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Estimation of turbulence scales in gravel-bed river flows

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Four scales are important in the study of turbulent flows: Kolmogorov dissipative scale; Taylor micro-scale or simply Taylor scale; integral or Taylor macro-scale; and the scale corresponding to the higher energy content, herein called energetic scale. All of them correspond to the size of different repetitive patterns present in the flow, each one related either to production, transport or dissipation processes. In the present research, turbulence scales are estimated throughout the vertical using instantaneous velocity profile measurements made in the gravel-bed Swiss river Venoge, using one 3D Acoustic Doppler Velocity Profiler. Fifteen velocity profiles, equally spaced in the spanwise direction with a distance of 10 cm and in the streamwise direction with a distance of 15 cm, were measured on a 3x5 rectangular horizontal grid. With a vertical resolution of around 0.5 cm, a 3D measuring grid covering was defined. Instantaneous velocities were sampled during 3.5 min at a frequency of 26 Hz. With a water depth of 0.20 m and the bed material composed of coarse round gravel with a D_{50} of 68 mm, the riverbed is hydraulically rough and the flow has relative submergence of 2.94 (ratio of the water depth by D_{50}). Kolmogorov scale is estimated from the dissipative dynamic scales; micro-scale estimation considers this as a measure of the amount of dissipation; the integral scale is defined from the 1D velocity auto-correlation function; and, the energetic scale is estimated from the energy spectrum based on a multilevel wavelet decomposition of the fluctuating velocity. Production is estimated directly from the measured shear stresses and mean velocity gradients whereas dissipation is estimated indirectly using the second Kolmogorov hypothesis by relating it with the energy spectral density function for the streamwise velocity fluctuations. The analyzed turbulence scales distribution may be described fairly well by power laws as indicated by previous authors; best-fit coefficients and exponents are presented as well as the ratio between both productive scales and between both dissipative scales. From these ratios, productive and dissipative ranges are inferred. These results contribute with empirical information essential for mixing and transport processes modelling in turbulent gravel-bed river flows.

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