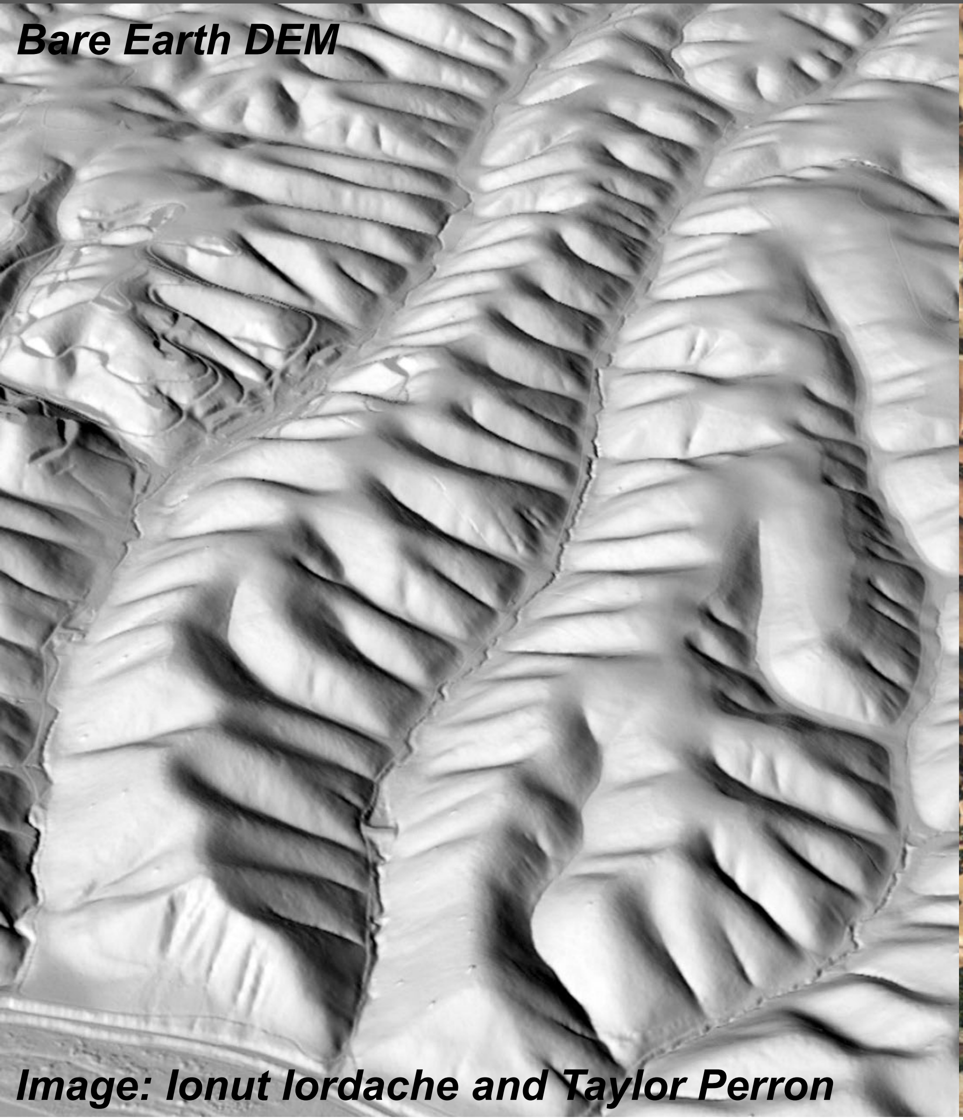
Discussion prompt



What is a **model**?

What do we **need to know** to model a landscape like this?

Simulating Earth surface dynamics

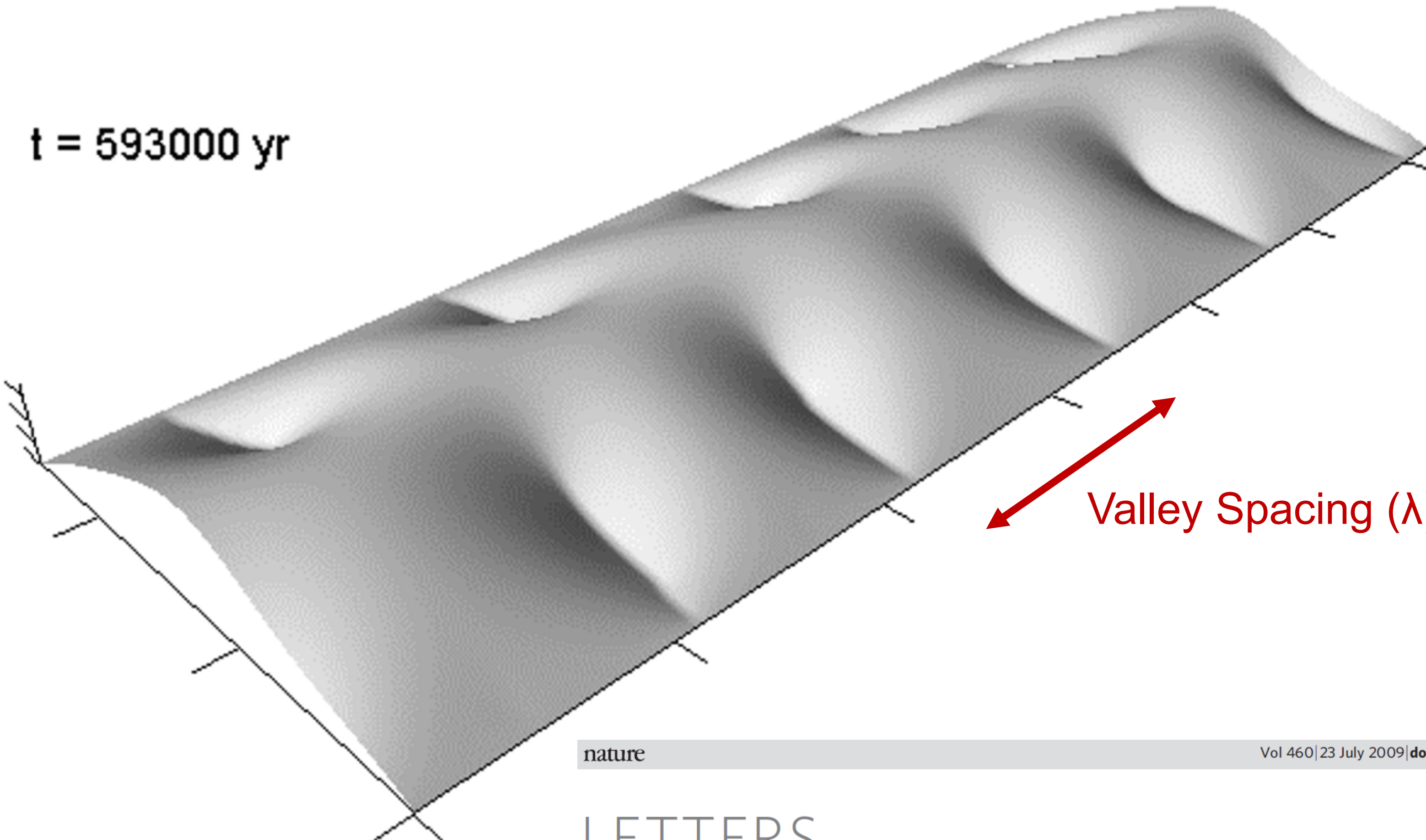
A **landscape evolution model** contains several components:

1) a statement of **continuity of mass**,
2) geomorphic transport functions that describe the generation and movement of sediment and solutes on **hillslopes**,
3) a representation of **runoff generation** and the routing of water across the landscape,
4) geomorphic transport functions for erosion and transport by **[flowing] water** and water-sediment mixtures,
5) numerical methods used to **discretize the solution** space and iterate forward in time

Tucker & Hancock (2010)

A cool simulation

$$\frac{\partial z}{\partial t} = Uplift\ Rate - \ Soil\ creep\ - River\ Incision$$



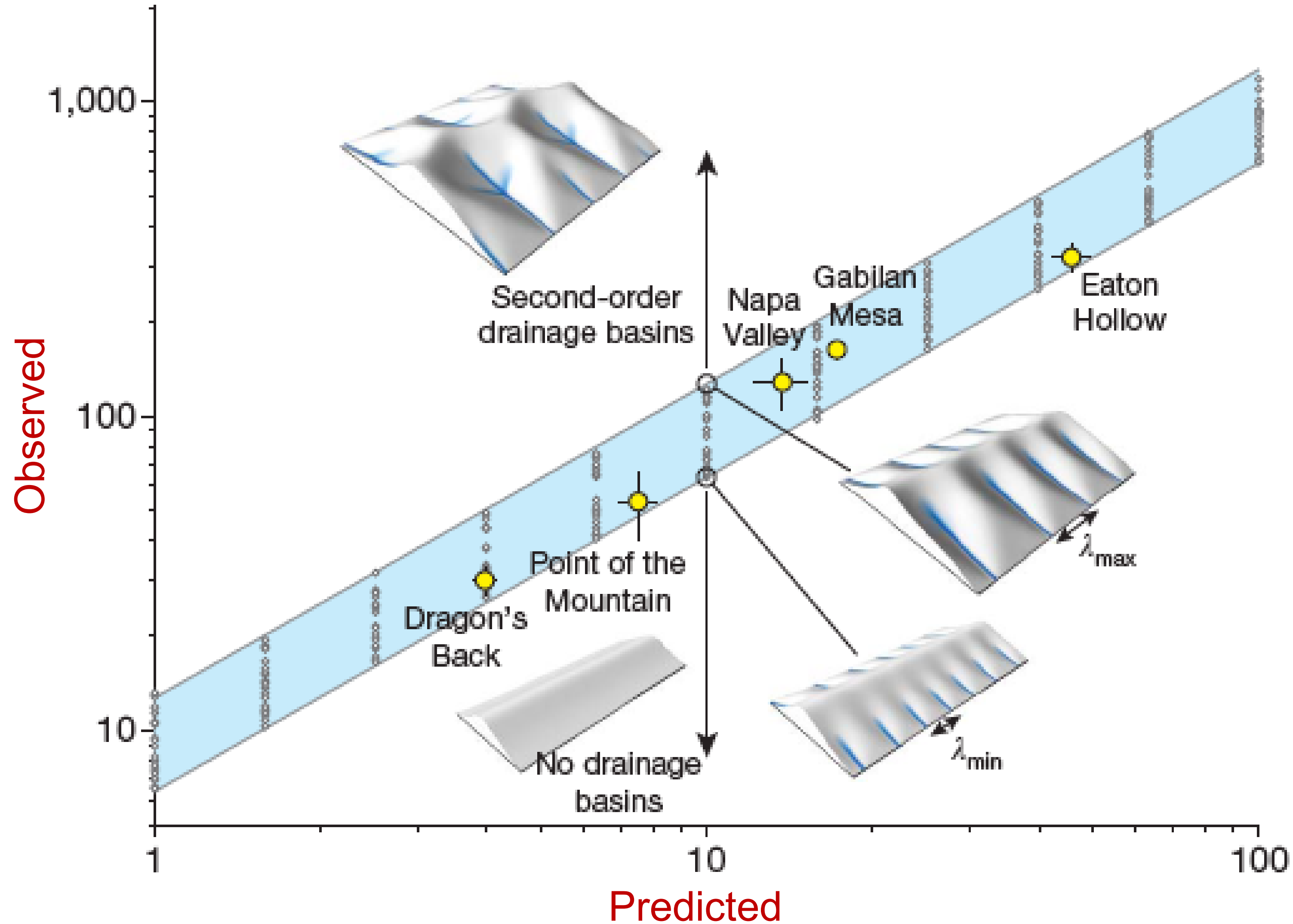

nature Vol 460|23 July 2009|**doi:10.1038/nature08174**

LETTERS

Formation of evenly spaced ridges and valleys

J. Taylor Perron[1], James W. Kirchner[2,3,4] & William E. Dietrich[2]

A cool result



This analysis used two **geomorphic transport laws** (+ uplift) to make a testable prediction

Geomorphic Transport Laws

A geomorphic transport law is a **mathematical statement** derived from a *physical principle* or mechanism, which expresses the mass flux or erosion caused by one or more processes in a manner that:

1) can be **parameterized** from field measurements,
2) can be **tested** in physical models, and
3) can be **applied** over geomorphically significant spatial and temporal scales.

Dietrich et al. (2003)

The soil 'diffusion' example

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Tucker & Hancock (2010)

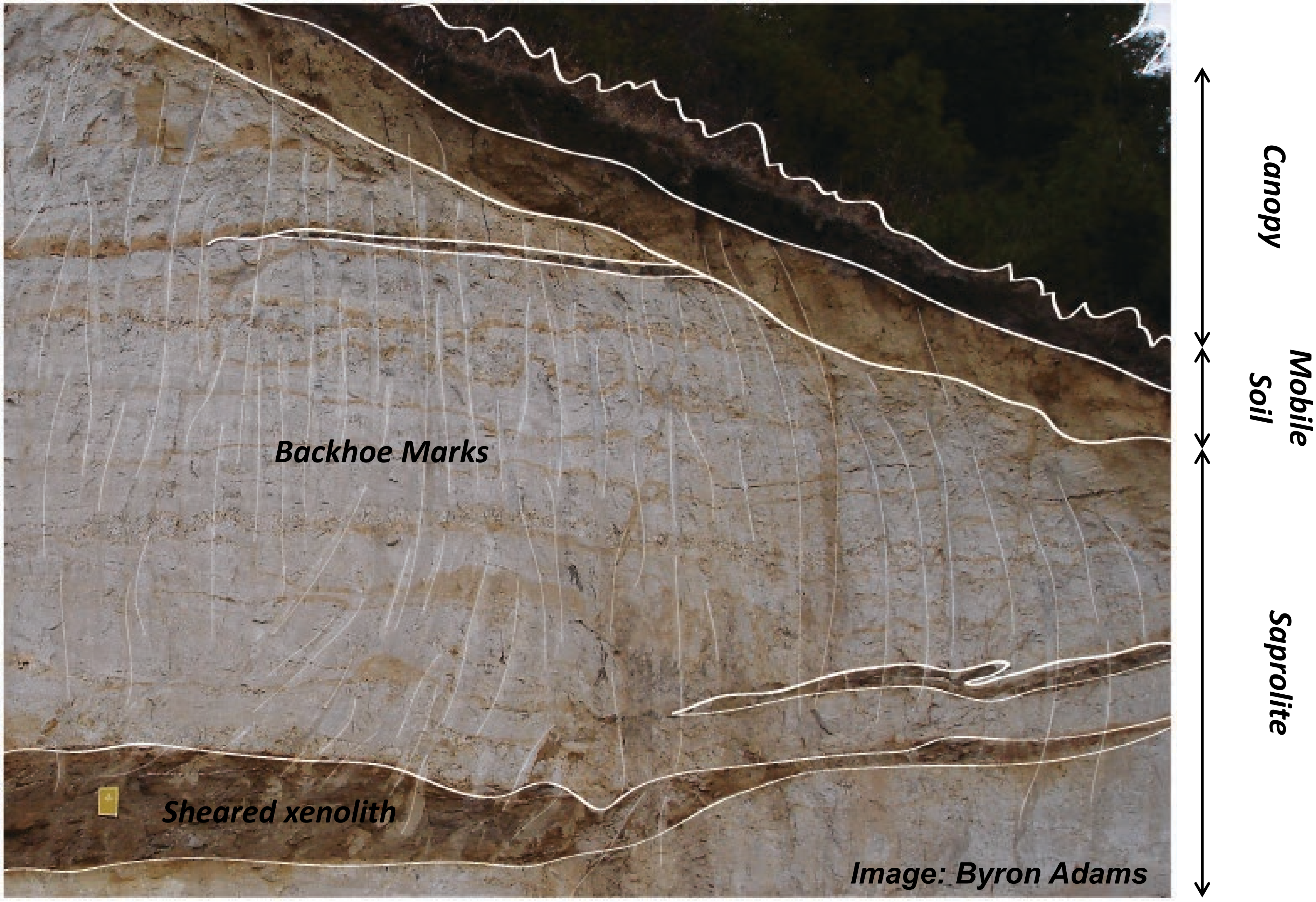
What makes this landscape look so unusual?

Is that it doesn't look like what we are used to

Even in the driest places

Even in the driest places

Soil is on the move



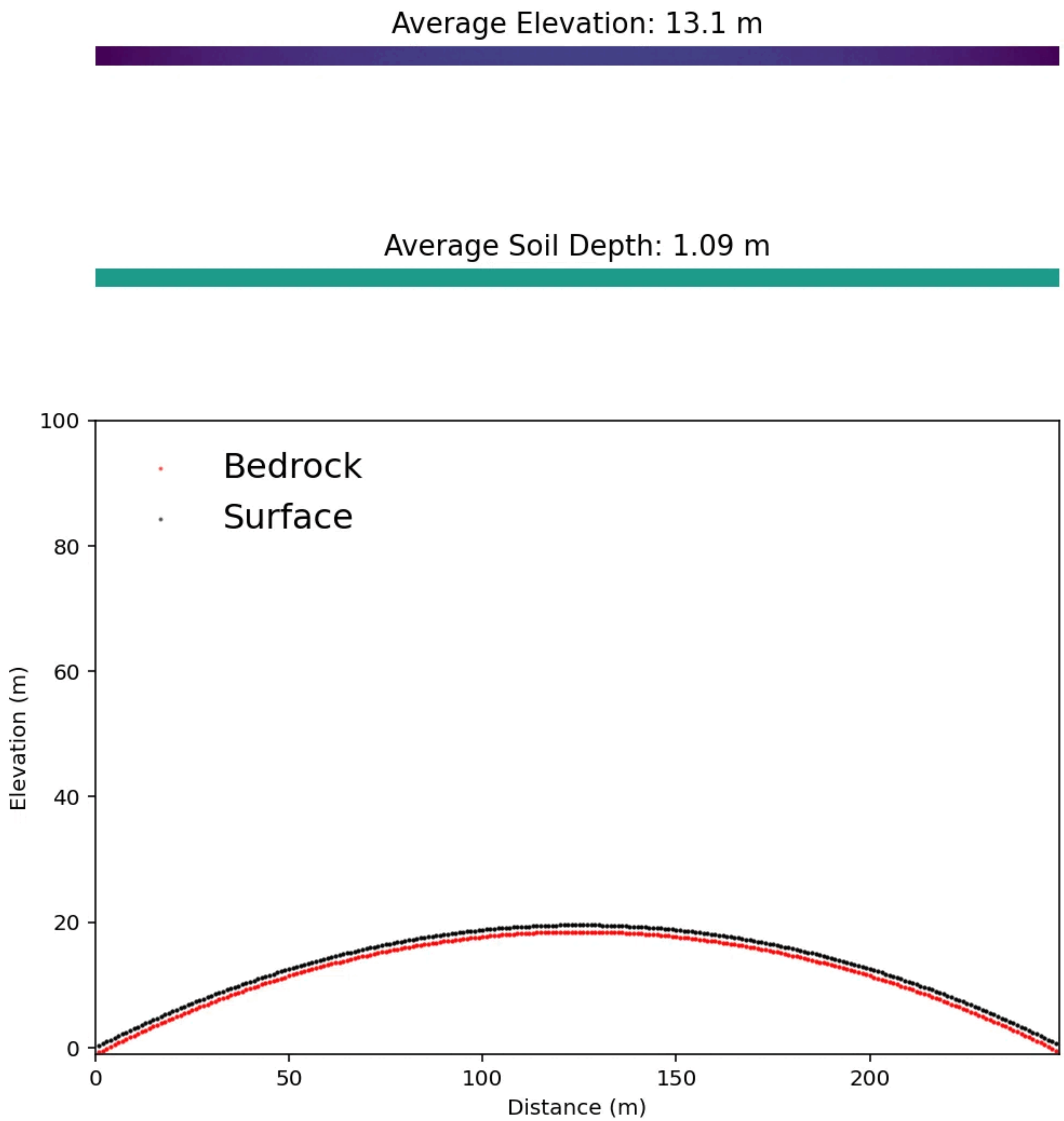
Albeit slowly

Soil creep

With a few lines of code, you'll be able to couple process components into your own custom model:

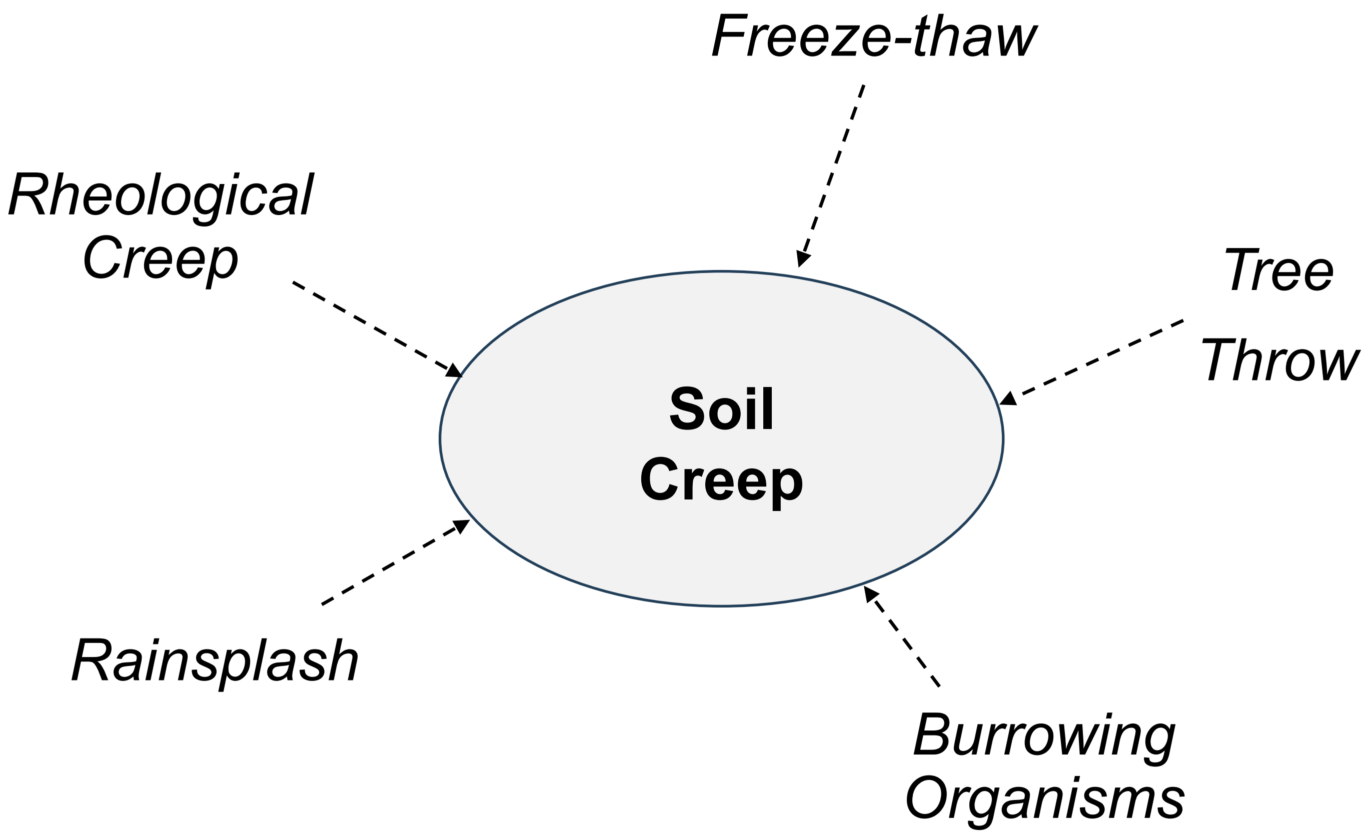
-Soil production

-Soil creep



Soil creep

Soil creep is the **slow downhill movement** of the mobile layer due to gravity



Constructing a mathematical statement

1. Conservation of mass

Tells us how fast the land surface height (z) is rising or falling at a given point.

$$\frac{\partial z}{\partial t} = U - \frac{\partial q}{\partial x}$$

Vertical Change	*Uplift Rate*	*Net Flux*
$\left[\frac{L}{T}\right]$	$\left[\frac{L}{T}\right]$	$\left[\frac{L}{T}\right]$

2. Geomorphic transport law for creep

Tells us the transport rate of soil as it moves downhill (hence the negative).

$$q = -K \frac{\partial z}{\partial x}$$

Soil Flux	=	*Transport Coefficient*	*Hillside gradient (1D)*
$\left[\frac{L^2}{T}\right]$		$\left[\frac{L^2}{T}\right]$	$\left[\frac{L}{L}\right]$

3. Combine the two

Conservation of Mass

$$\frac{\partial z}{\partial t} = U - \frac{\partial q}{\partial x}$$

Soil Creep

$$q = -K\frac{\partial z}{\partial x}$$

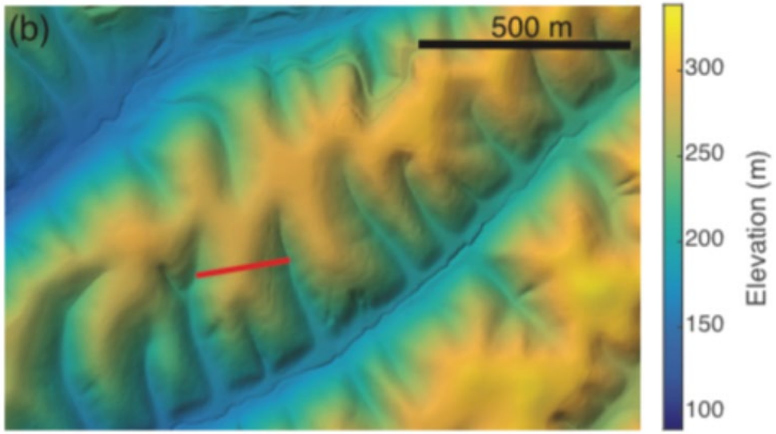
$$\frac{\partial z}{\partial t} = K\frac{\partial^2 z}{\partial x^2}$$

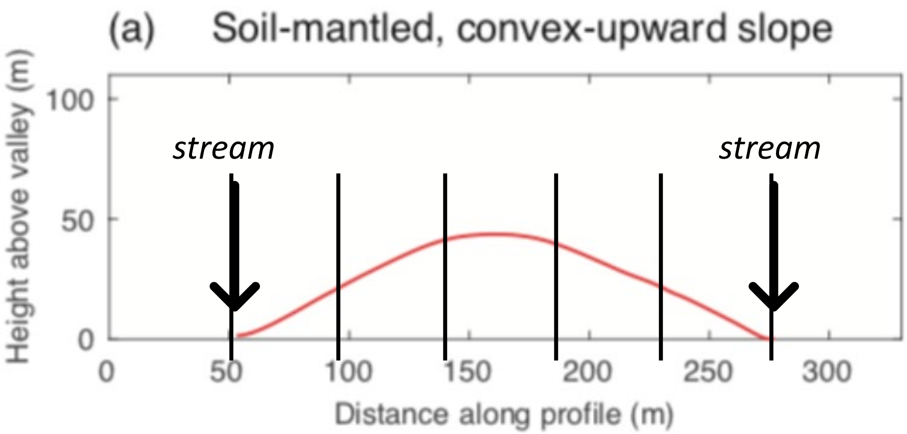
$$\left[\frac{L}{T}\right] \qquad \left[\frac{L^2}{T}\right] \quad \left[\frac{1}{L}\right]$$

We now have a **mathematical statement** that can be used to evolve topographic elevations

4. Discretize the problem

~ Inspiration ~





Setting up our 1D model

1. Divide our space into finite pieces
2. Finite-differencing those pieces

discretization

the process of taking a continuous feature and converting it into discrete counterparts