Using LiDAR data to define stream flow rating curves

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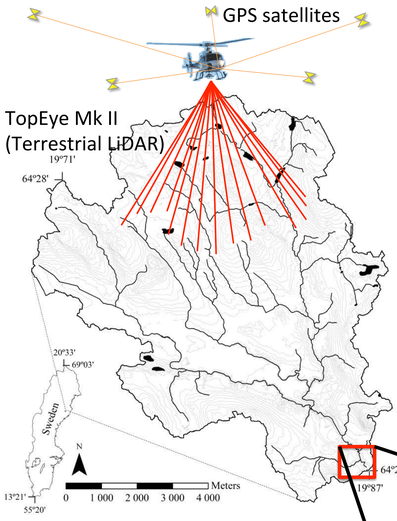
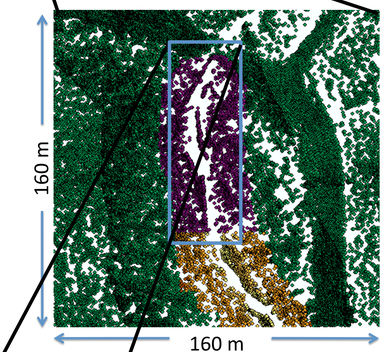
Question: Can LiDAR data characterize channel geometry well enough to constrain a flow model for generating rating curves?

1. LiDAR survey



LiDAR technique (Light Detection and Ranging) is based on emission of light and collection of backscatter from the illuminated surface. LiDAR allows for positioning of ground topography.

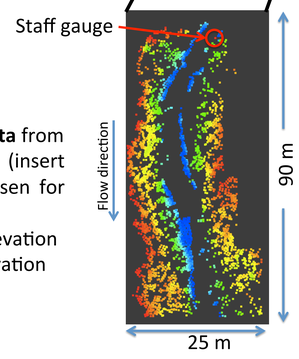
An aircraft borne LiDAR survey was conducted in August 2008, covering the boreal Krycklan Catchment located in northern Sweden.



LiDAR data in the plane of a 160 m by 160 m area, close to the catchment outlet, was initially processed. Backscatter caused by vegetation was filtered out.

To the right is topographic data with approximately 30-cm average of spacing.

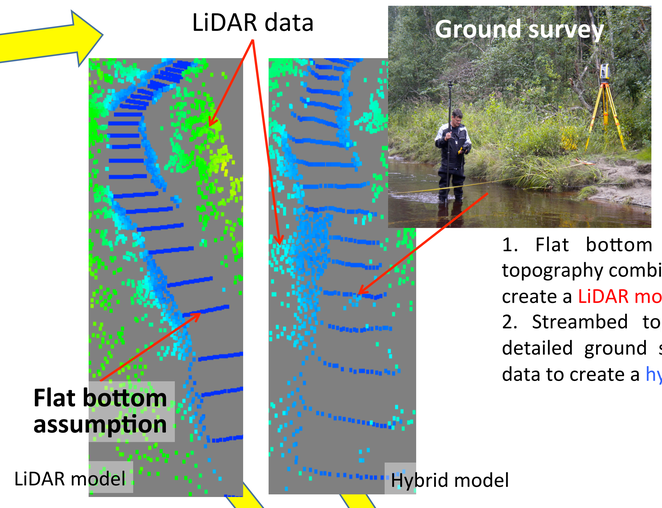
Purple and yellow color shows the area of riverbanks and floodplain.



Topographic data from the purple area (insert above) were chosen for the modeling.
Blue is deeper elevation
Red is higher elevation

Near infrared LiDAR is not capable of penetrating through the water surface. Attenuation of the LiDAR signal results in black areas that reflects the missing streambed topography.

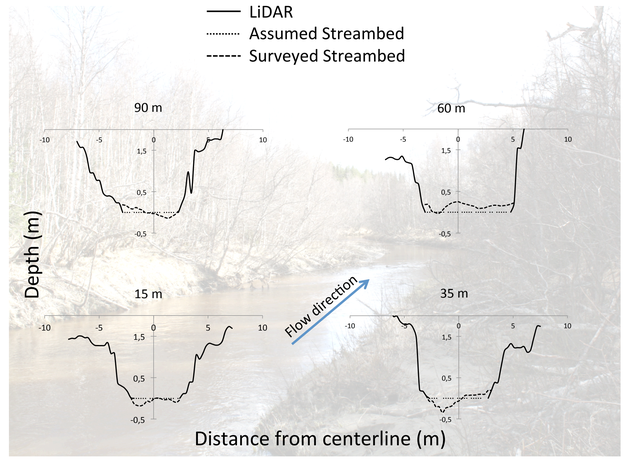
2. Model approach



LiDAR data was conducted at low water elevation (33 cm at the staff gauge), with only submerged parts of the streambed missing.

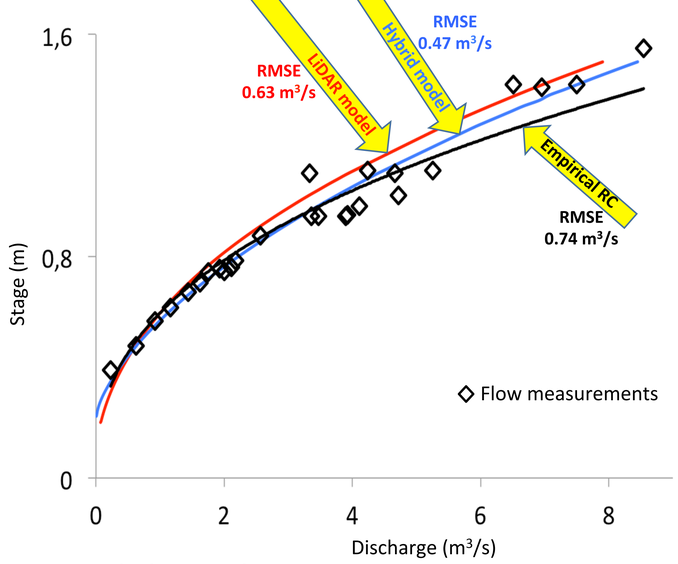
Two approaches to fill in for the missing streambed topography were adopted.

1. Flat bottom assumption of streambed topography combined with LiDAR data to create a LiDAR model.
2. Streambed topography measured from a detailed ground survey combined with LiDAR data to create a hybrid model.



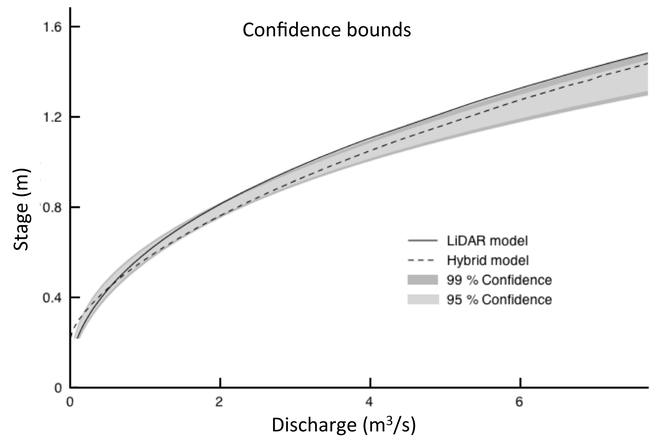
Cross sections at different distance from the staff gauge.
The deviation between the topographic information from the LiDAR survey and the detailed ground survey was estimated to be less than 0.35 m in overlapping areas.

1-D flow modeling



Modeled rating curves were compared to: (1) flow measurements, (2) the empirical rating curve, estimated from flow measurements, and (3) to confidence bounds, calculated for the empirical rating curve.

In general, the modeled rating curves were in agreement with measured flow. Both modeled rating curves were within the calculated confidence bounds. RMSE showed best agreement for the hybrid model.



3. Model result

Resistance factors quantified from the field surveys were used to calculate total channel roughness. A one-dimensional physically-based flow model was constrained with the calculated roughness to compute velocity profiles for every submerged grid point on a two-dimensional curvilinear grid. The model then calculated the stage-discharge relationship (a rating curve) over the full range of specified stages.

Answer: LiDAR data captured enough channel geometry to model rating curves using a physically-based model approach.

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