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UrbanTALES: A comprehensive dataset of Urban Turbulent Airflow using systematic Large Eddy Simulations

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The urban canopy layer (UCL) is characterized by a heterogeneous flow pattern that responds to heterogeneous urban geometries. The varying heights and layouts of buildings play a pivotal role in shaping this spatial variability, as they block, divert, and slow wind and determine the exchange of momentum and energy above the urban canopy. When representing these complex dynamics, however, research has conventionally relied on microscale simulations conducted over limited (often idealized) building arrays. Extending the findings to realistic urban neighborhoods and urban parameterizations presents a clear limitation, as evidenced by discrepancies in multi-model comparisons with observational data in cities.

More extensive datasets of urban airflow are needed to cover a range of realistic urban neighborhoods and provide a more holistic analysis of turbulent flow in different urban characteristics. Responding to this gap in the field, we developed a historically extensive and comprehensive dataset of Urban Turbulent Airflow based on state-of-the-art Large Eddy Simulations (UrbanTALES). The dataset includes 400 urban layouts with both idealized and realistic configurations. Realistic urban neighborhoods were obtained from major cities worldwide, incorporating variations in plan area densities [0.0625-0.64] and height distributions [4-70m]. Idealized urban arrays, on the other hand, include two commonly studied configurations (aligned and staggered arrays), featuring both uniform and variable height scenarios along with oblique wind directions.

UrbanTALES offers canopy-averaged data as well as 2D and 3D flow fields tailored for different applications in urban climate research. The dataset provides time-averaged wind flow properties, as well as second- and third-order flow moments that are critical for understanding turbulent processes in the UCL. Here, we describe the UrbanTALES dataset and its application, noting the unique opportunity to deploy a comprehensive representation of realistic urban neighborhoods for a) revisiting neighborhood-scale urban canopy parameterizations in various models and b) informing in-canopy flow and turbulent analyses. Furthermore, we discuss the application of this dataset for training Machine Learning algorithms for pedestrian wind speed.