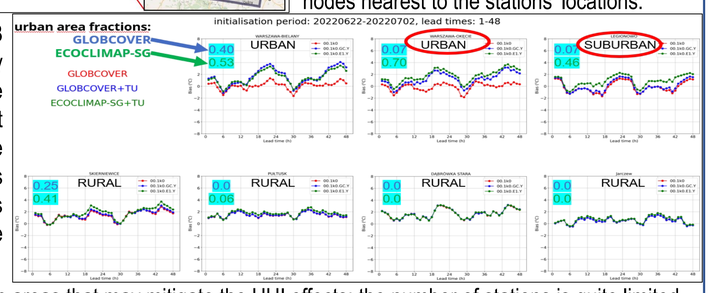
The recent advancements in urban parameterisation within the Consortium for Small-scale Modeling (COSMO), specifically focusing on incorporating Local Climate Zones (LCZs) using ECOCLIMAP-SG land use data for the TERRA-URB urban scheme. The set of the COSMO model simulations at the sub-kilometre scale for Warsaw agglomeration is carried out to justify the added value of using the urban scheme and ECOCLIMAP-SG dataset. The simulation results are compared with meteorological measurements from the surface stations at an hourly resolution. The investigated period covers a heat wave case at the end of June and the beginning of July 2022. The evaluation is performed considering the dependence of the model performance on lead time 48 hours ahead, separately for urban and rural stations

The model domain covers approximately one hundred square kilometres. The initial and boundary conditions are taken from the global ICON analysis every 3 hours. Hindcasts were initialised at 00UT every day from the 20th of June to the 1st of July 2022 and ran for 48 hrs ahead at 1-kilometre horizontal resolution.



NHMS's temperature data were used at hourly resolution. There are 2 stations in urban areas, one in the suburbs, and 4 in rural regions. It is worth noting that all stations are maintained according to WMO rules for surface meteorological stations. The model evaluation is performed on the model nodes nearest to the stations' locations.

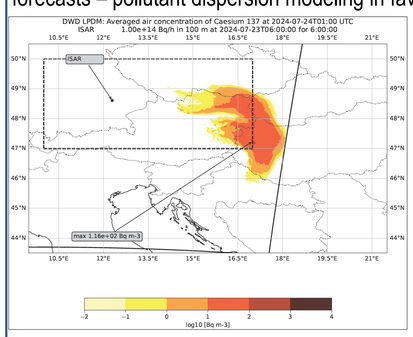
The surface temperature (COSMO model + TERRA_URB land-surface scheme) for the heatwave case appropriately responds to urban cover: The higher the temperature, the higher the urban cover; daily cycle follows the urban heat island pattern. The simulated series do not align with the observed ones as the model's urban cover at stations does not represent the existing ones at station locations and/or the stations are not representative of the surrounding area at the model's horizontal resolution.

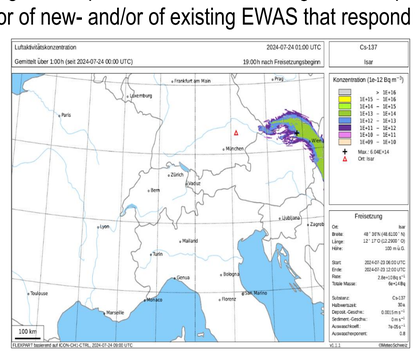


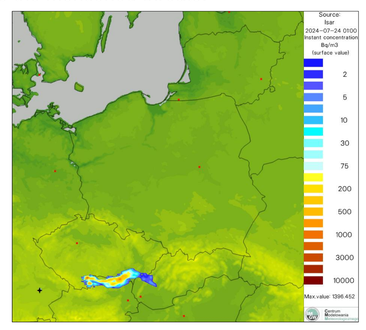
Limitations: simulation doesn't consider plant cover in urban areas that may mitigate the UHI effects; the number of stations is quite limited.

Early warninG and AnaLysIs sysTEm for release and dispersion of contaminants – EGALITE COSMO Priority Task

The aim of the task – gathering/exchange of the experience available among COSMO partners on the connection: numerical weather forecasts – pollutant dispersion modeling in favor of new- and/or of existing Early-Warning Systems that respond to the threats related to releases of contamination, dangerous due to its nature (i.e., radioactive, toxic…) and/or emission intensity. There's a need for improvement/ EWAS being able to respond to release of toxic and/or harmful substances into the atmosphere. "Early Warning" is the ability to quickly provide information about the occurrence of an event and its possible consequences. Released contaminations are dangerous due to its nature (radioactive, toxic) and/or emission intensity. Operational EWAS use meteorological data (an output from operational forecast models). PT EGALITE aims at gathering/exchange the experience available among COSMO partners on the connection: numerical weather forecasts – pollutant dispersion modeling in favor of new- and/or of existing EWAS that respond to the mentioned threats.







The setup of "dry runs" for release of radioactive material from NPP of Isar, Germany – location in domains

Comparison of results

FSS for first dry run
Left to right Concentration, dry- and wet deposition

FSS for second dry run
Left to right Concentration, dry- and wet deposition