Flow separation and roughness lengths over large bedforms in a tidal environment: A numerical investigation

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Abstract

This study characterizes the shape of the flow separation zone (FSZ) and wake region over large asymmetric bedforms under tidal flow conditions. High resolution bathymetry, flow velocity and turbulence data were measured along two parallel transects in a tidal channel covered with bedforms. The field data are used to verify the applicability of a numerical model for a systematic study using the Delft3D modelling system and test the model sensitivity to roughness length. Three experiments are then conducted to investigate how the FSZ size and wake extent vary depending on tidally-varying flow conditions, water levels and bathymetry. During the ebb, a large FSZ occurs over the steep lee side of each bedform. During the flood, no flow separation develops over the bedforms having a flat crest; however, a small FSZ is observed over the steepest part of the crest of some bedforms, where the slope is locally upto15°. Over a given bedform morphology and constant water levels, no FSZ occurs for velocity magnitudes smaller than 0.1 m/s; as the flow accelerates, the FSZ reaches a stable size for velocity magnitudes greater than 0.4 m/s. The shape of the FSZ is not influenced by changes in water levels. On the other hand, variations in bed morphology, as recorded from the high-resolution bathymetry collected during the tidal cycle, influence the size and position of the FSZ: a FSZ develops only when the maximum lee side slope over a horizontal distance of 5 m is greater than 10°. The height and length of the wake region are related to the length of the FSZ. The total roughness along the transect lines is an order of magnitude larger during the ebb than during the flood due to flow direction in relation to bedform asymmetry: during the ebb, roughness is created by the large bedforms because a FSZ and wake develops over the steep lee side. The results add to the understanding of hydrodynamics of natural bedforms in a tidal environment and may be used to better parameterize small-scale processes in large-scale studies.

Keywords: Tidal dunes, Recirculation zone, Numerical modelling

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