World Academy of Science, Engineering and Technology
International Journal of Computer and Systems Engineering
Vol:13, No:05, 2019

Sediment Patterns from Fluid-Bed Interactions: A Direct Numerical Simulations Study on Fluvial Turbulent Flows

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Abstract : We present results on the initial formation of ripples from an initially flattened erodible bed. We use direct numerical simulations (DNS) of turbulent open channel flow over a fixed sinusoidal bed coupled with hydrodynamic stability analysis. We use the direct forcing immersed boundary method to account for the presence of the sediment bed. The resolved flow provides the bed shear stress and consequently the sediment transport rate, which is needed in the stability analysis of the Exner equation. The approach is different from traditional linear stability analysis in the sense that the phase lag between the bed topology, and the sediment flux is obtained from the DNS. We ran 11 simulations at a fixed shear Reynolds number of 180, but for different sediment bed wavelengths. The analysis allows us to sweep a large range of physical and modelling parameters to predict their effects on linear growth. The Froude number appears to be the critical controlling parameter in the early linear development of ripples, in contrast with the dominant role of particle Reynolds number during the equilibrium stage.

Keywords : direct numerical simulation, immersed boundary method, sediment-bed interactions, turbulent multiphase flow, linear stability analysis
Conference Title : ICCFD 2019 : International Conference on Computational Fluid Dynamics
Conference Location : Amsterdam, Netherlands
Conference Dates : May 14-15, 2019