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3E.1: Three Perspectives on a Small-Scale Urban Wind Field: Comparing Reality, Wind Tunnel Experiments and Model Simulations

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City College of New York - SH - 207

Urban wind fields are highly variable in space and time due to ever-changing surfaces and obstacles within the roughness sublayer. The estimation of local wind conditions at a certain point of interest is a challenge for researchers and urban planners, while being highly relevant to ensure the quality of life in growing cities. Nowadays numerical models are utilized to get information about small-scale wind variability. Yet the resolution of most operational urban models is still too coarse to detect variations at a sub-building scale. Wind tunnel experiments allow for a detailed view around structures, while requiring a simplification of the shape and morphology. The most accurate wind data can be gathered by high resolution measurements in the real environment, but they are often limited in time, costly and can only provide information on selected spots, as the number of mounted instruments is limited.

This dilemma leads to the question: How can these three methods for wind field estimations at the very small scale in urban areas be usefully combined to obtain more comprehensive information on the wind conditions at a particular spot of interest?

The aim of this study is to detect the strong and weak-points of each method as well as to find a way to combine them. For this, the wind conditions along a large building in a rapidly developing city district are studied using all three methods. The target area is located at the river Elbe directly in the city centre of Hamburg, Germany. It was selected, as it features comparably simple incident flow conditions from the river. This simplifies the implementation of the area in numerical and wind tunnel models simulating the flow over and around the building.

The study’s first pillar are high resolution measurements in the real environment. A two-tier approach is applied in the experiment setup by measuring both the forcing and the local response to set up a well-defined test case. The undisturbed inflow conditions are measured by two wind masts, a wind LiDAR and a tethered balloon. The detailed structure of the flow on the north side of the building is detected by an array of twelve 3D-sonic anemometers mounted at six wind masts at 3 and 6 m above the street. Data from this array is recorded at 20 Hz to provide comprehensive insights into the spatial and temporal structure of turbulent flows. Intensive observation periods carried out at this site during four weeks in summer and winter 2017 provide data of various wind conditions.

Systematic and predefined boundary layer wind tunnel experiments are the second pillar of this study. Corresponding measurements for selected preferential flow directions are performed, allowing for an analysis of the full three-dimensional flow structure, thereby providing reliable information on the representativeness of local measurements.

As a third pillar, high resolution numerical simulations of the study area are carried out by the Parallelized Large-eddy Simulation Model (PALM) for the area of interest. Simulations feature a horizontal and vertical resolution of 1 m to get most accurate §D wind information as well as high resolution time series for specific measurement locations. Thus the simulations resolve the largest part of the turbulence generated by urban structures.

We will present a critical evaluation of these three complementary estimations of the wind field and demonstrate how these methods can be combined effectively.

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