[illegible] channel flows

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The dynamics of turbulent flows in oceans, rivers or man-made canals create a variety of different sediment bedforms. A particularly interesting phenomenon is the evolution of long straight sediment ridges, which are associated with turbulent mean secondary currents of Prandtl's second kind (Nezu and Nakagawa, 1993). In this talk, we will study the onset of sediment ridge evolution in a series of interface-resolved direct numerical simulations of turbulent open channel flows over a mobile sediment bed, for which we incorporate an immersed boundary method (Uhlmann, 2005) with a discrete element model for an accurate description of the individual particle motion (Kidanemariam and Uhlmann, 2014). Based on the information gained in these simulations, we will present a formation mechanism in which the evolution of sediment ridges is initiated by the presence of turbulent large-scale velocity streaks that naturally appear in turbulent open channel flows. The spanwise alternating high and low speed streaks generate laterally alternating zones of high and low erosion along the sediment bed, that, in turn, readily lead to the development of alternating troughs and ridges on the sediment bed. The secondary currents are identified as the statistical footprint of these streaks in the streamwise and time average (cf. figure 1).

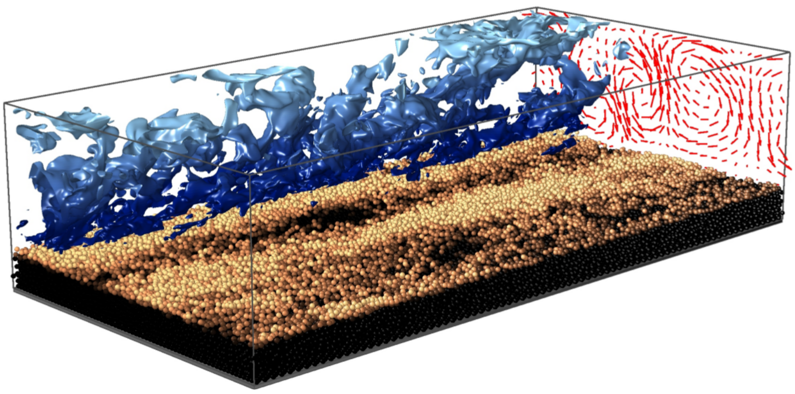

Figure 1: Instantaneous snapshot of sediment ridges and troughs together with a large-scale low-speed streak, visualized as isosorface of the streamwise velocity fluctuations u'. Main flow is from bottom left to top right. Particles' colors change from dark to bright brown with increasing distance from the bottom-wall. The orientation of the mean secondary flow is indicated by a vector plot at the downstream end of the domain. Simulation parameters: $Re_b = 9500, Re_\tau = 830, Ga = 57, \rho_p/\rho_f = 2.5, H_f/D = 25$.

References

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