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Development of a canopy stress method for large-eddy simulation over complex terrain

by
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Abstract

Abstract Numerical simulation is increasingly being used for atmospheric flow over complex terrain. Large-eddy simulation (LES) is a high-resolution technique in which a subgridscale model is necessary to solve the filtered Navier-Stokes equations (NSE). In addition to a high-quality mesh over complex terrain, classical LES techniques require to solve additional transport equations and use costly test-filtering operations. Nevertheless, such methods do not provide a widely accepted estimate for the turbulence-induced load on buildings, forests, mountains, etc.

In this talk, I will outline how to overcome some of the limitations of the LES technique for flow over complex terrain. In my Ph.D. study, the terrain is represented as a voxelized canopy, and the subgrid-scale stress of the canopy is represented as a quadratic function of the filtered velocity. To incorporate the energy dissipation associated with such canopy stress, the turbulent eddy viscosity is defined by the traceless symmetric part of the square of the velocity gradient tensor. I have tested the canopy stress methodology against the data collected from wind tunnel measurements of turbulent flow over forest-like and mountain-like obstacles at low Reynolds number Re. The results indicate that the canopy stress model can learn from idealized experiments and thus predict turbulence of real-scale complex terrain in the atmosphere. Considering the limitation of field-measurements and the lack of availability of high-performance computers, a turbulence modeling framework is developed using C++ programming to analyze the scale-invariant hypothesis for turbulent flow over complex terrain.