Wavelet analyses of turbulent flow above surface with 5 different classes of roughness

**Experimental set-up**

Boundary layer above five types of rough surfaces is simulated in a wind channel. Series of roughness elements generate a highly turbulent flow. Intensity of turbulence reaches up to 40%. Particle image velocimetry (one 2 kHz) provides a number of 2-D snapshots of instantaneous velocity vector. The flow dynamics in the vertical plane X-Z are investigated. The wavelet analysis is used to reveal the direction of coherent structures in the flow and their frequency of occurrence.

**Pod decomposition**

The mexican hat function reveals the frequency and time of appearance in the signal. Principle is to find the best convolution between the signal and mother wavelet. We adopted Matlab code developed by Torrence and Compo (1998). The dominant shape of the moddingsummary represents coherent structures with the majority of the TKE in the flow. The modes exhibit a consistent pattern in the vertical plane for various roughness classes. The dimension of the patterns increases with the increasing roughness. The first modes reveal almost no vertical structures but sweep and ejection events (a fast downward and a slow upward motion). Each mode has its own POD expansion coefficient which evolves in time and acts as a weight factor.

**Wavelet analysis**

The POD provides reliable results of the modes from the very turbulent flow. The most dominant mode contains 26% of TKE (slightly rough - SR) and 44% of TKE (very rough - VR). The shape of the modes is consistent, only the scale of the structures increases with the increasing roughness. Wavelet analysis is able to detect different type of energetic structure and manifest them in a transparent way.

**Conclusion**

The Mexican hat function is chosen as a better for evaluation of the direction of the sweep and ejection events. The rougher terrains exhibit the higher number of events centered at higher frequencies.

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