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MODELING AND SIMULATION OF TURBIDITY CURRENTS

*** T. Morales de Luna [1], M. J. Castro Díaz [2], C. Parés Madroñal [3] and E. D. Fernández Nieto [4]**

[1,2,3] Dpto. Análisis Matemático
Facultad de Ciencias - Univ. Málaga
Campus de Teatinos, s/n
29071-Málaga, Spain

[4] Dpto. Matemática Aplicada I
ETS Arquitectura - Univ. Sevilla
Avda. Reina Mercedes nº2
41012-Sevilla, Spain

Email: [1] morales@anamat.cie.uma.es, [2] castro@anamat.cie.uma.es, [3] pares@anamat.cie.uma.es, [4] edofer@us.es

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ABSTRACT

When a river contains an elevated suspended sediment concentration, to the extent that the river density is greater than that of the receiving water body, the river can plunge and create a hyperpycnal plume or turbidity current. After a river plunges into ocean, the resulting hyperpycnal plume can travel significant distances until it loses its identity by entraining surrounding ambient water and dropping its sediment load. A sketch of a turbid underflow is presented in Fig. 1.

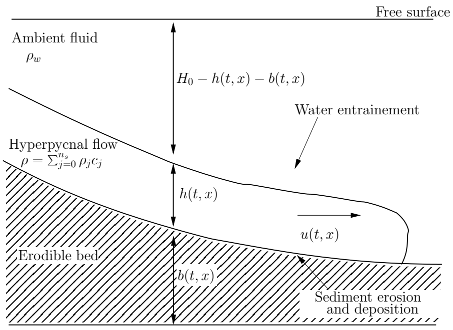

Figure 1: Sketch of hyperpycnal flow

There is great interest in turbidity currents because of their profound impact on the morphology of the continental shelves and ocean basins of the world. It is commonly accepted that they are one of the potential processes through which sediment can be transferred to the deep sea environments. These bottom currents influence the sea-bed morphology by depositing, eroding and dispersing large quantities of sediment particles. The resultant deposit often form porous layer of rocks which are potential sources of hydrocarbon. Therefore, understanding and predicting the geometry of these deposits is crucial for effectively exploring and exploiting these reservoirs.

An additional concern is the destructive effect that turbidity currents have on underwater structures, such as cables, pipelines and foundations.

Large-scale hyperpycnal flow or turbidity currents in the natural environment are difficult to monitor because of the unpredictable nature of the events. As a result, most of our knowledge about these flows is derived from small scale laboratory experiments like the ones described in [2], [4] and [3].

We present a numerical model of hyperpycnal flow generated by the plunging of a river. We shall consider $n_s \geq 1$ species of sediments with density ρ_j, for $j = 1, \ldots, n_s$ transported by a river with freshwater of density ρ_0. The river plunges into an ambient fluid (in general the ocean) of density ρ_w. Interaction between turbidity current and bottom is incorporated to the model, considering eroding and deposit effects as well as solid transport due to the velocity of the current. Water entrainment from above due to turbulence is also considered.

The equations are obtained from the two-dimensional equations under the hypothesis of shallow-flow, namely the hydrostatic distribution of pressure. Equations for conservation of fluid mass, sediment mass and fluid momentum are solved simultaneously. This type of model has been widely used in the simulation of turbidity currents (e.g., [7], [1], [4]). Vast applicability, low computational cost and conceptual simplicity are the main reasons that justify the option for a one-dimensional framework.

The equations are solve using path-conservative schemes presented by Parés, Castro et al. described in [6], [5].

Numerical simulations show a good agreement to laboratory results like the ones presented in [3] and [4].

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