Assessing Seasonal Changes of Spatial Complexity in Riverscapes using Drone-Based Laser Scanning

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Background:

Riverscapes are the entire spatially heterogeneous scene of the river environment.

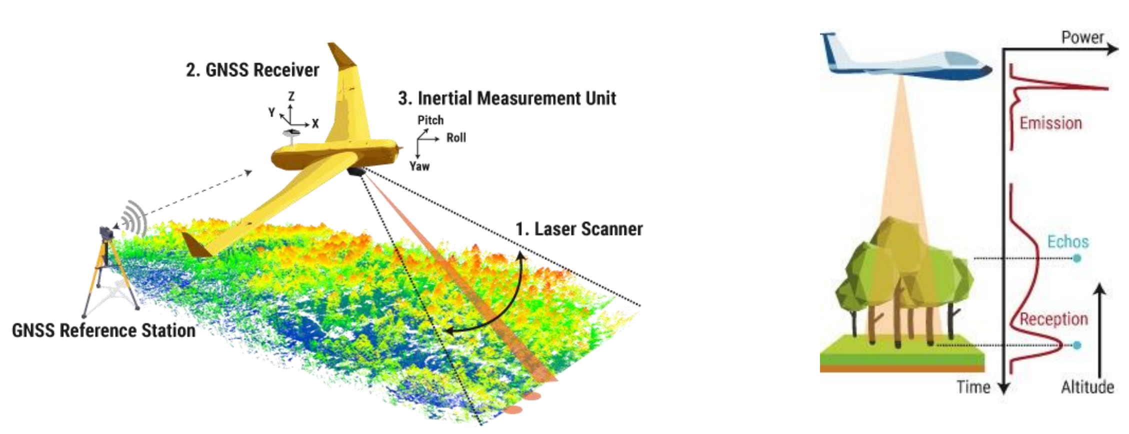
The study area is the VT StREAM Lab, shown above.

Objectives

- Collect Drone Laser Scanning (DLS) from StREAM Lab, a stretch of Stroubles Creek in Blacksburg, VA.
- Classify Lidar (ground and vegetation), create digital terrain models (DTM), canopy height models (CHM).
- Compare roughness metrics with field data and hydraulic modeling results.
- Compare seasonal changes of roughness, evaluate roughness though space and time

Laser Scanning:

Lidar (Light Detection and Ranging) is a form of remote sensing that emits a laser pulse to the surface of the earth to measure distances. This creates a 3D point cloud of all the points where a laser pulse hit a surface.



yellowscan-lidar.com

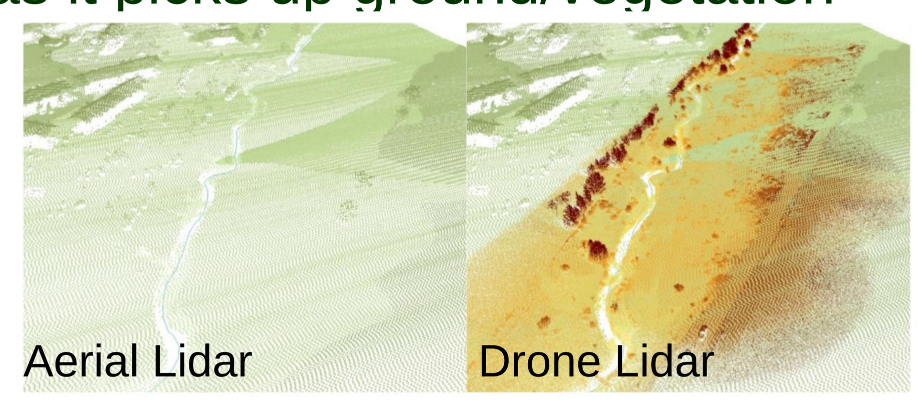
Drone Laser Scanning Collection:

- Drone – Pulse Aerospace Vapor 35
  - Weight = 30 lbs
  - Payload = 5 lbs
  - Cruise Time = 40 mins
- Lidar Unit – Yellowscan Surveyor Core
  - 2 returns per pulse
  - 450 points/m^2 at 20 m altitude
  - Calibrated IMU + GPS
- Flight Control Software
  - Sets waypoints for flight
  - Sets speeds, altitude.

Why Drone Laser Scanning (DLS)?

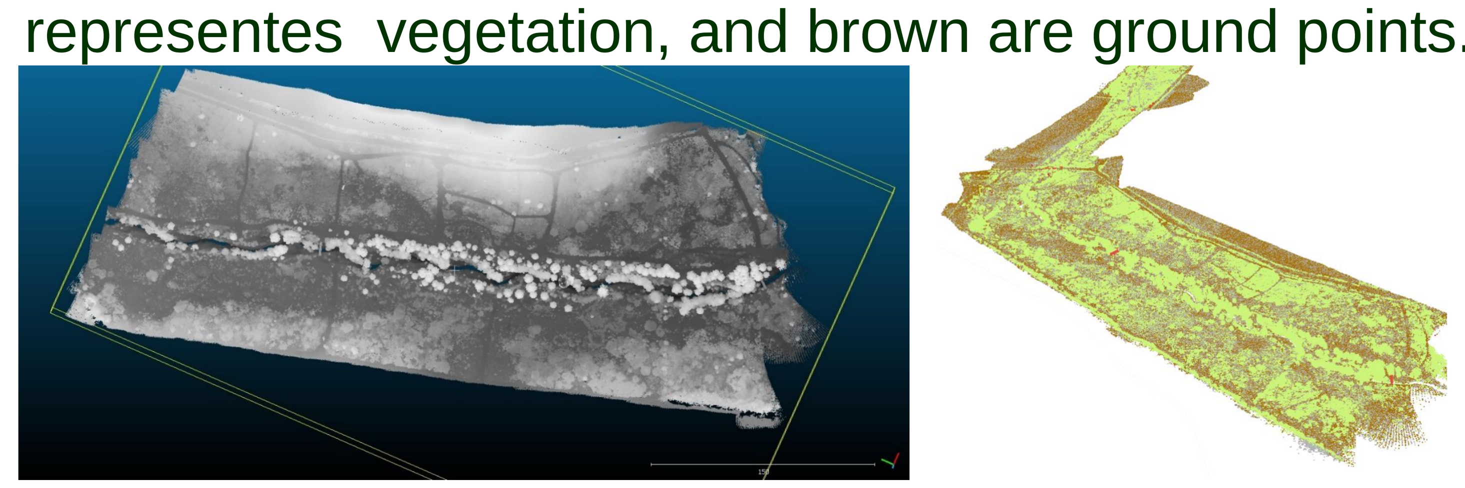
Riverscapes change in both space and time. Remote sensing can map riverscapes to take advantage of objective, spatially continuous, faster and less laborious surveys. Common remote sensing methods include:

- Aerial Lidar scanning can survey large areas, but produce point clouds with small point densities.
- Structure from Motion (SfM) is easy/cheap to make point clouds, difficult to find ground in dense veg.
- DLS combines the mobility of drones with the resolution of lidar, as it picks up ground/vegetation points.

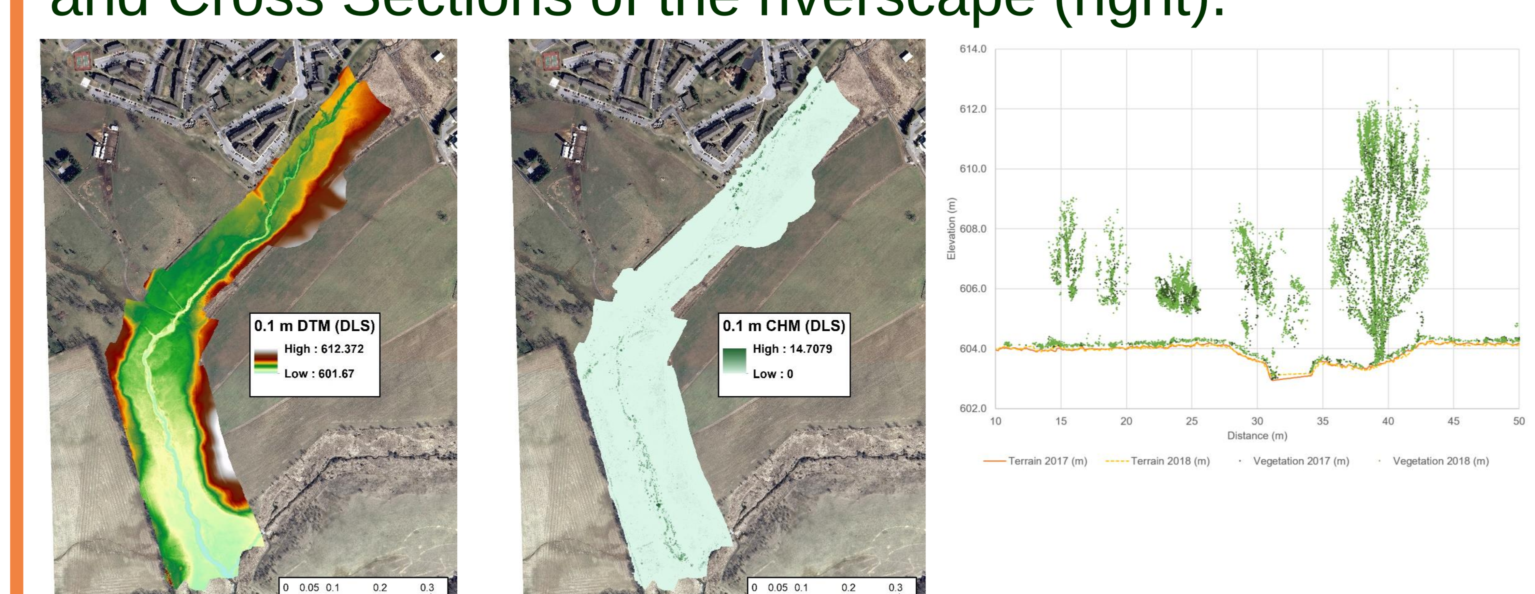


Lidar Products:

Point clouds (left) can be classified to ground, vegetation, and built structures (right). Green representes vegetation, and brown are ground points.



These point clouds can be converted to raster files for further analysis. Examples of products include Digital Elevation Models (left), Canopy Height Models (middle), and Cross Sections of the riverscape (right).



Seasonal Changes in Riverscapes:

Pictures above show the differences between Summer and Winter at the same location.

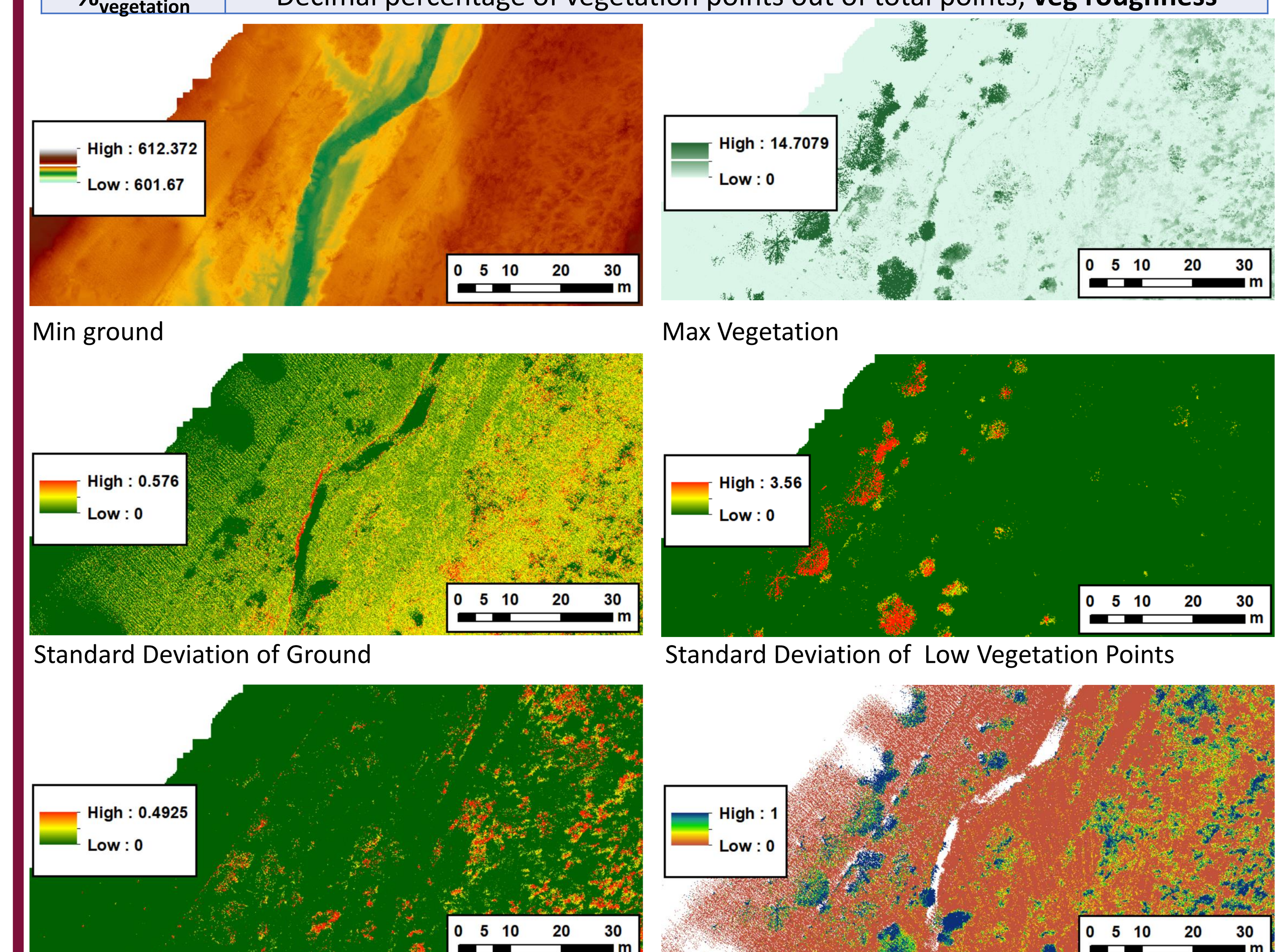
Roughness:

- In hydrology, roughness is a culmination of energy loss in stream channel.
- It is the resistance to flow caused by obstructions.
- Roughness is an important habitat metric, as it creates flow diversity.
- A roughness coefficient, *n*, used in Manning's equation, which is a fundamental equation in the field of hydrology.

$$Q = VA = \left(\frac{1.00}{n}\right)AR^{\frac{2}{3}}\sqrt{S}\ \text{(SI Units)}$$

Roughness Metrics:

Lidar Terrain and Vegetation Roughness Metrics (0.1 m Resolution)	
Min_{ground}	Minimum elevation of ground and unassigned points; **digital terrain model (DTM)**
$Max_{vegetation}$	Maximum height of vegetation points; **canopy height model (CHM)**
Σ_{ground}	Std. dev. of height of ground and unassigned points; **topographic roughness**
$\sigma_{low\text{-}veg}$	Standard deviation of height of low vegetation points; **vegetative roughness**
$\sigma_{high\text{-}veg}$	Standard deviation of height of high vegetation points; **vegtative roughness**
$\%_{vegetation}$	Decimal percentage of vegetation points out of total points; **veg roughness**



Min ground

Max Vegetation

Standard Deviation of Ground

Standard Deviation of Low Vegetation Points

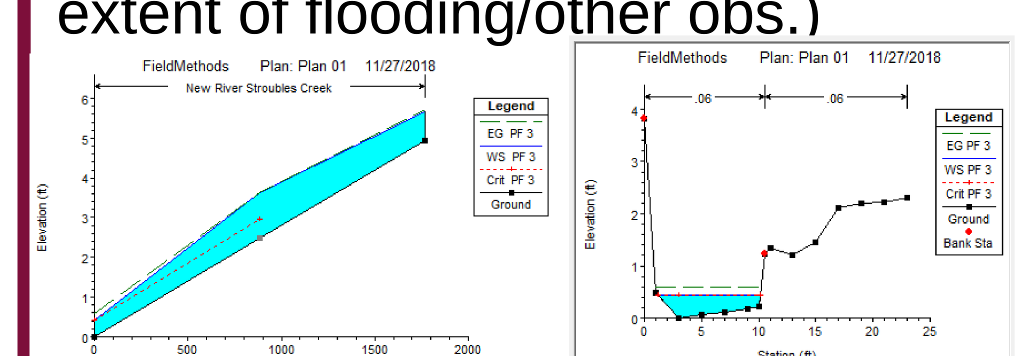
Standard deviation of High Vegetation Points

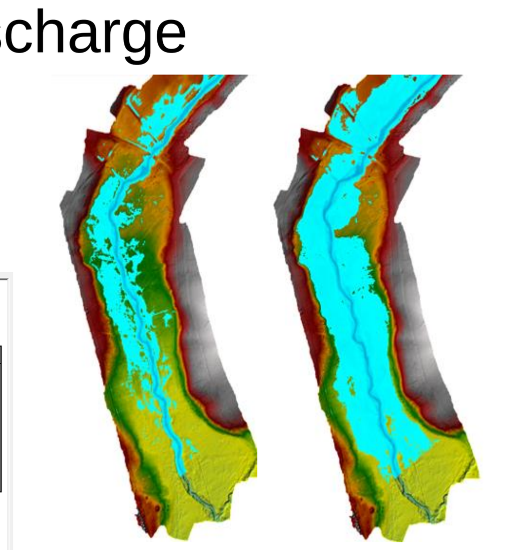
Decimal Percentage of Vegetation Points

Hydraulic Modeling/Field Data:

We will utilize HEC-RAS 2D, a US Corps of Engineering software package to evaluate flood inundation and roughness in the floodplain. Calculated roughness will be used to model flooding in StREAM lab along with:

- Drone lidar derived digital elevation models
- StREAM lab data to calculate discharge
- Surveyed channel geometries
- Visual observations (flagging the extent of flooding/other obs.)





Low flow

High flow