Erosion and sedimentation of a bump in fluvial flow

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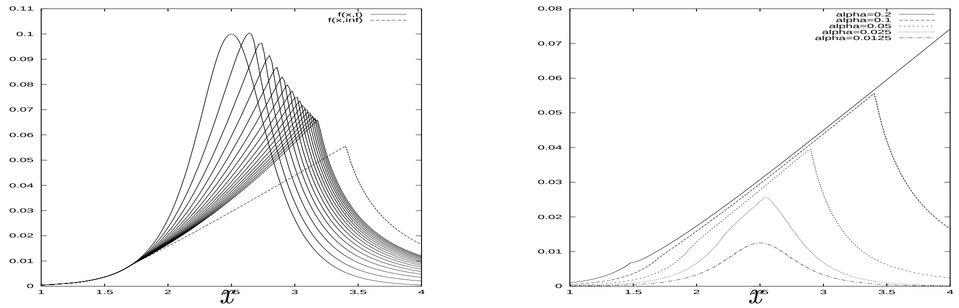
Abstract - In the present study the erosion and sedimentation of a dune in a fluvial flow is investigated. Here we use the framework of the "Interacting Boundary Layer theory" which allows a strong coupling between the boundary layer and the perfect fluid to compute the flow (assumed 2D, laminar, quasisteady because erosion and sedimentation is a slow process). The displacement of the dune occurs as follows: it is assumed that if the skin friction goes over a threshold value, the bump is eroded:

$$if \qquad \frac{\partial \tilde{u}}{\partial \tilde{y}}|_0 > \tau_s \qquad then \qquad -\frac{\partial \tilde{c}}{\partial \tilde{y}}|_0 = \beta(\frac{\partial \tilde{u}}{\partial \tilde{y}}|_0 - \tau_s)^\gamma, \qquad else \qquad -\frac{\partial \tilde{c}}{\partial \tilde{y}}|_0 = 0. \qquad (1)$$

Then, the concentration of sediment in suspension is convected but falls at a constant settling velocity $-\tilde{V}_f$ (the equation of transport of concentration is solved in Boundary Layer variables). In adimensionalised variables, the dune changes at a slow time scale according to the balance law:

$$\frac{\partial \hat{f}}{\partial \check{t}} = S_c^{-1} \frac{\partial \tilde{c}}{\partial \tilde{y}}|_0 + \tilde{V}_f \tilde{c}|_0. \qquad (2)$$

An example of displacement toward a final equilibrium state is presented on the left figure.



The dune shape ($\hat{f}(\bar{x}, \check{t})$ of maximum $\alpha = 0.1$) as a function of time $\check{t} = 0, 1, 2, 3..., 16, \infty$ (left) and final dune shapes for different starting values of α (right)

The final calculated stationnary bed profile is caracterized by a constant skin friction equal to τ_s. The upstream side is nearly linear, the lee side has a bigger slope (right fig.).

The advantage of this model is that a lot of hydrodynamical mecanisms have been considered without usual integral (or 1D) simplifications. Of course, the first hypotheses to introduce in the model would be a turbulent stress viscosity and diffusivity and for the river bed it would be interesting to introduce the slope limitation.