Bedload Dynamics in an Alpine River: A Case Study from the Ötztal, Austrian Alps

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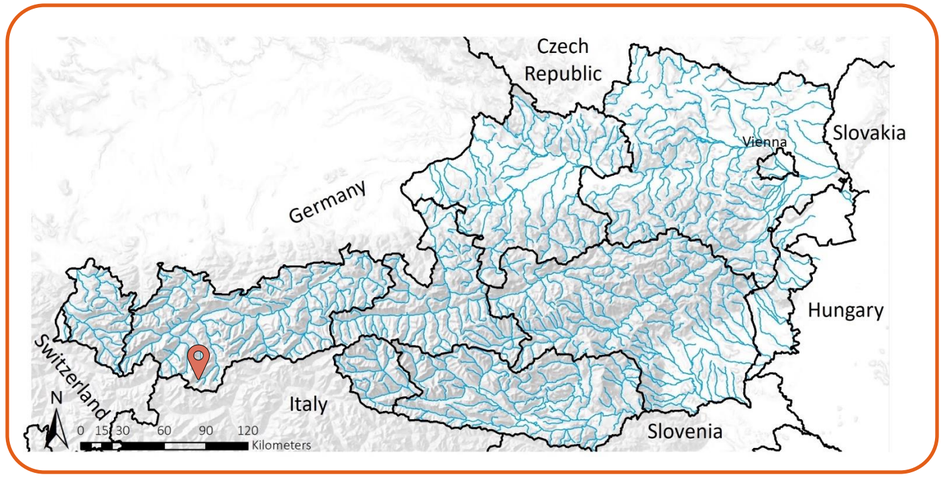
Where is this case study?

How is the bedload monitoring done?

What are the results?

Conclusions and is a look into the future possible?

Where? Austria – Vent – Rofenache River



4 glaciers

Area: 1891-3768 m a.s.l

High-alpine catchment with 98.7 km^2

1891 m a.s.l.

Width: 6,5 m

Gradient: 4,7 %

How? Integrative sediment monitoring

- Integrative monitoring system →**direct + indirect** measuring devices

- Direct method:
  mobile net sampler with different nets (mesh sizes 8mm and 2mm) for geophone system calibration

- Indirect method:
  12 **plate geophones** measuring the bedload transport every minute for information about temporal and spatial distribuation of bedload

mobile net sampler **VS0.5** (direct method)

plate geophone system (indirect method)

Rindler, R. et al. (2025) https://doi.org/10.1002/esp.70059, **Habersack. H. et al. (2017**) https://doi.org/10.1016/j.geomorph.2016.10.020

Results 1/3

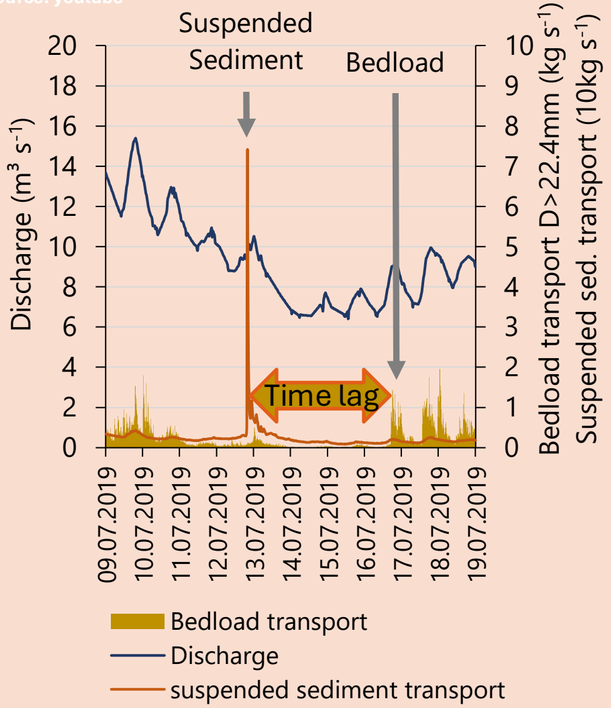
Single measurements

Measuring duration 20sec

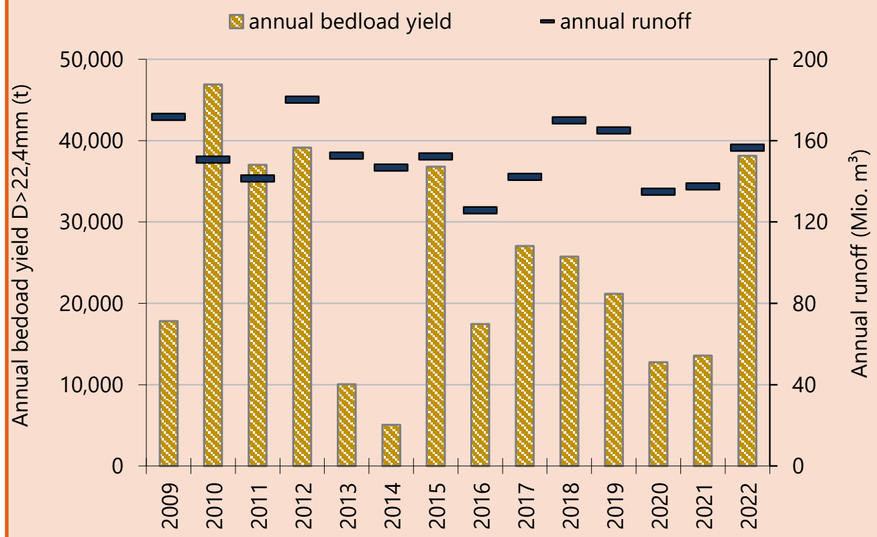
Total mass ≈ 110 kg bedload
specific transport rate
≈ 9,3 kg $m^{-1}s^{-1}$ (D>22,4mm)

Events & event history

Source: youtube



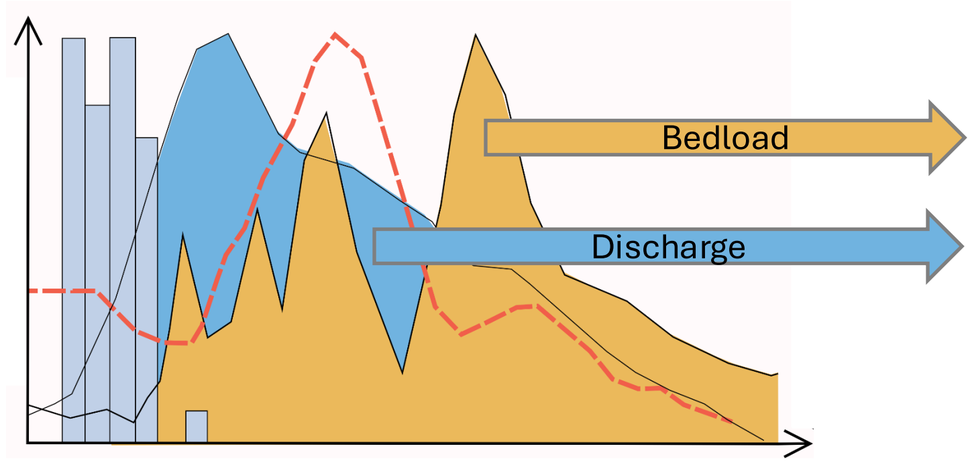
A Year to decades



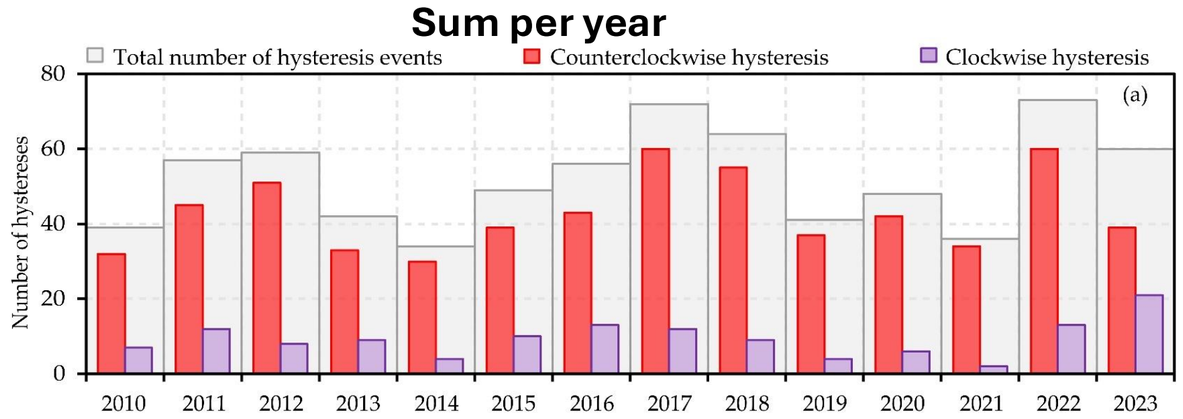
- Over longer time periods to register changes in bedload supply
- To strengthen process understanding
- Basis data for management plans (river measures) and sediment budgets

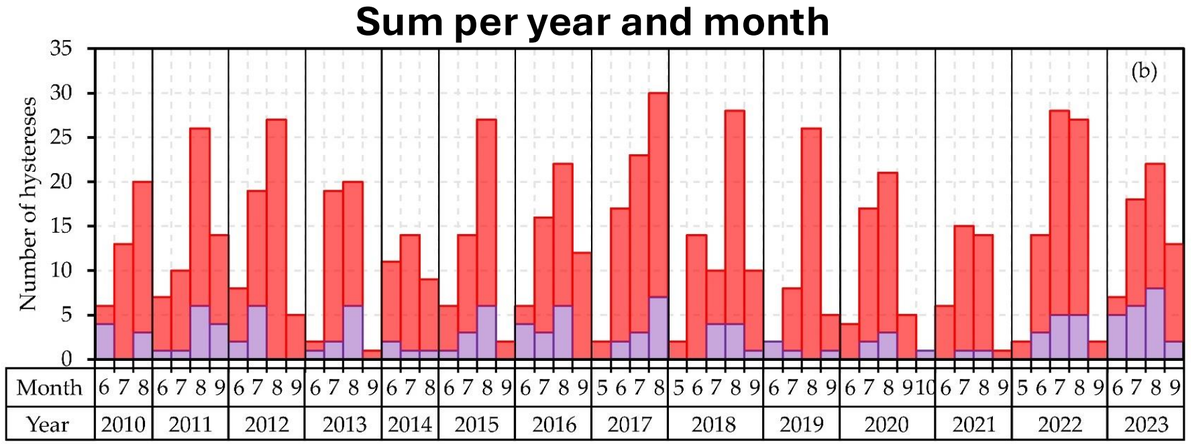
Results 2/3 - Bedload and discharge dynamics of 14 yrs

High-alpine rivers under climate change



Analysis of the bedload – discharge dynamics of a **14-year** period with clockwise and counterclockwise **hysteresis events**

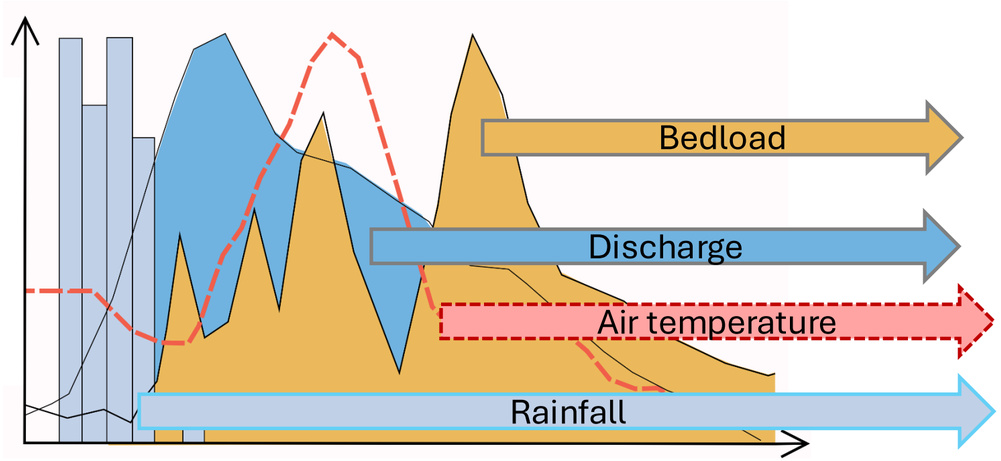




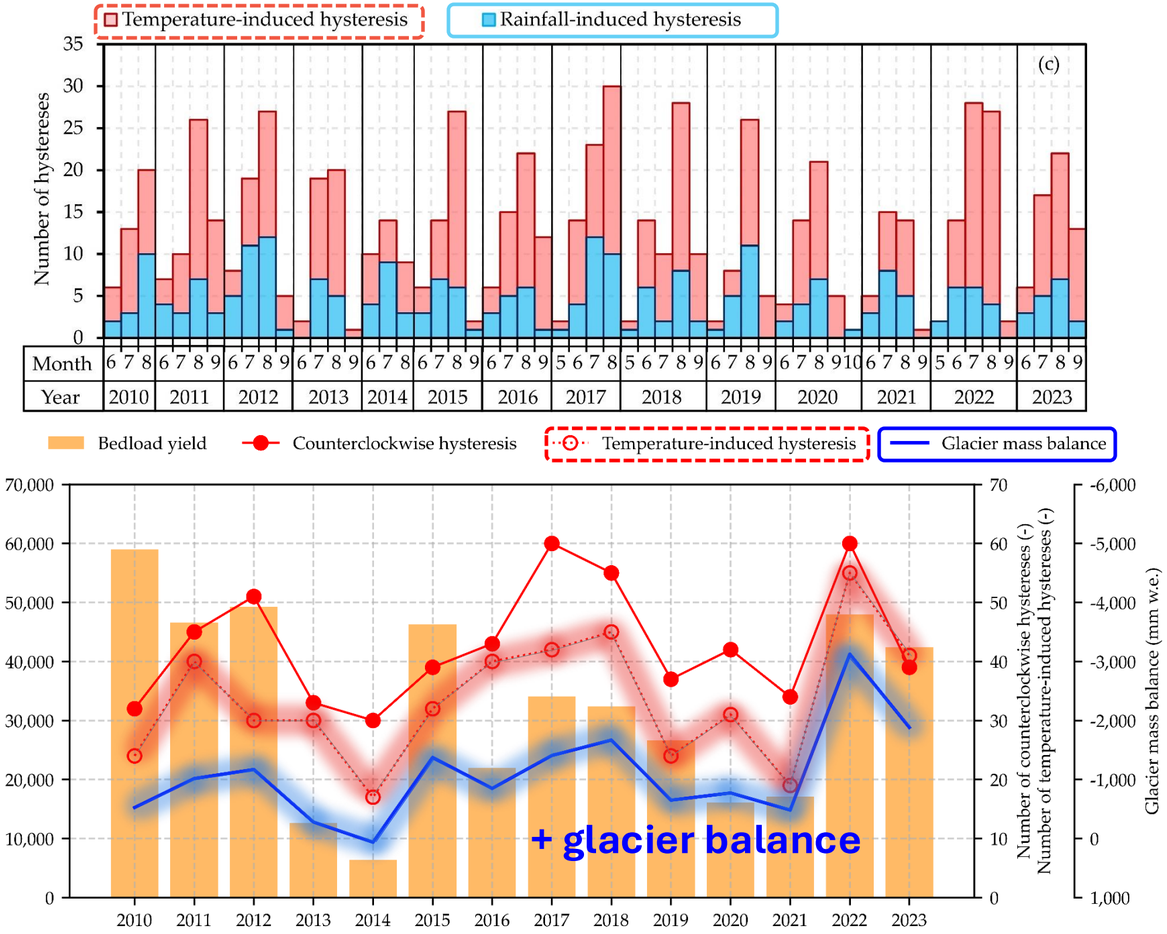
Schwarz, S. et al. (2025) https://doi.org/10.3390/w17091394

Results 3/3 - Bedload and discharge dynamics of 14 yrs

High-alpine rivers under climate change



Analysis of the bedload – discharge dynamics of a **14-year** period with clockwise and counterclockwise **hysteresis events** caused by **temperature- and rainfall**



Schwarz, S. et al. (2025) https://doi.org/10.3390/w17091394
Glacier balance: **WGMS (2024)** https://doi.org/10.5904/wgms-fog-2024-01

Conclusions

Key findings

- **Counterclockwise hysteresis** dominates, driven by delayed sediment release (mostly temperature-induced).
- **Clockwise hysteresis** less frequent, linked to nearby sediment sources (e.g., bank erosion).
- **Rainfall and temperature** are main drivers; no linear hysteresis = non-linear hydrological processes.

Context in Literature

- Hysteresis direction provides insights into sediment origin and transport processes (Mao et al. 2014).
- Glacier melt is a key driver of sediment dynamics in glaciated catchments (Savi et al. 2024, Comiti et al. 2019).
- (near) Future runoff from glacier melt is expected to decrease, as shown by climate projections (Compagno et al. 2024).

Implications

- Glacier retreat → Rainfall becomes key for bedload transport.
- Extreme rainfall → Mobilizes additional sediment sources → High transport rates.
- Longer melt season (3 → 5 months) → Increased sediment dynamics.

Future Perspectives

- Glacier meltwater decline → Reduced bedload transport.
- Heavy rainfall events → Significant sediment mobilization persists
- Climate adaptation (e.g., flood management) critical for small catchments (Haslinger et al. 2025).

Call to Action

Advanced monitoring & modeling needed to track long-term trends under climate change.

Schwarz, S. et al. (2025) https://doi.org/10.3390/w17091394

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Thank you for your attention!

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