NUMERICAL FLOW FIELD CHARACTERIZATION OF THE RIPPLE-DUNE AMALGAMATION PROCESS

Christian Frias, University of Pittsburgh, 412-478-2712, cef26@pitt.edu

1. Christian Frias, University of Pittsburgh
2. Jorge Abad, University of Pittsburgh

Most of the fluvial channels present bedforms such as dunes and ripples which are product of the interaction between hydrodynamics and sediment transport. Due to these bedforms the mean flow, water surface profile, shear stresses, Reynolds stresses and turbulent structures are significantly different from those presented in flat bed channels. Several numerical modeling studies have been performed to explain the interaction between the bedforms shape and the hydrodynamics. It is well-known that according to experimental comparison, the LES models were more suitable to reproduce the hydrodynamics structures mentioned above. On the other hand, most of the past studies have focused in bedforms without superimposition of dunes and ripples. Although the LES models used in previous studies have provided accurate flow structure description under single bedforms, there is not enough description of the flow under the condition of the ripple-dune transition and its relationship between the turbulence and sediment transport processes. Existing experimental work regarding to the ripple-dune transition have been found but with the main limitation of results obtained only for certain locations (probes or profiles) and without considering the effect of the bedforms on the water surface. A numerical model can overcome the later issue by having a complete scenario of the mentioned process. Thus, the interaction between turbulence, bedform geometry and sediment transport could be analyzed from several points of view in contrast to the experimental results.
The purpose of the present study is to extend the observations made by previous experimental results on the bedforms amalgamation process. To this end, three numerical simulations will be carried out to replicate an amalgamation process, a single dune case, a dune with a superimposed ripple on the dune stoss side case and a complete amalgamated ripple over dune case. The model used for the turbulence closure was the Dynamic Smagorinsky and a VOF method with a SIMPLE numerical scheme. The model was validated using the results from the ripple superimposed on the stoss side and the experimental data. Good correlation was found for the average velocities and Reynolds stresses on this case. Some of the results analyzed were the average, instantaneous and the fluctuations of hydrodynamics parameters such as velocity, pressure and stresses. Special attention was paid to the superimposed case since it has been proved in previous work that it presents the highest turbulence intensities and thus a very important influence in sediment transport. Additional, iso-surfaces of swirling strength were visualized to study the development of coherent structures on the flow field and its impact in the flow field. Furthermore, all the numerical models were performed using a free surface condition at the top of the domain to allow the model develop undulations on the water surface caused by effect of the bedforms. Moreover, a visual characterization of the wake layer, shear layer and boundary layer was performed for all the cases. Finally, an autocorrelation of the velocities was performed for different locations (probes) for all three cases to estimate the lag caused by the crest of the bedforms.