Combining wind tunnel modeling and numerical simulation to study turbulence and dispersion in planetary boundary layer flows

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Numerical modeling/simulation and wind tunnel modeling (which is a part of a broader methodology of physical modeling) will be presented as techniques inherently related within a triad of modern approaches to study atmospheric boundary layer (ABL), which also includes, as a cornerstone approach, field measurements and observations of the ABL. An overview will be given of neutral and convective atmospheric flows modeled in wind tunnels and investigated, in conjunction, using numerical techniques of different levels of complexity.
Typical approaches toward wind modeling of neutrally stratified turbulent atmospheric surface/boundary layer flow will be described and features of modeled flows will be discussed within a context of fulfillment of scaling and similarity requirements. Dispersion from a ground source in the neutral boundary layer flow will be analyzed in detail from the perspective of both wind tunnel and numerical modeling approaches.
The second part of the presentation will focus on coupling the wind tunnel modeling and numerical large eddy simulation (LES) to study turbulence and dispersion in the sheared atmospheric convective boundary layer (CBL) flow. Different measurement and flow visualization techniques applied to elucidate flow structure in the wind tunnel CBL will be demonstrated. Visualized flow patterns from the tunnel will be compared with visualizations of numerically simulated flow fields. Technical aspects of employment of LES methodology to reproduce spatially evolving CBL will be discussed. Mean flow properties and turbulence statistics for typical CBL flow regimes investigated numerically will be analyzed in comparison with wind tunnel data. Atmospheric CBL measurement data available for validation of the employed modeling/simulation techniques will be touched upon as well. Properties of dispersion in the spatially evolving CBL will be illustrated through the case of non-buoyant tracer emitted from a point source located at different elevations within the CBL. Additionally, using wind tunnel data in conjunction with LES output for feeding a Lagrangian model of dispersion in sheared CBL will be demonstrated.
Overall, a combination of wind tunnel modeling with high-resolution numerical simulation appears to be an attractive hybrid approach that allows to enhance, in a complementary way, capabilities if its individual constituents.