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Comparison of processes of river delta formation on Titan and Earth

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Abstract

The *Cassini-Huygens* mission has revealed the existence of hydrocarbon lakes and river valleys on Titan. We simulate processes of sediment transport and deposition on Titan and compare them with analogous processes on Earth and Mars, with several possible compositions of the liquid and the sediments. Our results show many similarities between the processes, but also some differences concerning e.g. the time scale of formation of depositional complexes.

1. Introduction

River deltas are formed when the flow enters the standing body of liquid. Ontario Lacus on the southern hemisphere of Titan contains what is interpreted as two-lobed river delta at the mouth long river valley. The *Huygens* probe landed on a plain strewn with icy 'pebbles', most probably rounded during transport by liquids. Determining whether fluvial landforms on Titan are created by the persistent flow or the occasional flash floods has implications for understanding the environment and modelling the climate of this moon.

2. Results

Figures 1 and 2 show results of simulations with the same geometry, initial liquid level and discharge at the inflow, but with different liquids (water on Earth, methane-nitrogen mixture on Titan) and solids (quartz and water ice, respectively). Note that the sediments have been pushed deeper into the lake in Titanian conditions (Figure 2).

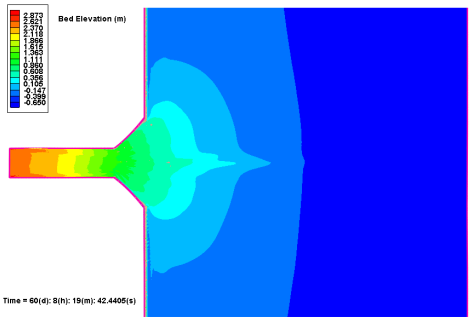

Figure 1: Bed elevation after 60 simulation days in terrestrial conditions.

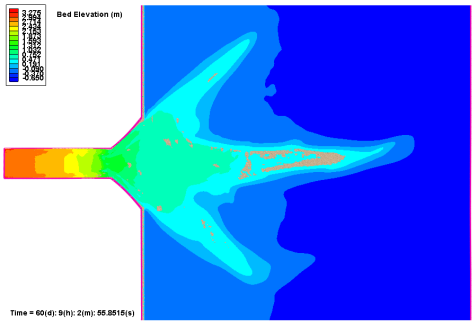

Figure 2: Bed elevation after 60 simulation days in Titanian conditions.

4. Tables

Table 1: Composition of two of the considered liquids possible on Titan's surface [1].

	"Rain"	Lake liquid
Methane	75%	10%
Ethane		74%
Propane		7%
Butane		8,5%
Nitrogen	25%	0,5%

5. Equations

Our model uses finite element method [FEM]. It is based on two-dimensional depth-averaged hydrodynamic equations (the Navier-Stokes equations and the continuity equation) [2].

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

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

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

Where u and v are depth-averaged velocity components in the x and y 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.

Additional equations are used to describe bed-load transport, suspended sediment transport and changes of the bed geometry (see e.g. [3]).

6. Summary and Conclusions

Our results agree with earlier analysis of [4] in that the transport rate of icy sediments on Titan is higher than for quartz sediments on Earth. The flow in Titanian rivers should be able to build and change river deltas faster than in terrestrial conditions. *Cassini* radar observations do not show changes in morphology of the delta in Ontario Lacus over several years. That suggest that adjacent river channel is currently dry.

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