Estimation of the dissipation in the roughness sublayer of the boundary layer over an Urban-like rough wall using PIV

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HIGHLIGHTS

- PIV is used to investigate the Turbulent Kinetic Energy budget including an estimation of the dissipation using the energy transfer equation and Large-Eddy Particle Image Velocimetry (LE-PIV).
- The shear layer that is induced by the presence of the roughness is shown to produce and dissipate energy, as well as, transport energy through advection, turbulent transport and pressure transport.
- The recirculation region within the wake of the roughness creates rapid longitudinal evolution of the mean flow inducing negative production.

ABSTRACT

In the present work a boundary layer developing over a rough-wall consisting of staggered cubes with a plan area packing density \( \lambda = 25\% \) is studied within the wind tunnel using Particle Image Velocimetry to investigate the Turbulent Kinetic Energy (TKE) budget. To access the full TKE budget an estimation of the dissipation \( \epsilon \) using both the transport equation of the resolved-scale kinetic energy and Large-Eddy Particle Image Velocimetry (LE-PIV) models based on the use of a subgrid-scale model following the methodology used in Large-Eddy Simulations. To use these models a low-pass filter must be applied to the data prior to the computation of the velocity gradients in the energy transfer term, using a cut-off wavelength larger than the Taylor micro-scale. This ensures a clear cut-off in the inertial range where the equivalence between the scale energy transfer and the dissipation holds. In the present work a box filter of different size was used within the canopy and above (for heights of \( z/h > 1 \)). The estimation of the dissipation using the two methods results in an agreement to within 10%, except in the recirculation region within the canopy, which contains small-scales that are not captured using the transport equation. The presence of the cube roughness has a significant influence on the TKE budget due to the strong shear layer that develops over the cubes. The shear layer is shown to produce and dissipate energy, as well as, transport energy through advection, turbulent transport and pressure transport. The recirculation region that forms through interaction of the shear layer and the canopy layer creates rapid longitudinal evolution of the mean flow thereby inducing negative production.

![Fig. 1 a) Turbulent Kinetic Energy budget; b) Production, all terms normalized by h/u.](image-url)