ON A TWO-LAYERS / TWO-PHASES / EXNER MODEL FOR SEDIMENT TRANSPORT WITH EROSION AND DEPOSITION EFFECTS

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In this work we deal with the geophysical problem of sediment transport in river. Our objective is to propose a complete model that describes both suspended and bed load sediment transport, as well as the interactions between them.

The whole physical system includes particles moving as bed load, suspended load and wash load, which is seen indeed as a subset of the suspended load. In the literature on this topic, several proposals to tackle the modelling of the sediment transport have been advanced. In general, the basis are the two-layer and two-phase models. The two-layer models are based on the fact that the different sediment transport types can be seen as separate layers with some kind of interactions among them. The two-phase models keep the property of one fluid formed up of two different components that interacts intrinsically, water and sediment, so the total column is seen as a mixture. Of course, both kind of models are not incompatible and the suitability of each one depends on the physical situations that one would like to focus on.
Furthermore, in this type of geophysical problems, the derivation of depth-integrated models −under the assumption of shallow flows− are extendedly accepted in order to get models mathematically and numerically manageable together with a good review in results that captures the essential effects.

In this work, we present the derivation of a two-layer sediment transport model for both suspended-load and bed-load phenomena, that includes the interaction between the different sediment loads. For this goal we use some established developments in order to obtain a new model that is as complete as possible. We consider the fluid-solid mixture model proposed by Jackson [4] as a basis and we follow different derivations to obtain the dynamics for the two layers. The top layer is defined as a suspension layer made up of water and grains, so we derive a two-phase model based on [3, 2]. For the layer below, we follow the derivation developed in [1] to obtain an Exner type model for arbitrary sloping beds. Erosion, suspension and deposition are considered in the whole system through appropriate boundary conditions. In order to well define the exchange of mass between sediment layers, mass and momentum conservation at the interface are imposed. The rate of erosion/deposition/suspension are defined following [5]. Thus, this model can be seen as a generalization of the existing models. Finally, several numerical tests will be presented.

References

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