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Numerical simulations of multiple and single channel rivers on Earth and Titan – further results

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Abstract

On Titan surface we can expect a few different geomorphological fluvial forms, e.g. fluvial valley and river channels. In present research we use numerical model of the river (Fig. 1) to determine the ranges of different fluvial parameters important for evolution of the rivers on Titan and on Earth. We have found that transport of sediments by suspended load is the main way of transport for Titan [1]. We also determined the limit of the river's parameters for which multiple-channel rivers are developed rather than single-channel rivers on the Earth [2] and on Titan.

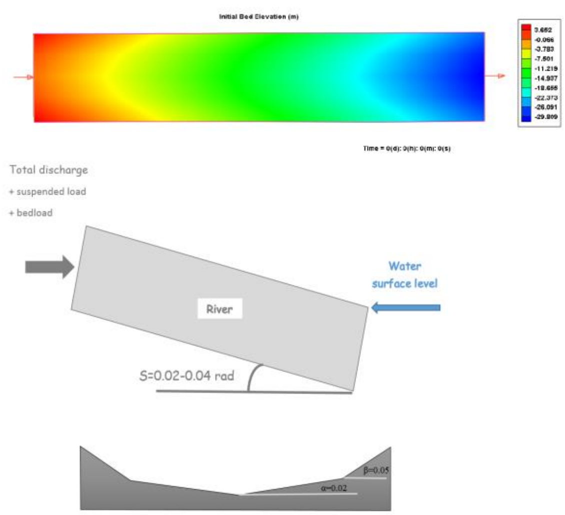

Fig. 1 The initial bed topography and other information about domain used for our simulations. The slope (S) of the river valley is S=0.01-0.04, length of the valley is 1 km, and width is 200 m. These parameters of the valley are based on the observation of rivers network at the Huygens landing site, during its descent [3]. Upper panel – topography, middle panel – cross section along the river, lower panel – cross section across the river

1. Introduction

Titan is the only moon that has dense atmosphere and flowing liquid on its surface. The Cassini-Huygens mission has found on Titan meandering river valleys, and processes of erosion, transport of solid material and its sedimentation. In this work we investigate the similarity and differences between fluvial processes on Titan and the Earth.

2. CCHE2D

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 and three dimensional convection-diffusion equation of sediment transport. For more information about numerical model see discussion in [1].

3. Parameters of the system

We performed our simulations for a few different parameters of liquid and material transported by a river. For Titan we used liquid corresponding to Titan's rain (75% methane, 25% nitrogen), for Earth - the water. Our solids are – basalt and quartz for the Earth, water ice for Titan. The rest of important parameters is presented in Tab. 1. 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.

Parameter	Earth	Titan
Gravity [m s^{-2}]	9.81672	1.352
Density of the liquid [kg m^{-3}]	999.84	518
Density of the solid [kg m^{-3}]	2650 and 3000	980
Viscosity of the liquid [Pa s]	8.9 x 10^{-4}	1.51 x 10^{-4}

Tab. 1 Important parameters of the model.

4. Results and Discusion

The results of our simulation show differences in river evolution on Titan and on the Earth. Our preliminary results indicate that suspended load is the main way of transport in simulated Titan's conditions [1].

Using numerical simulations we investigate river evolution for large *S*, i.e. larger than rivers investigated by other scientists (e.g. [4]). We obtained three main types of rivers (single channel, multiple channels and transitional). We found that the trend line for transitional rivers is a decreasing function of *Q* in space (*Q*, *S*) - Fig. 2. For large *S* the number of multichannel rivers decreases. Exponent in power function for trend line for large *S* is significantly lower than for low *S*. We found that equations of trend lines for transitional rivers obtained for Titan and Earth for basalt and quartz are similar.

Acknowledgements

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References

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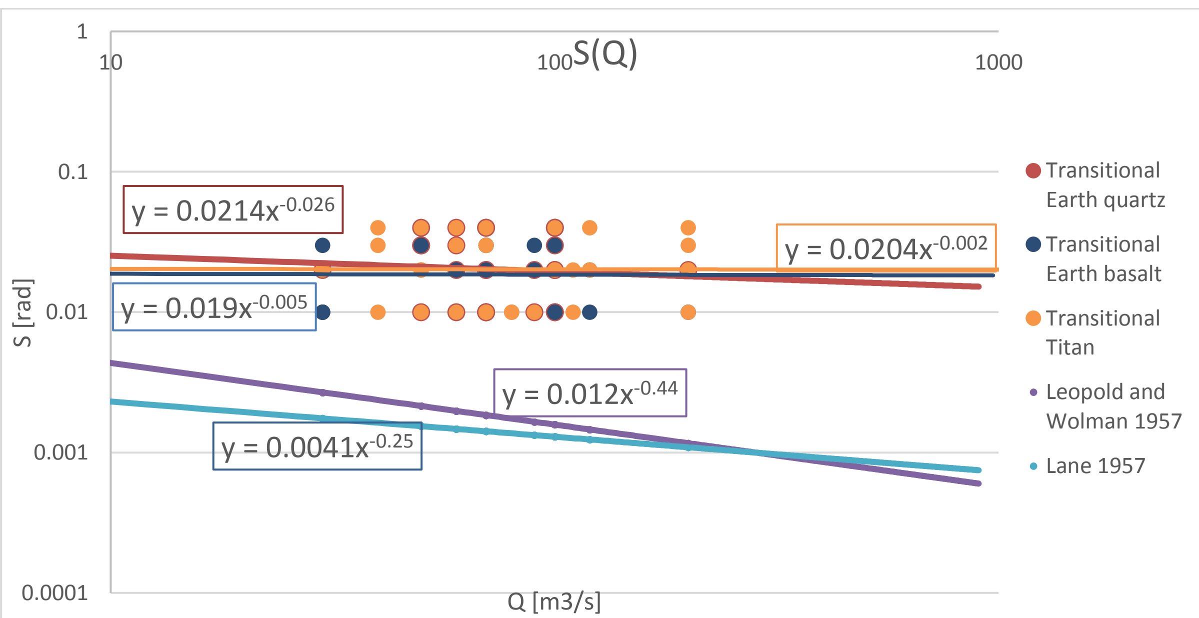

Fig. 2 Positions of simulated rivers for Titan in space (*d*, *Q*) - upper graph, and (*S*,*Q*) – lower graph, for all considered S and trend line (red) for transitional rivers (a power function). For lower panel there are shown also braiding and meandering predictors of Lane (1957) and Leopold and Wolman (1957) – lines purple and blue