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Dynamical modelling of fluvial deposition processes on Titan

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Observations of the Cassini-Huygens mission have revealed the complex environment on the surface of Titan, with rivers and lakes of liquid hydrocarbons and mobile sediments in form of dunes and rounded blocks of ice observed at the Huygens landing site. The presence of river valleys and identification of depositional landforms is a strong indication that Earth-like processes of sediment transport and deposition are operating on the surface of this moon. Our aim is to simulate these processes using numerical model to identify the similarities and differences between these processes on both bodies. Special attention is given to the processes at the river/lake interface which results are identifiable in satellite images, such as depositional landforms. The model is based on the Navier-Stokes equations for depth-integrated two dimensional, turbulent flow. Additional equations are used to describe transport of sediments.

We have considered the problem of von Karman parameter known as von Karman constant. In fact its value could vary in the range of 0.25 to 0.6 (see eg. Gaudio, Miglio, Dey, J. Hydraulic Res., 48: 658-663, 2010). However, it does not depend of the fluid parameters but on the properties of the bed sediments. This fact allows the use of model developed for terrestrial rivers.

The flow equations consist of the depth-integrated 2D momentum equations for turbulent flows and the depth-integrated continuity equation:

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -g\frac{\partial Z}{\partial x} + \frac{1}{h}\left(\frac{\partial\left(h\tau_{xx}\right)}{\partial x} + \frac{\partial\left(h\tau_{xy}\right)}{\partial y}\right) - \frac{\tau_{bx}}{h\rho} \tag{1}$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} = -g\frac{\partial Z}{\partial y} + \frac{1}{h}\left(\frac{\partial\left(h\tau_{yx}\right)}{\partial x} + \frac{\partial\left(h\tau_{yy}\right)}{\partial y}\right) - \frac{\tau_{by}}{h\rho} \tag{2}$$

$$\frac{\partial Z}{\partial t} + \frac{\partial\left(uh\right)}{\partial x} + \frac{\partial\left(vh\right)}{\partial y} = 0 \tag{3}$$

where u and v are depth-integrated velocity components in directions x and y, t is the time, h is the local depth, g is the gravitational acceleration, Z is the water surface, τ_{ij} are depth integrated Reynolds stresses, and τ_{bi} are the shear stresses on the bed and flow interface.

We explore the flow properties and the deposition of material as a function of several parameters. We observe sedimentation at the mouth of the river creating river delta in conditions corresponding to surfaces of Titan and Earth. Deltas forming in Titan's conditions are found to evolve faster, accumulation of sediments forms the mouth bar and diverges the flow in a shorter period of time than in terrestrial conditions. Our results are compared with observations of the Cassini probe.

We are also planning the experimental work on this subject to compare with results of numerical modelling.

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