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Instantaneous structure of a boundary layer subjected to free-stream turbulence[1] R. JASON HEARST, Norwegian Univ Tech (NTNU), CHARITHA DE SILVA, University of Melbourne, EDA DOGAN, KTH Stockholm, BHARATHRAM GANAPATHISUBRAMANI, University of Southampton —
A canonical turbulent boundary layer (TBL) has a distinct turbulent/non-turbulent interface (TNTI) separating the rotational wall-bounded fluid from the irrotational free-stream. If an intermittency profile is constructed separating the flow above and below the TNTI, this profile can be described by an error-function. Within the turbulent region, the flow is separated by interfaces that demarcate uniform momentum zones (UMZs). We observe that these characteristics of a TBL change if there is free-stream turbulence (FST). First, the entire flow is rotational, and thus a distinct TNTI does not exist. Nonetheless, it is possible to identify an interface that approximately separates the flow with mean zero vorticity from the distinctly wall-signed vorticity. This turbulent/turbulent interface is shown to be closer to the wall than the traditional TNTI, and the resulting intermittency profile is not an error-function. Also, UMZs appear to be masked by the free-stream perturbations. Despite these differences, a velocity field of a TBL with homogeneous, isotropic turbulence superimposed and weighted with the empirical intermittency profile, qualitatively reproduces the 1st and 2nd-order statistics. These findings suggest that a TBL subjected to FST may be described by a simple model.

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