Morphology of boulder-bed semi-alluvial channel beds: a flume study modelling streams in northern Fennoscandia

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2pct_largeclasts.zip *(22.61 KB)*

5pct_largeclasts.zip *(32.58 KB)*

DEM_2pct_pre.zip *(1.1 MB)*

DEM_2pct_q1.zip *(1.11 MB)*

DEM_2pct_q10.zip *(1.06 MB)*

DEM_2pct_q2.zip *(1.03 MB)*

DEM_2pct_q50.zip *(1011.45 KB)*

DEM_5pct_pre.zip *(947.7 KB)*

DEM_5pct_q1.zip *(973.95 KB)*

DEM_5pct_q10.zip *(971.95 KB)*

DEM_5pct_q2.zip *(988.21 KB)*

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2020-96-1-1.zip *(~10.09 MB)*

Citation

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Description

In northern Fennoscandia, semi-alluvial boulder-bed channels with coarse glacial legacy sediment are abundant and due to widespread anthropogenic manipulation during timber-floating, unimpacted reference reaches are rare. The landscape context of these semi-alluvial rapids— with numerous mainstem lakes that buffer high flows and sediment connectivity in addition to low sediment yield— contribute to low amounts of fine sediment and incompetent flows to transport boulders. To determine the morphodynamics of semi-alluvial rapids and potential self-organization of sediment with multiple high flows, a flume experiment was designed and carried out to mimic conditions in semi-alluvial rapids in northern Fennoscandia. Two slope setups (2% and 5%) were used to model a range of flows (Q1, Q2, Q10 & Q50) in a 8 x 1.1 m flume with a sediment distribution analogous to

field conditions; bed topography was measured using structure-from-motion photogrammetry (SfM) after each flow to obtain digital elevation models (DEMs). Ground-based LiDAR was used to obtain control points needed to create the SfM-based DEMs. The DEMs have a resolution of 5 x 5 mm; separate DEMs are shown for initial conditions at each slope and after each flow. Exported sediment after the 2% slope flows was replaced into the flume and the bed was mixed to create similar initial plane bed conditions before the 5% slope flows as with the 2% slope setup. Shapefiles of digitized grains > D84 are also included. These were created based on the initial conditions for each slope separately. Analyses of the DEMs were done by creating DEMs-of-difference (DODs) by subtracting DEMs from one another to obtain elevation changes. These elevation changes were analyzed for the entire flume an in relation to >D84 grains. Results of these analyses have implications for restoration of gravel spawning beds in northern Fennoscandia and highlight the importance of large grains in understanding channel morphodynamics.

A mobile-bed physical model of the semi-alluvial prototype streams in northern Sweden was setup in an 8-m long, 1.1-m wide fixed-bed flume at the Colorado State University Engineering Research Center in Fort Collins, Colorado, USA. Using a geometric (yr and zr) scaling factor of 8, the initial sediment distribution was scaled-down to be analogous to that in the semi-alluvial prototype streams; because the D10 was 4 mm and Dmin was 0.14 mm, all sizes were sand-sized or above so there were no issues with cohesiveness. No sediment feed was provided from upstream, creating clear water conditions, and this is consistent with the prototype field conditions with very low levels of suspended sediment or annual sediment flux and little sediment input from the hillslopes or upstream reaches. Two flume setups were used with initial bed slopes of 0.02 and 0.05 m/m, respectively. Before the flows were run, the grain size distribution was thoroughly mixed in the flume, and checks were made to ensure equal sediment depth and the desired slope throughout the flume length. For each slope, four runs were conducted with flows analogous to the summer high (Q1), the 2-year (Q2), 10-year (Q10), and 50-year (Q50) flows in the prototype streams. Each flow was run for 60 minutes, which surpassed the time necessary until equilibrium conditions were met, as defined by minimal to no visible sediment transport or transport out of the reach. As no boulder (>D84) movement was detected (other than slight rotation) during any flow, equilibrium conditions were only based on transport of the fine sediment fraction. After each flow, the bed topography and channel geometry were measured (described below) before running the next higher flow.

Structure-from-motion photogrammetry (SfM) was used to create digital elevation models (DEMs) of bed topography. SfM-created DEMs were constructed before all runs at each slope setup and after each run, with progressively higher flows. For each flume setup with different slopes, a terrestrial LiDAR scan (TLS) was used to determine a coordinate system and be able to georeference the SfM scans, based on targets affixed to the flume walls. The TLS scans provided exact xyz coordinates of the targets, which were used to georeference the SfM-based DEMs. A Canon EOS Rebel T3i DSLR camera with a fixed, non-zoom lens (Canon EF-S 24 mm prime lens), which minimizes edge distortion of photos, was mounted to a movable cart on rails ~30 cm above the flume bed. Photos were taken ~20 cm apart looking upstream and downstream at an oblique 45° angle. The images were processed using AgiSoft PhotoScan Professional to obtain topographical point clouds.

The topographical point clouds were imported into ArcMap 10.5.1 and rasters were created with a grid size of 5 mm to create digital elevation models (DEMs) of the topography for the initial conditions at each slope setup and after each flow, with a precision of 2 mm. In areas with missing data, the neighboring points were iteratively averaged to interpolate elevations for pixels. The flume study area was clipped to 7.0 m and 6.3 m in length for the 2% and 5% slope setups, respectively, to remove the upstream turbulent section containing much coarser sediment and a headcutting section at the downstream portion of the flume. In order to analyze erosion and deposition of sediment in relation to

large grains, grains >D84 were identified and digitized using ArcMap 10.5.1.

Data contains personal data

No

Language

English

Time period(s) investigated

2015-08-01 – 2015-09-01

Data format / data structure

Geospatial

Geographic spread

Geographic location: Västerbotten Province, Norrbotten Province, Jämtland Province, Västernorrland County, Sweden, Finland

Geographic description: The study models a type of stream that is common in northern Fennoscandia (Scandinavia & Finland) and is not based on a specific stream in a particular geographic area.

Responsible department/unit

Department of Ecology and Environmental Science

Funding

- Funding agency: Swedish Research Council Formas
- Funding agency's reference number: 2014-00484

Research area

Physical geography (Standard för svensk indelning av forskningsämnen 2011)

Oceanography, hydrology and water resources (Standard för svensk indelning av forskningsämnen 2011)

Keywords

Rivers/streams, Watercourse

Accessibility level

Access to data through SND
Data are freely accessible

Use of data

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Versions

Version 1. 2020-10-21

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DDI 2.5

DDI 3.3

DCAT-AP-SE 2.0

JSON-LD

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