Numerical Modelling of flumes with moving dunes – TELEMAC3D and Sisyphe

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ABSTRACT

The numerical modelling of three dimensional bed form formation remains challenging (quelle?). Indeed, there have been major advances and some successful dune modelling has been shown (i.e. Nabi 2012, Tuijnder 2010). However, it seems that dune modelling is still not applicable in engineering practice, where most projects are 2D-hydrodynamic simulations and bed forms are accounted for by either parametric methods (i.e. Yalin, 1992) or empiric formulations (i.e. v Rijn, 1984).

Dunes are the major bed forms in waterways. If they are only represented indirectly by a dune predictor and an average bed height, they are responsible for high uncertainties concerning water depth and shipping capacity. Not only does the presence of dunes considerably modify the flow structure with vortex creation in the lee of bed forms, also the sediment transport rates are changed.

The prediction of dune characteristic dimensions (height and length) with numerical modules and configurations that are applicable in project work is therefore of high interest.

The objective of this presented work is to validate a full 3D morphodynamics model to represent the bed forms dimensions as well as the characteristic time scales for dunes formation. Here we apply the open source Telemac system (release 6.1).

In the BAW moveable bed experimental flume (in Karlsruhe) three-dimensional dunes have been produced and studied. The flume has a dimension of 30x2m and is filled with uniform sediment with a D50 of 1mm. High resolution measurements provide an excellent data base for the calibration of a numerical model.

The capacity of TELEMAC3D and SISYPHE for modelling dune dynamics and features has been shown in previous studies (Goll and Kopmann, 2012a+b), where the emergence and movement of dunes were successfully reproduced. Nonetheless there were shortcomings: the correct form in terms of skewness of the dune slopes and their curvature (kurtosis) were only partially reproducible. Also a carefully calibrated parameter was necessary and the model results were highly sensible to the choice of turbulence model, bed load formula as well as slope and deviation functions.

To reduce some of the difficulties of reproduction, a second dune study with only two dimensional dunes was calculated with the same calibrated numerical model. The study flume is the one of the Laboratory of Hydraulic Research, Hokkaido University, Japan. The mobile bed region has the dimension of 10x0.1m and the flume is filled with uniform sediment of D50 = 0.28mm. Several studies have been conducted (Giri and Shimizu 2006, Toyama et al 2007) and from this selected runs have been calculated with TELEMAC3D and SISYPHE for this paper. It was possible to explicitly reproduce the 2D dunes of the experimental runs with the same calibrated parameter set as for the BAW flume (see Fig.1). The shape of the dunes has not been considered so far, but the height matches the experimental results already.

Further flumes shall be calculated to find a parameter set that fits a maximum of dune formation scenarios. In the end a configuration for project work will be extracted and the numerical system will be tested on a river stretch comparable to common project work configurations and problems.

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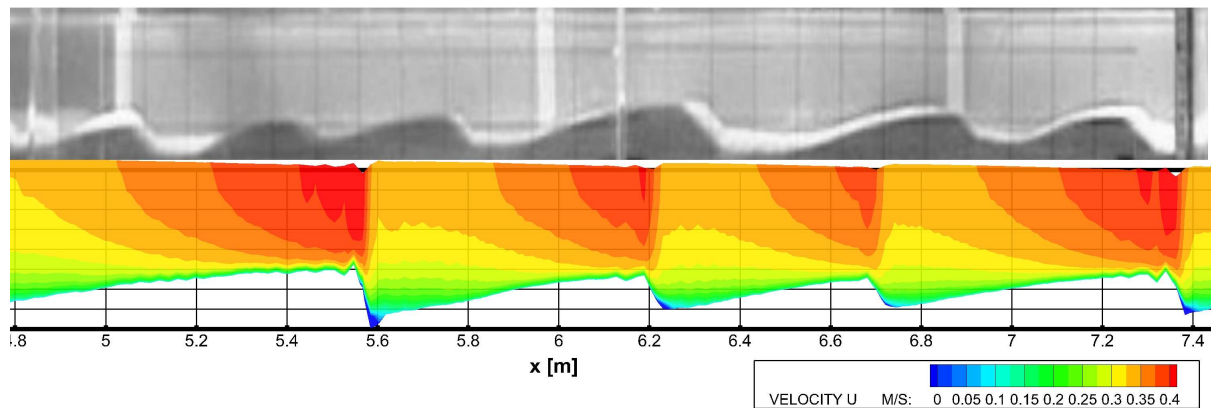Yalin, M. S. 1992. *River Mechanics*. Elsevier, New York.

Figure 1: Calculations (preliminary results) with Sisyphe/Telemac3d after 4h simulation time (longitudinal section) in comparison to results from Giri & Shimizu, 2006, run A-1.