SPECTRAL CHARACTERISTICS OF THE ATMOSPHERIC SURFACE LAYER OVER A SALT PLAYA

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Under nearly ideal conditions, the atmospheric surface layer (ASL) comes close to mimicking the turbulent boundary layer (TBL) flow expected in a very large wind tunnel, and, until recently, has remained an untapped resource in the study of fundamental TBL physics. Because no other facility exists that can generate TBLs with Reynolds numbers as high as those encountered in the atmosphere, without placing severe demands on the spatial resolution of current measurement technology, it seems rational to seek answers to Reynolds number scaling relations by probing the ASL.

The present study explores the spectral characteristics of the velocity in the ASL under conditions of near-neutral thermal stability, and represents an extension of the previous work of Metzger[1] to vertical heights greater than 1 m. Experiments were performed during May, 2005 on the salt playa of Utah's western desert. The aerodynamic roughness length of this surface typically measures about 0.2 mm. Data were acquired from a 5 m tower of thirty-one simultaneously sampled, single-element, hot-wire probes, in conjunction with a 32 m tower containing nine simultaneously sampled, three-dimensional, sonic anemometers. The combined hot-wire and sonic anemometry measurements allow the full range of dynamical scales in the streamwise velocity to be captured, at least up to 5 m. Spectra of the vertical and spanwise velocity components, and the streamwise velocity above 5 m, are limited to relatively low frequencies (≤ 10 Hz).

Spectra from the present field data are compared with the lower Reynolds number wind tunnel data of Klewicki and Falco[2]. Certain features in the spectra from the present data, such as scaling with distance from the surface and the lack of an extended region with -1 slope, agree with high Reynolds number, smooth-wall superpipe results [3]. Observations of the scaling of the spectra are also discussed in terms of the recent work of Wei et al.[4] regarding the exchange of balance of forces in the mean momentum equation across the TBL, and the mixing transition identified by McKeon and Morrison[5].

References

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