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On the routes to inertial mean dynamics in smooth- and rough-wall turbulent boundary layers[1] JOSEPH KLEWICKI[2], FARAZ MEHDI, University of New Hampshire — Connections between the structure of smooth- and rough-wall turbulent boundary layers are established within the context of the order of magnitude properties exhibited by the terms in the mean momentum equation. These properties are shown to be associated with the processes by which inertial mean dynamics emerge with distance from the wall. A key element is the process by which the vorticity field becomes three-dimensional. In the smooth-wall case, vorticity stretching leads to the three-dimensionalization of the vorticity field in the region where the mean viscous force retains leading order. This underlies the well-established Reynolds number scaling behaviors exhibited by smooth-wall flows. Roughness modifies (generally augments) the process by which the vorticity field becomes three dimensional, rendering scalings for the route to inertial mean dynamics that depend on the relative scale separations between the inner, roughness, and outer scales. Evidence (from existing and recent experiments) of these combined scaling regimes is presented. The present analyses provide a basis for predicting where and physically why Townsend's similarity hypothesis should hold, as well as under what conditions outer similarity loses validity.

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