Scale-wise Relaxation to Isotropy in Turbulent Boundary Layer over Rough Terrain

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The Kolmogorov hypothesis of local isotropy is fundamental in stochastic models of turbulence and generally assumed to hold for atmospheric turbulence. According to Kolmogorov's second similarity hypothesis, there is a range of turbulent scales (inertial subrange) that are statistically isotropic and the statistics of these scales have a universal form that is uniquely determined by the TKE dissipation rate. Recent work based on atmospheric turbulence measurements has shown that the scale-wise route turbulence takes to reach isotropy at these smallest scales is uniquely determined by the anisotropy of the energy-containing eddies. In this study, we explore the connection between large-scale anisotropy and the route to small-scale isotropy through direct numerical simulations (DNS). We perform simulations of neutral flow over flat and rough (wavy) surfaces at different Reynolds numbers, to investigate the scale-wise anisotropy as a function of height from the surface and surface roughness. We employ velocity spectra and structure functions to examine the local isotropy hypothesis and compare the indirect estimates of the TKE dissipation rate to the calculated ones. The analysis of the anisotropy invariants aims to explain the relaxation to isotropy and the degree of anisotropy at different scales and regions of the boundary layer. Furthermore, the Reynolds stresses budget is explored in light of the return-to-isotropy terms and the redistribution of TKE among the three components.