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Simulating, Measuring, and Parameterizing Turbulent Boundary Layer Flow over Multi-Scale, Fractal Canopies

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In many regions the atmospheric surface layer is affected substantially by vegetation canopies. Most previous work has focused on effects of vegetated terrain characterized by a single length scale, e.g. a single obstruction of a particular size, or canopies consisting of plants, often modeled using a prescribed leaf-area density distribution with a characteristic dominant scale. It is well known, however, that typical flow obstructions such as canopies are characterized by a wide range of length scales, branches, sub-branches, etc.. Yet, it is not known how to parameterize the effects of such multi-scale objects on the lower atmospheric dynamics. This work aims to study boundary layer flow over fractal, tree-like shapes. Fractals provide convenient idealizations of the inherently multi-scale character of vegetation geometries, within certain ranges of scales. We report on Large Eddy Simulations whose results are compared with a ongoing experiments that also aim at understanding drag forces acting on fractal trees. The experiments are performed in a water tunnel facility that uses optically index-matched fluid. This enables to access the full 3-D flow volume with Particle-Image-Velocimetry. The measurements complement computer simulations using LES, and the aim is to use the results to develop downscaling parameterizations for unresolved branch drag forces with a technique called Renormalized Numerical Simulation (RNS).

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