Marine turbulence in nearshore and surfzone areas

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Climate change and sea level rise create a lot of concerns with regard to the vulnerability of coasts all around the world. However, few of the flood risk studies take into account the morphodynamic evolution of the coast over the long-term period of the prediction. Indeed, the numerical simulation of beach morphodynamics is a very challenging problem. It requires the calculation of forces by waves and currents on the shore. A neglected aspect is the interaction between sediments and turbulence above the bottom. Even though it is has been acknowledged for a long time that sediments in the water column cause drag modulation, it is not properly accounted for in numerical models. At best, the energy loss to sediment transport is implicitly accounted for by tuning the bottom friction parameter.

Based on a long time investigation of this problem, based primarily on laboratory flume test data and the failure to simulate these experiments with any numerical model, including experience with the author's (finite elements) research code FENST-2D, the main bottleneck has been identified in the turbulence model, which cannot properly take into account particle-turbulence interactions. Even in advanced models based on two-phase flow theory where the k-epsilon model is adapted semi-empirically with extra dissipation terms, the models fail because they neglect the fact that turbulence is no longer fully-developed in the bedload transport layer and that the near-bottom boundary conditions for turbulent kinetic energy and its dissipation rate should be adapted accordingly.

A new modelling strategy has been designed, applicable to large scale 3D coastal engineering studies, consisting of a two-layer turbulence model (a new low-Reynolds mixing length model in the bottom layer and a compatible new low-Reynolds k-epsilon model for the outer layer), including semi-empirical corrections for particle-turbulence interactions. The new mixing-length model also lies at the basis of a new dynamic bottom friction model, accounting for energy dissipation by the sediments above the bottom. The latter has already successfully been implemented in a 2DH model for the Belgian coast and Scheldt estuary [*Bi & Toorman*, 2015].

Within the framework of the CREST - Climate Resilient Coast project (www.crestproject.be) attention is given to the incorporation of wave energy dissipation by different mechanisms. One of the aims is to implement the new bottom friction closure in a 3D wave-resolved modelling of beach morphodynamics. For this purpose, the modelling strategy will be implemented in OpenFOAM. Eventually the model will be used to study how beach erosion extracts energy from the waves and modifies their properties and their subsequent impact on the coast during storm conditions.

REFERENCE:

Bi, Q. & E.A. Toorman (2015). Mixed-sediment transport modelling in the Scheldt estuary with a physics based bottom friction law. *Ocean Dynamics*, 65:555-587.

Oral preference