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Subgrid-scale drag modeling for fractal trees: a dynamic downscaling approach

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LES ideas, in particular the dynamic model (Germano et al., 1991), are extended and applied to the problem of SGS drag modeling for flow over trees. The SGS branch drag coefficient is determined as in dynamic LES modeling by enforcing model consistency between SGS branches and the smallest resolved branches, and assuming scale invariance of the drag coefficient. Dependence of the drag coefficient on the geometrical configuration of the branch (e.g. orientation relative to the incoming flow) is allowed for in the formulation, which results in a linear system for the drag coefficients. The spatial distribution of the SGS drag force is determined by downscaling the distribution measured from the smallest resolved branches. Results are obtained by performing LES of high-Re turbulent flow over idealized leafless, self-similar fractal trees as a test case. A posteriori tests show that the dynamic drag coefficients are stable in many cases, although less robust coefficients are associated with trees with a high degree of branching. The total SGS drag force is observed to be a significant fraction of the total drag force on the tree, highlighting the importance of the drag model. Observed nontrivial dependence of the dynamically obtained drag coefficients on branch orientation will also be presented.