EUROAQUAE+

River morphodynamics

Part 1: The river system

Institute of Geophysics
Polish Academy of Sciences

Michael Nones
mnones@igf.edu.pl

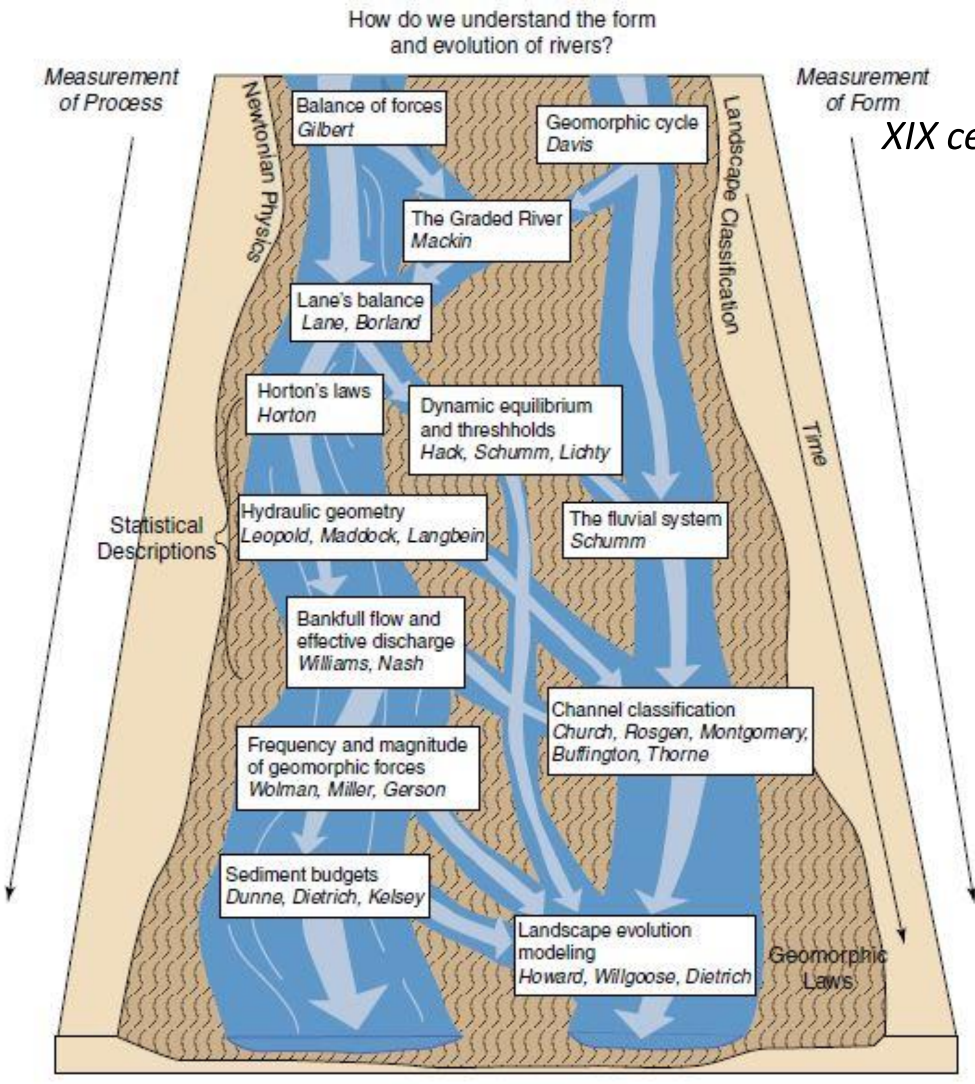
Introduction

Human interaction with river environments (Euro-Mediterranean region):

- 6000BC Nile, Tigris and Euphrates deviation of main channels for irrigation (3000BC along the Nile gauges to measure level)
- . . .
- 0 AD Roman reservoirs for water, aqueducts (Italy)
- XV century, Da Vinci engineered channels with automatic regulations (Italy)
- XVIII century, Chezy hydraulic law for channel design in Paris (France)
- . . .
- XIX century, engineered dams and impoundments to create artificial reservoirs for water use in irrigation and hydropower

Trends and currents in fluvial geomorphology (Grant, 2013)

XIX century



present

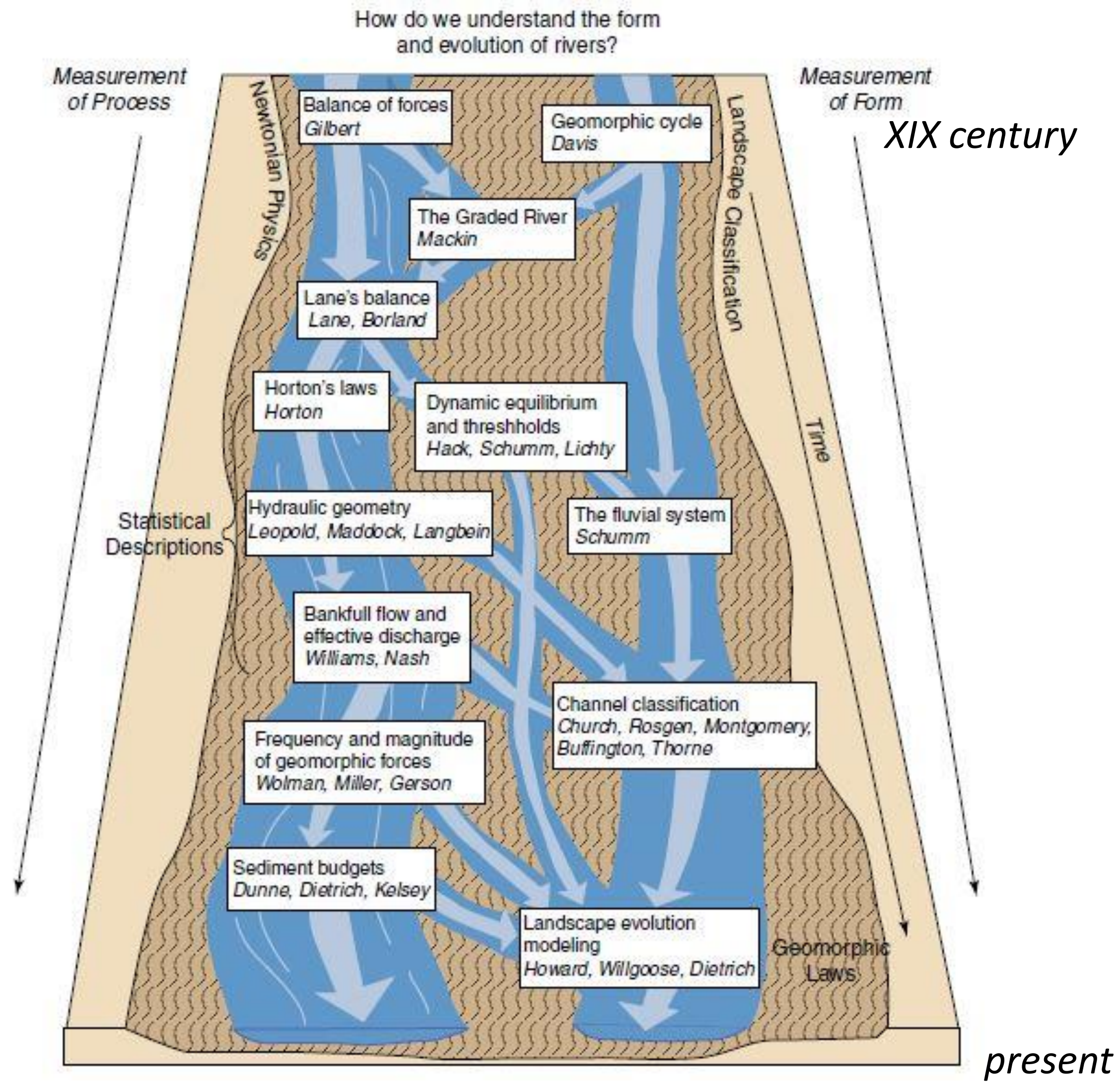
Introduction

How to approach geomorphology:

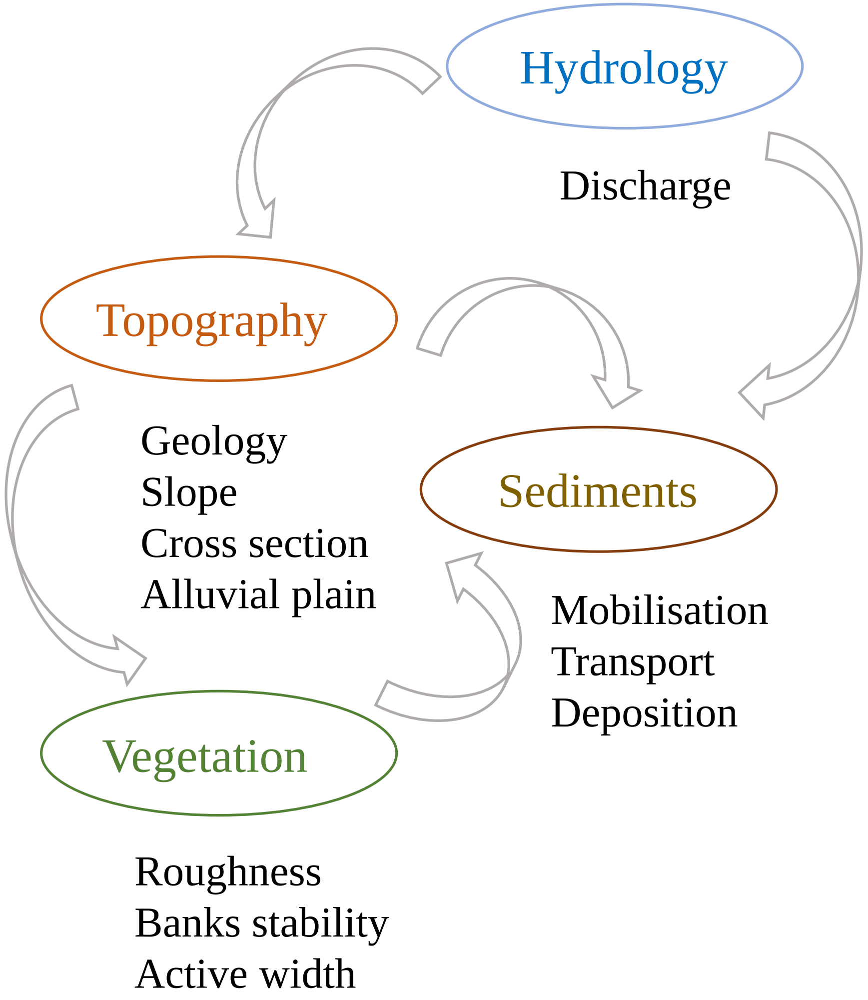
Study of physical processes: modelling landscape evolution, equilibrium models, statistical analysis,

Study of shape and form: geography, remote sensing, GIS techniques

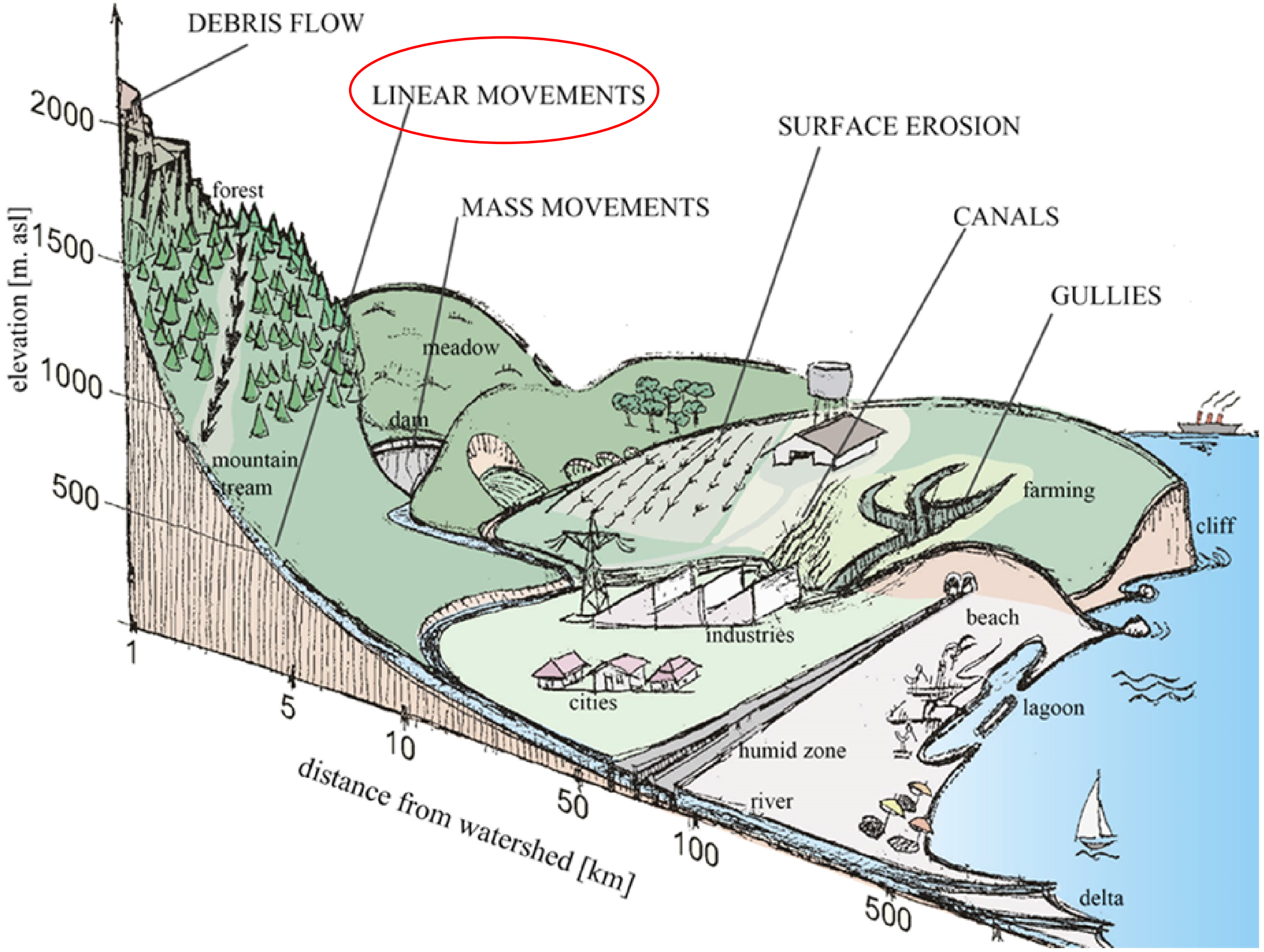
Trends and currents in fluvial geomorphology (Grant, 2013)



The river system

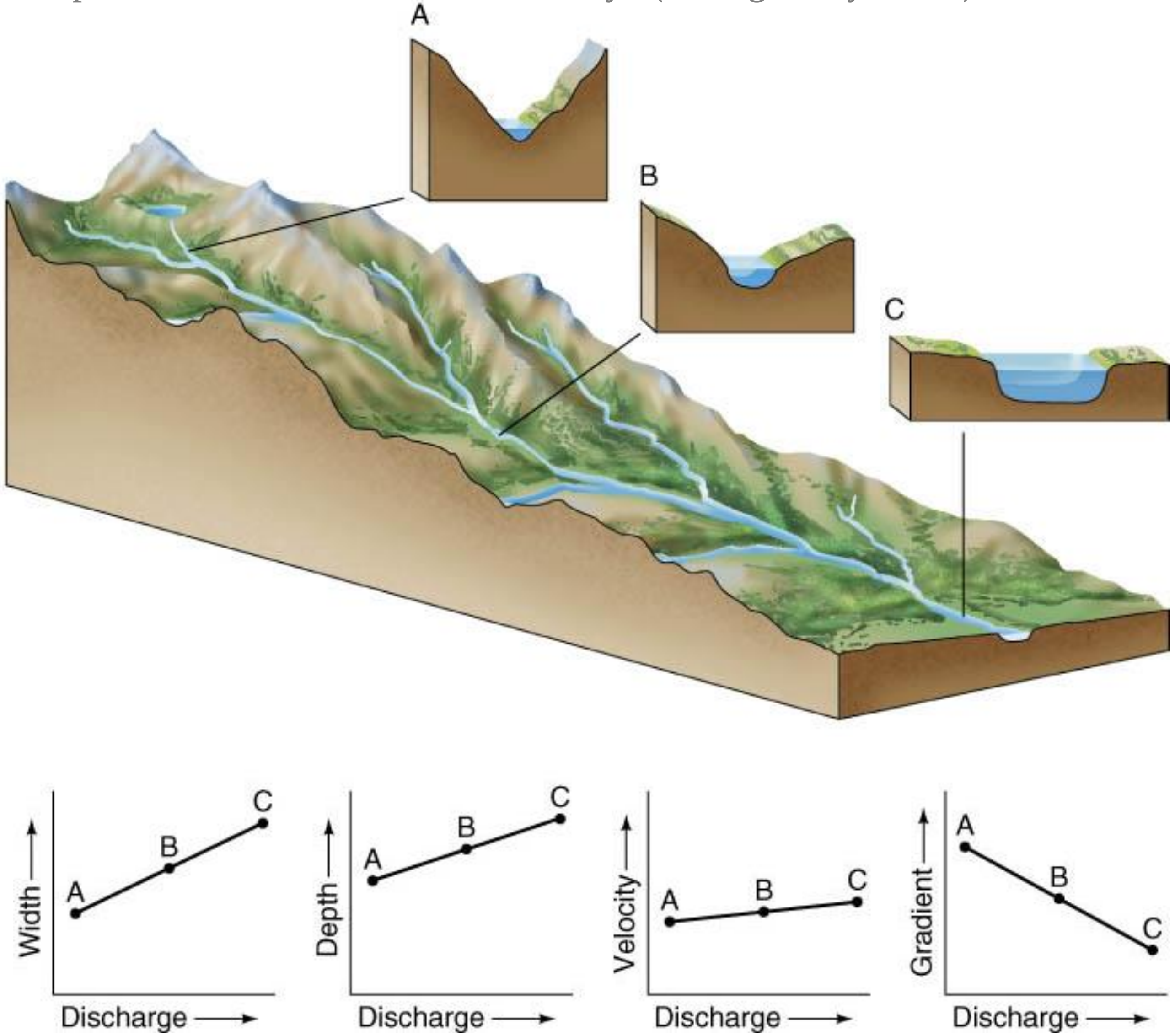


Sedimentary systems: main sediment motions type (Di Silvio, 2006)



The river valley

Spatial characteristics of river valleys (Montgomery, 2012)



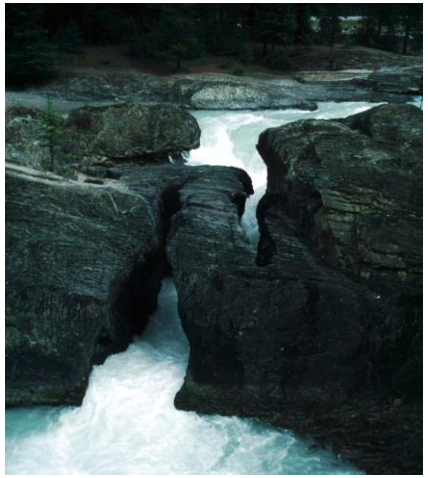
Main downstream trends:

- discharge ↑
- width ↑
- depth ↑
- velocity ↓
- gradient ↓
- grain size ↓

Alluvial vs bedrock rivers

An **alluvial river** is one in which the bed and banks are made up of mobile sediment and/or soil. Alluvial rivers are self-formed, meaning that their channels are shaped by the magnitude and frequency of the floods that they experience, and the ability of these floods to erode, deposit, and transport sediment. For this reason, alluvial rivers can assume a number of forms based on: the properties of their banks, their flow, the local riparian ecology and the amount, size, and type of sediment that they carry.

A **bedrock** river is a river that has little to no alluvium (sediments and debris) mantling the bedrock over which it flows. However, most bedrock rivers are not pure forms, they are a combination of a bedrock channel and an alluvial channel. The way one can distinguish between bedrock rivers and alluvial rivers is through the extent of sediment cover



Examples of alluvial (up) and bedrock (left) rivers (Montgomery, 2012)

Bedrock rivers

Fixed channel boundaries (channels floored by bedrock and lacking an alluvial bed cover)

- high transport capacity well in excess of sediment supply
- low storage: ALL sediment input is balanced by downstream sediment transport

In steep terrains, where landslides are common, the rate of river incision sets the pace for landscape lowering:

if the river can’t carry away material stripped from the slopes and carve the valley deeper, then the valleys will fill with sediment and the surrounding hills will lower.

Colorado river (Montgomery, 2012)

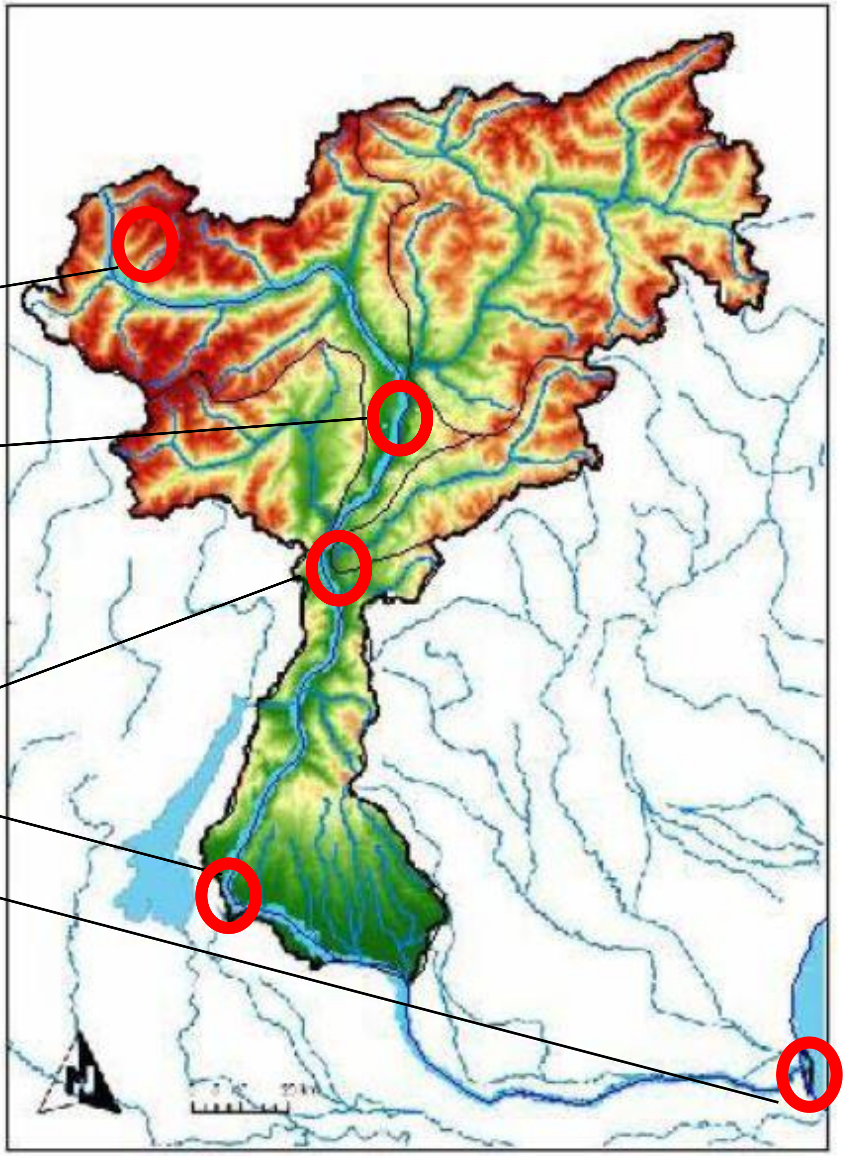
The river system

FLUVIAL MORPHOLOGY attains all river sub-systems:

- Mountain torrents
- Piedmont reach
- Urban reach
- River mouth

and components:

- River confluences
- Bars and islands, meanders
- Bedforms

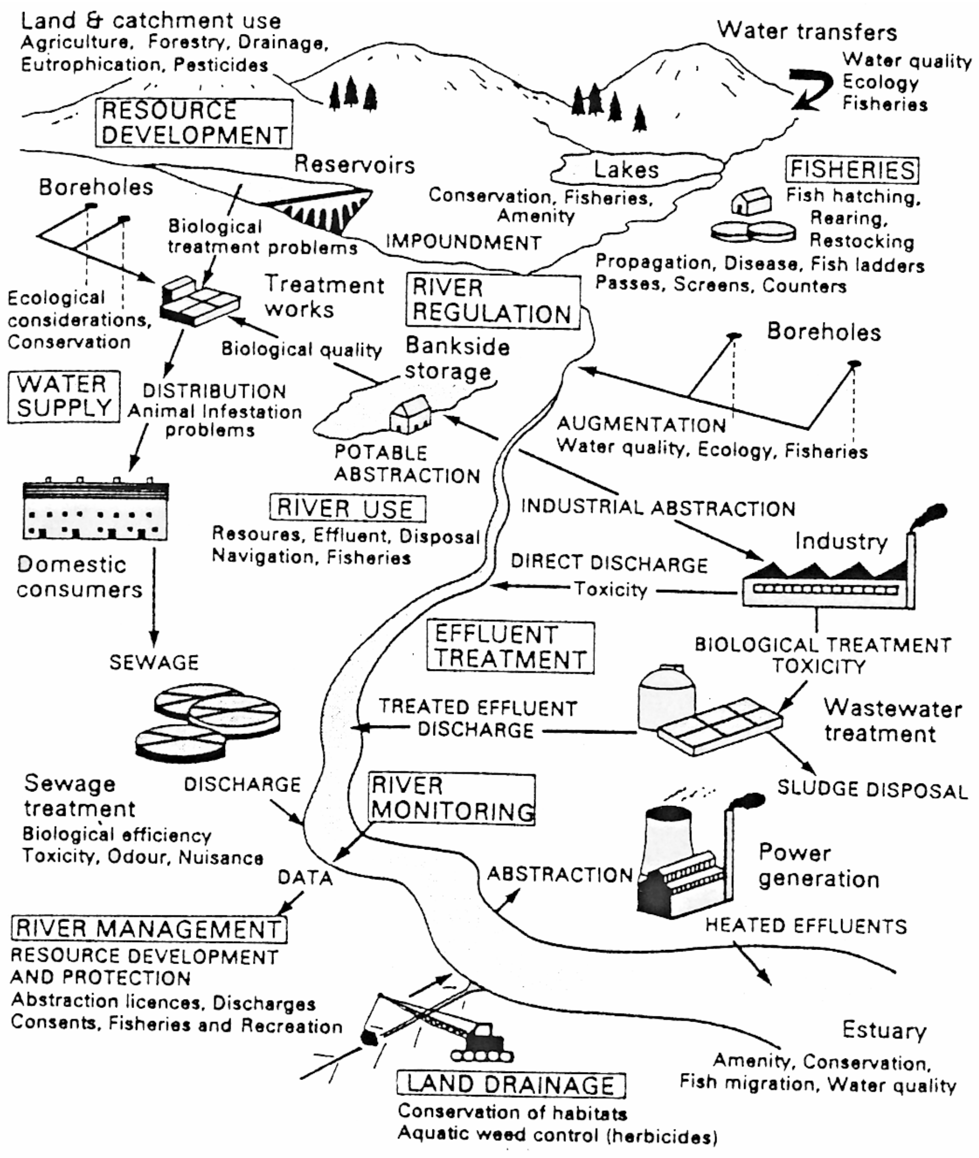


Adige river basin (Di Silvio et al., 2008)

The river system

Present river are highly anthropised:

- regulated liquid and solid discharges through reservoirs and weirs
- water supply (domestic, industrial, agricultural)
- pollutants from human activities (point and diffused sources)



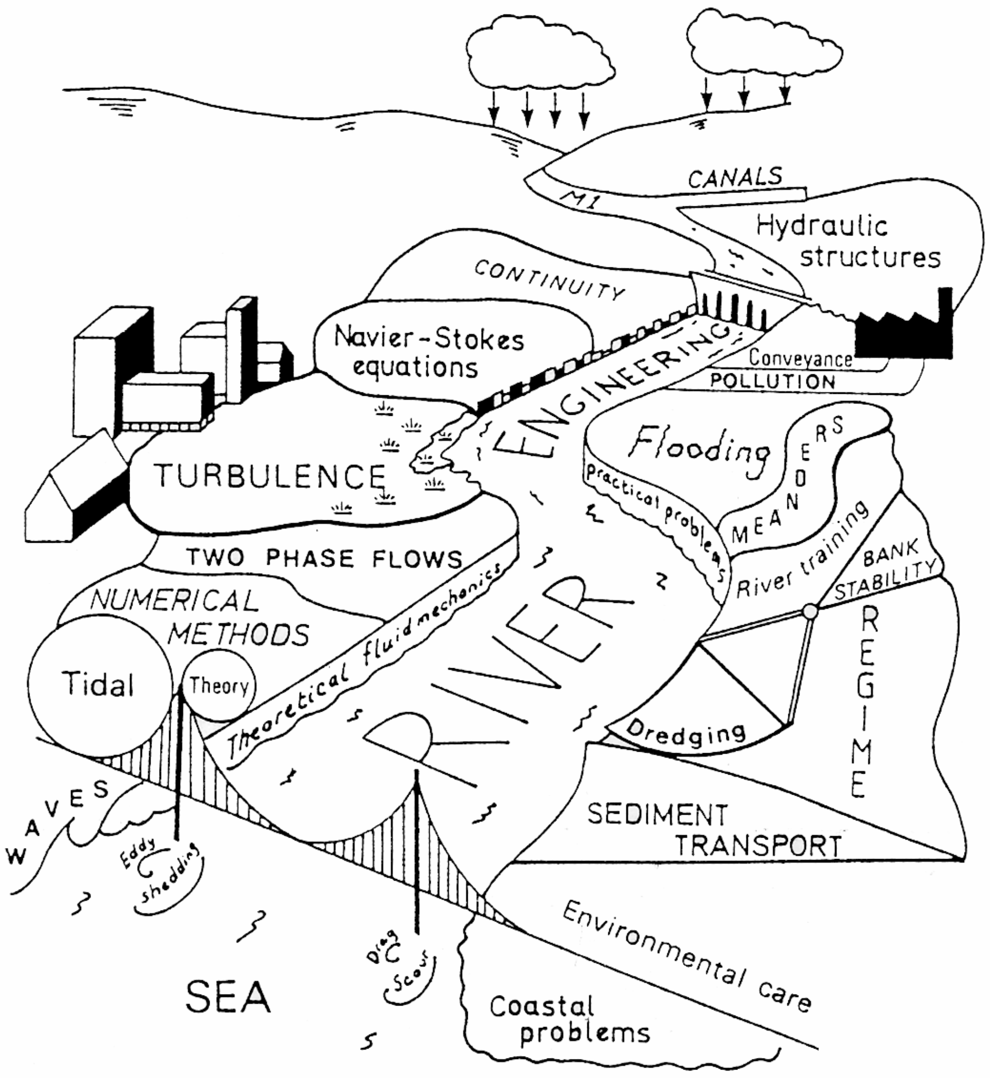
Complexity of present river systems (Montgomery, 2006)

The river system

- hydrological forcing
- fluid motion model (N-S simplified) and solvers
- sediment transport relation
- sediment related problems
- anthropic pressures (pollution, inline structures, dredging)
- downstream BC (sea level, waves, tides, coastal protection)

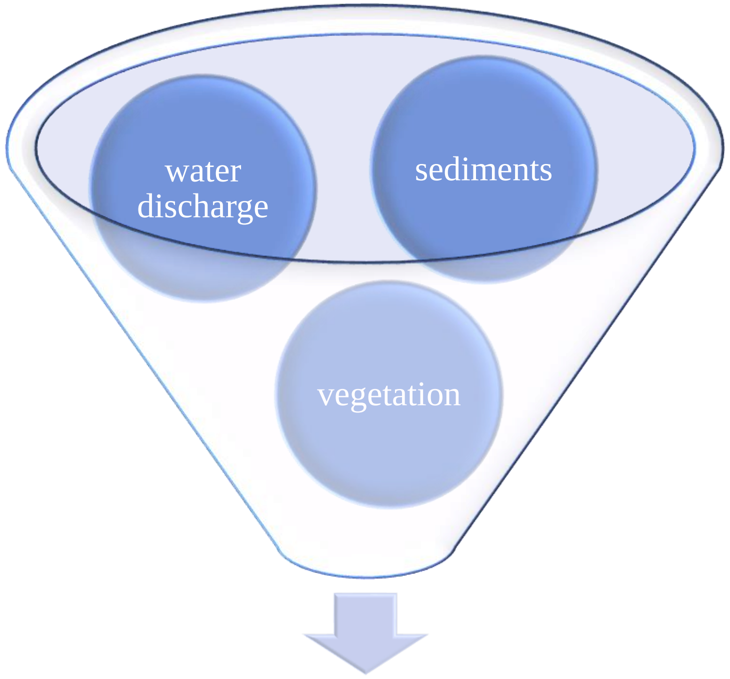
- Is equilibrium possible?

River system as an engineer sees it. (Montgomery, 2006)



River morphology

Evolution of river landscapes



planar forms and bedforms

Free bars along a tributary of Vistula river (photo by A. Radecki-Pawlik)

Meandering river in Chile (photo by O .Link)

A delicate balance

River landscapes shape for variations in:

– liquid discharge

– solid discharge (both magnitude and characteristic grainsize distribution)

those lead to erosional and depositional processes and therefore changes in local slope

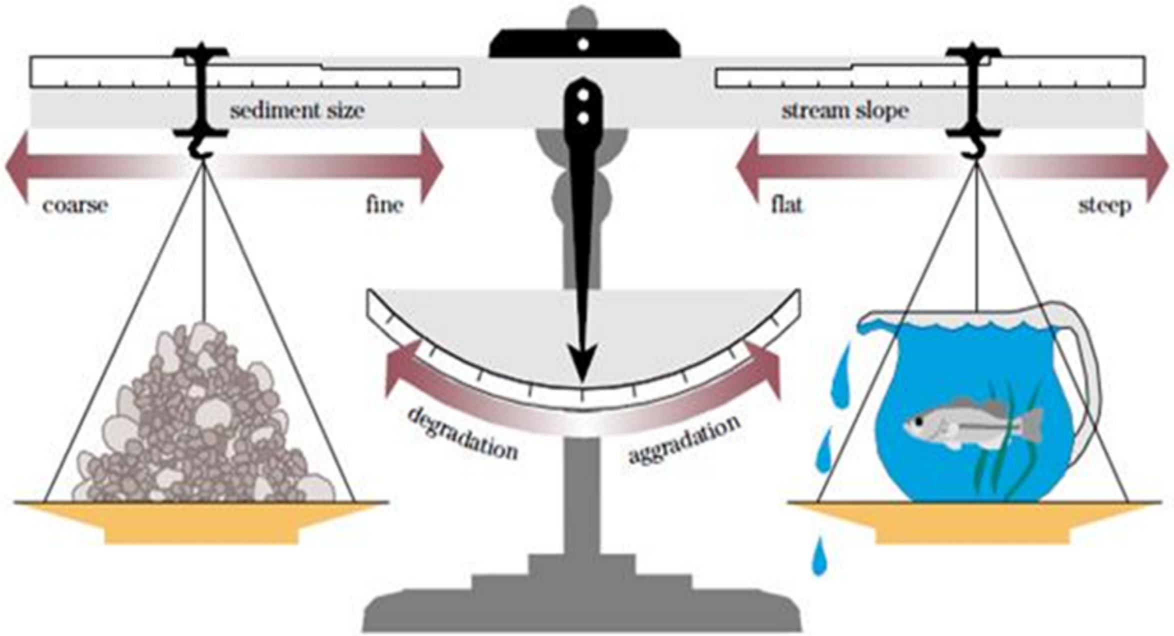
→ effecting the discharges

→ affecting sediment transport

→ affecting morphology

Short term feedbacks vs. Long term feedbacks

Interplay between the two main actors (Rosgen, 2006)



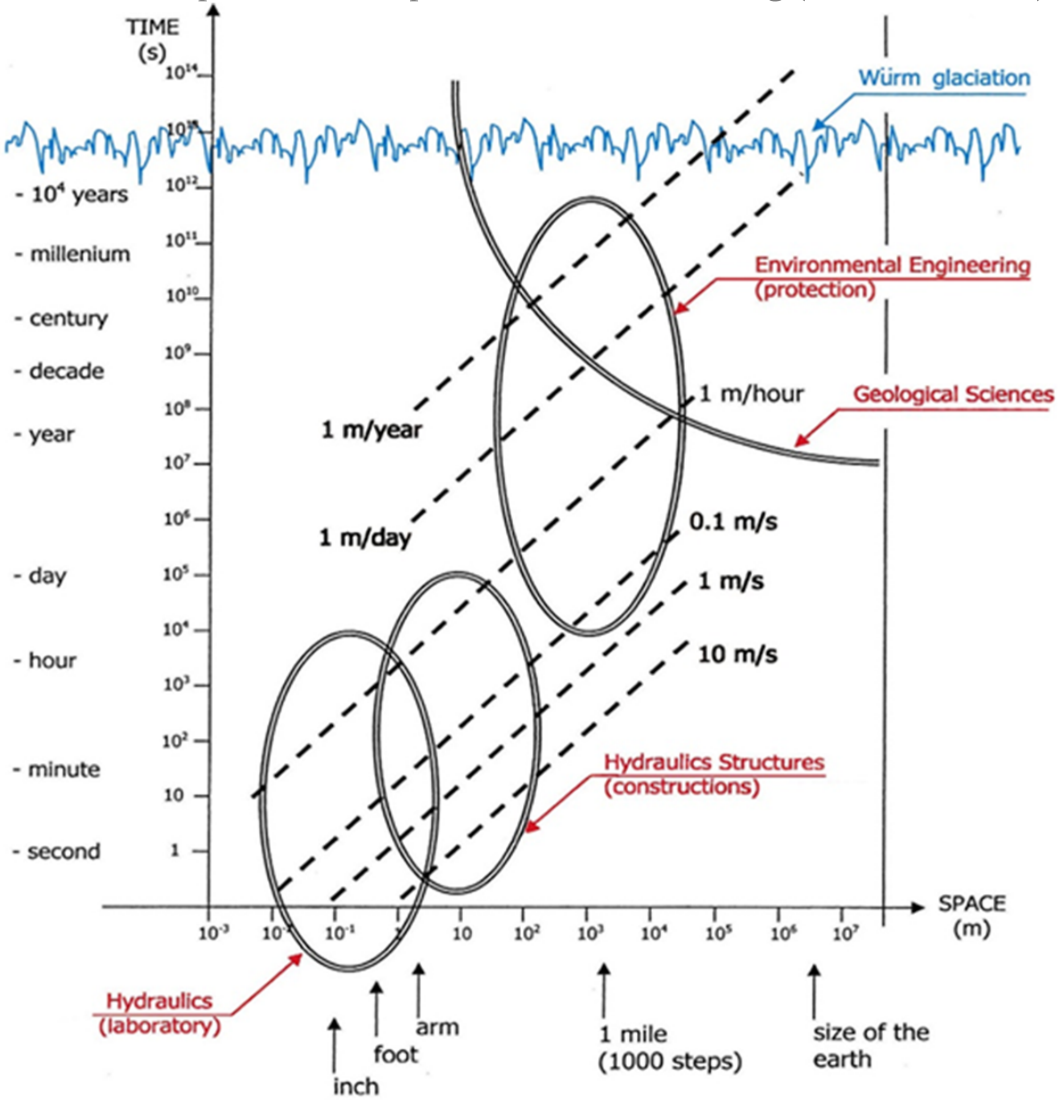
Long-term evolution

River morphology has higher inertia to changes than river hydrological regime.

→ long-term modelling is an appropriate approach

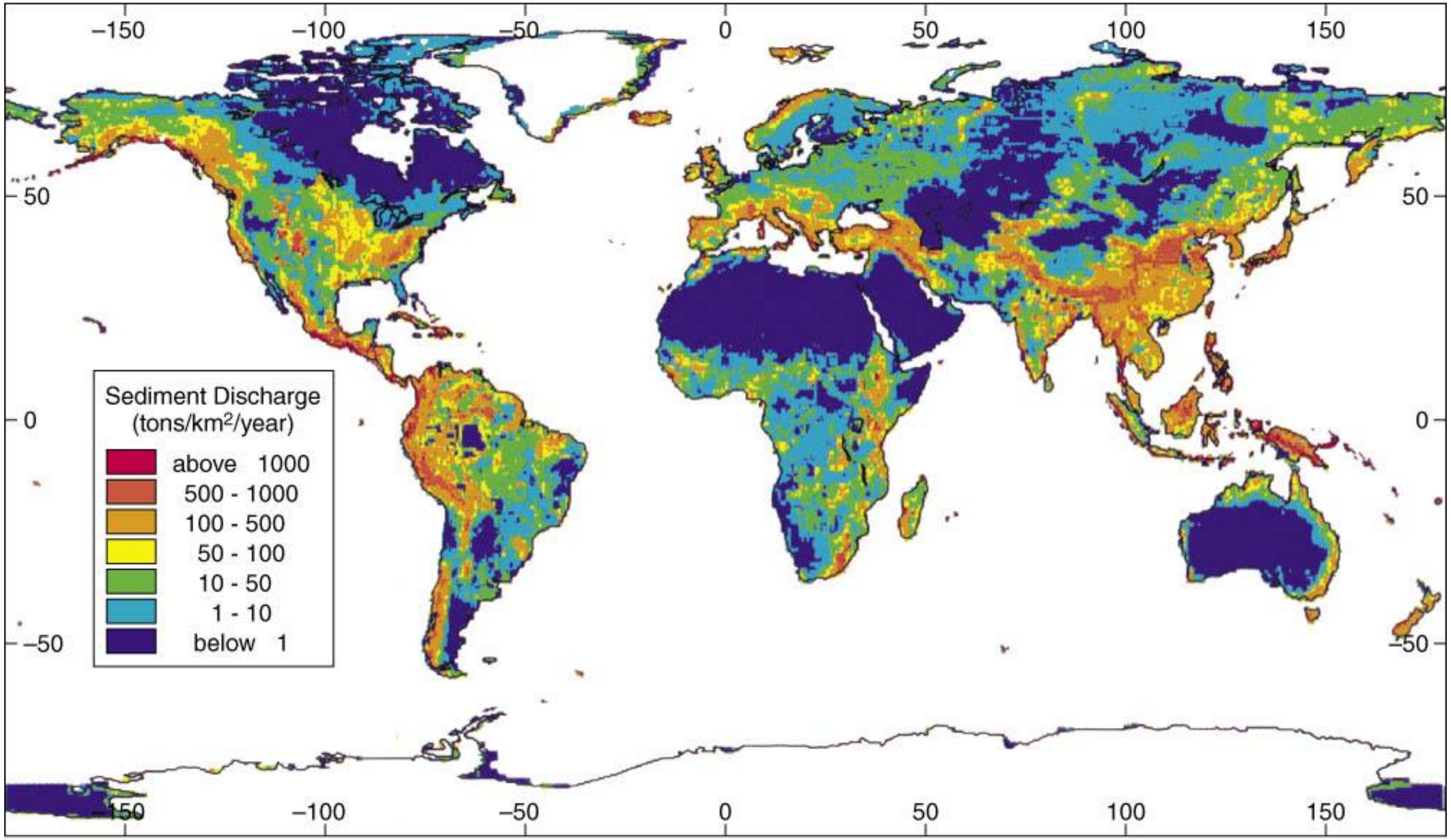
Morphological perturbations propagate slowly compared to water and sediment input disturbances.

Spatial and temporal scales in modelling (Di Silvio, 2006)



Global sediment yield

Global sediment yield by rivers (Montgomery, 2012)



Natural Dams

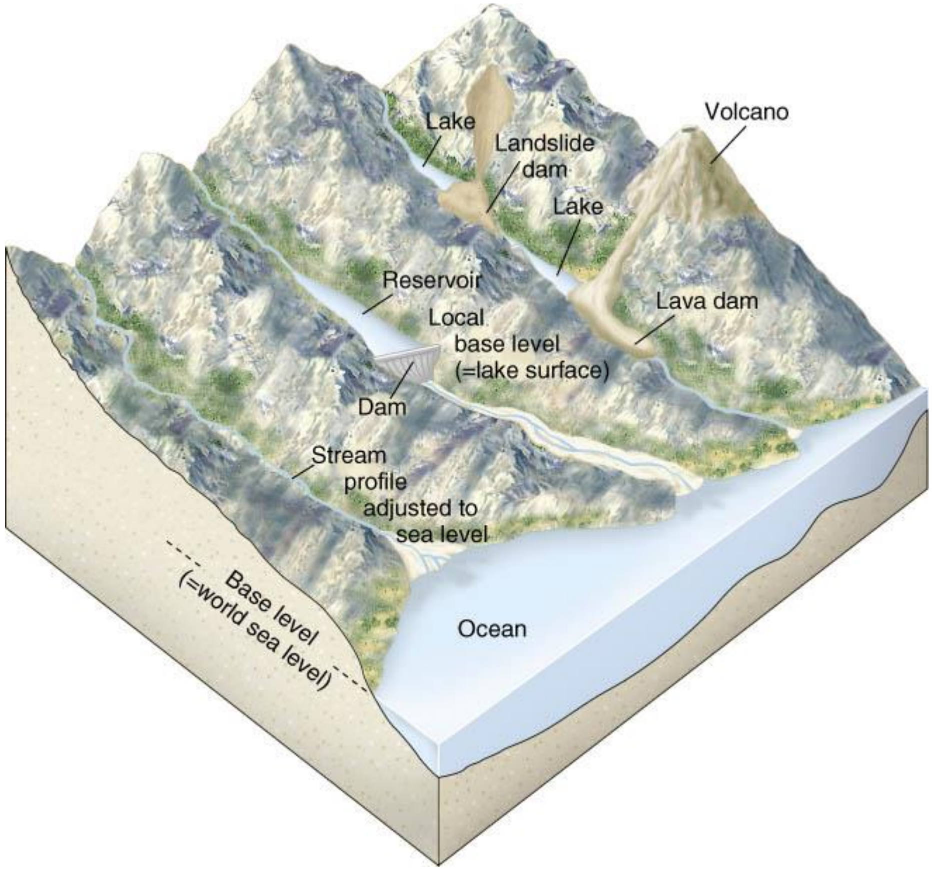
The courses of many streams are interrupted by lakes that have formed behind natural dams consisting of:

- landslide sediments
- glacial deposits
- glacier ice
- lava flows

act as a local base level and create irregularities in streams' long profiles

Both natural and artificial dams built across a stream create a reservoir that traps nearly all the sediment that the stream formerly carried to the ocean

Globally, anthropogenic dams have reduced the sediment load that reaches the oceans by half



Natural dams (Montgomery, 2012)