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Assessment of the optimal initial and boundary conditions for the LES-based model PALM

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Proper assessment of urban atmosphere and climate by physics-based Computational Fluid Dynamic (CFD) models has been a pressing topic in the urban modeling community. Due to the ever-increasing number of city dwellers, continuous urbanization, and consequent modification of the urban atmosphere, this topic is and will remain popular in the future. The most advanced microscale models widely used for urban boundary layer studies, typically based on the Large Eddy Simulation (LES) principle, are currently the ones whose higher accuracy and ability to capture physical processes in the urban atmosphere have been well-validated. However, to fully assess their reliability, the necessity of testing the influence of the initial and boundary conditions (IBC) on the model outputs is a crucial issue that needs to be addressed.
Four different three-day episodes throughout the year 2019 have been modeled using the PALM model system for experiment purposes. Two of the episodes encompass extreme weather events (e.i., a heatwave and a bad air quality period), and the other two episodes are chosen to represent non-extreme and usual weather conditions. In this experiment, an ensemble of 16 different WRF model realizations differing in parameterization setup is created and it serves as a source of IBC for the PALM model simulations. Firstly, a method for optimal WRF ensemble member selection has been developed, based on which subgroup of the ensemble members has been selected for driving the microscale model. The microscale model 8 x 8 km simulation domain is located in the realistic urban area in the city of Prague, its horizontal resolution is 10m. Altogether, 14 simulations have been performed with identical configurations except for the driving conditions. The PALM model outputs have been evaluated against radio-soundings, and compared to the WRF model driving conditions, both quantitatively and qualitatively.
This study shows that PALM model outputs are largely influenced by the imposed driving conditions and that the majority of errors originate from the mesoscale model, and propagate into the microscale simulation. The sensitivity of the microscale model on different IBCs is significant, but the PALM model is capable of attenuating the errors coming from the WRF model. Finally, the experiment stresses the importance of high-quality driving data and shows the complexity of the process of acquiring such data.