



How 2D Hydraulic Modelling Can Improve Landscape Analysis in Tectonic Geomorphology?

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1 TECTONIC INFORMATION FROM CHANNEL NETWORK AND ISSUES

Theoretical background → Channel extraction from High Resolution DEM → Slope-area relationship

In a variety of natural landscapes, fluvial channels tend to follow:

$$S = k_s A^{-\theta}$$

(Hack, 1957; Flint, 1974)

Assuming $U=E$ and that a stream power incision model applies, one predict that :

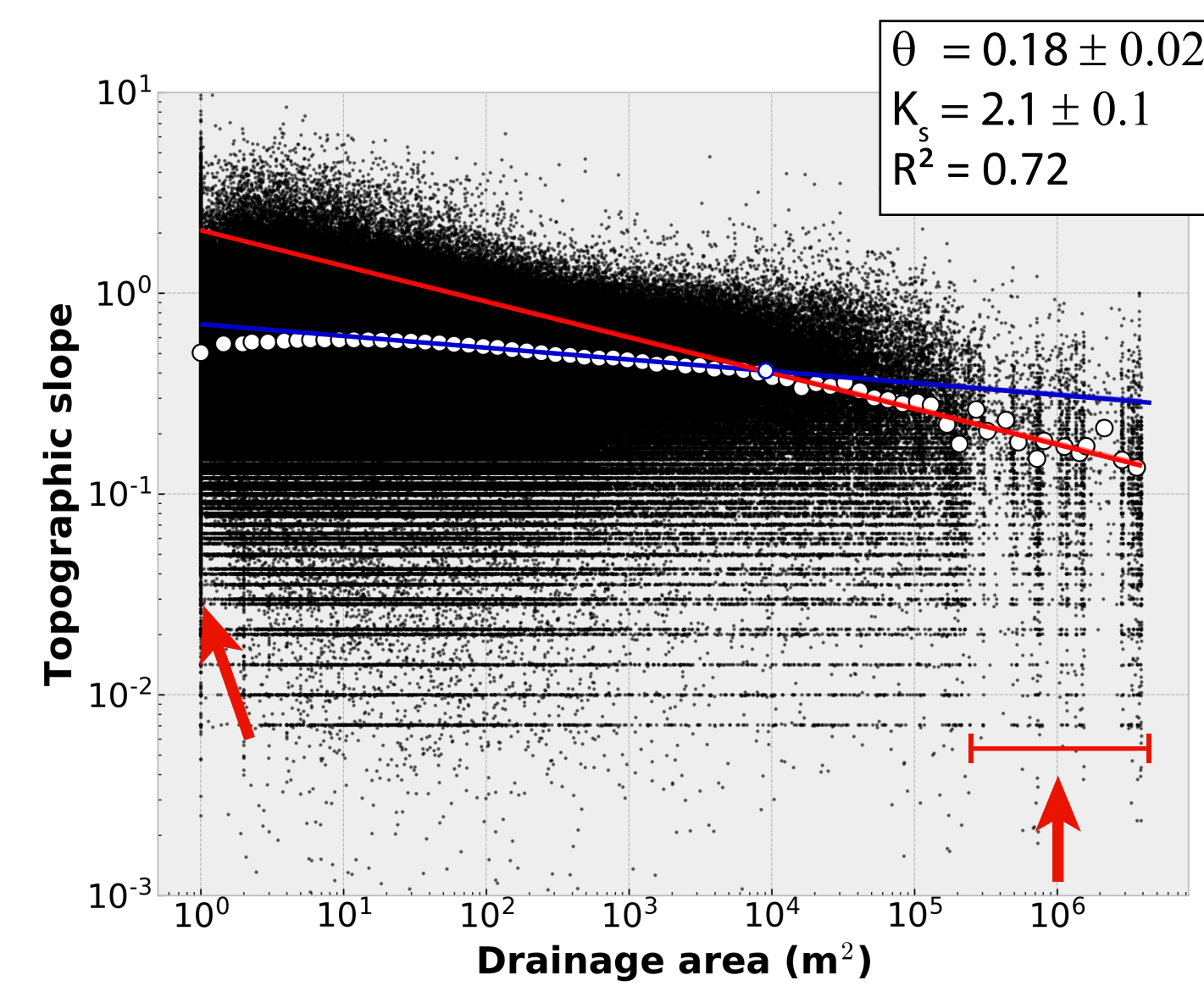
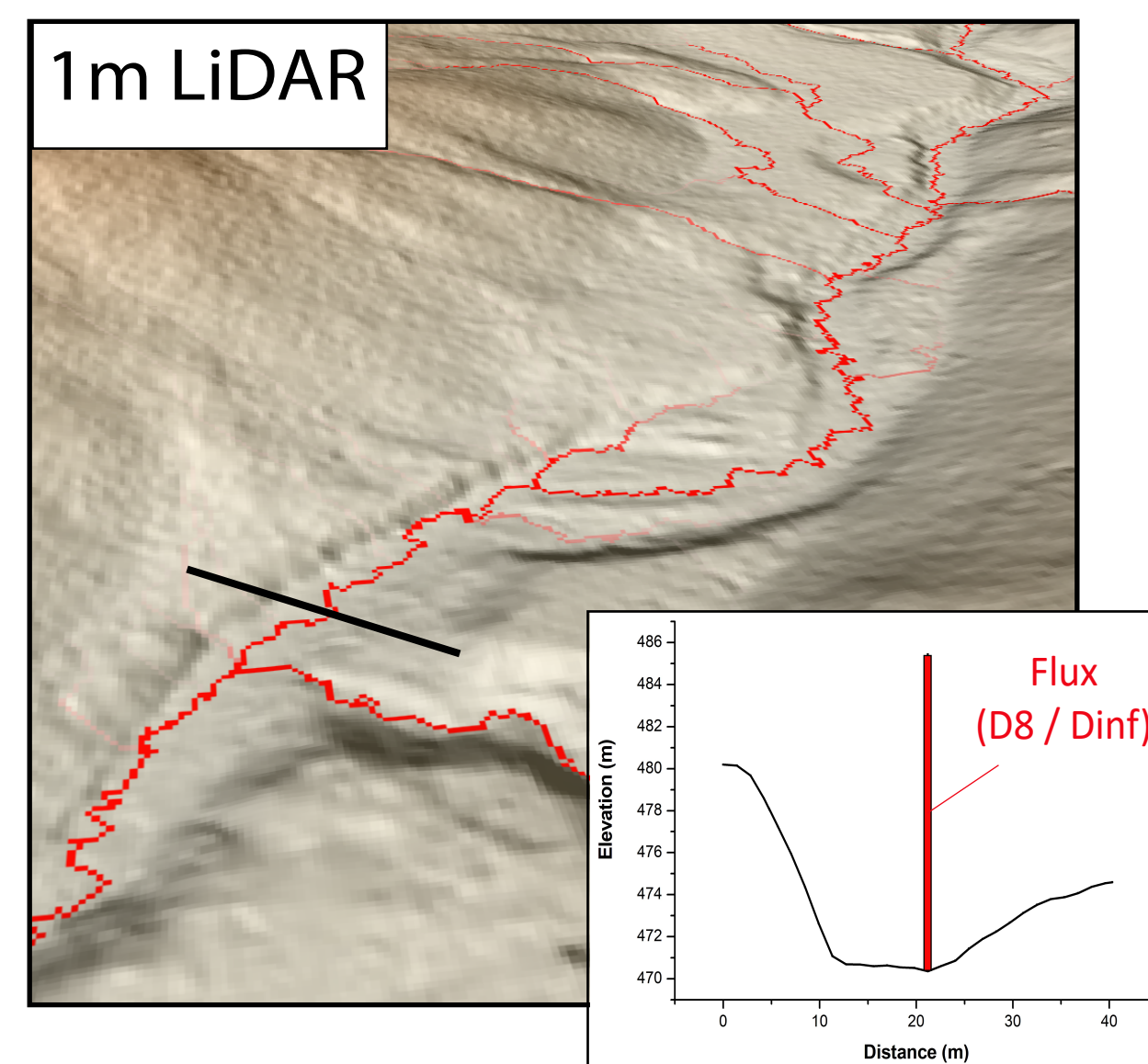
$$k_s = (U/K)^{1/n}$$

(Howard, 1994; Wobus et al., 2006; Lague, 2014)

→ Tectonic information could theoretically be extracted from channel morphology

k_s : channel steepness index, θ : concavity index, S : Topographic slope, A : drainage area, U : uplift rate, E : Erosion rate, K : Erodability coefficient

Issue when channel width > 1 pixel



NEED FOR A NEW METHOD ACCOUNTING FOR CHANNEL WIDTH

2 METHODOLOGY: SOLVING 2D HYDRODYNAMICS TO DESCRIBE CHANNEL WIDTH

The 2D shallow water equations

Water mass balance equation

$$\frac{\partial h}{\partial t} + \frac{\partial U h}{\partial x} = 0$$

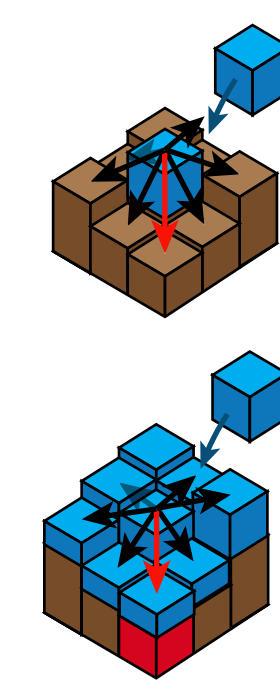
Flow depth

Flow velocity

Hypothesis

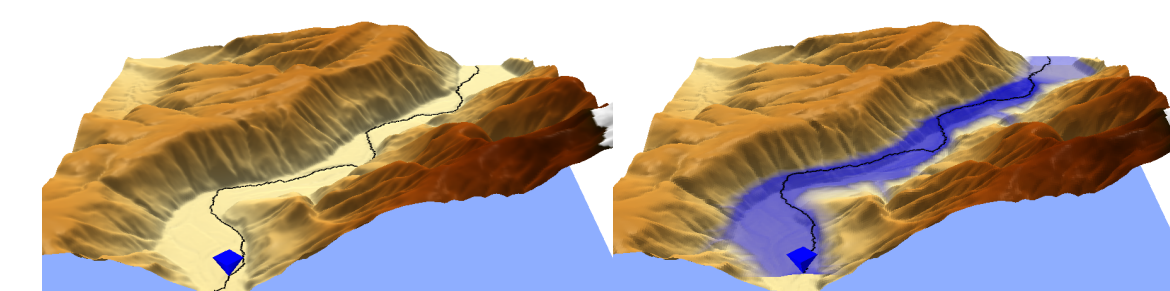
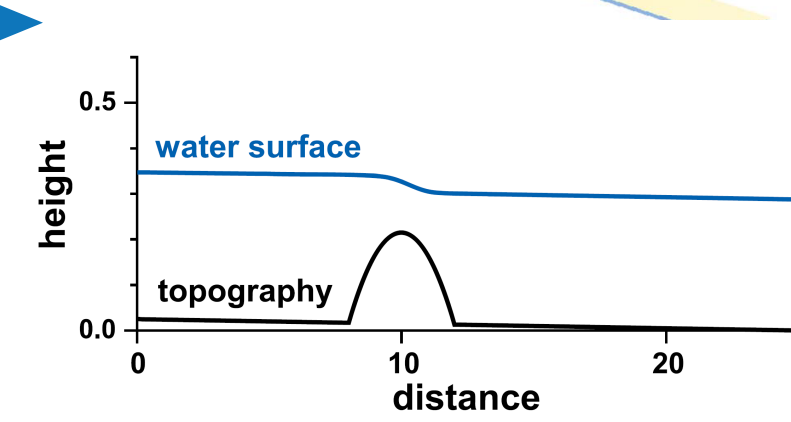
Inertial terms are negligible
Basal friction >> other frictional terms

precipiton : water volume



Fill depressions

Account for channel morphology



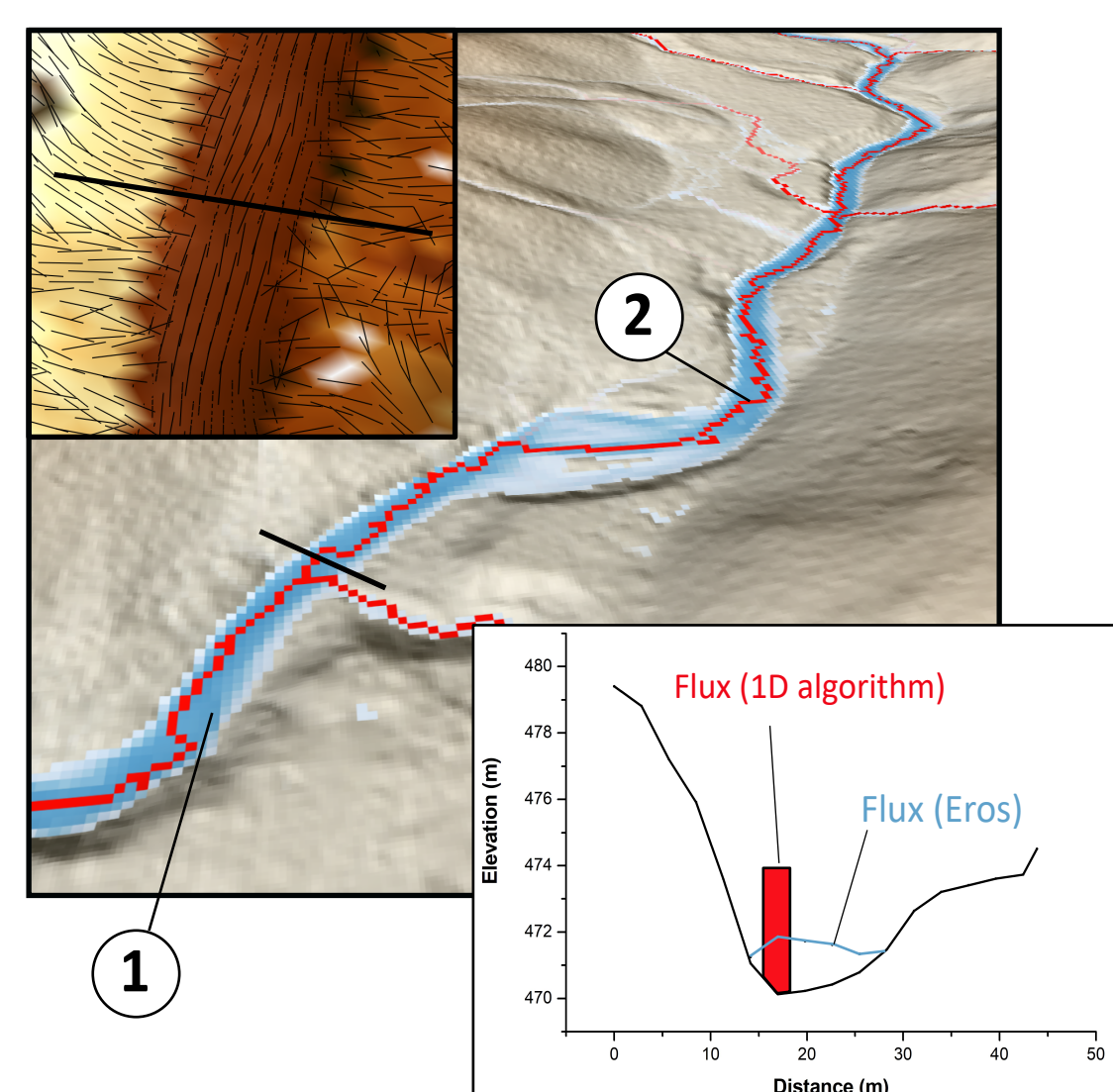
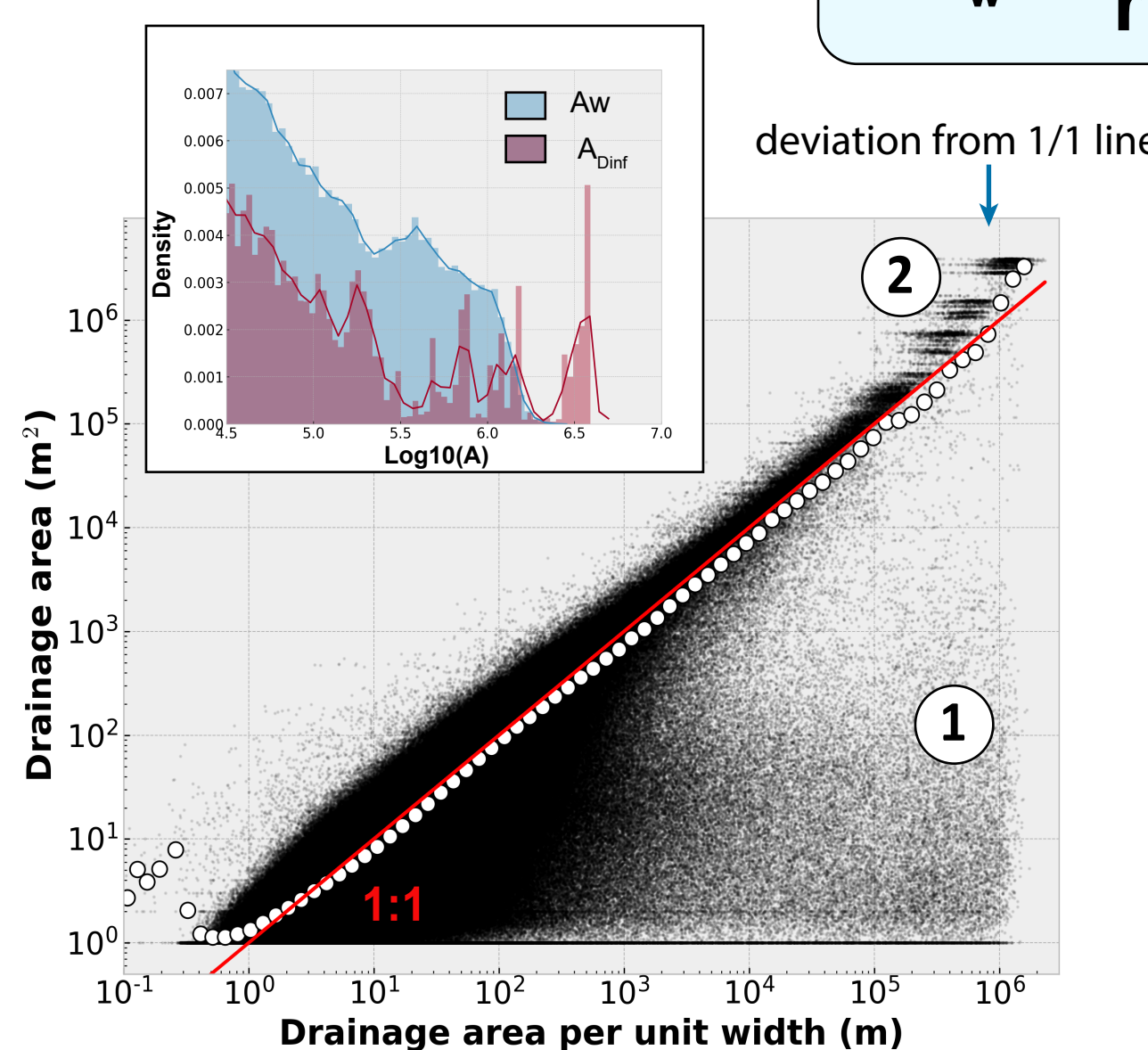
(Davy et al., 2017)

NEW HYDRO-GEOMORPHIC DESCRIPTORS

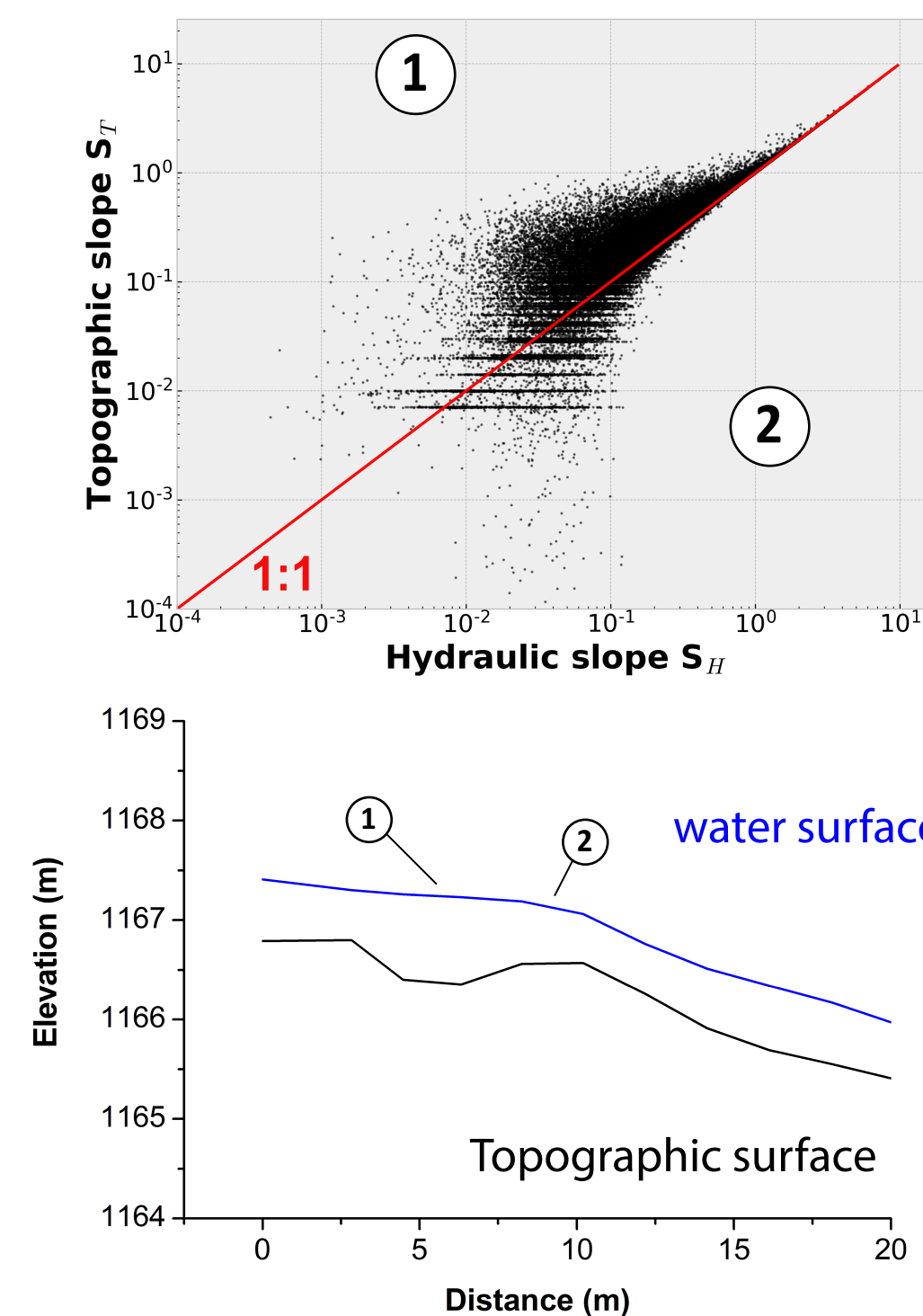
The drainage area per unit width

$$A_w = \frac{q}{r}$$

A_w : drainage area per unit width (m)
 q : unit discharge (m^2/s)
 r : rainfall rate (m/s)

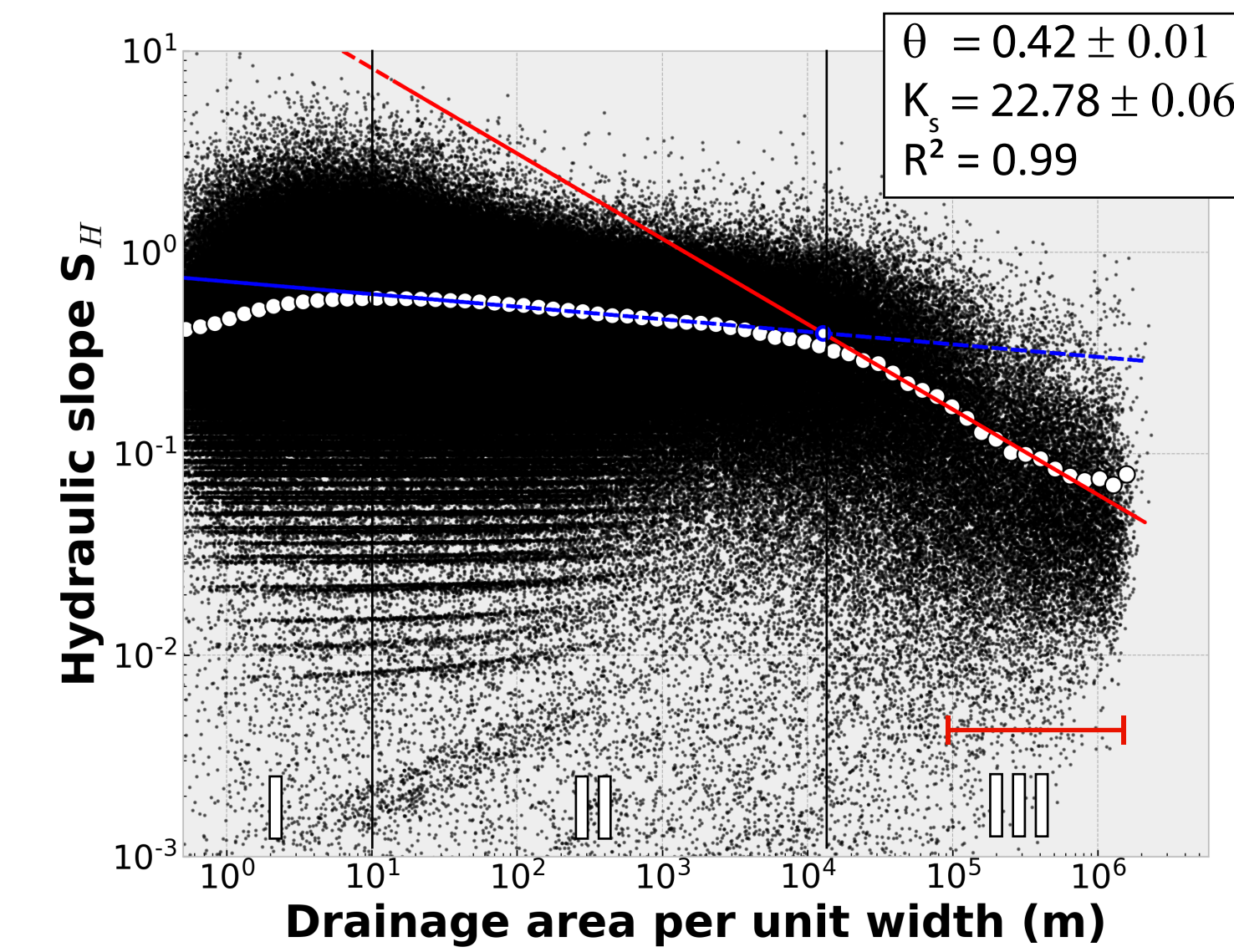


The hydraulic slope



3 APPLICATION EXAMPLE TO THE MULE FORK CATCHMENT, CALIFORNIA

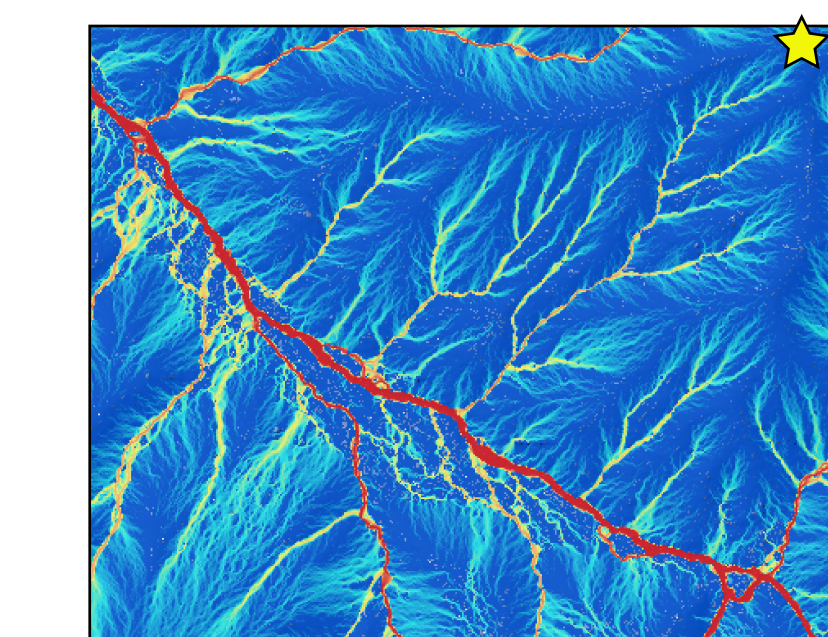
The hydraulic slope - drainage area per unit width relationship



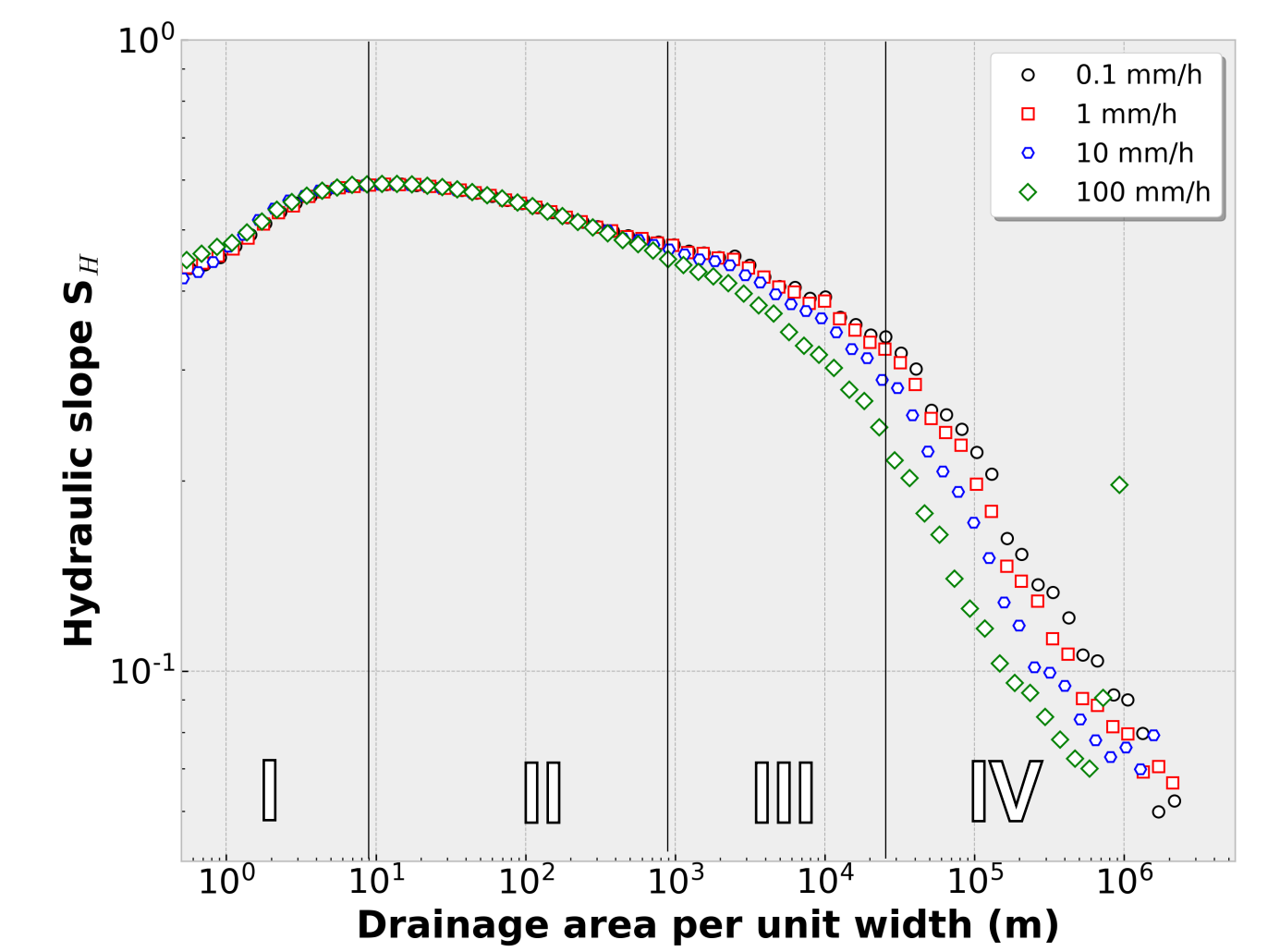
Input parameters

Precipitation rate: 10 mm/h
Resolution: 1m
Manning's coefficient: 0.04

Drainage Area per unit width

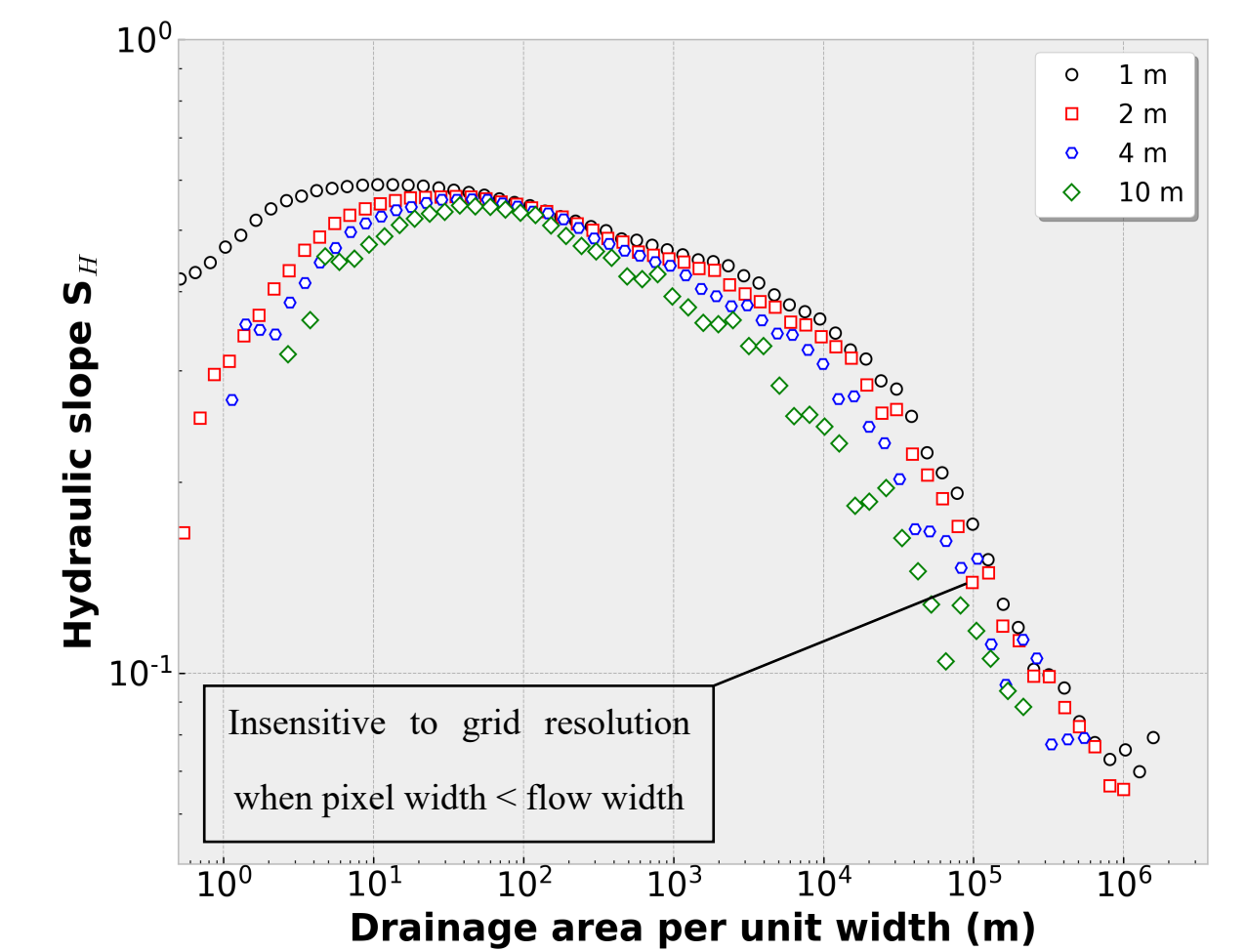


Sensitivity of fluvial extent to runoff intensity

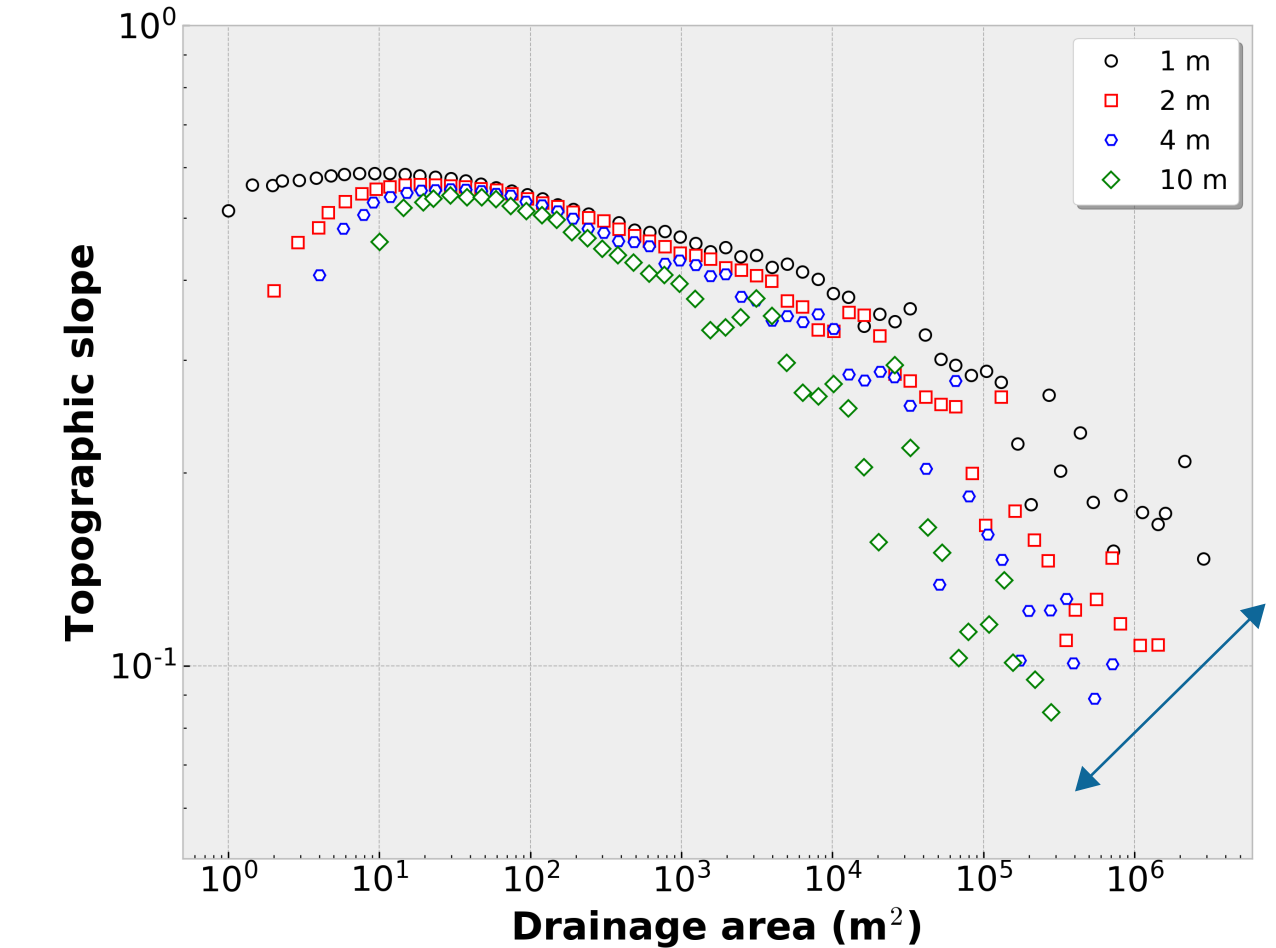


Sensitivity to the grid resolution

2D hydrodynamics model



D-infinity flow routing



Combined analysis at various runoff yield new insights into landscape organisation

Area: 3 Km²
Lithology: granite
MAP: 685 (mm/h)



0 250 500 m

Convex hillslopes
Concave hillslopes/colluvial domain
Intermittent channelized signature
Permanent channelized signature

4 TAKE HOME MESSAGE

2D hydraulics model have several benefits:

- Directly account for channel width in the calculation of fluvial hydraulic variables (unit discharge, hydraulic slope, shear stress etc..)
- Richer description of landscape organization for various runoff intensities
- A sharper transition between colluvial and channelized domain
- A much clearer expression of the concavity and steepness index than the traditional slope-area analysis
- Reduced sensitivity to DEM resolution compared to slope-area analysis

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