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1. Background: glacier-fed rivers

- Discharge and sediment flux fluctuate over daily, seasonal and decadal scales
- Availability/connectivity of sediment sources change during the melting season
- Sediment size distribution is wide (sand/silt to boulders)
- Peak bed load can occur before or after peak discharge
- Relationship between discharge and bed load is complex.

How does a river respond to unsteady flow and sediment supply in terms of bed load, active area, surface texture and topography?

How does unsteady response compare to

2. Laboratory simulations

We simulated a glacier-fed river in a 25-m long laboratory flume where input discharge and sediment supply can be assigned via a software-controlled pump and feeder.

We tested three bed configurations (plane bed, alternate bars, wandering) and two grain size distributions (uniform, mixture) for a total of six channel setups.

For each channel setup, we ran a set of **steady flow** runs to define reference conditions and sets of identical, triangular hydrographs to simulate daily cycles. Hydrographs were run with in-phase and shifted sedigraphs.

BED CONFIGURATIONS



INPUT HYDROGRAPHS/SEDIGRAPHS In-phase sedigraph Shifted sedigraph

Different duration



steady flow behaviour?

This poster in a nutshell:

- Under unsteady flow conditions, bed load and active area show hysteresis patterns. During the rising limb, sediment transport is more intense and occurs over a smaller area
- Topography changes during cycles but is not in equilibrium with instantaneous discharge
- Surface texture depends on discharge through topography: high relief is associated with stronger spatial sorting

3. Data acquisition

- **Output bed load** acquired by load cells
- Active area from time-lapse imagery: portions of bed where sediment is moving have different colour in subsequent images (Redolfi et al., 2017)
- **DEMs** obtained from high-res imagery using Structure-from-Motion
- Maps of surface grain size obtained from spatial correlation of colour: larger grain size = pixel colour is correlated over a larger spatial scale



During hydrographs, clockwise hysteresis of bed load occurs regardless of sediment input timing. Hysteresis is stronger for fast cycles, mixed sand, complex morphology.



5. Active area

Under steady flow, the area of the bed where sediment moves increases with discharge.

During hydrographs with uniform sand, active area shows counterclockwise hysteresis.

With mixed sediment, active area at low flow is larger than it is under comparable steady flow conditions especially for shifted sediment input.



6. Bed topography

Under steady flow, topography different reaches a equilibrium configuration for each discharge, but bedforms do not attain this condition during hydrographs, especially if cycles are rapid.

Discharge change during hydrographs is slow enough to produce a limited morphological response to discharge, but too fast to allow bedforms to reach equilibrium with flow conditions.





7. Surface texture

Bed **relief** favours **spatial sorting**, with coarse particles accumulating on high, flat areas (bar tops). For high discharge,

The response of spatial sorting to unsteady flow is mediated by changes bed relief. If in morphological response is limited, spatial

HYDROGRAPHS



relief is low and sorting is absent.

sorting during cycles also shows small change.



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