Minimization principles for the evolution of a sandy sea bed interacting with a shallow sea

Application to hazard quantification in oil transport by seas by the estimation of buried oil in the intertidial beaches

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Abstract

Minimization principles are used in fluid-structure coupling to model sandy sea beds evolution. A sandy bed is seen as a structure with low stiffness. Water motion in shallow domains is described by the Saint Venant equations. This coupling is based on the assumption that the bed adapts to the flow in order to minimize some energy quantity together with minimal sand transport. The approach is shown being equivalent to the use of an Exner equation for the bed with a nonlocal expression for the sediment transport flux. Because the choice of the functional permits to include different physical quantities which might play a role in bottom morphodynamics, the approach is also a tool for validating different modeling hypothesis.

The presentation also aims at quantifying the impact of state uncertainties in littoral erosion to provide confidence bounds on deterministic predictions of bottom morphodynamics. Two constructions of the bathymetry standard deviation are discussed. The first construction involves directional quantile-based extreme scenarios using what is known on the flow state Probability Density Function (PDF) from onsite observations. We compare this construction to a second cumulative one using the gradient by adjoint of a functional involving the energy of the system. Our aim is to keep the computational complexity comparable to the deterministic simulations taking advantage of what already available in our simulation toolbox.

These ingredients are used to illustrate the dynamics of nearshore sand bars and their interaction with infra-gravity Waves.We also consider the application of the platform to the quantification of the amount of buried oil in the intertidial beach zones. This is a major hazard in oil transport by sea with either ships or coastal pipelines.

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