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Longitudinal momentum transport in an experimental free-surface channel flow over a transverse variation of roughness

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We present experimental results of a free-surface channel flow developing on a bottom with a transverse variation of roughness. Small rectangular obstacles ($3.2 \times 1.6 \times 1.15\ cm^3$, with a planar density $\lambda_p = 0.25$) were attached in the central part (35 cm wide) of a 1.1 m wide and 10 m long hydraulic flume. Here, preliminary results for a flow of relative depth $h/H = 0.11$ are presented and discussed. Values of the global Reynolds and Froude number, defined as $Re = UH/\nu$ and $Fr = U/\sqrt{gH}$ with U the mean longitudinal velocity, are respectively equal to 30000 and 0.3. PIV measurements were performed in ten vertical planes parallel to the flume, yielding velocity fields at different positions along the transverse direction between and above the obstacles, and in three horizontal planes above the obstacles. Temporal and spatial averaging were performed to extract vertical profiles of U, W and $\overline{u'w'}$ at different locations along the variation of roughness.

As the boundary layers develop above the central rough region and the smooth external regions, variations in the turbulent components along the transverse direction drive a secondary circulation that depends on the roughness contrast, but also on relative depth of the fluid and the presence of side walls. To study these variations, the vertical U profiles were fitted by logarithmic laws using the measured momentum fluxes in the canopy, avoiding ad-hoc parametrisations. It is shown that the roughness contrast combined with the side-wall boundary-layers drive strong secondary currents that transport momentum in a more efficient way than the usual vertical turbulent flux $\overline{u'w'}$. As a consequence, logarithmic profiles are found only above regions where the vertical component of the secondary flow is weak. An analysis of the different terms

of the mean longitudinal momentum equation is performed at the intersection of the horizontal and vertical planes of measurements to determine for each position which process dominates. The combined effects of the roughness contrast and the limited flow depth are then discussed and perspectives of this experimental study for the near-future are presented as a conclusion.