Evaluation of ICON-LAM and COSMO high-resolution simulations with urban parameterisation for Warsaw, Poland

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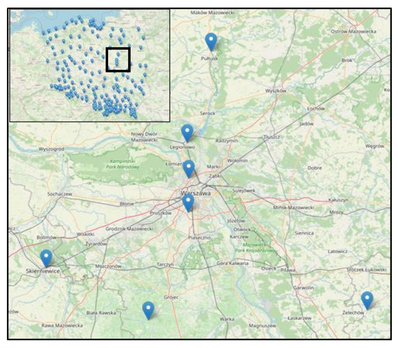
SCREEN CAPTURE WELCOME

Introduction

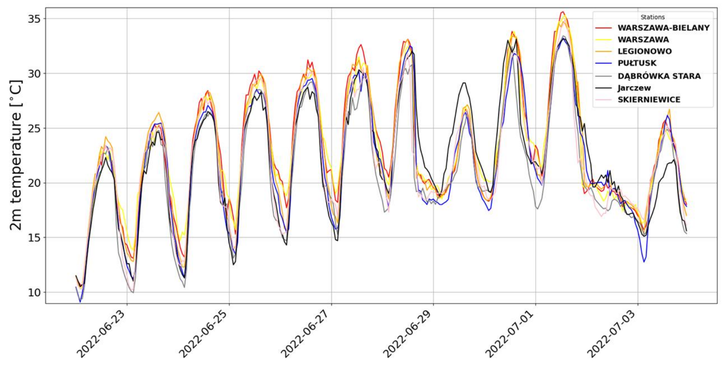
The rapid development of urban areas and the impacts of global climate change make cities increasingly vulnerable to environmental challenges, including extreme weather and climate events. While operational numerical weather prediction (NWP) models are crucial in supporting emergency management systems, they often lack the necessary details and do not adequately account for the complex physical interactions between buildings, artificial surfaces, and meteorological processes. Improving these models is vital to enhance weather prediction accuracy in urban areas, offering better preparation and response to emergencies. Such advancements are crucial for protecting urban populations and infrastructure from the impacts of climate change and urbanization. This work presents the results of evaluating NWP hindcasts at hectometric scales for Warsaw agglomeration. Warsaw is the capital of Poland, located at the Vistula River in the greater North European Plain. Its population is estimated at 1.8 million residents within a greater metropolitan region of 3.1 million. An observed temperature increase is attributed to urban development and is intensifying during this century. Land use changes lead to a rise in the UHI effect and urban ventilation, triggering flash flood hazards.

Study area and case period

For the test simulation, a period of **heat wave and strong convection** in the city area was selected, covering the end of June and the beginning of July 2022. The National Hydrological and Meteorological Service's measurement and observation data were used. During this period, on 26-28 June, the maximum temperature in urban areas exceeded 30°C, and on 30 June and 1 July**, the highest monthly temperatures** of 34°C and 36°C, respectively, were observed. On 1 July, the front passed through with heavy, followed by rapid cooling.



The stations in the area of interest.



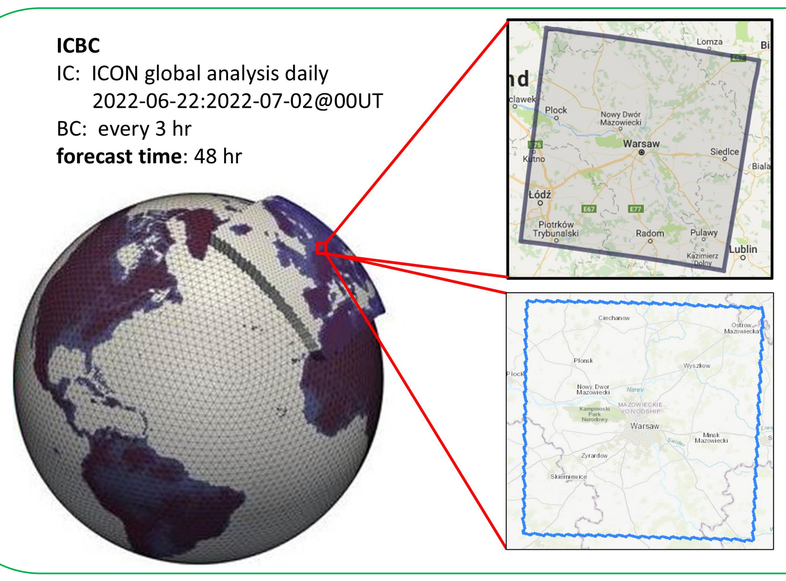
The courses of near-surface temperature at stations in the analysed period.

Model configuration

The models' domains cover approximately 100 x 100 km2. The COSMO and ICON-LAM models are tested at 1 km and 600 m resolutions, respectively. GLOBCOVER and ECOCLIMAP-SG are used for COSMO simulation, and ICON-LAM is run with GLOBCOVER. The models have implemented a bulk urban canopy parameterisation, TERRA_URB (Wouters et al. 2016, 2017), which uses spatially variable urban canopy fields based on the Local Climate Zones (LCZ) approach and ECOCLIMAP-SG for the COSMO. In the GLOBCOVER case, the urban parameterisation utilises one artificial class that characterises impervious urban areas in cities.

The initial and boundary conditions are the global ICON analysis. Hindcasts were initialised at 00UT every day from 22 June to 1 July 2024 and ran for 48 hours.

ICBC
IC: ICON global analysis daily
2022-06-22:2022-07-02@00UT
BC: every 3 hr
forecast time: 48 hr



COSMO
Resolutions:
- ❖ 1 km

Landuse:
- ❑ GLOBCOVER
- ❑ ECOCLIMAP-SG

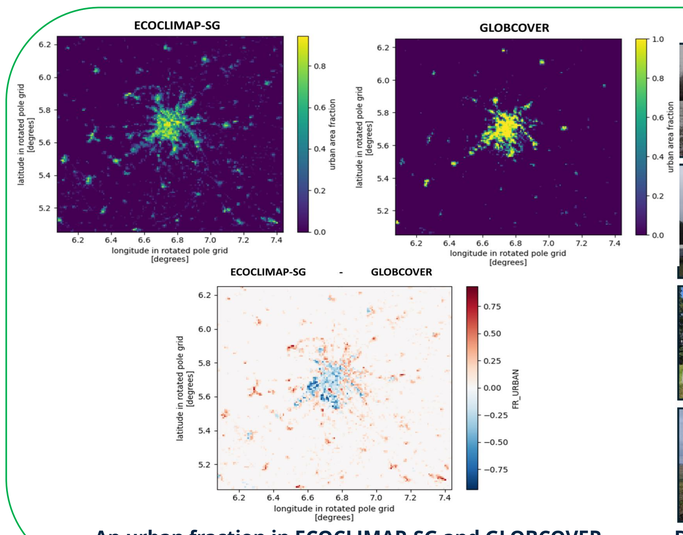
ICON
Resolution
- ❖ 600 m
- ❖ no TERRA_URB

Landuse:
- ❑ GLOBCOVER

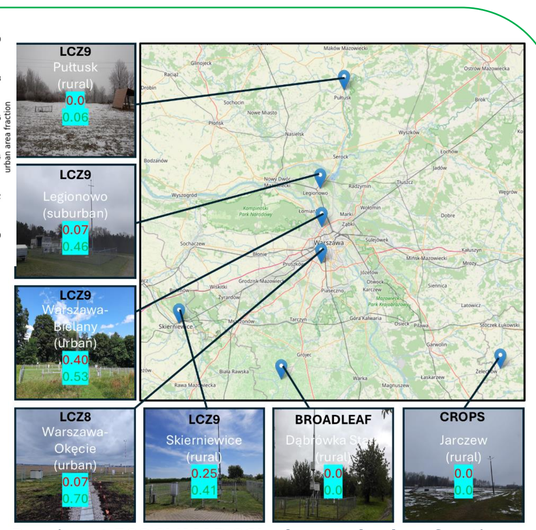
Landuse and stations' characteristics

Landuse datasets are utilised to generate fields of surface physical parameters on the model target grid using an aggregation procedure made by the EXTPAR module based on lookup tables. The tables consist of the values of the parameters for every land use class. As an example of the resulting fields on the model target grid, we show the **differences between the urban area fraction fields for ECOCLIMAP-SG and GLOBCOVER**.

The model evaluation is performed on the model nodes nearest to the stations' locations. The distinction between the two land use datasets results in different physical characteristics of the stations' nodes regarding urban fraction and physical parameters. It is worth noting that the individual node is sitting of fractions aggregated land use classes, not the predominant one.



An urban fraction in ECOCLIMAP-SG and GLOBCOVER and their difference.



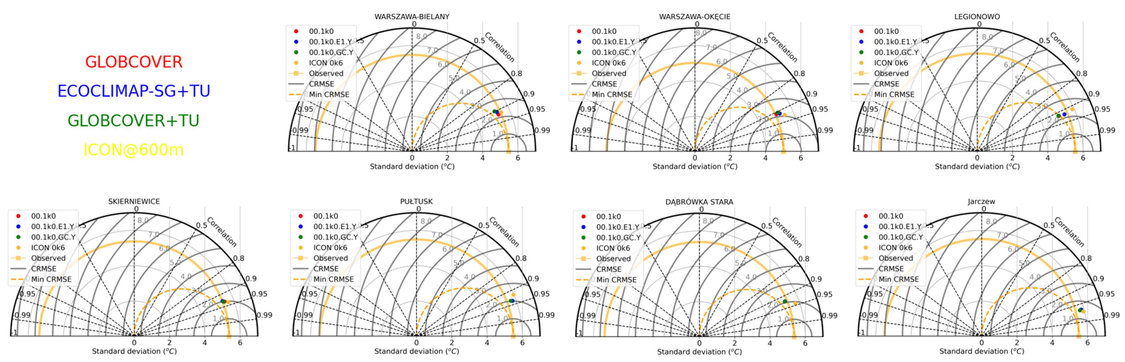
Dominant ECOCLIMAP-SG's class and urban fractions (GLOBCOVER, ECOCLIMAP-SG) for the stations.

Results and discussion

- Using TERRA_URB and ECOCLIMAP-SG does not have a clear impact on better reproduction of observed temperature in urban areas
- In rural areas, simulated COSMO results differ slightly, which follows the expectations
- GLOBCOVER based ICON-LAM simulations without TERRA_URB mostly reproduce the worst observed temperatures
- The obtained results are possibly affected by different characteristics of the sites in landuse datasets and the unrepresentativeness of the datasets to stations' locations and measurements

initialisation period: 20220622-20220701, lead times: 1-48

GLOBCOVER
ECOCLIMAP-SG+TU
GLOBCOVER+TU
ICON@600m



Evaluation results for individual stations employing Taylor diagrams.

Summary and outlook

- ICON-LAM and COSMO hindcasts have been evaluated for heatwave case in the Warsaw domain
- No clear improvement has been found with ECOCLIMAP-SG utilising LCZ approach landuse and TERRA_URB urban parametrisation
- Accurate landuse datasets, along with representative measurements, are crucial for the improvement of NWP in urban areas
- Other meteorological parameters should be tested (relative, wind, soil/surface temperature, precipitation), including vertical profiles and remote-based variables
- The evaluation should cover longer periods, including variable synoptic conditions

References

Wouters, H., M. Demuzere, U. Blahak, K. Fortuniak, B. Maiheu, J. Camps, D. Tielemans and N. P. M. van Lipzig, (2016): The efficient urban canopy dependency parametrization (SURY) v1.0 for atmospheric modelling Description and application with the COSMO-CLM model for a Belgian summer. Geosci. Mod. Dev., 9, 3027-3054. DOI 10.5194/gmd-9-3027-2016.

Wouters, H., M. Varentsov, U. Blahak, J.-P. Schulz, U. Schättler, E. Bucchignani and M. Demuzere, (2017): User guide for TERRA_URB v2.2 The urban-canopy land-surface scheme of the COSMO model, Ghent University, 12 pp. (Available at the Cosmo site).

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MODELE IMGW-PIB modele.imgw.pl

CONSORTIUM FOR SMALL SCALE MODELING COSMO

citask

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