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Direct numerical simulation of a high-entrainment turbulent boundary layer[1] GUILLEM BORRELL, U. Politecnica Madrid, AYSE G. GUNGOR, JAVIER JIMENEZ — It has been reported that certain rough surfaces modify the outer region of turbulent boundary layers, but not those of channels or pipes. Besides their surface geometries, all those experiments share relatively large spreading and entrainment rates, which is known to modify the outer intermittent layers of external turbulent flows, but is absent from channels. To separate the effect of surface geometry from that of entrainment, we present a direct simulation of a zero-pressure-gradient turbulent boundary layer, at $Re_\theta = 1400 - 4500$, in which the friction coefficient is augmented by a smooth volumetric force, restricted to the viscous layer below $y^+ = 25$, and proportional to the streamwise component of the velocity. The spreading rate increases by 70%, equivalent to a sand roughnes $k_s^+ \approx 60$. The resulting changes in the velocity and pressure fluctuations, and in the velocity correlation lengths, are compared with those of rough-wall experiments.

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