TURBULENCE STRUCTURE IN A FRACTAL FOREST UNDER VARYING ATMOSPHERIC CONDITIONS

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ABSTRACT

Canopy flow for homogeneous atmospheric conditions and neutral thermal stratification is well studied [1, 2]. Since the pioneering large-eddy simulation (LES) of Shaw and Schumann [3], the forest stands have been treated as a porous body of horizontally uniform (leaf) area density LAD(z) with constant drag coefficient C_D. This approach is sometimes called field-scale approach. Current finer scale applications and field campaigns consider the heterogeneity of the canopies (so called plant-scale approach).

Here, we investigate the turbulence structure of a heterogeneous forest stand by high-resolution numerical modeling using EULAG (Eulerian/semi-Lagrangian geophysical fluid solver) [4]. For this purpose, the forest elements in the numerical simulation are mimicked with immersed boundaries, representing fractal Pythagoras trees (Fig. 1). This approach was recently used to model neutrally and stably stratified air flow past buildings [5] and ground water flow through porous media [6]. In contrast to studies of neutral flow past a single 3D fractal tree [7], we observe a wide range of scales (5 cm - 100 m). Vortex shedding behind individual branches or trunks is resolved as well as the integrated response of the Pythagoras grove on the flow. Our neutral reference run produces physical meaningful results in the turbulence statistics, that are quantitatively comparable to former field-scale LES and wind tunnel experiments.

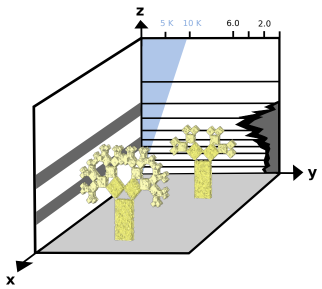

Figure 1: Pythagoras grove

A focus of our study is the investigation of the turbulence structure due to different thermal background stratification and heating/cooling of the crown space. Besides statistical quantities (e.g. turbulent kinetic energy, vorticity, power spectra and energy flux), onset and formation of coherent structures are investigated. We observe temperature ramps and thermals above the forest canopy. Inside the canopy, vortex shedding behind the individual branches has a considerable effect on e.g. the energy spectrum as observed in field-experiments [8].

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