Earth Surface Process Modeling - Introduction

April 2025

Me…

- Jean Braun
- Professor at the GFZ (GeoForschungsZentrum) in Potsdam
- Professor at University of Potsdam
- Professor in Grenoble, Rennes, Harvard, Berkeley, Australian National University
- PhD in Oceanography from Dalhousie University, Canada
- BSc & MSc in Physics from University of Liège, Belgium

Me…

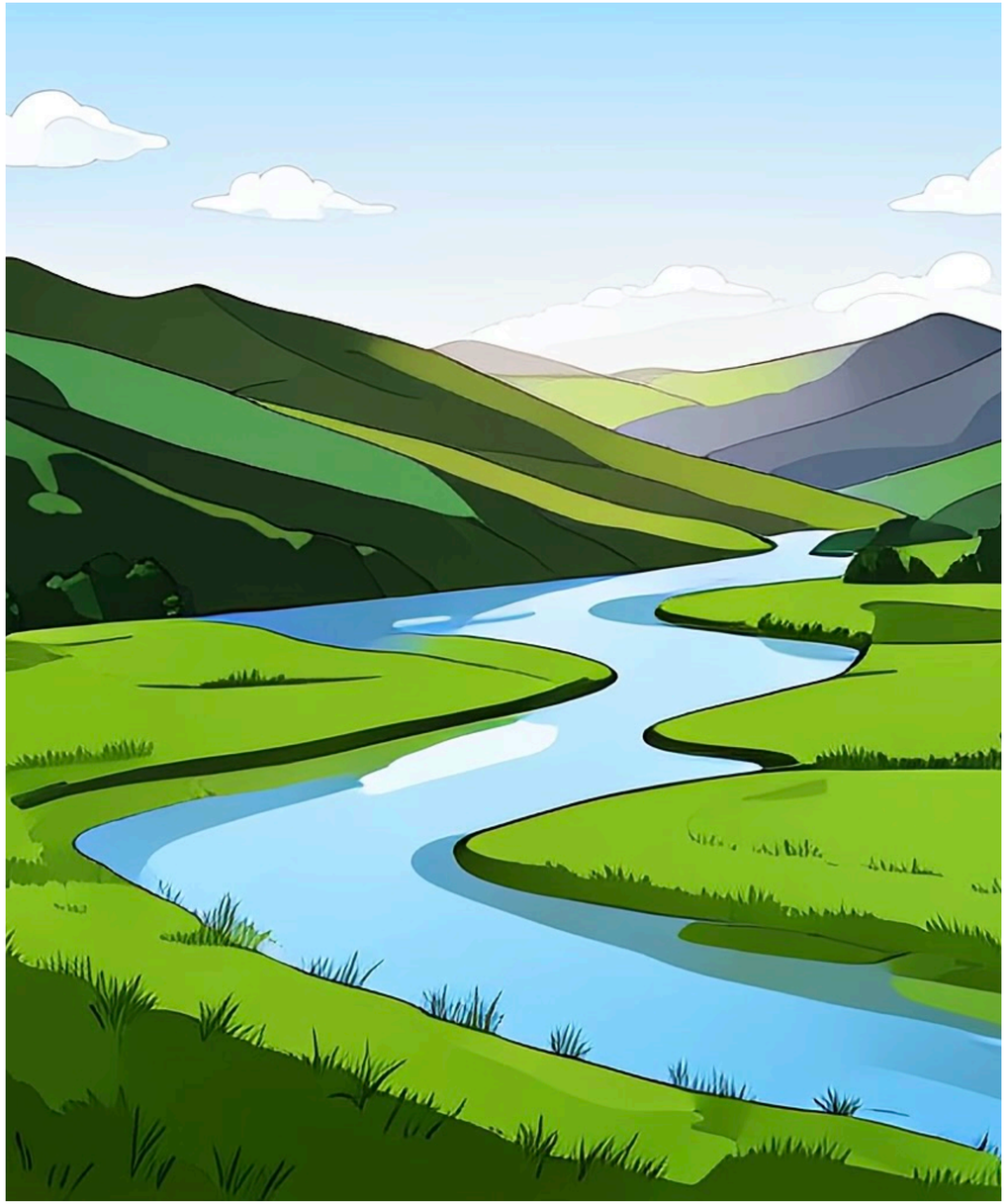
- Jean Braun
- Broad range of interests: tectonics, structural geology, thermochronology, geomorphology, biodiversity, etc.
- Common approach: developing equations and solving them using novel and efficient methods
- Address questions at the interface between fields and “spheres”

You…

- Who are you?
- Which Master are you enrolled in?
- Have you started a research project yet? If so, briefly describe it
- What is your competence in coding in Python?
- What is your competence with partial differential equations?
- What is your competence in tectonics and/or geomorphology?

Rivers

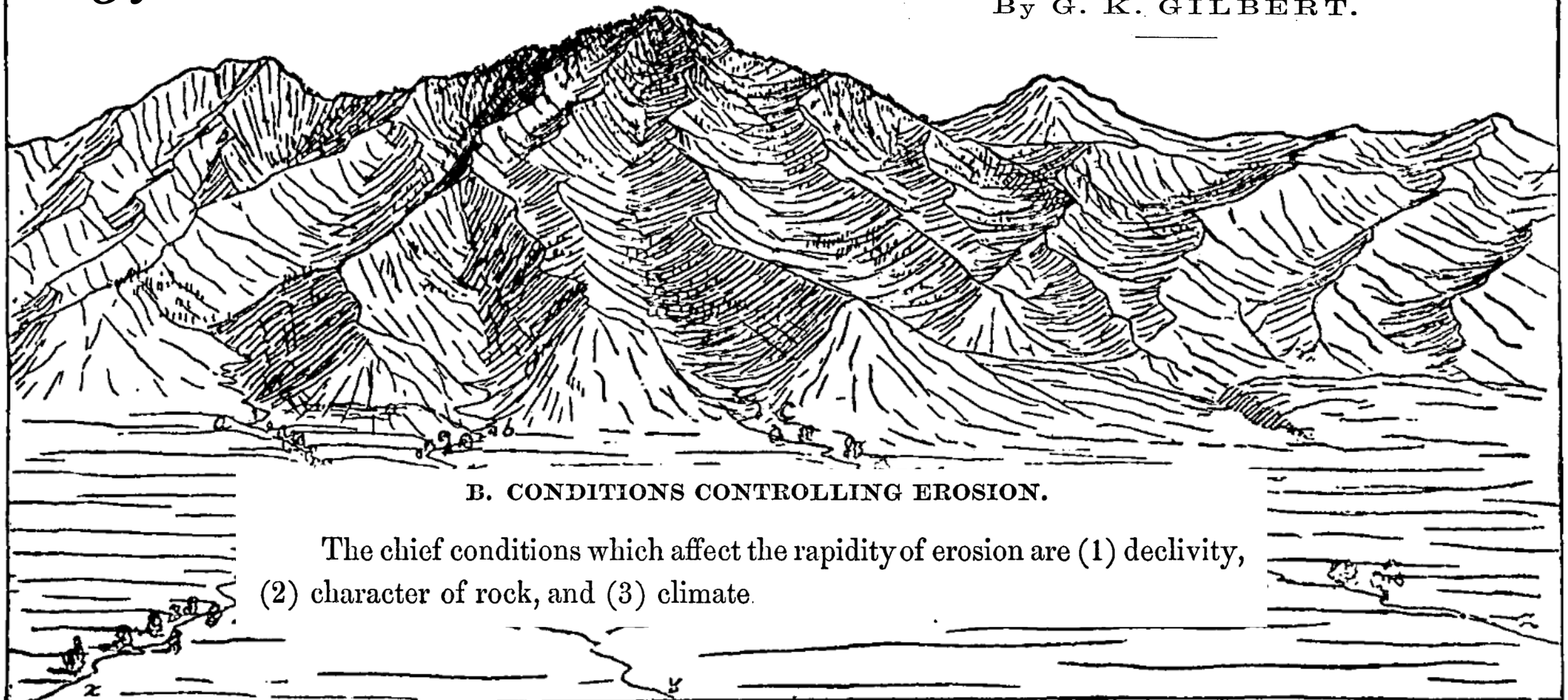
- Erode (incise) the landscape
- Create slope and drive hillslope processes
- Transport and deposit sediment



$$\frac{\partial h}{\partial t} = U - K_f A^m S^n$$

GEOLOGY OF THE HENRY MOUNTAINS.

By G. K. GILBERT.

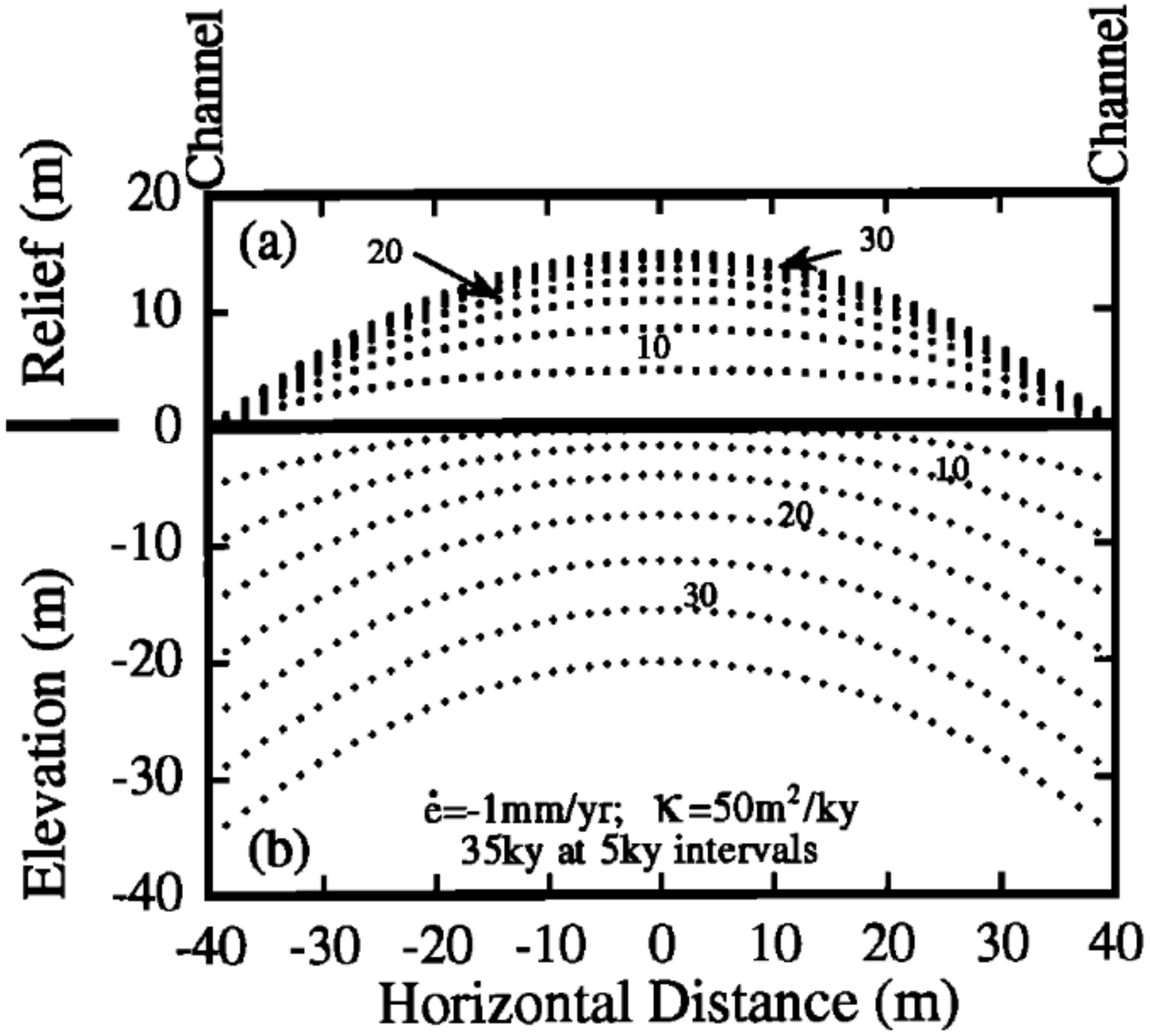


B. CONDITIONS CONTROLLING EROSION.

The chief conditions which affect the rapidity of erosion are (1) declivity, (2) character of rock, and (3) climate.

Hillslopes

- Transport of material under the influence of gravity
- Processes are slow or catastrophic
- Yields characteristic forms



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Evolution of the Santa Cruz Mountains, California, through tectonic growth and geomorphic decay

Robert S. Anderson
Department of Earth Sciences and Institute for Tectonics, University of California, Santa Cruz

Diffusion

Diffusion of the landscape results from conservation of mass and a transport law that linearly relates mass flux to local slope. Conservation of mass results in the erosion equation

$$\frac{\partial z}{\partial t} = -\frac{1}{\rho_b}\nabla Q \qquad (7)$$

where Q is the "specific mass discharge" of sediment on the hillslope, or discharge of mass per unit width of slope [=] M/LT, and ρ_b is the bulk density of the mobile regolith. When this discharge is proportional to the local slope, i.e., when

$$Q = -k\nabla z \qquad (8)$$

with k a transport coefficient reflecting the efficiency of the geomorphic process, the erosion equation becomes the diffusion equation

$$\frac{\partial z}{\partial t} = \kappa \nabla^2 z, \qquad (9)$$

Approach

- Describe process
- Build the equation
- Develop a numerical scheme
- Test/verify it
- Use it to solve an interesting problem

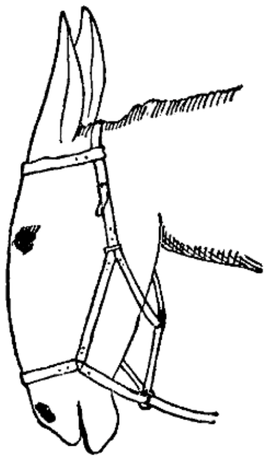

FIG. 5.—Ways and Means.

Course content

- Hillslope diffusion (1D and 2D)
- Stream Power Law (SPL) (1D and 2D)
- FastScape algorithm
- FastScape LEM
- Project/report preparation

Practicalities

- Jupyter notebooks
- Small project with report/paper
- Computer room at Uni Potsdam
- Calendar

ESPM 2025

April 24	May 2 (Friday)	May 8	May 15	May 23	May 29	Jun 6	June 12	June 19	June 26	July 3	July 10	July 17
Intro	Diffusion	Diffusion	Xsimlab		SPL	SPL	SPL	FastScape	FastScape	FastScape	Project	How to write a report
Diffusion	Diffusion	Diffusion	Xsimlab		SPL	SPL	SPL	FastScape	FastScape	FastScape	Project	How to write a report