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Energy amplification in turbulent flows over complex walls MITUL LUHAR, University of Southern California — Many boundary layer flows in natural and manmade systems are characterized by the presence of complex walls (e.g. porous, rough, or patterned) that can substantially alter the near-wall turbulence. For example, the streaks and streamwise vortices prevalent in smooth-walled flows are often replaced by structures resembling Kelvin-Helmholtz vortices in flows over porous media and vegetation canopies. While stability analyses can reproduce some of these observations, they are limited in their ability to generate predictions for spectra and coherent structure in fully turbulent flows. The present effort seeks to address this limitation by extending the resolvent formulation to account for complex walls. Under the resolvent formulation, the turbulent velocity field is expressed as a linear superposition of propagating modes, identified via a gain-based decomposition of the Navier-Stokes equations. The presence of the complex substrate is modeled as a distributed body force, which alters the gain (i.e. energy amplification) and structure of the modes. Preliminary results show that this approach reproduces key observations from previous simulations and experiments of flow over porous media, vegetation canopies, as well as riblets with minimal computation.

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