Geophysical Research Abstracts
Vol. 14, EGU2012-8695-1, 2012
EGU General Assembly 2012

Improvements on turbidity current models. Application to Adra River (southern Spain)

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article

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January 20, 2012

The model for turbidity currents presented *Morales et al. (2009)* has been modified and used for the simulation of real world river outflows into the sea. The model used takes into account the interaction between the turbidity current and the bottom, considering deposition and erosion effects as well as solid transport of particles at the bed load due to the current. Water entrainment from the ambient water in which the turbidity current plunges is also considered. Motion of ambient water is neglected and the rigid lid assumption is considered. The model is one-dimensional and is obtained as a depth-average system of equations under the shallow water hypothesis describing the balance of fluid mass, sediment mass and mean flow.

Despite model performance was good while comparing with laboratory experimental data, we found out that it did not reproduce suitable results when applied to real geometries for rivers in southern Spain. Our guess was that this was due to the simple friction term parametrizations the model implemented. The authors of this work considered the usual form commonly used in the literature for this term:

$$\tau = -(1+\alpha)\, c_D\, |u|u. \tag{1}$$

where the term $c_D|u|u$ parametrizes the friction between the hyperpycnal plume and the sea bottom and the $\alpha\, c_D|u|u$ term represents friction between fluids (hyperpycnal plume and ambient fluid), been α the ration between these two friction terms. u is the depth-average velocity of the turbidity current.

We propose to split these two contributions and treat them independently considering for each of them the following expressions:

Botton Friction Parameterization

An usual Manning-type parametrization:

$$\tau_f = -g\, h \, \frac{M^2}{h^{\frac{4}{3}}} \, |u| \, u. \tag{2}$$

being g the gravity, h the thickness of the hyperpycnal plume, and M the Manning coefficient.

Interface Friction Parameterization

To parameterize the interface friction we consider the following parameterization:

$$\tau_i = -\alpha(\chi) \frac{h_1\, h}{r\, h_1 + h} \, |u| \, u. \tag{3}$$

where $h_1 = \max\{H - (z_b + h), 0\}$ represents the ambient fluid layer thickness, $r = \dfrac{\rho_w}{\rho_m}$ is the ratio of densities between ρ_w, density of the water in the receiving basin, and ρ_m, density of the turbidity current computed as

$$\rho_m = \rho_0(1 - \Sigma c_j) + \Sigma c_j \, \rho_j \tag{4}$$

being ρ_0 river water density, c_j for $j = 1, \ldots, n_s$ represents the vertical average volume concentration of the jth sediment whose constant density is ρ_j.

Finally , $\alpha(\chi)$ modulates friction intensity as a function of the thickness of the ambient fluid layer, between a minimal, α_0, and a maximal, α_s, value. The analytical expression considered for this function, being a linear convex combination of these two values, writes as:

$$\alpha(\chi) = \alpha_0(1 - g(\chi)) + \alpha_s \, g(\chi)) \tag{5}$$

where

$$g(\chi) = \frac{1}{G_{max}} \left(\frac{\chi\,(1+\chi)}{1+\chi^2} \right)^n \qquad \text{con} \quad \chi = \begin{cases} \frac{h_1}{H_R} & \text{si } h_1 \leq H_R \\ 1 & \text{si } h_1 > H_R \end{cases} \tag{6}$$

where H_R is a reference depth value and $G_{max} = \max(g(\chi))$.

We will present numerical simulations on simplified and realistic geometries, investigating the role of slopes and input flows in the evolution of the morphology of the seabed surface.

References

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