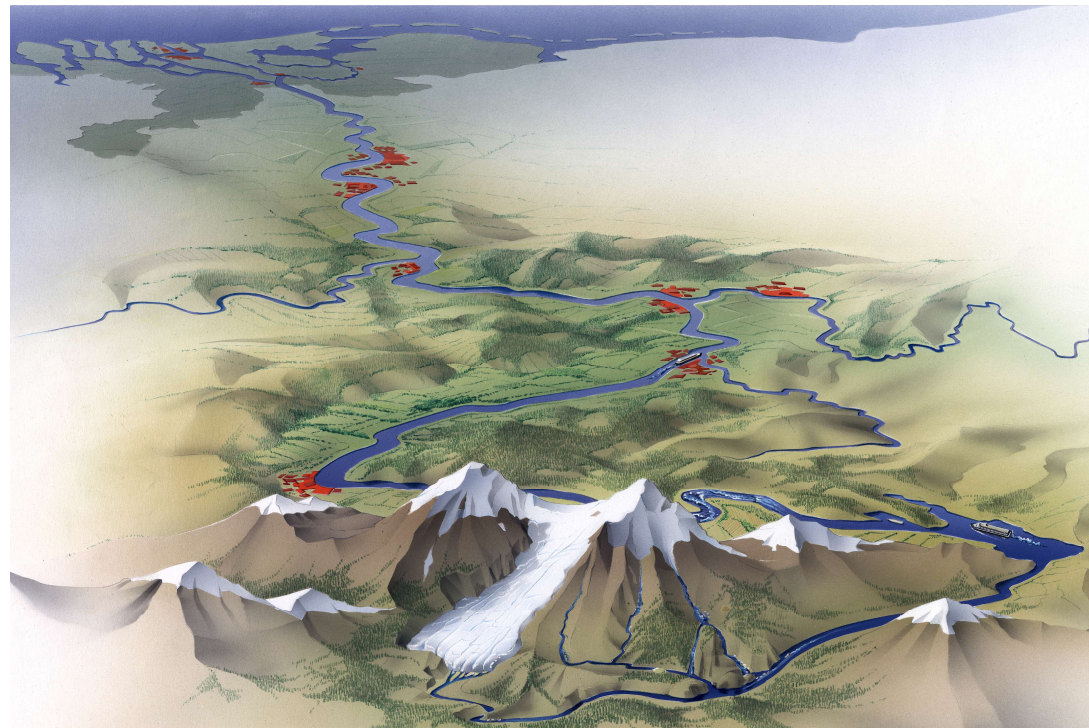


From Source to Mouth

The sediment budget of the Rhine in the Period 1991-2010



Paul Maas, 1998

Roy Frings

Rijkswaterstaat
Maastricht

Gudrun Hillebrand

Bundesanstalt für
Gewässerkunde

Human civilization first developed along the banks of rivers such as Tigris, Euphrates, Nile, Ganges and Yangtze



Alexandria, Nile Delta
www.ropesmeer.org



Rivers are of great value to mankind...

Habitation
Irrigation
Transport

Drinking water
Building materials
Sewage disposal

Food
Archeology
Energy

Culture
Recreation



... and have key roles in ecosystems



Wildebeest trek,
Mara river, Tanzania

Photo: J. Vogt

Rivers are dynamic systems...

Rhine, Switzerland

Photo: U. Wuchner

... whose channels are constantly being reshaped...



Waal, Netherlands

Photo: Frings, 2013

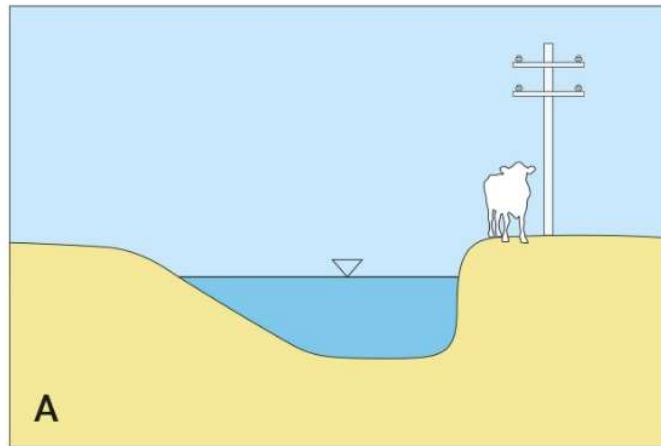
... giving rise to fascinating landforms!



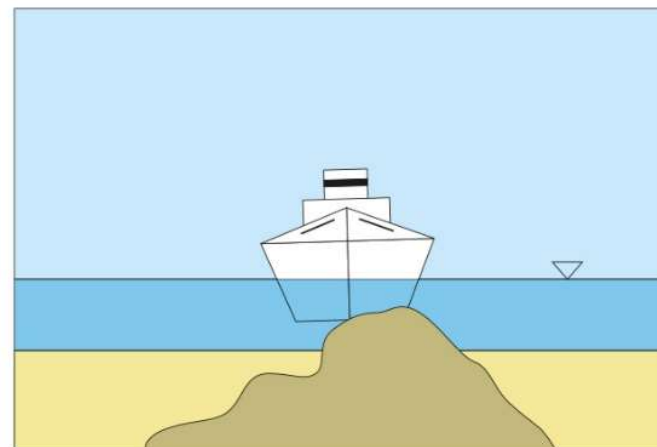
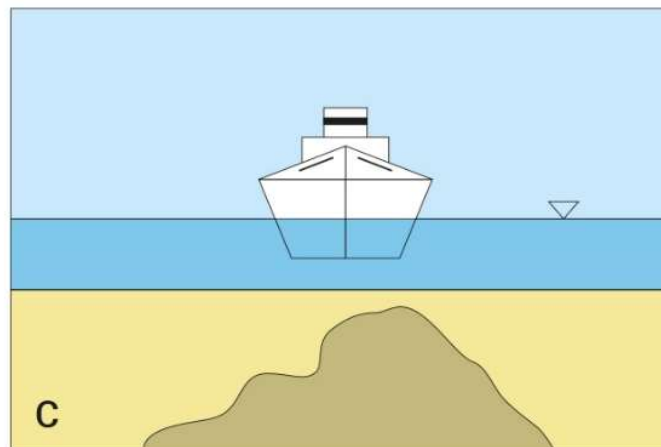
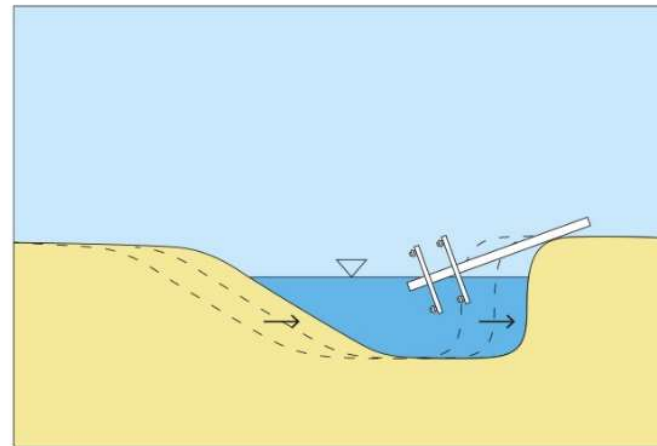
Hinterrhein
Photo: Frings, 2013

Problems due to erosion

Before

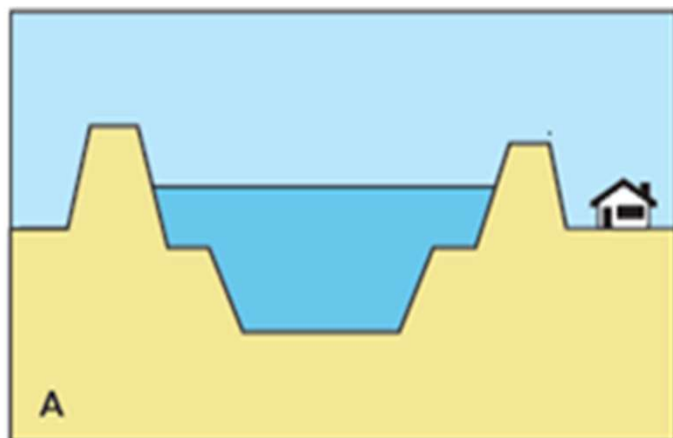


After

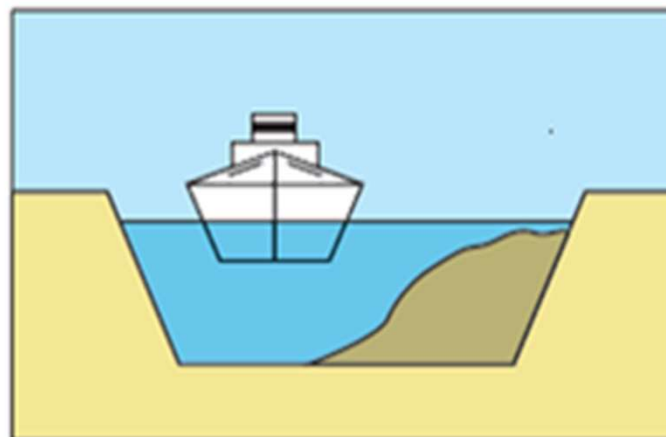
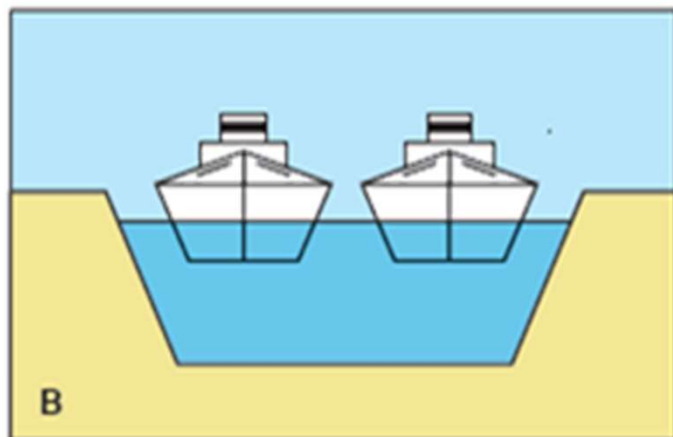
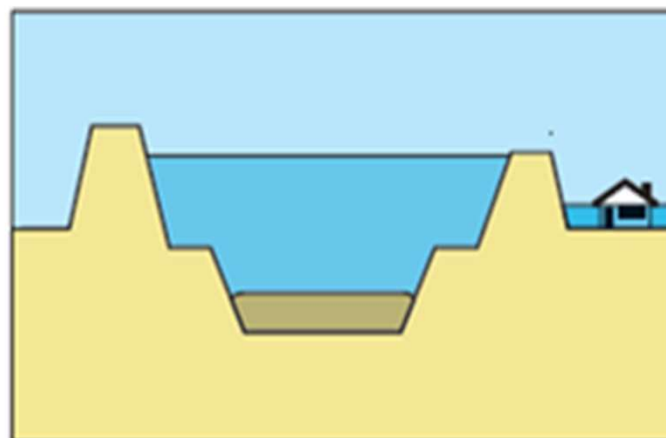


Problems due to sedimentation

Before

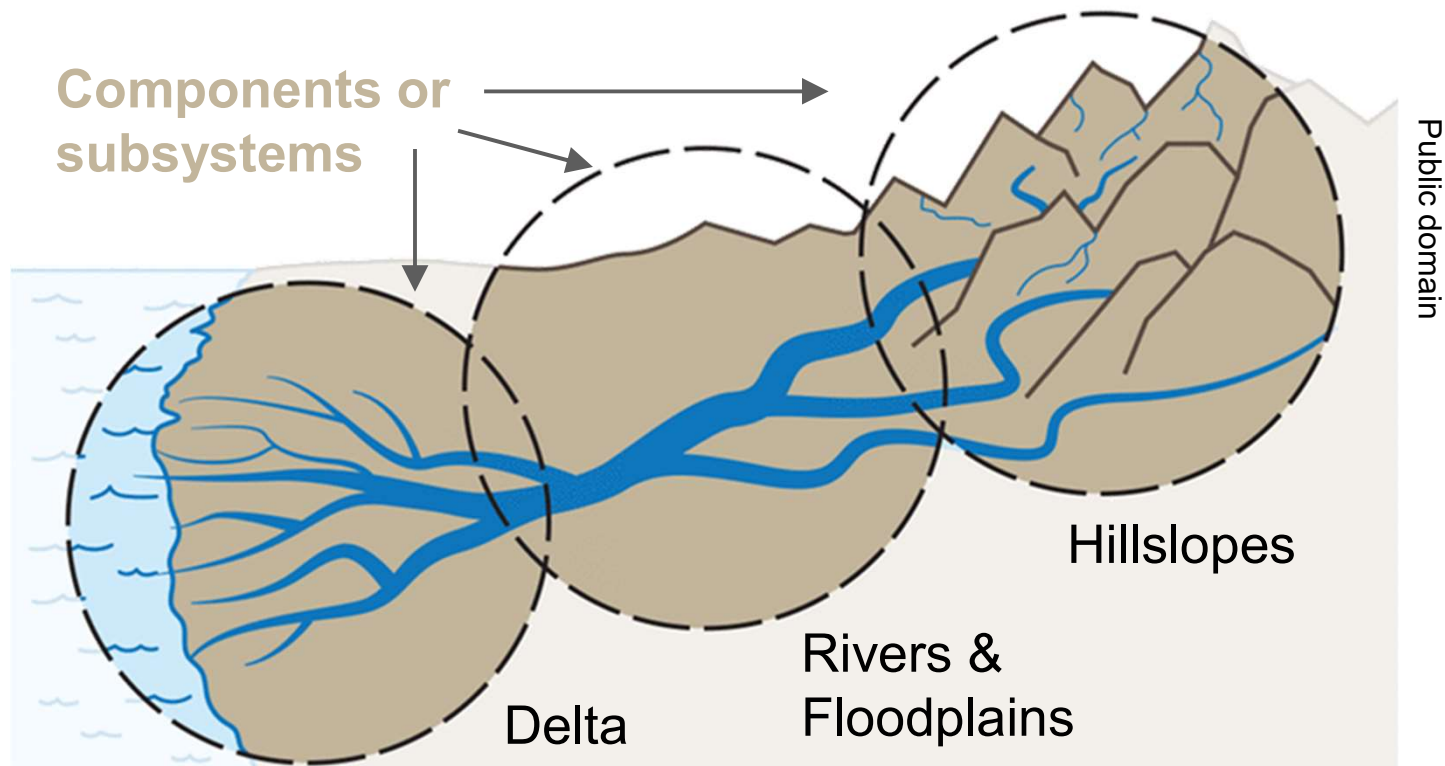


After

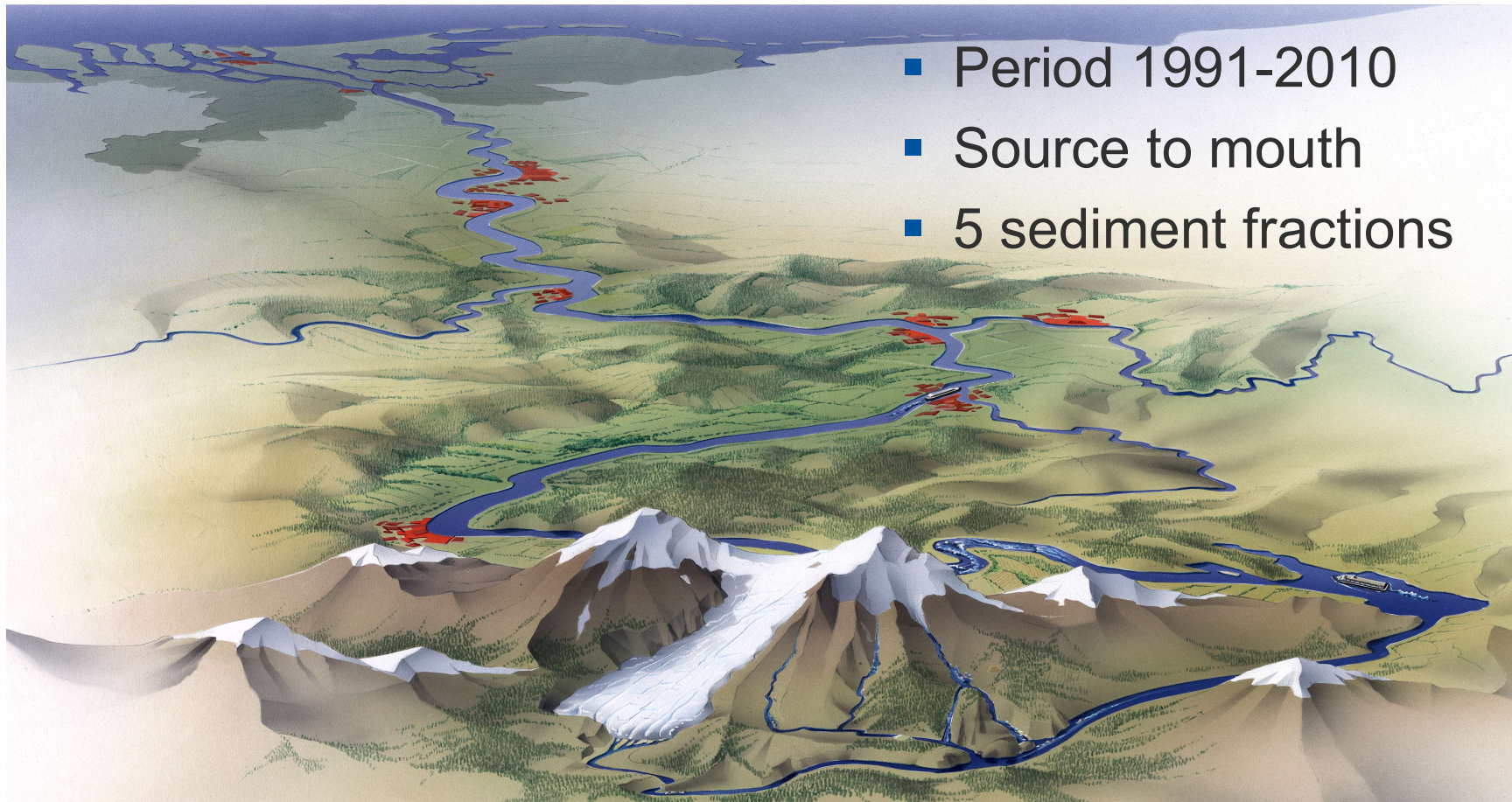


Frings 2021

The river as cascade of water and sediment

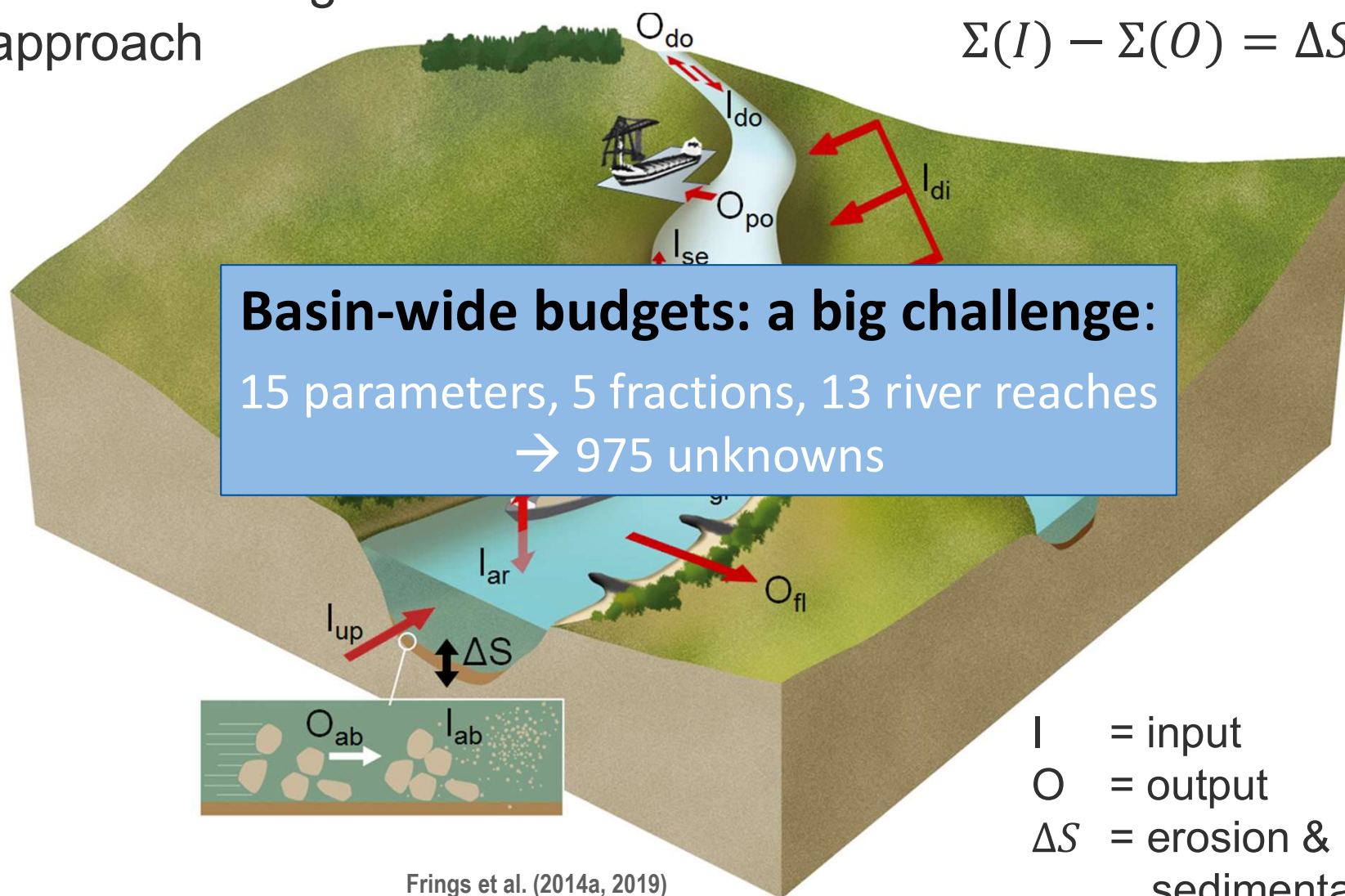


Objective: To quantify the Rhine's sediment fluxes and to identify their sources and sinks

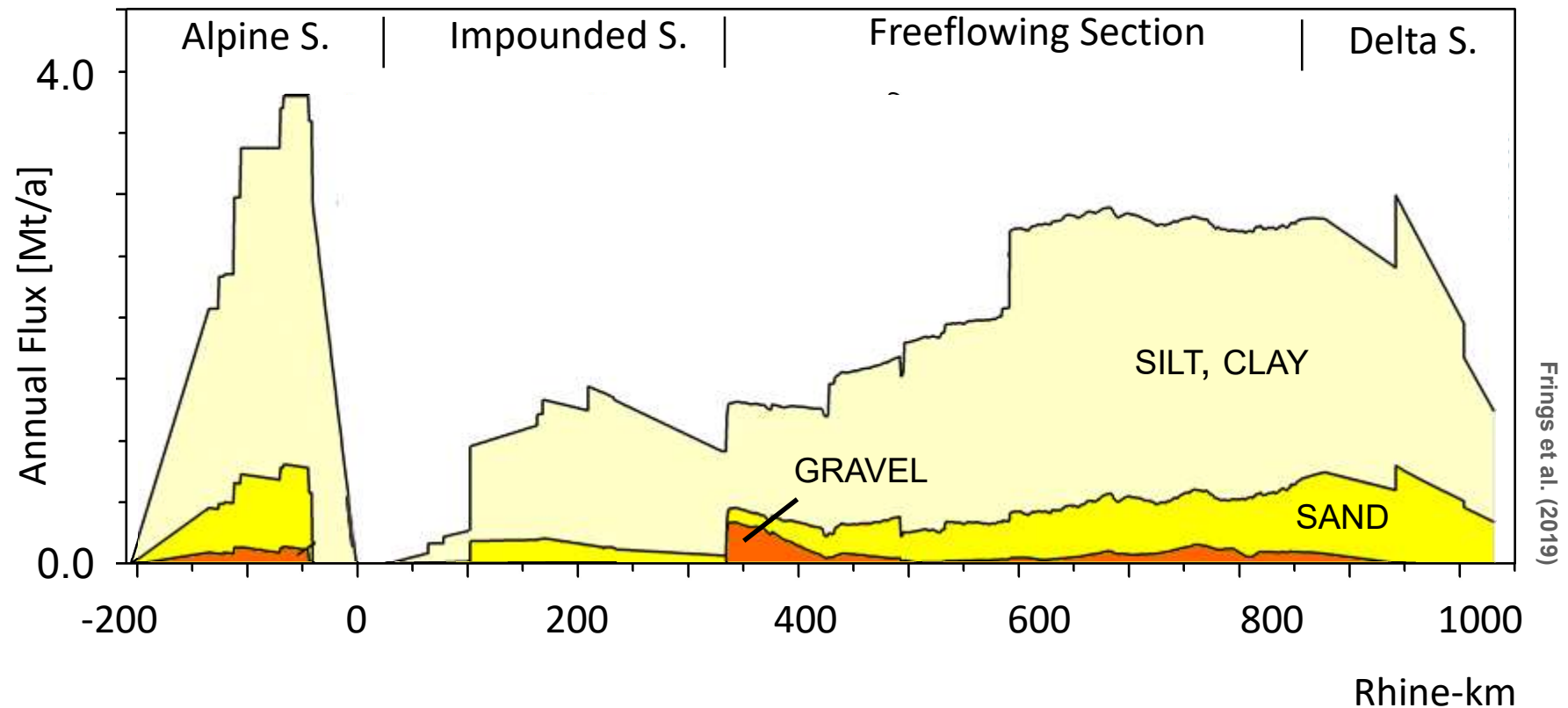


Sediment budget approach

$$\Sigma(I) - \Sigma(O) = \Delta S$$



Sediment fluxes from source to mouth

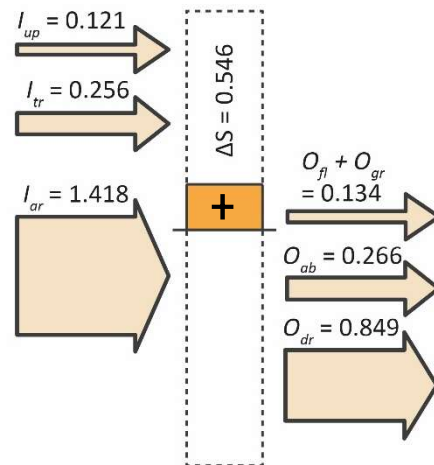


→ Note: this is something special, receiving international recognition, which would never have been possible without the CHR

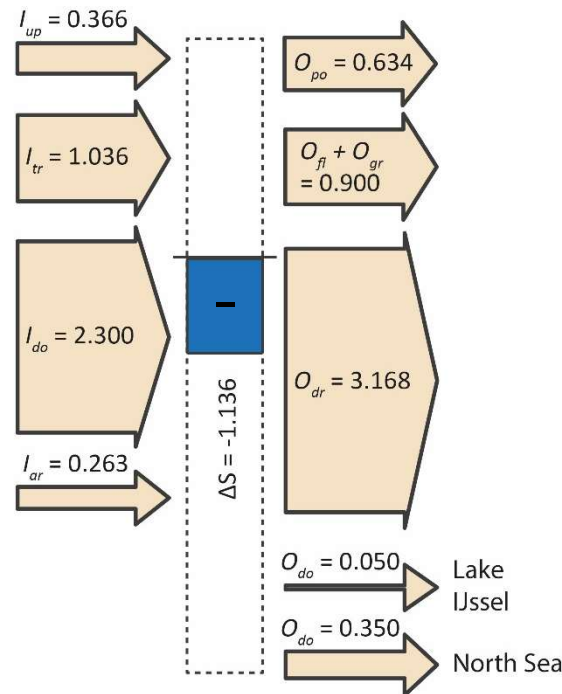
Sediment sources and sinks

Values in Mt/a

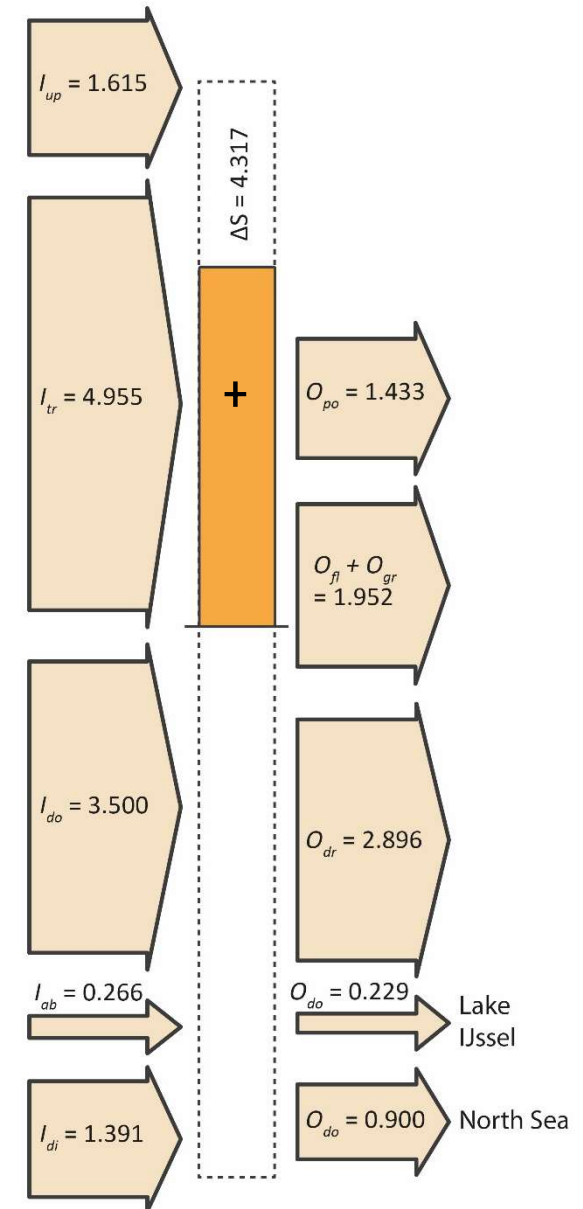
Gravel/cobbles



Sand



Silt, Clay



1. System understanding

- Order in the chaos of data
- Human impact
- Global perspective
- Identification of key problems
- Knowledge gaps



2. Directions to go

- Research agenda
- Solutions to problems
- Monitoring strategies
- Dredging/nourishment
- Improve numerical models

3. Communication

- Among countries
- Society





- Start: A weird idea of a Dutch scientist in Germany
- Funding: Federal Institute of Hydrology (BfG)
- Progress: After adoption by the CHR
- Needed: Patience, persistence, ability to adapt
awareness of political sensitivities
- Helpful: International advisory committee
- Difficult: Data collection, data compatibility
 - 8 administr. units, 3 languages
 - Need to involve external parties
 - Incomplete timeseries
 - Knowledge gaps
 - Different techniques, conflicting data→ Extra measurements, validation, conversion



It is important to deal with sediments

CHR really set a standard for basin-wide sediment studies

Keep investing in data

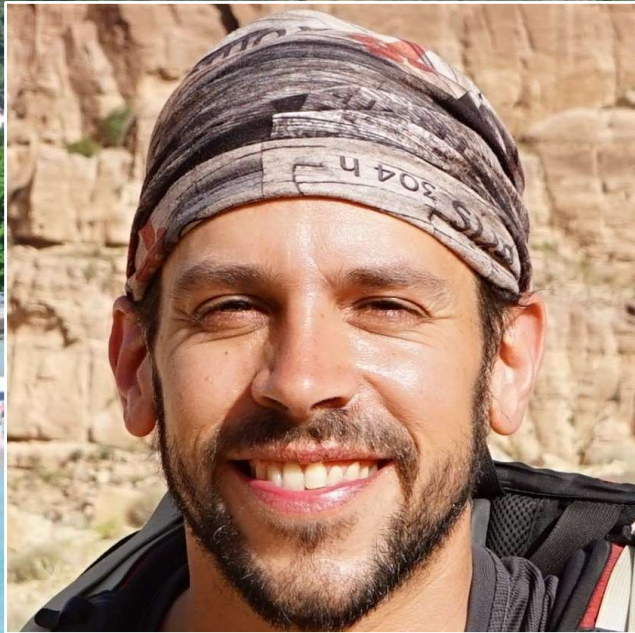
Collection + harmonization

Improve data exchange

Accept asymmetry

Support a cross-boundary research community

Why not organize an excursion from source to mouth? 😊



Thank you very much for your attention!

*We enjoyed every minute of this project, meeting so many nice people
We all share the love for this exceptional river.*



This study was carried out under the banner of the International Commission for the Hydrology of the Rhine Basin (CHR).

We thank all those who contributed to this study.

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