Main field: Earth Sciences & Environment

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"Integrated urban environmental modeling: From development to implementation"

Our research initiative focuses on the combined examination of urban climate and atmospheric pollution through an integrated methodology employing high-resolution numerical modeling and data fusion techniques. This approach seamlessly merges urban scale large-eddy simulations, performed at a meter-scale using the PALM code (Parallelized Atmospheric Large-eddy Simulation Model), with a kilometer-scale meteorological simulations conducted with the Enviro-HIRLAM code (High Resolution Limited Area Model). To enhance the precision and details of environmental assessments and predictions, we will integrate remote-sensing and citizens' data into modeling results. This integrated approach will ensure comprehensive understanding of urban environmental dynamics.

Background Information

More than 70% of the European Union population is directly impacted by urban climate and air quality issues. However, addressing these concerns has proven to be exceptionally challenging. Even smaller urban areas are characterized by complex surface geometries, elevated concentrations and emissions at ground level, and significant deviations from typical local climate patterns. These factors influence performance of meteorological and air quality models, render regular observations inadequate and incomplete, and make statistical interpolation methods less accurate.

On the observational side, there exists a large amount of data sources, including various monitoring networks, research infrastructures, and invaluable citizens' observations. Effective solutions depend on application of advanced data fusion and interpolation techniques, as shown by Johansson et al. (2015) and Schneider et al. (2017). Such techniques can produce user-friendly and high-resolution environmental quality maps. However, these techniques are computationally intensive and require access to high-performance computing resources.

On the modeling side, we have well-established integrated modeling systems capable to provide detailed meteorological and air quality information down to the spatial scale of a few kilometers, as described by Baklanov et al. (2017a). Nevertheless, such modeling chains lack the critical final component, namely, detalisation of street-level information. This missing link is essential to make the data relevant and actionable for stakeholders, as recognized by Baklanov et al. (2017b).

In previous collaborative project (High-Resolution Integrated Urban Environmental Modeling; Esau et al., 2021) we made progress in developing and demonstrating key components of the numerical modeling technology required to bridge this knowledge gap. The PALM modelling system has undergone significant development over the last years, and currently the version 23.04 is available. This version includes internal nesting and external coupling with meso-scale models, such as WRF, ICON, and to some degree with numerical weather prediction MEPS. In this project, we aim to establish connections to larger-scale models through the Enviro-HIRLAM seamless modelling chain. We are at the point when we cross from development to implementation. Our proposal considers high-performance computing-related aspects of this technology. It will lead to seamless integration of meteorological models and urban observational data, incorporating the turbulence-resolving PALM model, and ultimately bridging the gap between model predictions and on-the-ground reality.

References:

Johansson et al. (2015). Fusion of meteorological and air quality data extracted from the web for personalized environmental information services. Enviromental Modeling and Software, 64, 143–155. https://doi.org/10.1016/j.envsoft.2014.11.021

Schneider et al. (2017). Mapping urban air quality in near real-time using observations from low-cost sensors and model information. Environment International, 106, 234–247. https://doi.org/10.1016/j.envint.2017.05.005

Baklanov et al. (2017a). Enviro-HIRLAM online integrated meteorology–chemistry modelling system: strategy, methodology, developments and applications (v7.2). Geoscientific Model Development, 10, 2971–2999. https://doi.org/10.5194/gmd-10-2971-2017

Baklanov et al. (2017b). From urban meteorology, climate and environment research to integrated city services. Urban Climate. https://doi.org/10.1016/j.uclim.2017.05.004

Esau, I., Bobylev, L., Donchenko, V., Gnatiuk, N., Lappalainen, H. K., Konstantinov, P., Kulmala, M., Mahura, A., Makkonen, R., Manvelova, A., Miles, V., Petäjä, T., Poutanen, P., Fedorov, R., Varentsov, M., Wolf, T., Zilitinkevich, S., & Baklanov, A. (2021). An enhanced integrated approach to knowledgeable high-resolution environmental quality assessment. Environmental Science & Policy, 122, 1–13. https://doi.org/10.1016/j.envsci.2021.03.020