Abstract Submitted
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Non-equilibrium three-dimensional boundary layers at moderate Reynolds numbers[1] MARCO G. GIOMETTO, Department of Civil Engineering and Engineering Mechanics, Columbia University, New York 10027, ADRIAN LOZANO-DURAN, Center for Turbulence Research, Stanford University, California 94305, GEORGE I. PARK, Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania, Pennsylvania 19104, PARVIZ MOIN, Center for Turbulence Research, Stanford University, California 94305 — Non-equilibrium wall turbulence with mean-flow three-dimensionality is ubiquitous in geophysical and engineering flows. Under these conditions, turbulence may experience a counter-intuitive depletion of the turbulent stresses, which has important implications for modeling and control. Current turbulence theories are established mainly for statistically two-dimensional equilibrium flows and cannot predict such a behavior. In the present work, we propose a multi-scale model explaining the response of non-equilibrium wall-bounded turbulence under the imposition of three-dimensional strain. The analysis is performed via direct numerical simulation of turbulent channels at friction Reynolds numbers up to 1000. We show that scaling properties of the Reynolds stress are consistent with a model comprising momentum-carrying eddies with sizes and time scales proportional to their distance to the wall. We further demonstrate that the reduction in Reynolds stress follows a spatially and temporally self-similar evolution caused by the relative horizontal displacement between the core of the momentum-carrying eddies and the flow layer underneath.

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Marco G. Giometto
Columbia University

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