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Large-eddy simulations of the restricted nonlinear system[1] JOEL BRETHEIM, DENNICE GAYME, CHARLES MENEVEAU, Johns Hopkins University — Wall-bounded shear flows often exhibit elongated flow structures with streamwise coherence (e.g. rolls/streaks), prompting the exploration of a streamwise-constant modeling framework to investigate wall-turbulence. Simulations of a streamwise-constant (2D/3C) model have been shown to produce the roll/streak structures and accurately reproduce the blunted turbulent mean velocity profile in plane Couette flow. The related restricted nonlinear (RNL) model captures these same features but also exhibits self-sustaining turbulent behavior. Direct numerical simulation (DNS) of the RNL system results in similar statistics for a number of flow quantities and a flow field that is consistent with DNS of the Navier-Stokes equations. Aiming to develop reduced-order models of wall-bounded turbulence at very high Reynolds numbers in which viscous near-wall dynamics cannot be resolved, this work presents the development of an RNL formulation of the filtered Navier-Stokes equations solved for in large-eddy simulations (LES). The proposed LES-RNL system is a computationally affordable reduced-order modeling tool that is of interest for studying the underlying dynamics of high-Reynolds wall-turbulence and for engineering applications where the flow field is dominated by streamwise-coherent motions.

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