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Dependence of near-surface similarity scaling on scalewise anisotropy of atmospheric boundary layer turbulence

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Earlier results of Stiperski and Calaf have demonstrated an intrinsic tie between turbulence anisotropy and the data scatter traditionally found in near-surface similarity scaling relationships. This interconnection was shown to exist in both, canonical-type flow conditions for which similarity scaling relationships were originally developed for, as well as in more complex flow conditions (e.g. terrain induced flow complexity, directional wind shear, etc.). More specifically, for unstable stratification, anisotropy was found to be the dominant processes causing the failure of scaling among the various datasets. Results highlighted the fact that there cannot be a single similarity scaling curve that fits all states of anisotropy, unless anisotropy is taken into account in the scaling itself. Alternatively, for stable stratification, isotropic turbulence is clearly the reference turbulence state in weakly stable boundary layers with well-developed turbulence, but anisotropy itself cannot explain all the variability observed in more strongly stable regimes.

In this work we take a scale-dependent approach in the analysis of turbulence anisotropy and its tie with similarity scaling relationships. For this purpose, a traditional structure-function formalism is applied. At the larger scales, the structure functions are highly related to the turbulent energy of the system, while at the smaller scales, the structure functions are more related to the gradients. Therefore, results of this analysis provide a deeper understanding on the scalewise structure of near-surface turbulence, its relationship to the integral anisotropy states, and the correspondence with similarity scaling for different thermal stratification and different ambient induced complexities (e.g. terrain, wind shear, etc.). Further, results allow identify different routes of relaxation to isotropy with the corresponding link to complexity and potential ties to scaling relationships.