Morphological river development in the Rur basin

- Results from two case studies -

Stefanie Wolf, M.Sc.
Dr.-Ing. Anna-Lisa Maaß
Dr. rer nat. Verena Esser

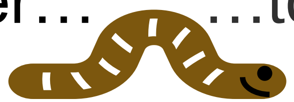
Chair and Institute of Hydraulic Engineering and Water Resources Management, RWTH Aachen University
wolf@iww.rwth-aachen.de

DR. PECHER AG | Branch Office Emscher-Lippe | Goldbergstraße 14 | D-45894 Gelsenkirchen
annalisa.maass@pecher.de

Chair of Physical Geography and Geoecology, RWTH Aachen University
verena.esser@geo.rwth-aachen.de

Contents

- **Introduction and motivation**
  - from the Wurm to the Rur River… …to the Meuse River



- **Humanized river systems – example of the Rur River**
  - Objective
  - Working packages
  - Materials and methods – field measurements
  - Next steps (numerical modelling)

- **First Results and outlook**

Introduction and motivation

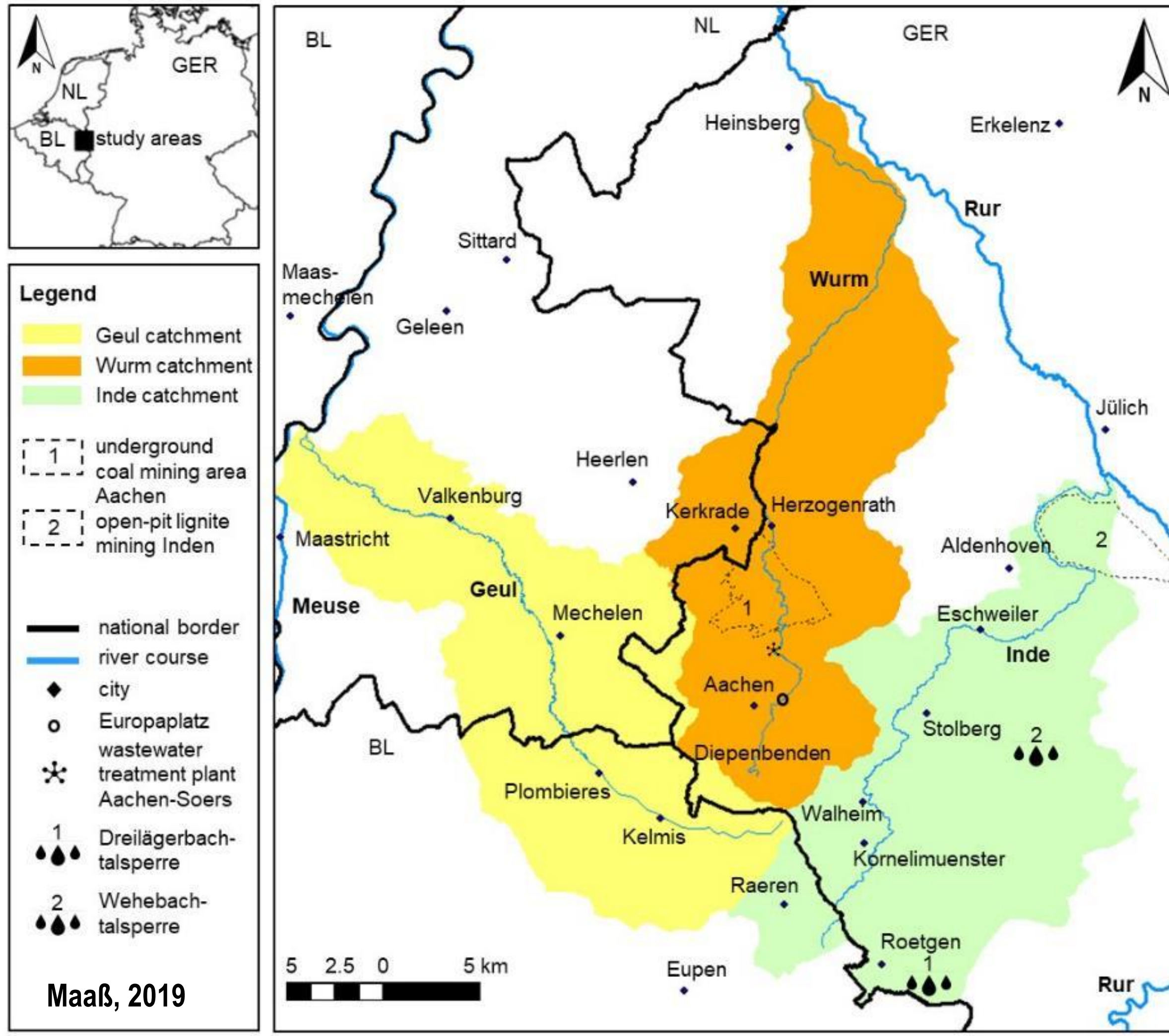
Catchment: 356 km²

Length: 57.9 km

MQ: 3.5 m³/s

Characteristics:

1. Low mountain river near the Dutch-German border
2. Gravel-bed river
3. sediment that is carrien along the river in the water phase and deposited on the floodplains is fine cohesive sediment (clay, silt, fine sand)

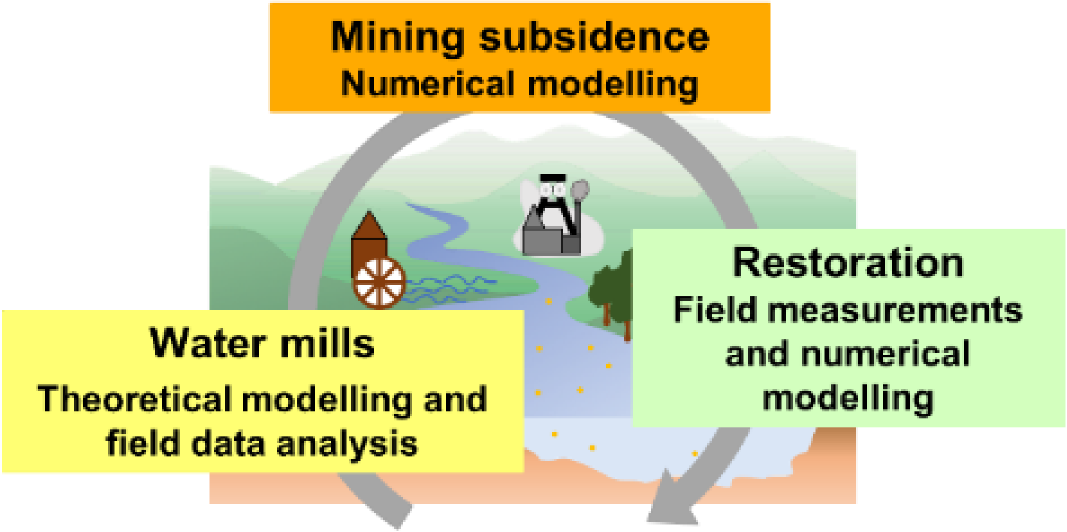


DFG research project „Human impacts on fluvial morphodynamics and contaminant dispersion in small river catchments (case study: Wurm, Lower Rhine Embayment)“ (2015-2019)

Materials & methods – Wurm River

Objective

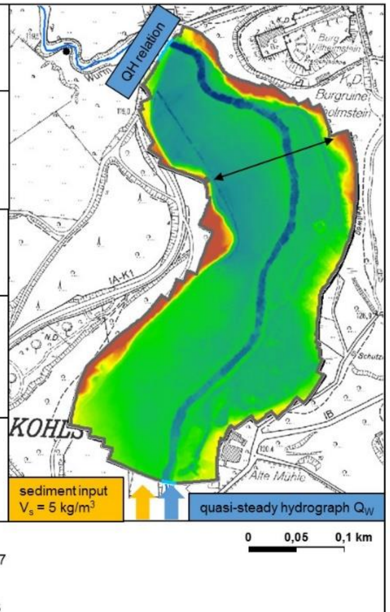
Improving the understanding of sediment transport processes and morphological changes on a river basin scale of small river-floodplain systems and using this knowledge during the planning, realization and monitoring of restoration interventions



Maaß, 2019

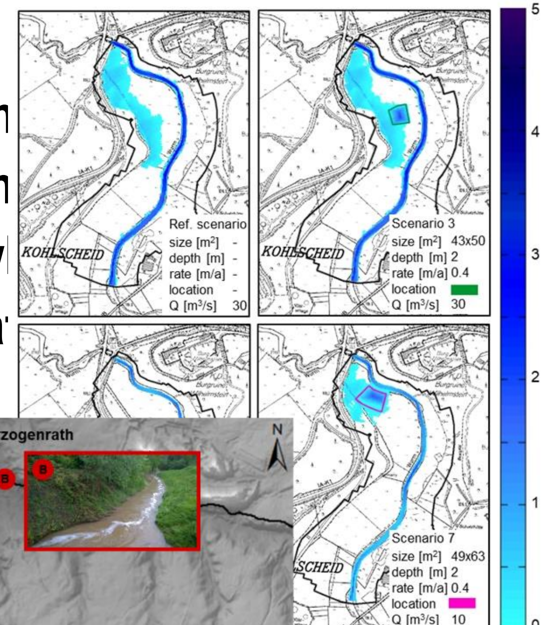
Materials & methods – Wurm River

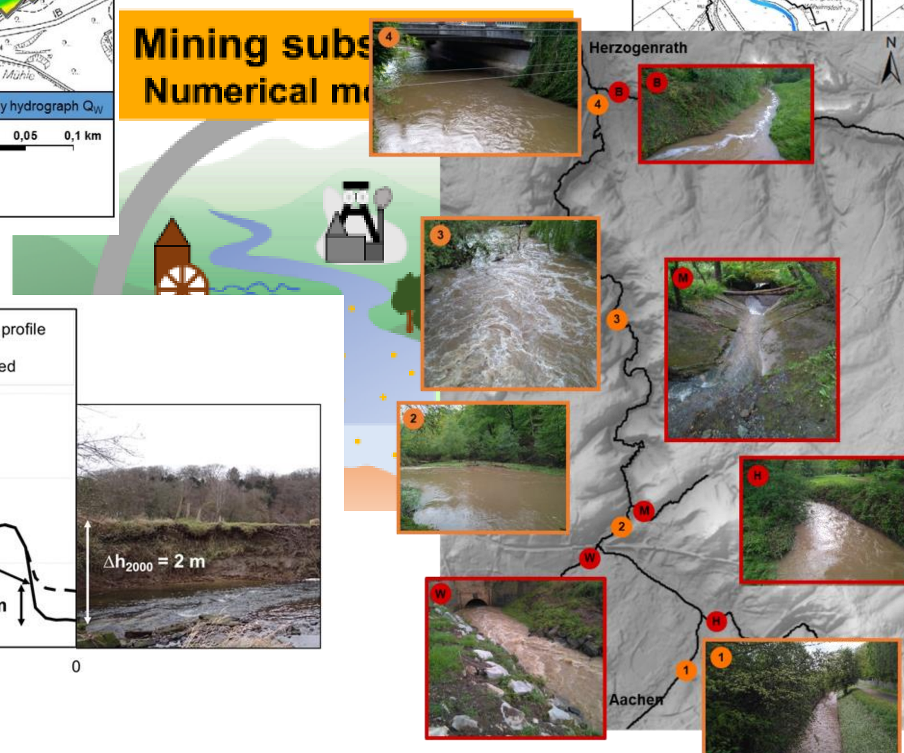
Grid properties	
Total number of cells	18,383
Cells for the main channel	1,513
Average cell size	8.33 m^2
User specified parameters	
Time step	0.01 min
Simulation period	200 year
morFactor	Q dependent
Erosion parameter	$1 \cdot 10^{-6}$ kg/m²/s
One-well mixed sediment layer	
Initial conditions	
Water level	constant
Sediment concentration	0 mg/l
Sediment layer thickness	4 m
Floodplains	
Mean grain diameter (d_{50})	24.5 µm
Chézy friction coefficient	31 $m^{1/2}/s$
$\tau_{c,ero,floodplains}$	12 N/m^2
$\tau_{c,sed,floodplains}$	1,000 N/m^2
Settling velocity (w_s)	0.5 mm/s
Riverbed	
Mean grain diameter (d_{50})	33 mm
Chézy friction coefficient	31 $m^{1/2}/s$
$\tau_{c,ero,riverbed}$	45 N/m^2
$\tau_{c,sed,riverbed}$	1 N/m^2

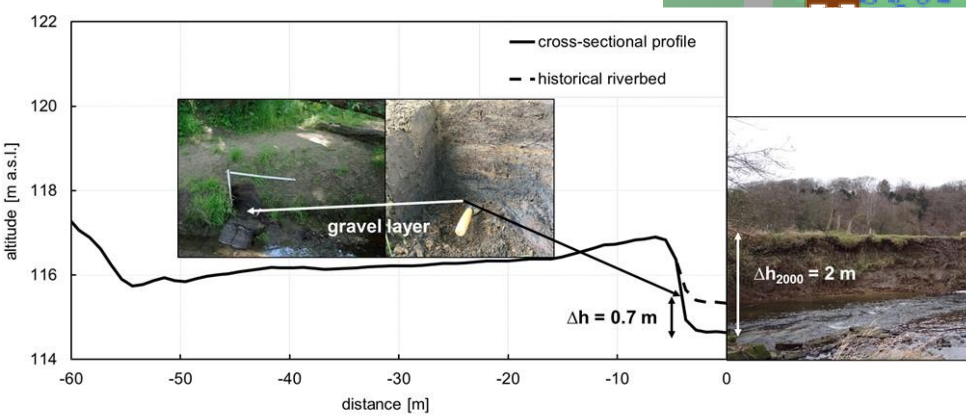


Objective

tanding of sediment tran
changes on a river basin
ms and using this know
nd monitoring of restora







Maaß, 2019

Results & outlook to the Rur River

- Construction of transverse structures such as mill weirs
  - increase of (fine) sediment deposits
- Removal of transverse structures
  - incision of the river bed and decoupling of the river and the floodplains
- Mining-induced subsidence
  - Local increase of floodplain sediment deposits
  - Plays a minor role in small river basins with deeply incised river bed
- River restorations are still human impact factors.

➡ How can we transfer the results of the **Wurm River (sub-catchment / third order river / lowland)** to the **Rur River (second order river / uplands)?**

- Research project “Humanized river systems” (2019-2022)

Introduction of the Rur River

Catchment: 2.338 km^2

Length: 163 km

MNQ: 12.95 m^3/s

MHQ: 86.11 m^3/s

Main Tributaries:

Urft, Inde, Wurm

Reservoirs:

Nine water reservoirs

Urfttalsperre (1900-1905)

Rurtalsperre (1934-1938 & 1955-1959),

Staubecken Heimbach (1934/1935)

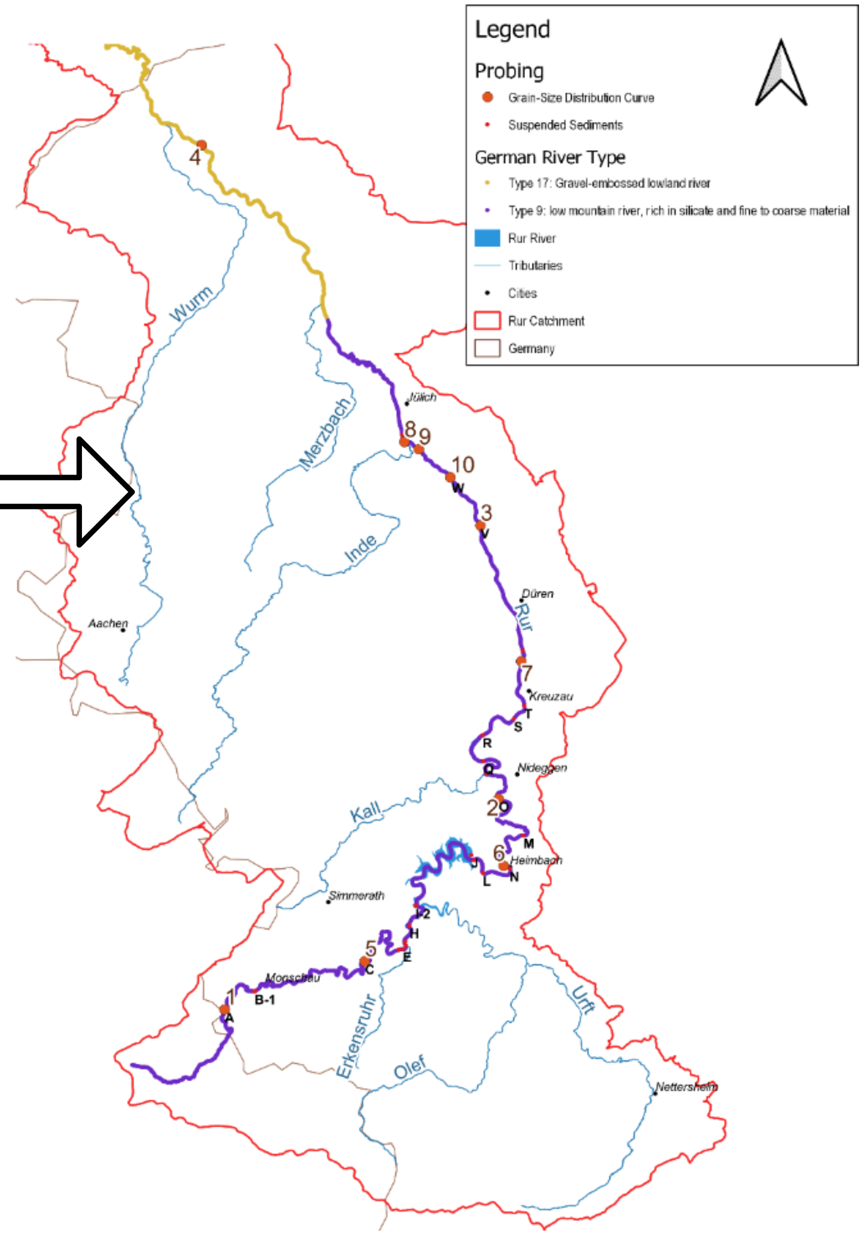
Staubecken Obermaubach (1934/1935)

→ 251 Mio.m³

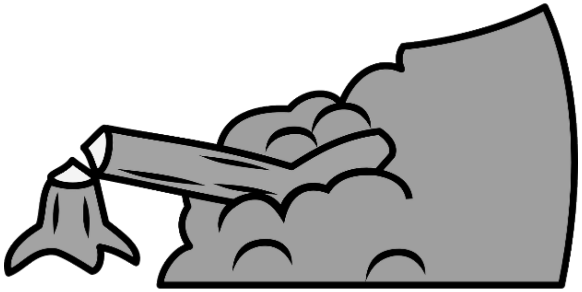
2 River types:

1. Gravel embossed lowland river
2. Low mountain river, rich in silicate and fine to coarse material

River Type 17:
gravel embossed
lowland River



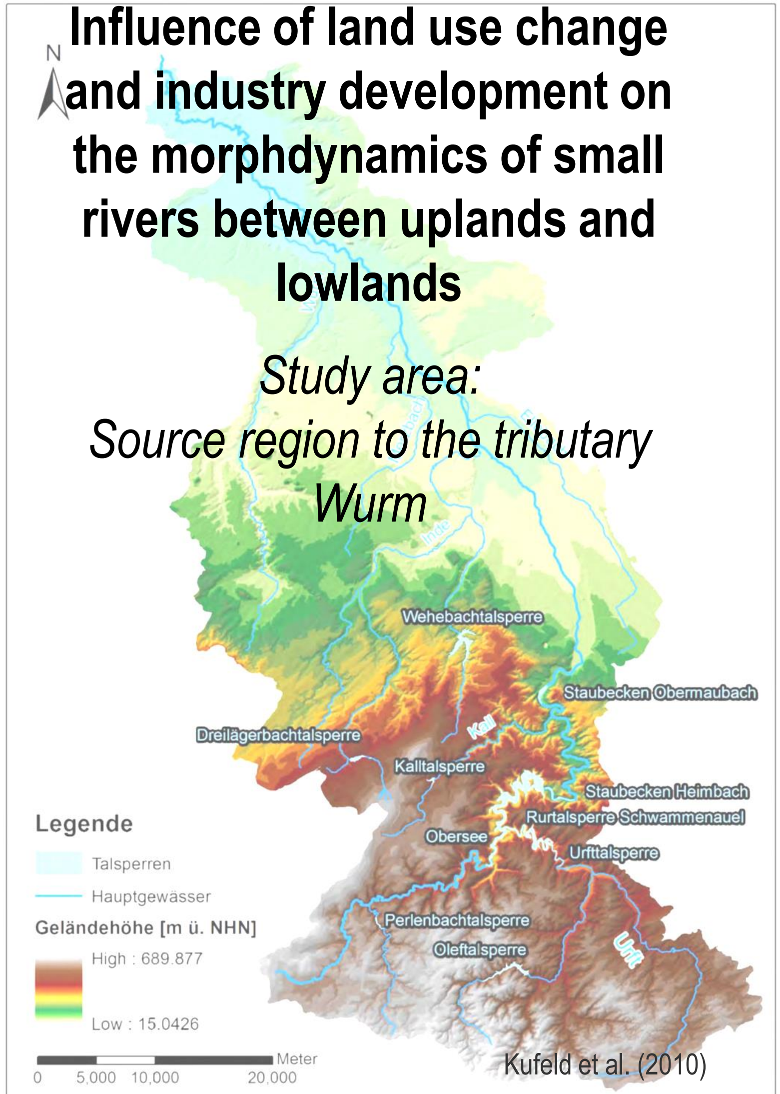
Objective & working packages



WP1:
Medieval interventions

Influence of land use change and industry development on the morphdynamics of small rivers between uplands and lowlands

Study area:
Source region to the tributary Wurm

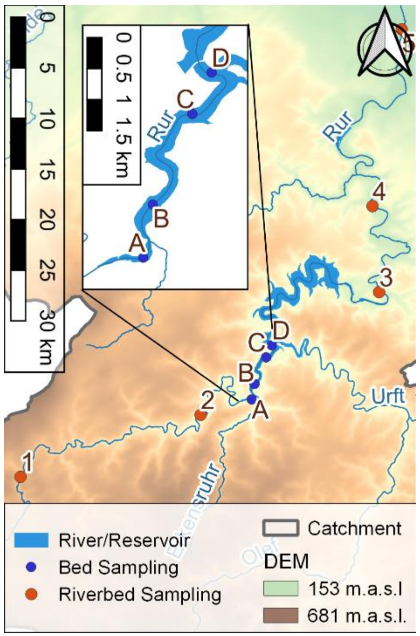


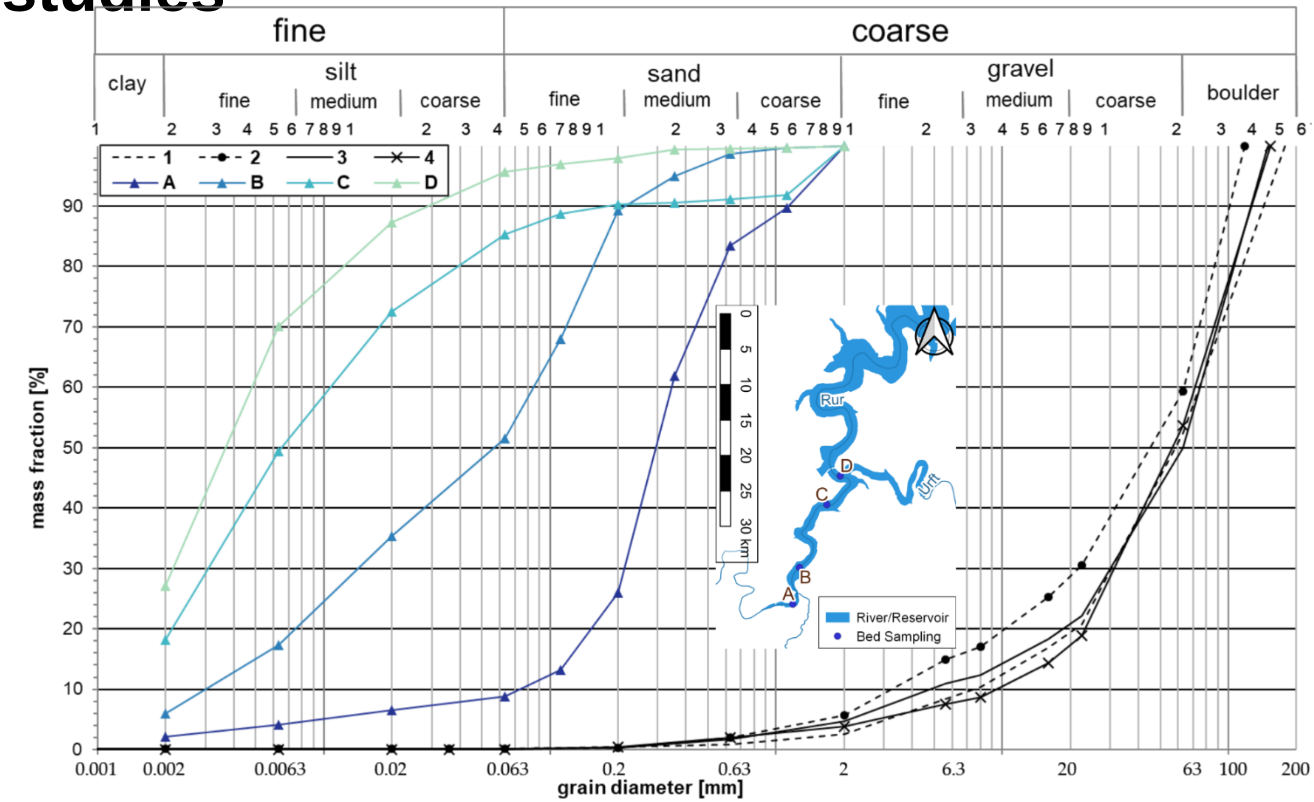
WP3:
Current measures

WP2:
Modern influences

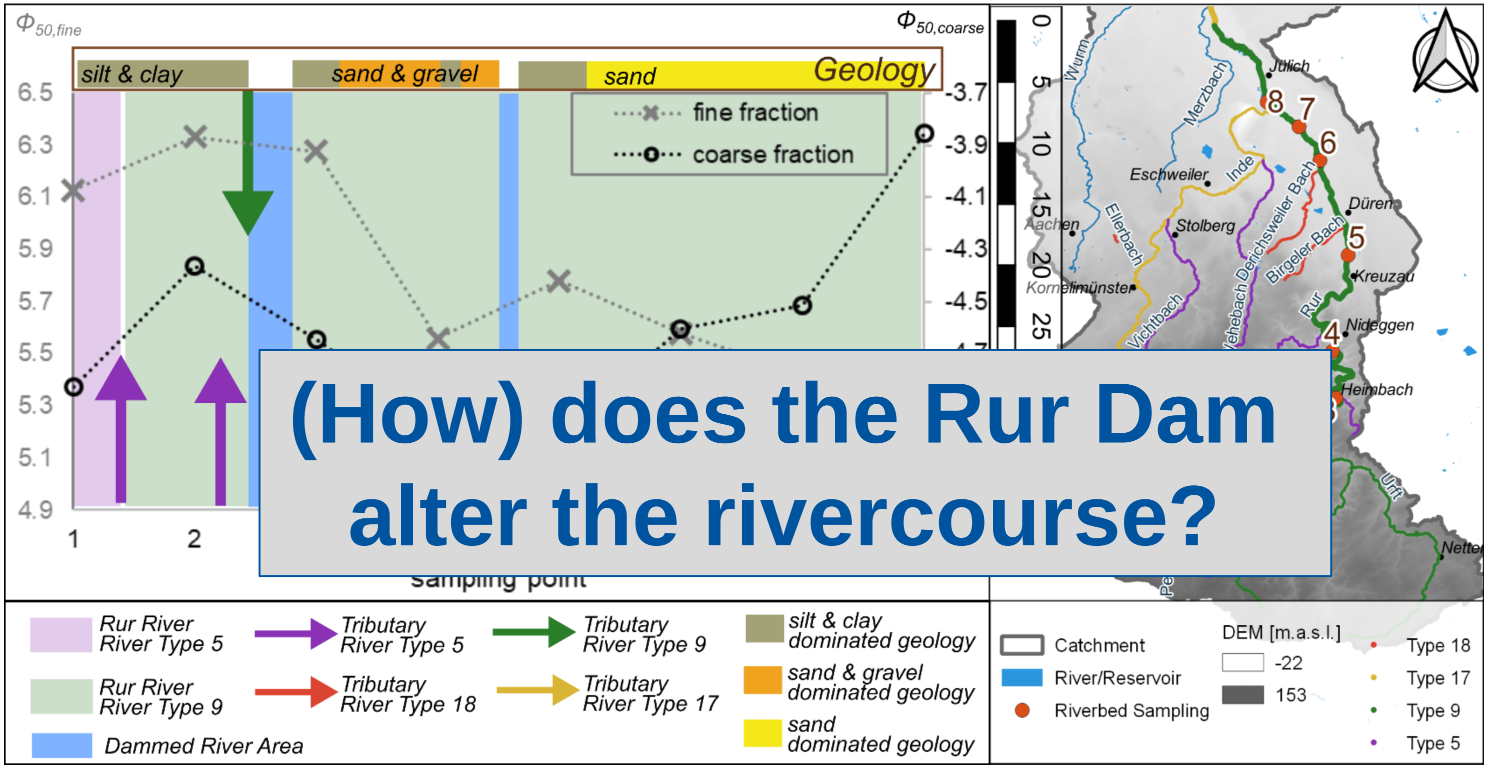
WP 4:
Synthesis

Sedimentary studies





Sedimentary studies

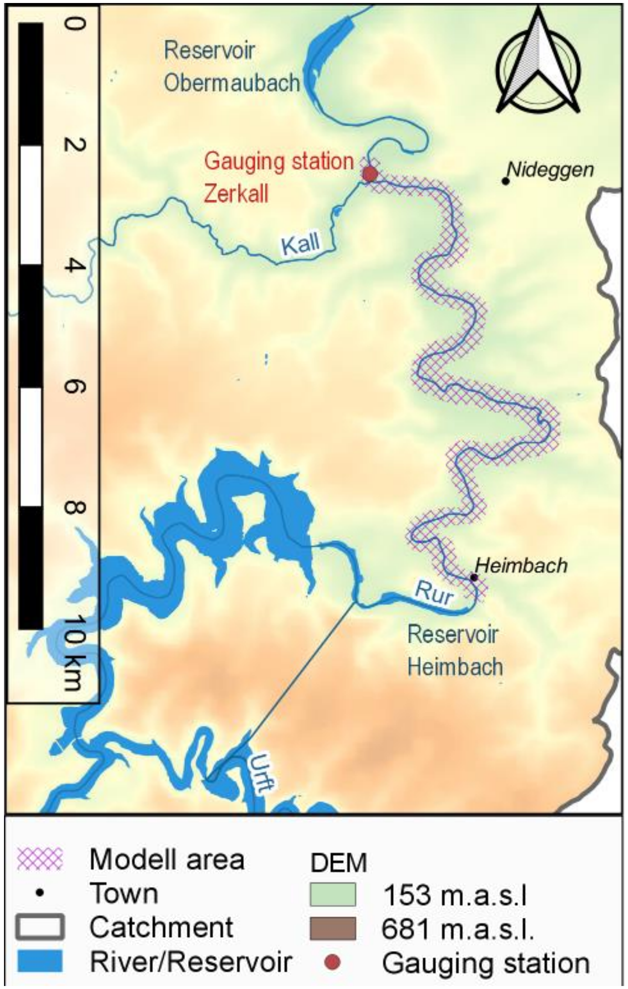


(How) does the Rur Dam alter the rivercourse?

River Type 5	River Type 9	River Type 18	River Type 17
coarse material-rich, siliceous low mountain streams.	low mountain river, rich in silicate and fine to coarse material	loess-loam dominated lowland streams	gravel-embossed lowland river

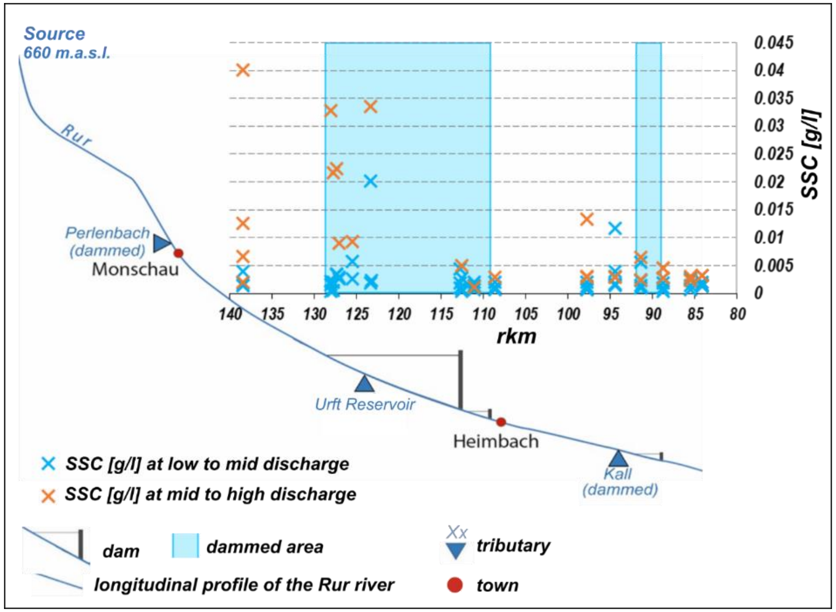
Main impacts of a dam – literature review

1. Sediment deficit (Williams und Wolman 1984; Brousse et al. 2020, Kondolf 1995)
2. Increase of mean grain size diameter (Williams und Wolman 1984; Kondolf 1997, Kantoush et a. 2010)
3. Alteration of flow regime, often reducing the mean annual discharge (Adib et al. 2016, Brandt 2000, Rovira und Ibàñez 2007, Walling 2012, Brousse et al. 2020, Phillips et al. 2005)

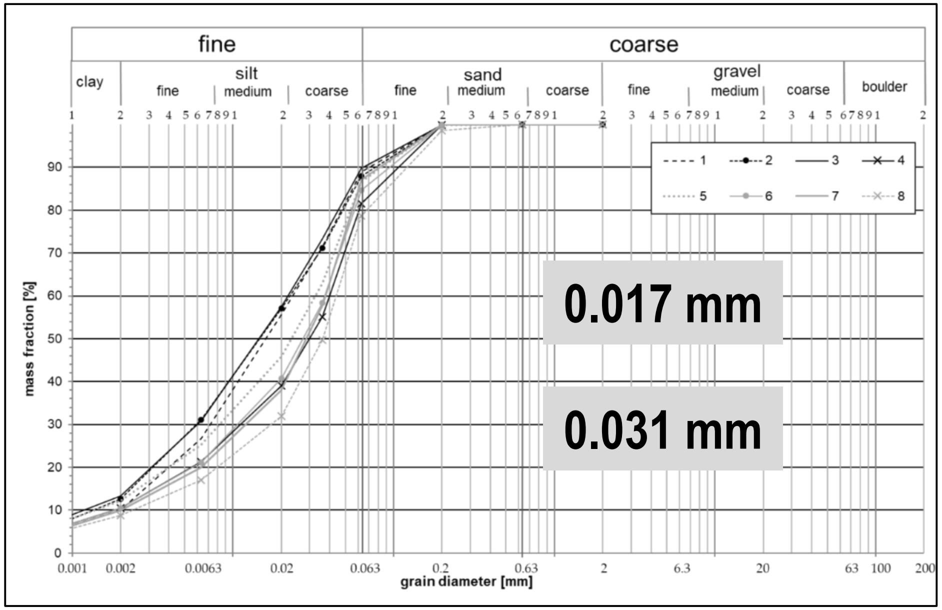


Materials & methods

Sediment deficit: Suspended Sediments

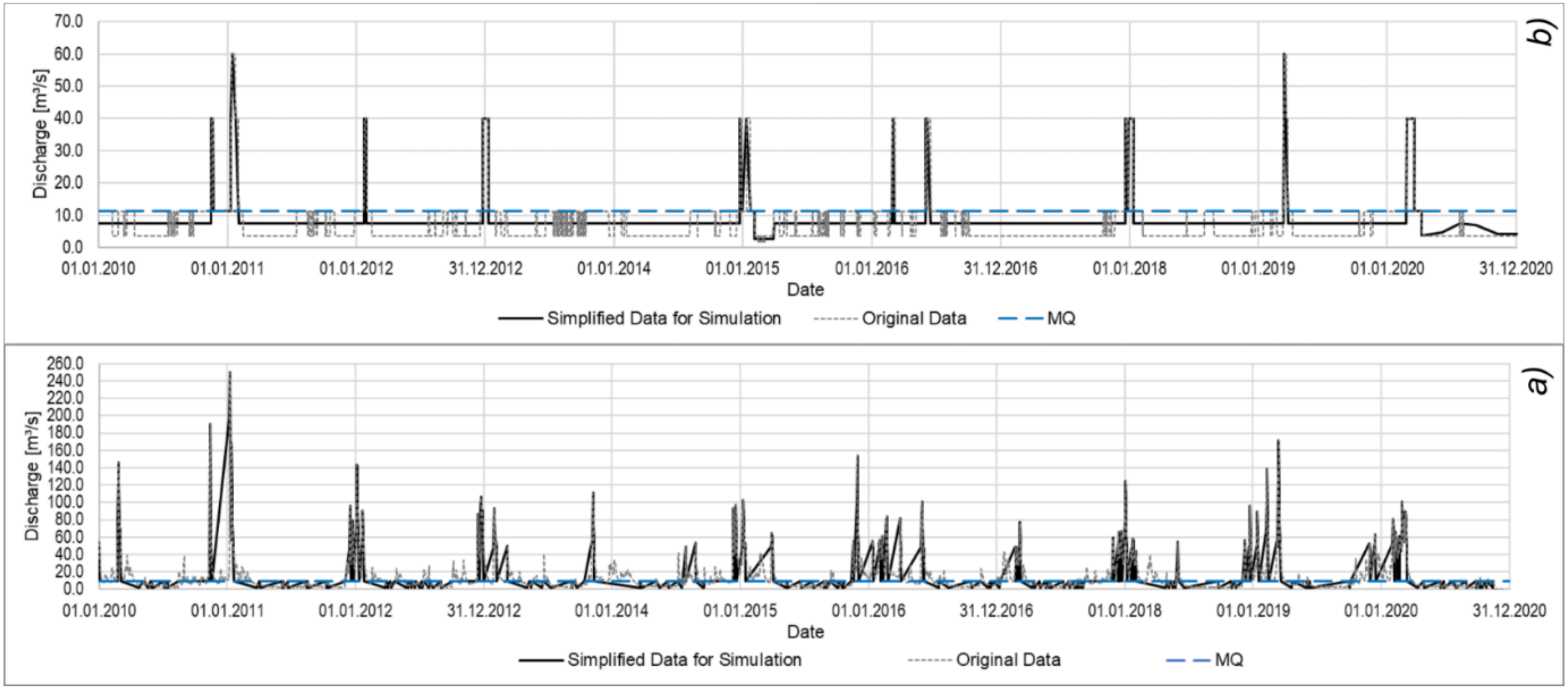


Grain size diameters: Fine fraction river soil



Materials & methods

Flow alteration

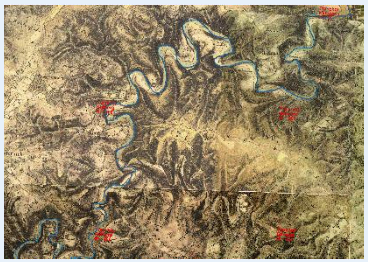
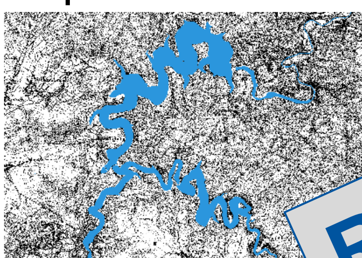
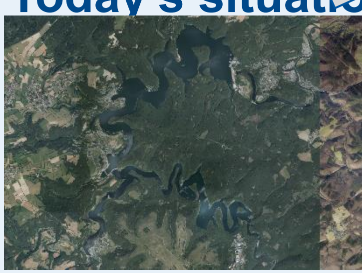


Timelines of discharge for the simulation.

a) tailored timeline resembling pre-dammed conditions (grey dashed) and simplified timeline for simulation (black), MQ=9.4 m³/s.

b) b) timeline showing dam discharge (grey dashed) and simplified timeline for simulation (black), MQ=11.3 m³/s.

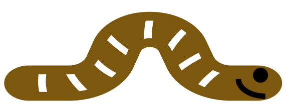
Next steps

	Description	Inflow - Discharge	Inflow - Sediment	Sediment settling velocity
1	**Pre-dam** conditions 	Pre-dam discharge timeline	No sediment deficit, SSC=0.00922 g/l	Small mean sediment diameter, v = 0.188 mm/s
2	Impacts **after dam** ... nt 	Post-dam discharg... ti...	S... ...cit, ...0018 g/l	Small mean sediment diameter, v = 0.188 mm/s
3	**Today’s situati...n**; ... has ... er 	Post-dam discharge timeline	Sediment deficit, SSC=0.0018 g/l	increased mean sediment diameter, v = 0.383 mm/s

Results: next Symposium

First results & outlook

- **Wurm River - Lowlands**
  - Transverse structures = water mills
  - **Fine sediments** play **key role** in morphological river development; floodplains are main sediment sources and deposits
- **Rur River - Uplands**
  - Transverse structures = dams
  - Gravel embossed rivers: separation of coarse and fine fraction; strong driver: **Geology**



→ **Approval of (first) results** (main drivers for morphological river development on different catchment scales and of different river types)


Thank you for your attention!
We look forward to your questions!
IWW

Sources

Adib, Arash; Foladfar, Hesam; Roozy, Amir (2016): Role of construction of large dams on river morphology (case study: the Karkheh dam in Iran). In: Arab J Geosci 9 (15). DOI: 10.1007/s12517-016-2693-2.

Brandt, S.Anders (2000): Classification of geomorphological effects downstream of dams. In: CATENA 40 (4), S. 375–401. DOI: 10.1016/S0341-8162(00)00093-X.

Brousse, Guillaume; Arnaud-Fassetta, Gilles; Liébault, Frédéric; Bertrand, Mélanie; Melun, Gabriel; Loire, Remi et al. (2020): Channel response to sediment replenishment in a large gravel-bed river: The case of the Saint-Sauveur dam in the Buëch River (Southern Alps, France). In: River Res. Applic. 36 (6), S. 880–893. DOI: 10.1002/rra.3527.

Kondolf (1997): PROFILE: Hungry Water: Effects of Dams and Gravel Mining on River Channels. In: Environmental management 21 (4), S. 533–551. DOI: 10.1007/s002679900048.

Kondolf, G. Mathias (1995): Managing bedload sediment in regulated rivers: Examples from California, U.S.A. In: John E. Costa, Andrew J. Miller, Kenneth W. Potter und Peter R. Wilcock (Hg.): Natural and Anthropogenic Influences in Fluvial Geomorphology, Bd. 89. Washington, D. C.: American Geophysical Union (Geophysical Monograph Series), S. 165–176.

Maaß, Anna-Lisa (2019): Looking back, locking forward – Human impacts on fluvial morphodynamics since the Industrial Revolution and the return to a natural morphological river state, Dissertation, doi: 10.18154/RWTH-2019-08256.

Phillips, Jonathan D.; Slattery, Michael C.; Musselman, Zachary A. (2005): Channel adjustments of the lower Trinity River, Texas, downstream of Livingston Dam. In: *Earth Surf. Process. Landforms* 30 (11), S. 1419–1439. DOI: 10.1002/esp.1203.

Rovira, Albert; Ibàñez, Carles (2007): Sediment management options for the lower Ebro River and its delta. In: J Soils Sediments 7 (5), S. 285–295. DOI: 10.1065/jss2007.08.244.

Walling, D. E. (2012): The role of dams in the global sediment budget. Erosion and Sediment Yields in the Changing Environment (Proceedings of a symposium held at the Institute of Mountain Hazards and Environment, CAS-Chengdu, China, 11-15 October 2012). In: IAHS Publ. (356), S. 3–11.

Williams, Garnett P.; Wolman, Markley Gordon (1984): Downstream effects of dams on alluvial rivers. Hg. v. U.S. Departement of the Interiour (GEOLOGICAL SURVEY PROFESSIONAL PAPER, 1286).