Flow separation and shear stress over angle-of-repose bed forms: A numerical investigation

Auteurs: Alice Lefebvre[a], Andries Paarlberg[b], Christian Winter[a]

[a]MARUM-Center for Marine Environmental Sciences, University of Bremen, Germany
[b]HKV consultants, Lelystad, The Netherlands

Abstract

Large asymmetric bed forms commonly develop in rivers. The turbulence associated with flow separation that develops over their steep lee side is responsible for the form shear stress which can represent a substantial part of total shear stress in rivers. This paper uses the Delft3D modeling system to investigate the effects of bed form geometry and forcing conditions on flow separation length and associated turbulence, and bed form shear stress over angle-of-repose (30° lee side angle) bed forms. The model was validated with lab measurements that showed sufficient agreement to be used for a systematic analysis. The influence of flow velocity, bed roughness, relative height (bed form height/water depth), and aspect ratio (bed form height/length) on the variations of the normalized length of the flow separation zone, the extent of the wake region (where the turbulent kinetic energy (TKE) was more than 70% of the maximum TKE), the average TKE within the wake region and the form shear stress were investigated. Form shear stress was found not to scale with the size of the flow separation zone but to be related to the product of the normalized extent of the wake region (extent of the wake region/extent of water body above the bed form) and the average TKE within the wake region. The results add to understanding of the hydrodynamics of bed forms and may be used for the development of better parameterizations of small-scale processes for application in large-scale studies.

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