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Differences between evolution of Titan's and Earth's rivers

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Titan is the only celestial body, beside the Earth, where liquid is present on the surface. Liquid forms a number of lakes and rivers. In our research we use numerical model of the river to determine differences of evolution of rivers on the Earth and on Titan. We have found that transport of sediments on Titan is more effective than on Earth for the same river geometry and discharge.

1 Introduction

Titan is a very special body in the Solar System. It is the only moon that has a dense atmosphere and flowing liquid on its surface. The Cassini-Huygens mission has found on Titan meandering rivers, and indicated processes of erosion, transport of solid material and its sedimentation. This paper is aimed to investigate the similarity and differences between these processes on Titan and the Earth.

2 Basic equations of our model

The dynamical analysis of the considered rivers is performed using the package CCHE modified for the specific conditions on Titan. The package is based on the Navier-Stokes equations for depth-integrated two dimensional, turbulent flow.

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

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

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

and three dimensional convection-diffusion equation to describe movement of sediments:

$$\frac{\partial c_k}{\partial t} + \frac{\partial(uc_k)}{\partial x} + \frac{\partial(vc_k)}{\partial y} + \frac{\partial(wc_k)}{\partial z} - \frac{\partial(\omega_{sk}c_k)}{\partial z} = \frac{\partial}{\partial x}\left(\epsilon_s\frac{\partial c_k}{\partial x}\right) + \frac{\partial}{\partial y}\left(\epsilon_s\frac{\partial c_k}{\partial y}\right) + \frac{\partial}{\partial z}\left(\epsilon_s\frac{\partial c_k}{\partial z}\right) \tag{4}$$

where u, v and w are depth-averaged velocity components in the x, y and z directions, respectively; t is time; Z is the fluid surface elevation; h is the local fluid depth; g is the gravitational acceleration; τ_{ij} are the depth integrated Reynolds stresses; and τ_{bx} and τ_{by} are shear stresses at the bottom in the x and y directions, respectively. c_k is concentration and ω_{sk} is terminal velocity of k-size sediment, ϵ_s is turbulent diffusivity.

3 Parameters of the model

We considered our model for a few kinds of liquids found on Titan. The liquid that falls as a rain (75% methane, 25% nitrogen) has different properties than the fluid forming lakes (74% ethane, 10% methane, 7% propane, 8.5% butane, 0.5% nitrogen). Other parameters of our model are: inflow discharge, outflow level, grain size of sediments etc. For every calculation performed for Titan's river similar calculations are performed for terrestrial ones.

4 Results and Conclusions

We compare results of our calculation for flow of different liquids and for sediment transport for the Earth and for Titan. The basic statement is that on Titan the transport of sediment is more efficient than on Earth for rivers of the same geometry and total discharge.

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