Conference Poster, Published Version

Goll, Annalena; Kopmann, Rebekka; Villaret, Catherine

Numerical modelling of flumes with moving dunes

Bundesanstalt für Wasserbau
Federal Waterways Engineering and Research Institute

www.baw.de

Numerical modelling of flumes with moving dunes

TELEMAC3D and Sisyphe

Annalena Goll[1,2] , Rebekka Kopmann[1] and Catherine Villaret[3]

[1] Federal Waterways Engineering and Research Institute (BAW), 76187 Karlsruhe, Germany
[2] Université Paris-Est, Saint-Venant Laboratory for Hydraulics, ENPC, EDF R&D, CETMEF, 78400 Chatou, France
[3] EDF R&D Laboratoire National d'Hydraulique et Environnement (LNHE), 78400 Chatou, France

Experimental flume

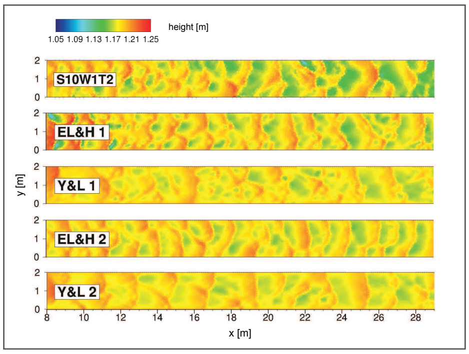
Left: groyne installations, initial state; Right: fully developed, fixed dunes

Experimental Flume

- Length: 30m
- Width: 5m (2x2m)
- First half moveable, second half fixed bed
- Discharges: 77-240 l/s
- Water level: 15-25cm
- Slope: leveled to 0.6‰ (1.2‰)
- Bed-load: sand (D50=1mm)
- Installations: none, groynes, fixed bed

The experimental flume is situated at BAW, Karlsruhe, Germany. In its two halves moving and fixed dunes are studied. Several installations and discharges have been recorded in the first half with moving dunes and can be used to calibrate the numerical model. In the second half naturally formed dunes have been fixed and allow to study the flow around these three-dimensional dune forms in detail.
The laboratory based three-dimensional photogrammetric measurement system (3D-PTV) for monitoring the alluvial bed topography allows for repeated, instantaneous recording of dune beds during water flow. Over the fixed dunes an Acoustic Doppler Velocimetry (Vectrino I+II) records the velocities and their standard deviations for all three spatial directions.

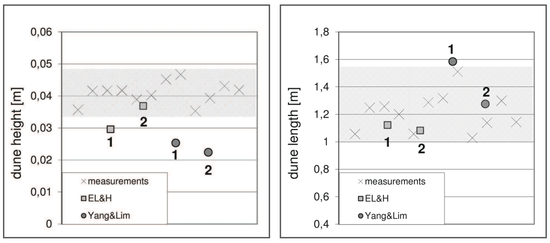
Numerical simulations



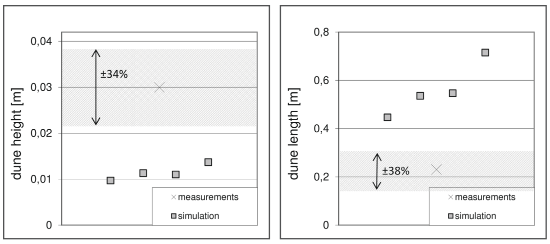
Measurements S10W1T2 compared to simulation (after 18h) Bedload transport formula of Engelund & Hansen and Yang & Lim,
1) slope effect Soulsby and deviation Talmon,
2) slope effect Koch&Flokstra and deviation Apsley&Stansby

With the open source TELEMAC suite (opentelemac.org) with the modules Telemac3D and Sisyphe it was possible to simulate the emergence, development and movement of three-dimensional dunes.

The overall best results compared to the measurements are presented here. They were gained with the bed load formulas of Engelund & Hansen and Yang & Lim.
Comparison of the bottom topography after 18h (left) and the corresponding average dune height and length (top right) show that even though the formed features of the bottom match the measurements quite well and the overall performance of the simulation was very good, the values of dune height are not in the same range.
Due to this, the used parameter settings were tested on an other flume based at Hokkaido University, Japan (Giri and Shimizu, 2006). The flume is 10cm wide, 30m long and the bottom sediment is uniform sand (D50=0.28mm). In the experiment two-dimensional dunes were produced. Simulations of the flume (bottom right) did not yield completely satisfying results. Different parameter sets and mesh configurations were tested, but the simulation results did not have the same quality as the ones of the BAW flume.



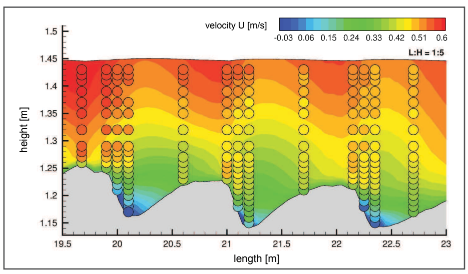
Measurements of 3 BAW runs at different times compared to simulations
1) slope effect Soulsby and deviation Talmon,
2) slope effect Koch&Flokstra and deviation Apsley&Stansby



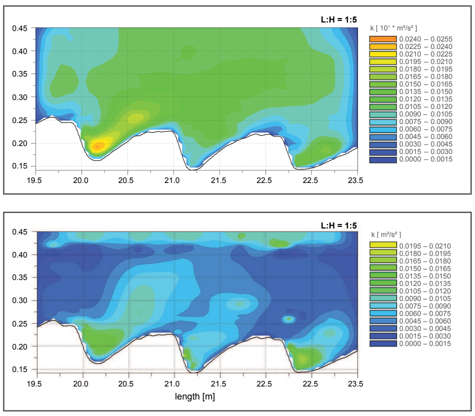
Measurements of Hokkaido experiment compared to different simulations with mesh and parameter combinations

Validation of hydrodynamics

Due to unsatisfying translation of the simulation parameters on other experiments, in a second step the turbulent hydrodynamics of the BAW flume are studied in detail.
Measurements of the flow field around the fixed dunes are compared to hydrodynamic simulations with Telemac3D.



Longitudinal velocities of the flow field around fixed dunes
Circles: measurements with ADV; Contour plot: simulation results



Turbulent kinetic energy k
Top: simulation k [$10^1 * m^2/s^2$]; Bottom: measurements k [m^2/s^2]

The flow field is matched very well. The pattern of the turbulent kinetic energy is good, but the values are not in the same range: the simulated ones are about eight times lower.

Conclusions

It was shown that dune modelling is possible with the TELEMAC suite. The correct dune shapes are subject to several influencing factors such as bed load transport formula, slope effect and deviation formulas, morphodynamic time step as well as hydrodynamic parameters. It seems that the results are not easily reproducible with other boundary conditions or models.
Analysis of the highly turbulent flow field around the dunes have shown, that the turbulence model might be not sufficient. The next step will be further calibration of the turbulence model with the shown measurements.