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Physical consistency of subfilter-scale models for large-eddy simulation of incompressible turbulent flows

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Abstract Most practical turbulent flows cannot be computed directly from the Navier-Stokes equations, because not enough resolution is available to resolve all relevant scales of motion. We therefore turn to large-eddy simulation to predict the large-scale behavior of incompressible turbulent flows. In large-eddy simulation, the large scales of motions in a flow are explicitly computed, whereas effects of small-scale motions are modeled using subfilter-scale models. We study the construction of subfilter-scale models for large-eddy simulation, focusing on consistency with important mathematical and physical properties. In the current presentation we will, in particular, focus on the preservation of the symmetries of the Navier-Stokes equations by subfilter-scale models, and on their compliance with the near-wall scaling, dissipation behavior and realizability of the true turbulent stresses. We will show that existing subfilter-scale models do not all satisfy the desired properties, and we discuss new 'physically-consistent' subfilter-scale models that are nonlinear in the local velocity gradient.

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