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Andreas Acrivos Dissertation Award Talk: Modeling drag forces and velocity fluctuations in wall-bounded flows at high Reynolds numbers

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The sizes of fluid motions in wall-bounded flows scale approximately as their distances from the wall. At high Reynolds numbers, resolving near-wall, small-scale, yet momentum-transferring eddies are computationally intensive, and to alleviate the strict near-wall grid resolution requirement, a wall model is usually used. The wall model of interest here is the integral wall model. This model parameterizes the near-wall sub-grid velocity profile as being comprised of a linear inner-layer and a logarithmic meso-layer with one additional term that accounts for the effects of flow acceleration, pressure gradients etc. We use the integral wall model for wall-modeled large-eddy simulations (WMLES) of turbulent boundary layers over rough walls. The effects of rough-wall topology on drag forces are investigated. A rough-wall model is then developed based on considerations of such effects, which are now known as mutual sheltering among roughness elements. Last, we discuss briefly a new interpretation of the Townsend attached eddy hypothesis-the hierarchical random additive process model (HRAP). The analogy between the energy cascade and the momentum cascade is mathematically formal as HRAP follows the multi-fractal formulism, which was extensively used for the energy cascade.