Frozen-turbulence hypothesis in wind-tunnel model of atmospheric boundary layer

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Although the main assumption of Taylor's frozen-turbulence hypothesis [1] is not met in many boundary layers the hypothesis, it is commonly used to calculate integral length scales from point measurements. Wind tunnel modeling was used to analyze flow in the vicinity of the meteorological observatory Kopisty (CZE). Particle image velocimetry with high temporal resolution (TR-PIV) allowed us to analyze both temporal and spatial correlations in the turbulent flow fields simultaneously and to evaluate the frozen-turbulence hypothesis.

The measurements in vertical and horizontal planes reveal that there is a very good agreement between integral length scales based on various methods. The major semiaxis of two-point correlation ovals in the vertical cross-section is about 10° tilted up in the downstream half of the correlation oval. The tilt angle is negligible in the upstream half due to the vicinity of the surface. The integral length scales increase with the height and their magnitude agrees well with the tabled atmospheric data [2]. The intensity of turbulence in the streamwise velocity fluctuation is 24% and 20% at 40 m and 80 m height, respectively. Such values cannot be assumed small and therefore the main assumption of Taylor's hypothesis of frozen-turbulence is not met. However, our measurement shows that the spatial and temporal dimensions can be interchanged using the local velocity as the transfer factor, see Fig. 1.

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[1] Townsend, Turbulent Structure of Turbulent Shear Flow. Cambridge University Press (1976).
[2] Counihan, *Atmospheric Environment*, **9**, 871 (1975).

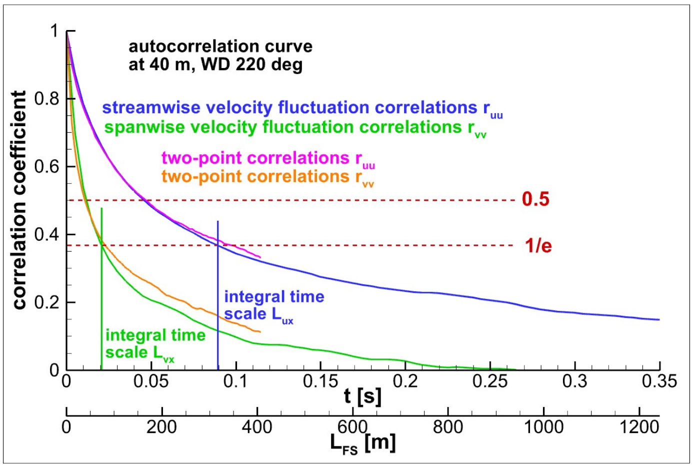

Figure 1: Comparison of the autocorrelation and two-point correlation curves in the horizontal plane at the height of 40 m.