ESRM433/SEFS533
Lab 10

Objectives:

- *Comparison of lidar*
  - *Cloud Metrics / Rumple / Tree Segmentation between ALS & TLS*
  - *Cloud Metrics and RH between ALS and GEDI*

Data and Software:

- *LAB10 data*
  - *ALS – From the WA DNR lidar portal*
  - *TLS (included in zip file)*
    - 2019-08-18 Pack Forest TMLS.laz
    - 2019-08-22 Hall of Mosses TMLS.laz
  - GEDI – *From lab 9*
- *RStudio*
- *CloudCompare*

What you will turn in:

- *No submission template. You will submit a report with several required figures included.*

Welcome to Lab 10 for ESRM433/SEFS533

Comparison of lidar

You will use your knowledge of lidar to compare TLS to ALS and ALS to GEDI. You will be using some of the outputs from lab 9 for this lab.

Please make use of the discussion board on canvas for this assignment! You may share and post code snippets to help each other out. Don't post your figures you are creating, but code can be shared.

To start, download the LAB10TLS from Canvas.
There is TLS data collected from a lidar backpack at sites in:

- Pack Forest
- Olympic Natrional Park
  - Hall of moses - https://www.nps.gov/olym/planyourvisit/visiting-the-hoh.htm

PART 1
ALS &TLS comparison processing steps with required figures

You will have 2 plots for this part centered at:
Pack Forest - 1185950 555180 (EPSG 2927) / -122.31625, 46.84141 (WGS 84)
ONP - 797785 941189 (EPSG 2927) / -123.93314, 47.86372 (WGS 84)

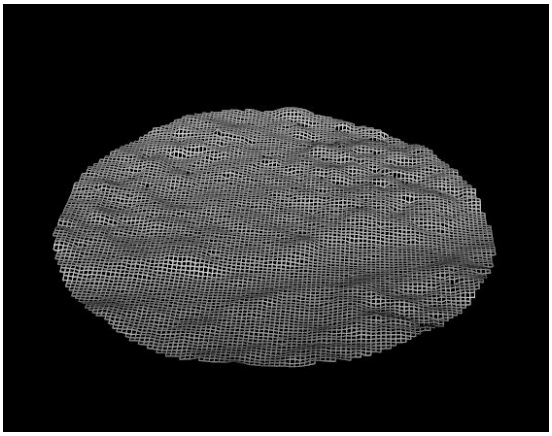
Download the ALS point clouds at those two locations from the Washington DNR lidar portal website.

- Read in the two ALS laz files and the two TLS laz files into R

  - ALS files (you downloaded from the DNR) (Assuming Pack 2013)
    - WA_031_rp.laz
    - q47123g8201.laz
  - TLS files (provided via canvas):
    - 2019-08-18 Pack Forest TMLS.laz
    - 2019-08-22 Hall of Mosses TMLS.laz
- Define the crs in R
- clip_circle the files to the plot extent:
  - Pack Forest ALS & TLS (epsg 2927)
    - x = 1185950, y = 555180, radius = 50
  - ONP ALS & TLS (epsg 2927)
    - x = 797785, y = 941189, radius = 50
  - Future steps for the TLS will only use these clips
- writeLAS the four lidar clips and bring them into cloudcompare to produce a figure.

REQUIRED FIGURES: An image of the ALS and TLS plotted together for both the pack forest and ONP sites (two screen shots). Example given has the TLS could in white and the ALS cloud in red for the Pack forest plot. Fully captioned.

- Classify the points in both TLS point clouds using the either pmf or csf and the classify _ground command.
- Use rasterize_terrain to make DTMs for both the TLS point cloud clips
  - plot_dtm3d to make sure your DTMs are good quality. You will likely need to try different values in the production of the DTMs.

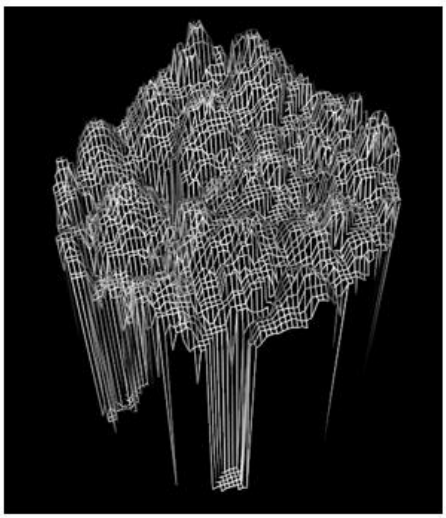


REQUIRED FIGURES: Two screen shots of your two produced dtms. Fully captioned with the technique used to make them.

- Normalize your point clouds using the DTMs from the TLS.
  - normalize_height

  - Use the Pack forest TLS DTM to normalize both the ALS and TLS clips from Pack forest
  - Use the ONP TLS DTM to normalize both the ALS and TLS clips from ONP.
- Create a DSM for all four clips using rasterize_canopy, Your choice what algorithm to use.
  - Plot each DSM and grab screen shots. You will be including them in the report
- Generate the rumple_index for each of the four DSMs.
  - rumple_index(DSM)

REQUIRED FIGURES: Four screen shots. One of each of your produced DSMs with the rumple index included in the caption along with the algorithm used to produce the DSM.



Rumple index = 5.739937....

- Use focal statistics to smooth your DSM. You can do this step before generating the screenshots and rumple index but the smoothing may cause an error with the rumple index.
- segment_trees using the normalized las clips and the smoothed DSMs.

REQUIRED FIGURES: Four screen shots. The plotted lidar data colored by the tree segmentation for each of the normalized lidar clips. Fully captioned with the algorithms used to create the tree segmentation.

- cloud_metrics for each of the clips. Remember, we only want to use points above 2m for the cloud metrics. Deriving canopy cover values is required and you must report the cloud metrics for zmax, zmean, zsd, zq25, zq95

REQUIRED TABLE:

	Zmax	Zmean	Zsd	Zq25	Zq95	CC
Pack TLS						
Pack ALS						
ONP TLS						
ONP ALS						

That is all for the processing of the ALS/TLS plot…

Part 2:
ALS & GEDI comparison processing steps with required figures for the report

You are going to create cloud metrics from ALS data for the locations of your six identified GEDI footprints you used in lab 9. You will compare cloud metrics derived from ALS data to the metrics and full waveform figure from GEDI data. You will then create a canopy height model for an area by subtracting an ALS derived DTM from a DSM and make a figure comparing the ALS canopy height model to the GEDI RH100 mean raster.
For the purpose of this lab, we are going to assume that there is no error in the GEDI pulse locations. In reality there is some error and that can account for oddities in the data.

You will be reusing some of the data from lab 9.

- Table from question 12
- Figures from question 13
- The RH100 mean raster

To complete this portion, of the lab you will need to:

- Download the point cloud data for each of your 6 GEDI footprint locations. Hopefully you will have multiple points within one lidar tile.
- Download at least one DTM and DSM tile

The steps you will need to do in order:

- Convert your GEDI point location Lat and Long (from lab 9 table 12) into WA state plane south coordinates. A google search for “convert latitude and longitude to state plane” should provide some online conversion tools.
- Read in all the .laz files into R
- Define the projection
- Clip the laz files to match the location and approximate area of a GEDI shot. Make sure to report the footprint size.
- Normalize the height of your lidar clips.

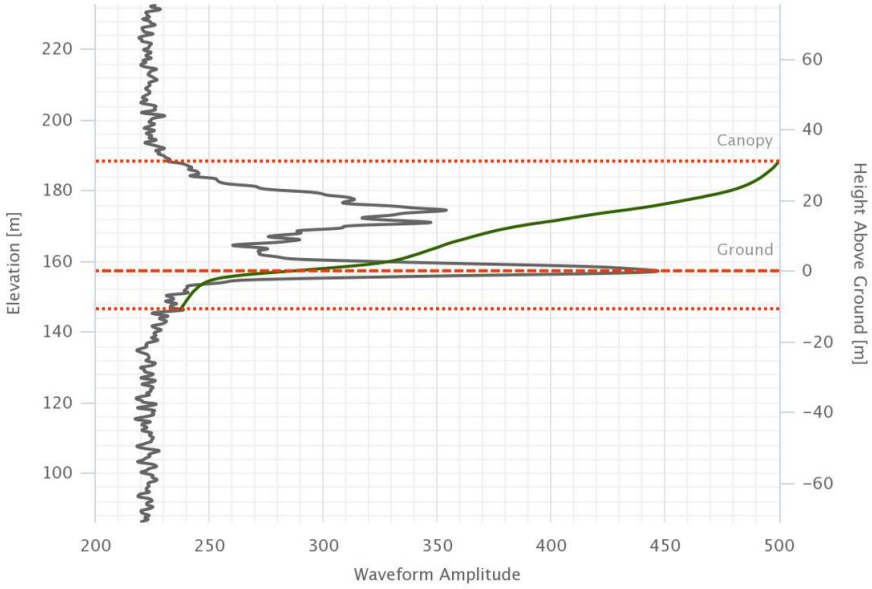
ESRM433/SEFS533

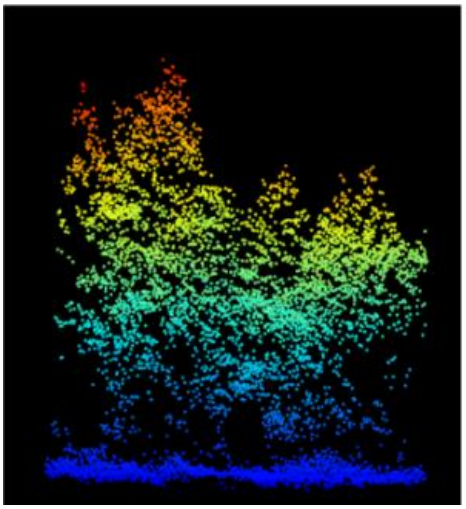
Lab 10

- Plot the lidar point clouds and take screen shots. (hold onto these for now, you'll use them in an upcoming step)
- Produce cloud_metrics for each of the four plots. You will want to record the zmax, zmean, zstd, zq90, zq75, zq50, and zq25.

REQUIRED FIGURES: 6 figures. Each figure should have the waveform from lab 9, a screenshot of the NORMALIZED ALS point cloud at that location (clipped to the diameter of the GEDI footprint), and a summary of the ALS cloud metrics.

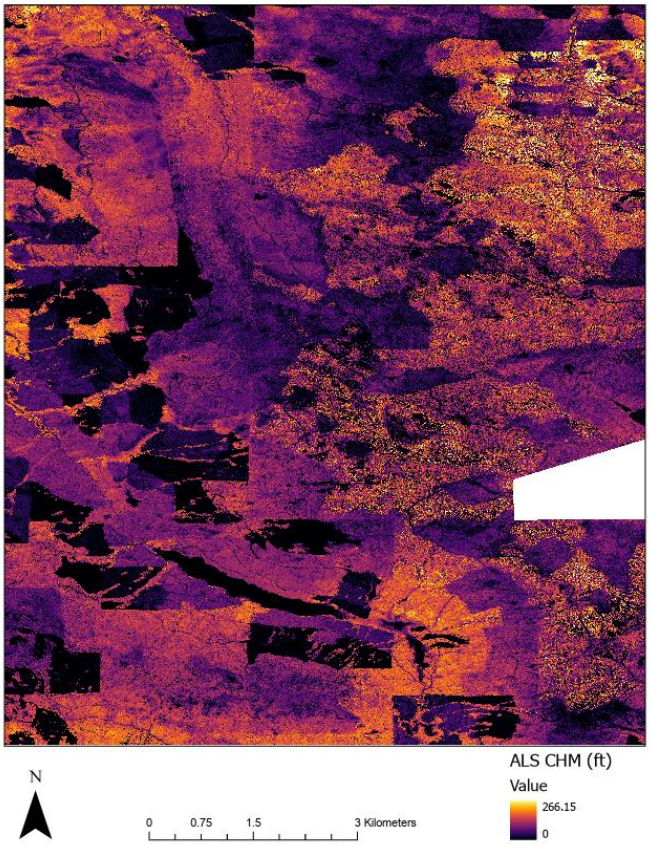
Below is an example.

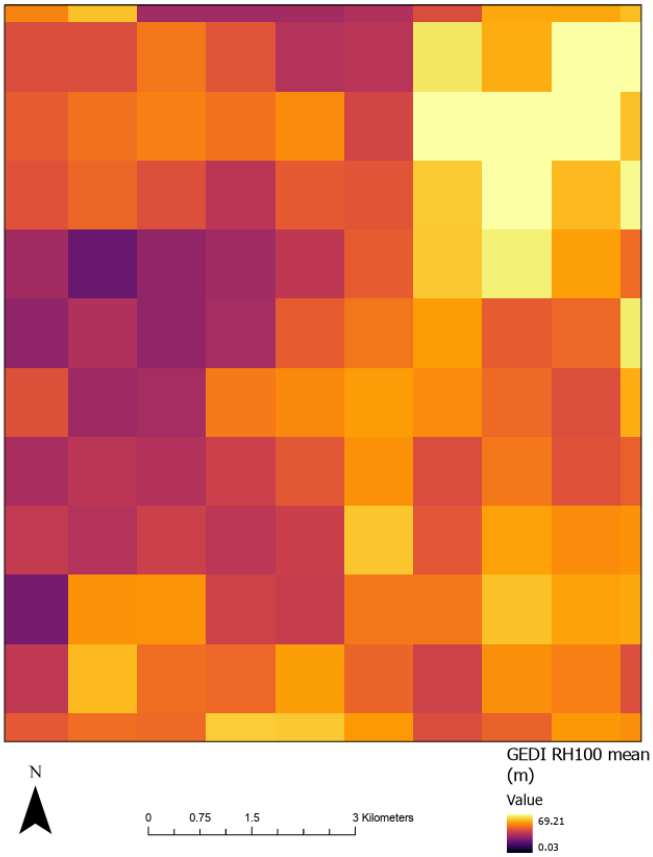




ALS	feet	meters
zmax	110.68	33.7439
zmean	53.8	16.40244
zsd	19.6	5.97561
zq25	41.58	12.67683
zq50	54.1	16.4939
zq75	66.6	20.30488
zq90	79.7	24.29878

REQUIRED FIGURES: Create a CHM from the vendor supplied DSM – DTM. You can use one or more tiles to do this. Create a map from the CHM and a map of the same area using the GEDI RH100 mean data.





PUTTING IT ALL TOGETHER

ESRM 433:

All your figures and tables need to be fully captioned and submitted in one PDF. All figures need to be high quality and captions need to describe in brief what the image is of, what data was used, and how it was created.

SEFS 533:

You will include all of the required figures and tables in a cohesive report. This doesn't need to be a formal paper in a scientific format. Think of it more as a technical report you are presenting to someone to describe the process of obtaining and processing ALS, as well as how MLS and GEDI compare to ALS.

INTRODUCTION: ~400 words

- What is lidar?
- What is ALS?
- What is TLS?

ESRM433/SEFS533

Lab 10

- What is GEDI?
- How has lidar been used for quantifying forest structure and topography?
    - Feel free to include figures from your past labs as examples.
- Include citations of some of the optional reading from the class or some of the papers used in the lidR functions.

METHODS & RESULTS: as many words as needed.

- Where are your areas of interest?
    - What is the dominate vegetation there?
- Where did you get the data?
- **ALS comparison to TLS**
    - A cohesive narrative walking through all the produced figures. All figures must have full captions. The goal is to convey the steps it takes to process the data. A reader not familiar with lidar should understand what was done at each step of the processing and how ALS differs from TLS.
- **ALS comparison to GEDI**
    - A cohesive narrative walking through all the produced figures. Explain point returns vs full waveform data.

DISCUSSION: ~300 words

- How does the data from the two sites compare?
    - What is similar
    - What is different
- At each site, does the data seem to agree or does the data seem conflicting depending on the sensor?
- What are some of the short comings of the lidar data?
- What are your assumptions and limitations of the data?

WORKS CITED:

- Minimum of 5 works cited with proper inline citation. Citation method does not matter.