



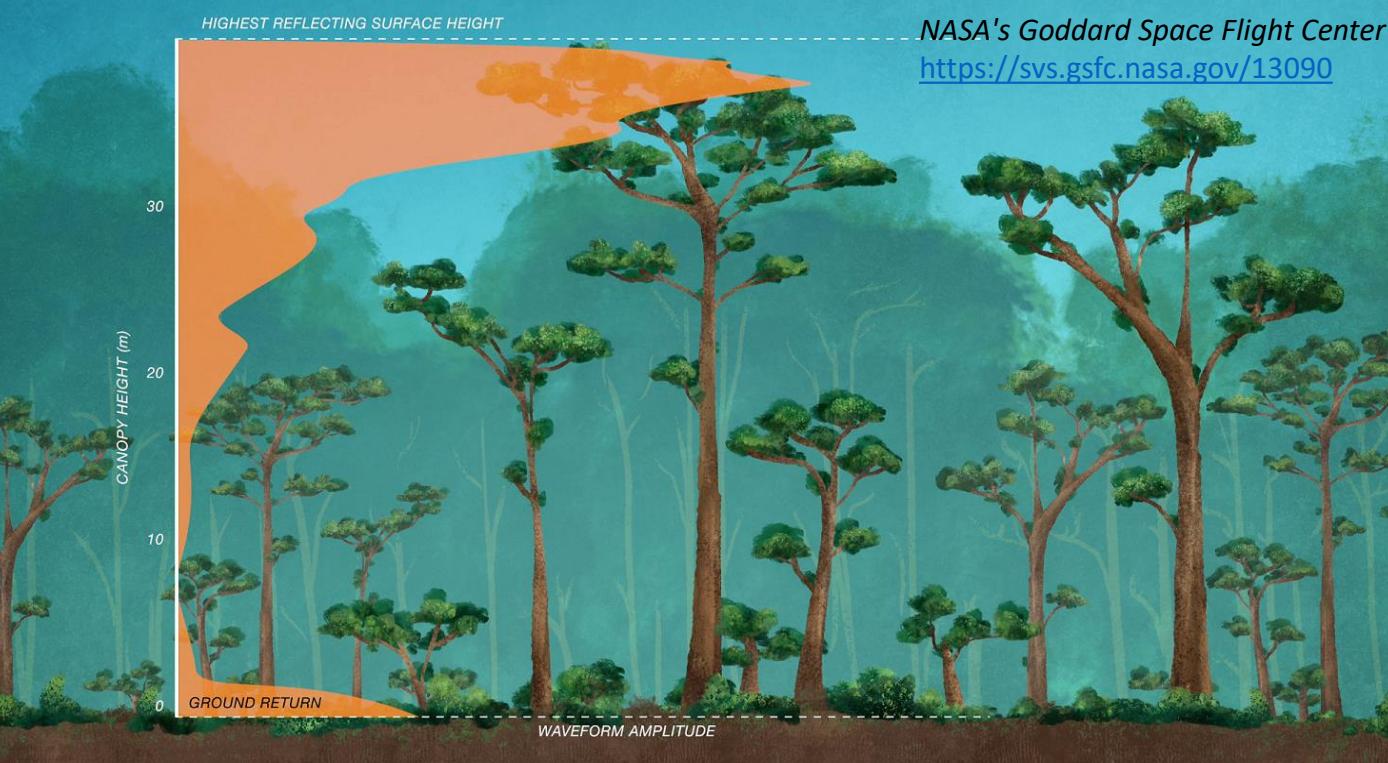
Workshop: Introduction to Lidar for forest applications

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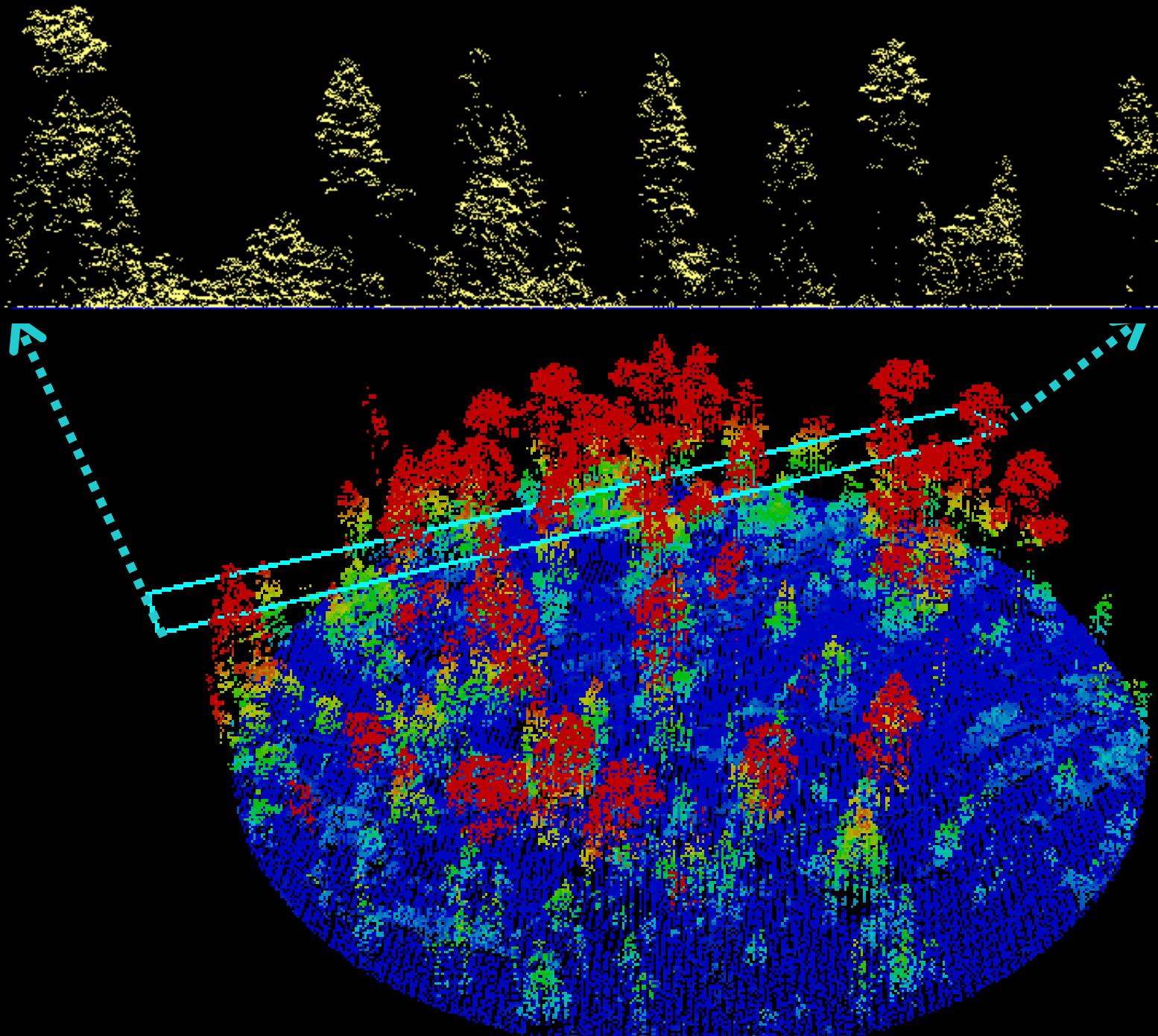


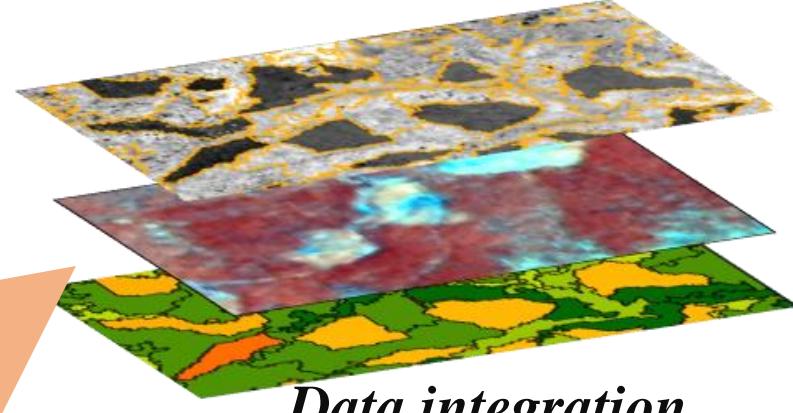
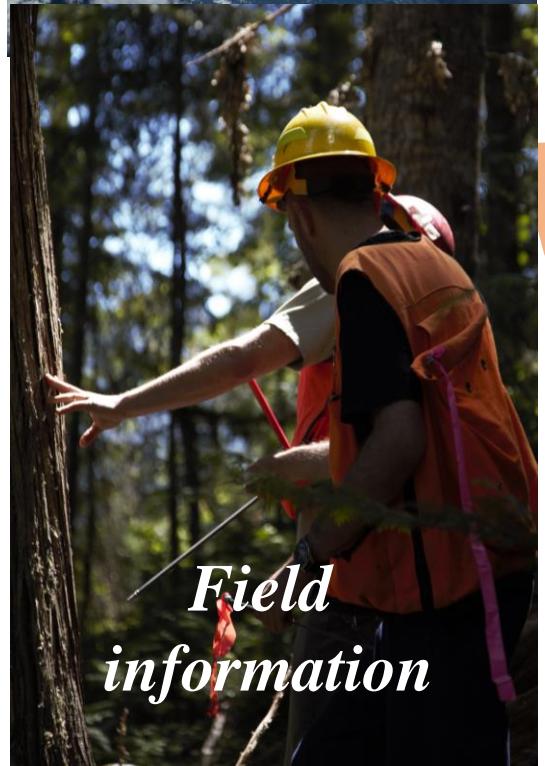
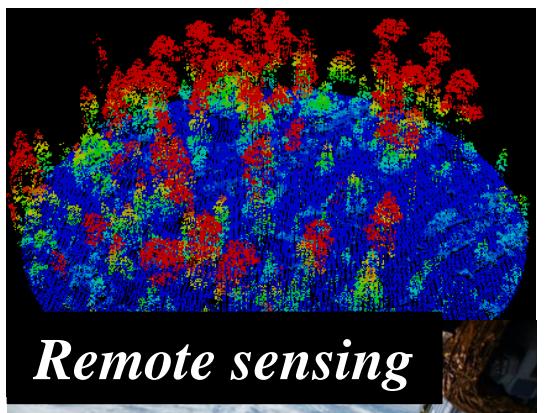
NASA's Goddard Space Flight Center
<https://svs.gsfc.nasa.gov/13090>

*Direct measures
that relate to
vegetation*

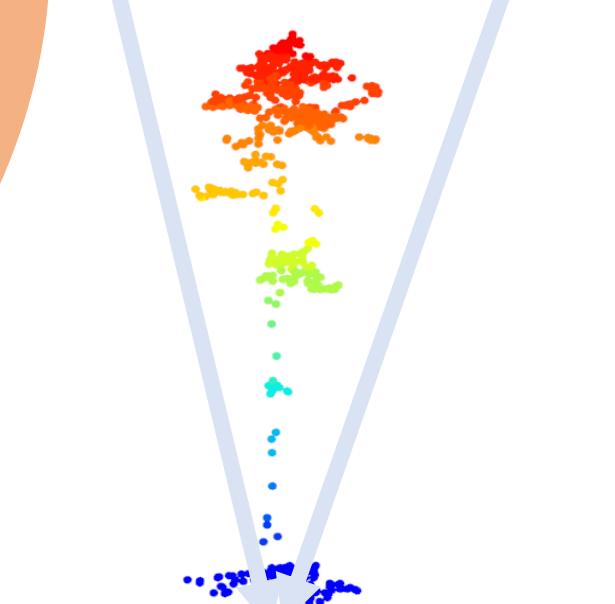
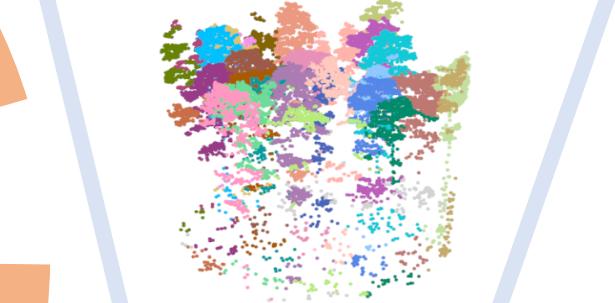
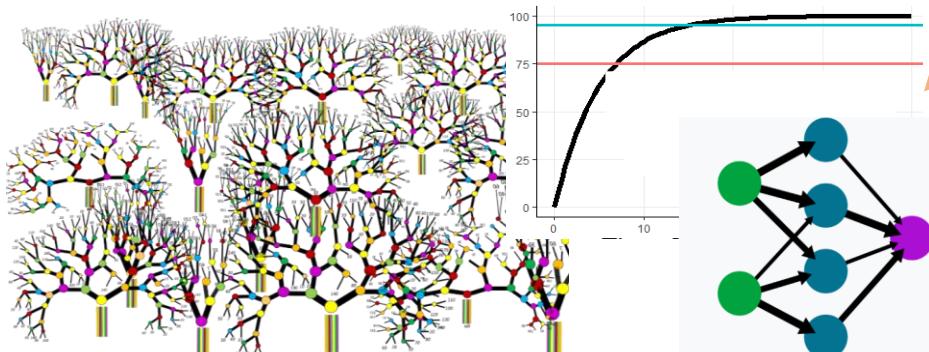
Remote Sensing

- Large scale coverage
- Temporal frequency
- Monitoring of remote areas
- Cost-effective

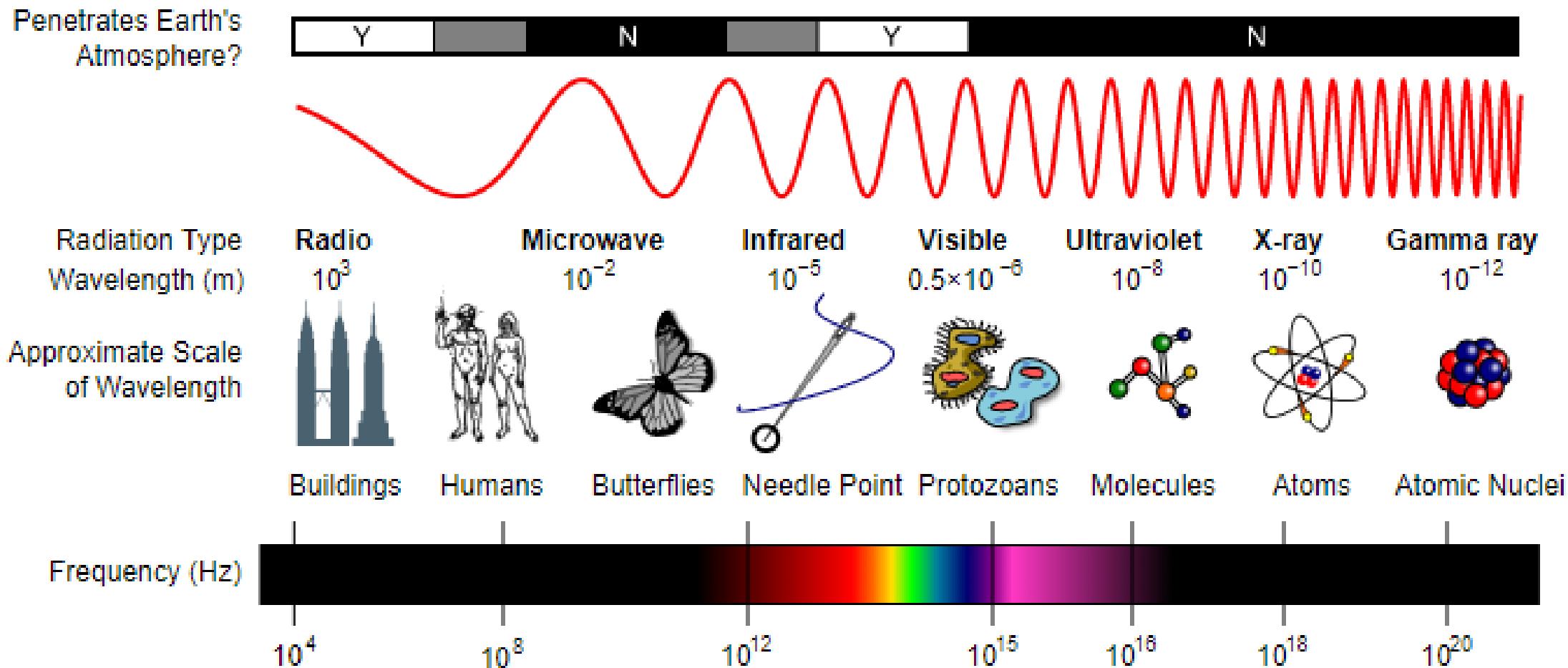


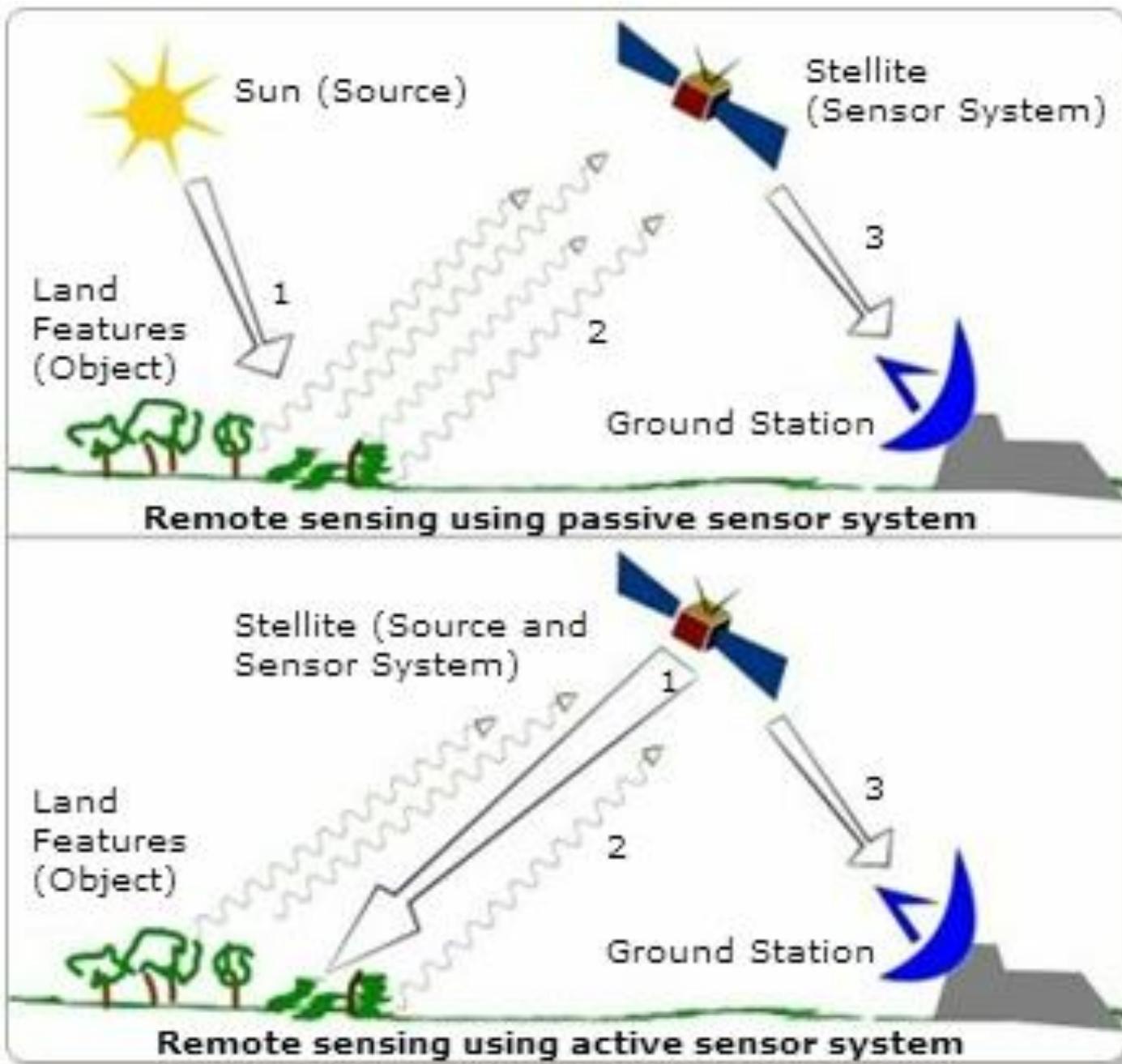


Spatially explicit maps of key forest attributes and ecological indicators



Remote Sensing: electromagnetic Spectrum





Passive

Reflected solar radiation
Solar-induced emitted radiation
Longwave radiation emanating from the surface or atmosphere due to thermal properties

Optical

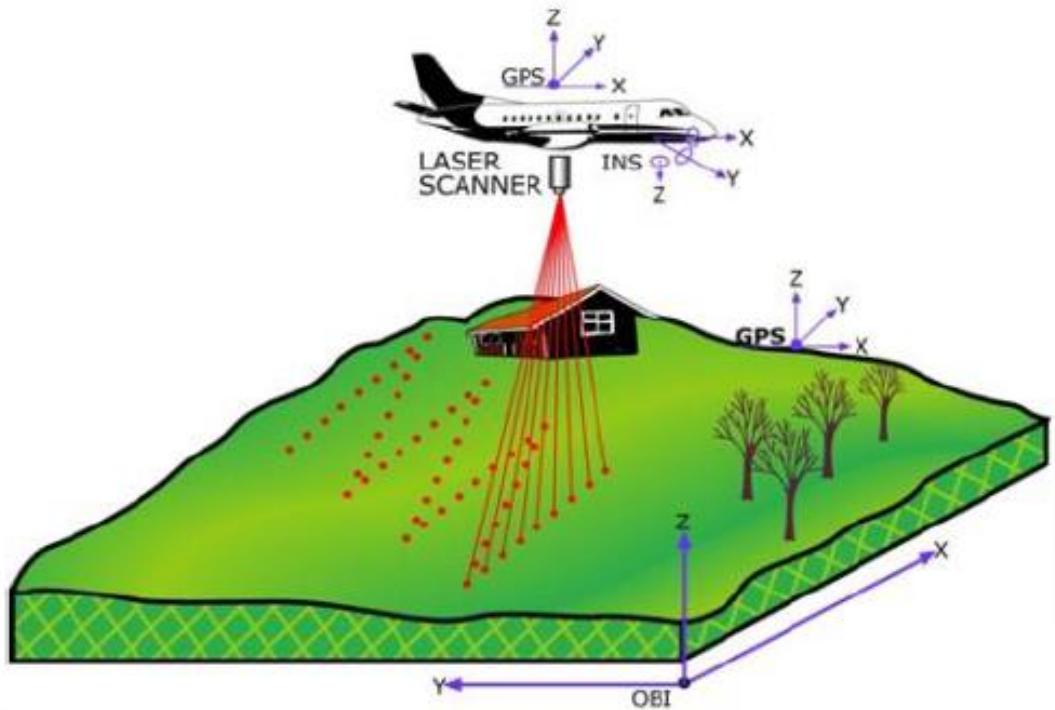
Active

Instrument emit their own source of energy and the sensor records back what is reflected.

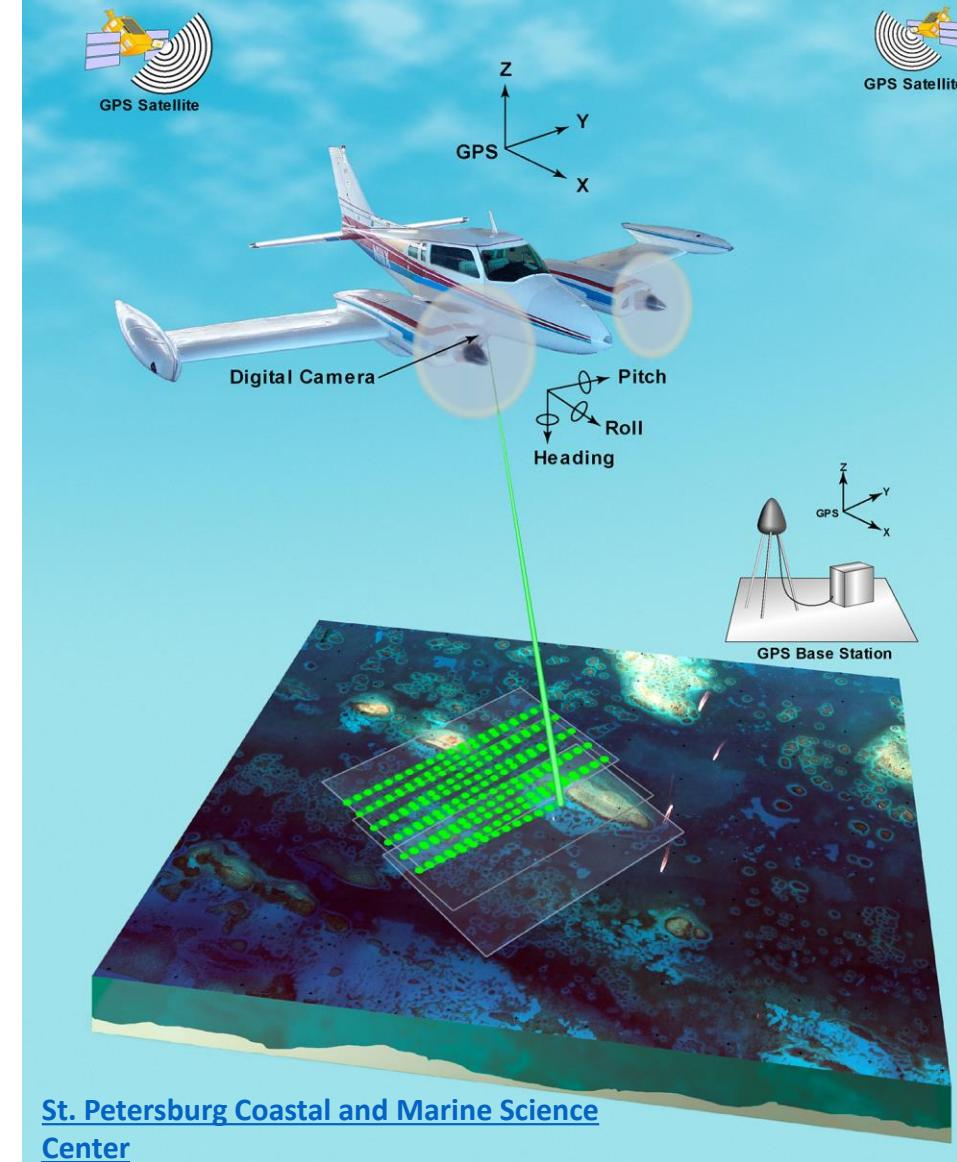
LiDAR, Sonar, Radar

Light Detection and Ranging (LiDAR)

LASER SCANNING



- Active remote sensing instrument
- Emission of laser pulses
- Distance to the target surface
- For terrestrial studies, green or NIR wavelength



[St. Petersburg Coastal and Marine Science Center](#)

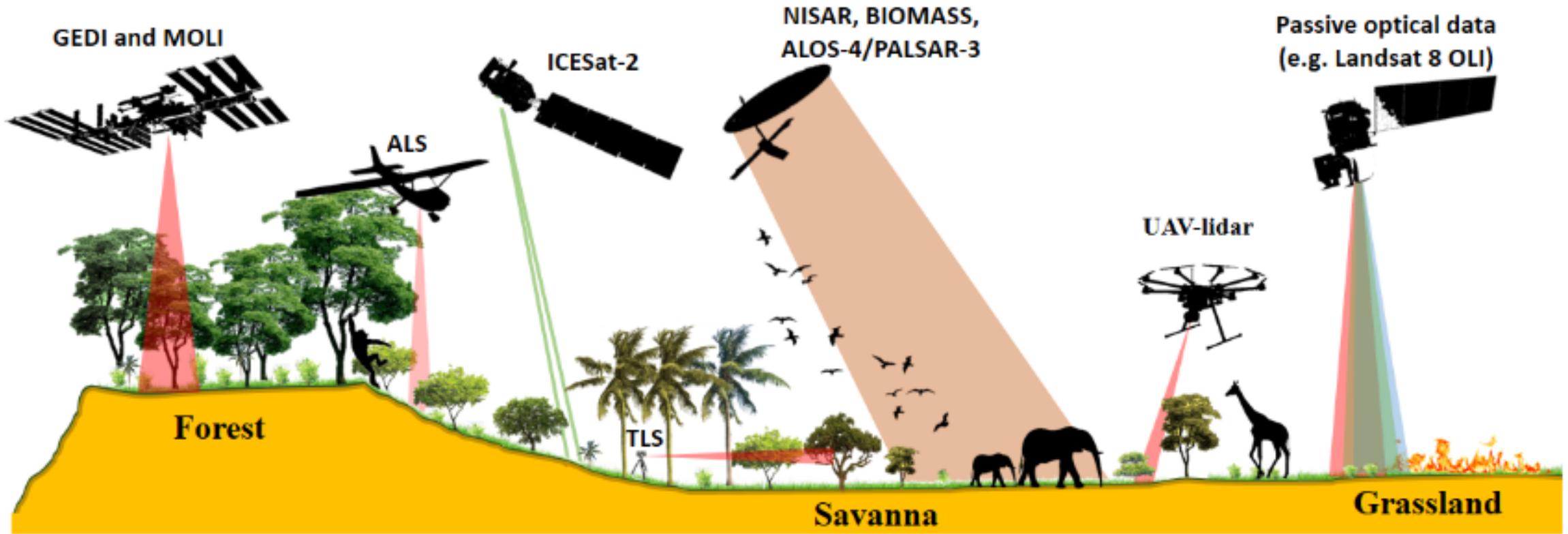
$$D = \frac{\text{travel time} * \text{speed light}}{2}$$

AIR acquisition platforms



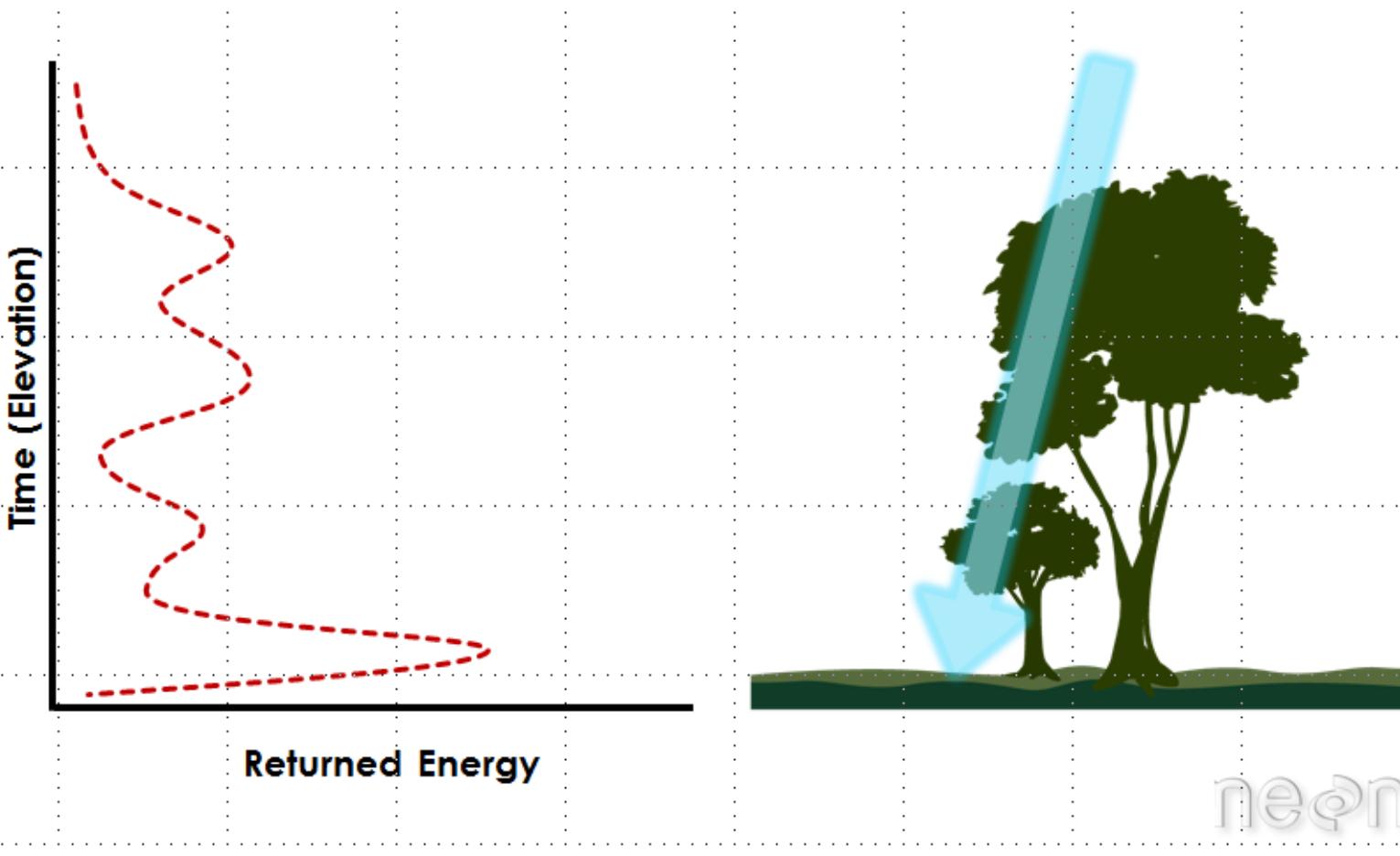
Image: CryoSat measuring sea ice thickness (source: esa.int)

LiDAR acquisition platforms



Silva et al.,

Light Detection and Ranging (LiDAR)



Type of surface

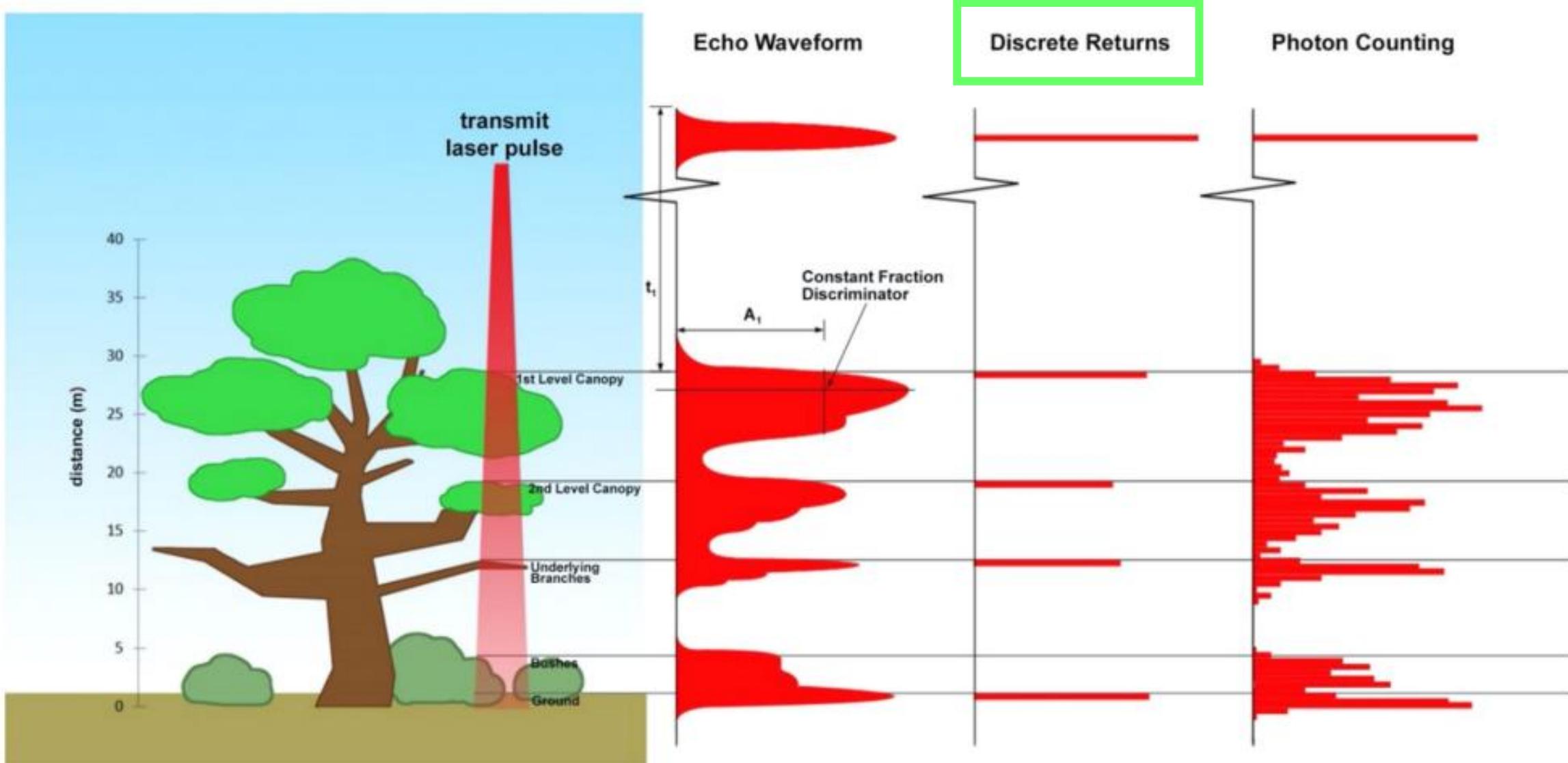
Waveform: distribution of energy

Amount energy: intensity

Peaks of energy: more light or photons returns

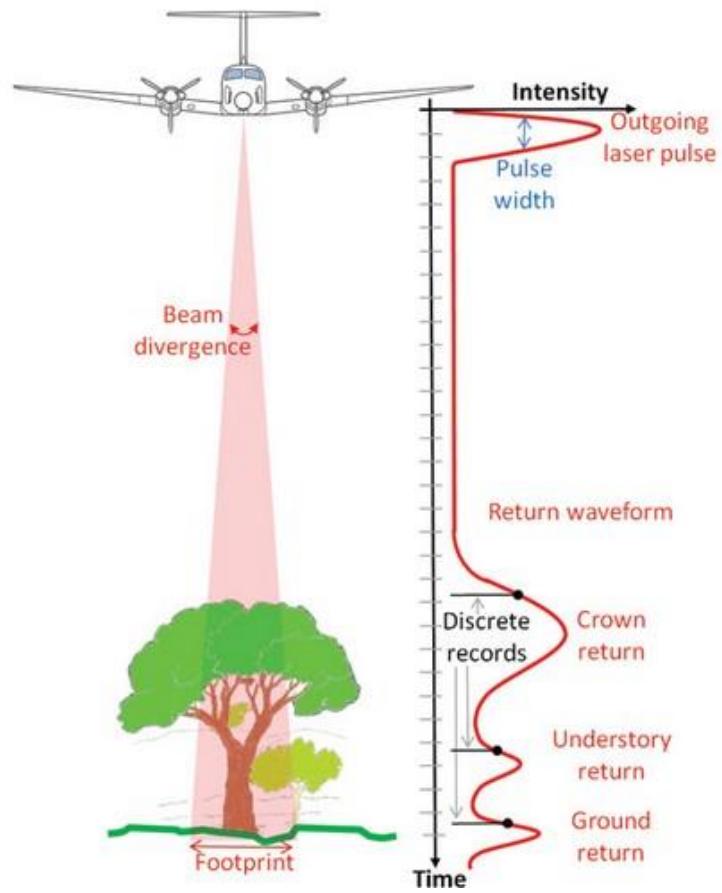
Peaks: objects

LiDAR detection



Source: ICESAT-2 ATBD, adapted from Harding, 2009

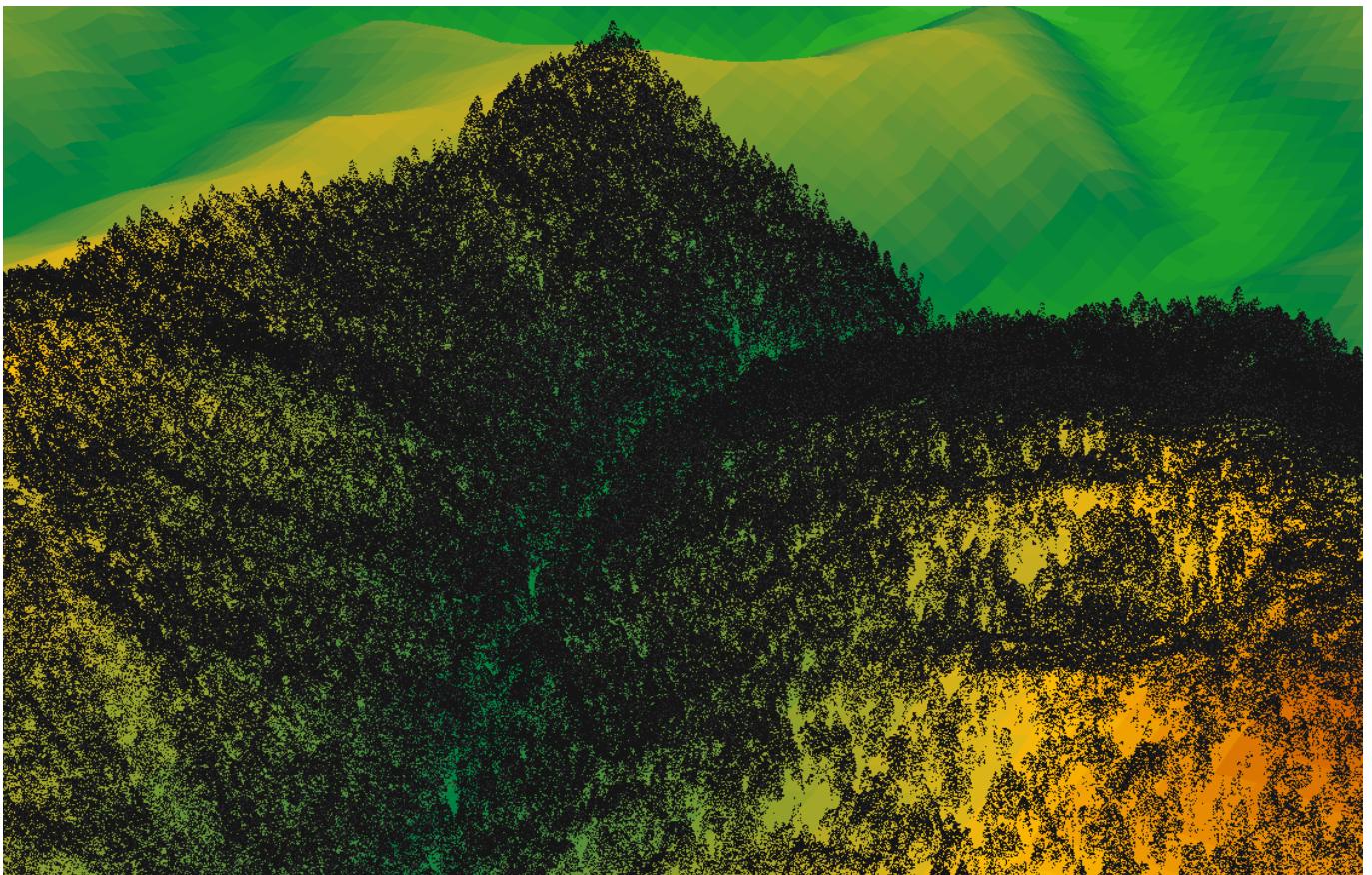
Light Detection and Ranging (LiDAR)



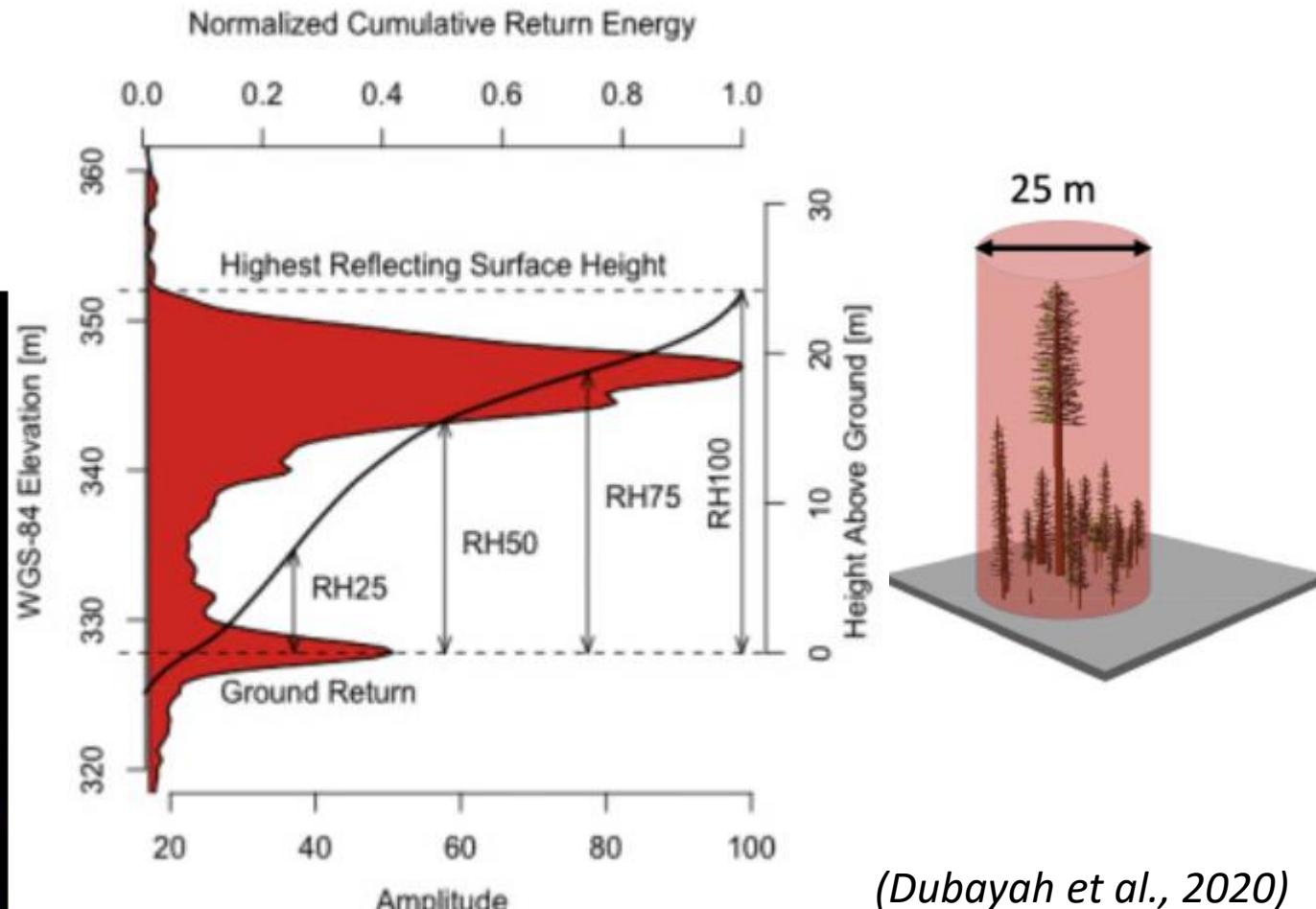
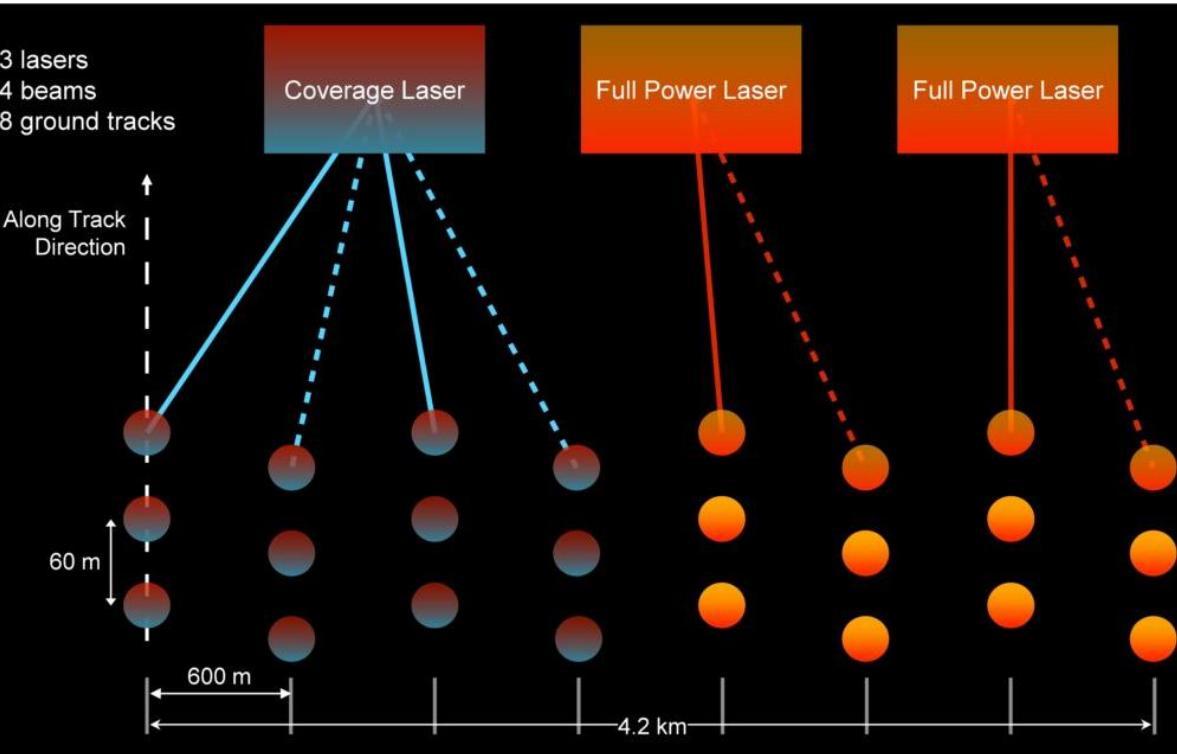
(Fernandez-Diaz et al., 2011)

**Direct measures that relate
to vegetation structure**

Discrete return LiDAR:
3D Point cloud
(X, Y and Z coordinates of the points)



The Global Ecosystem Dynamics Investigation (GEDI)



- Vegetation structural data of tropical and temperate forests (51.6 degrees N and S)
- Waveform and sampling instrument

<https://svs.gsfc.nasa.gov/13090>

NASA's Goddard Space Flight Center



LiDAR applications

Structural information of the vegetation

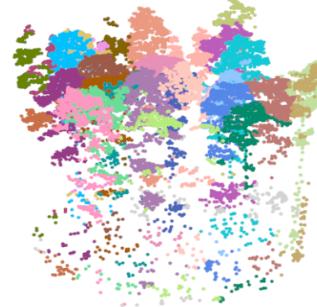
↓
Suitable for forest applications

- Topography
- Forest inventory
- Climate smart forestry
- Disturbance mapping
- Land use
- Species distribution mapping.....

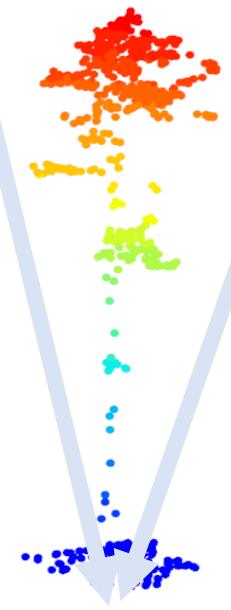
Landscape level



Plot level

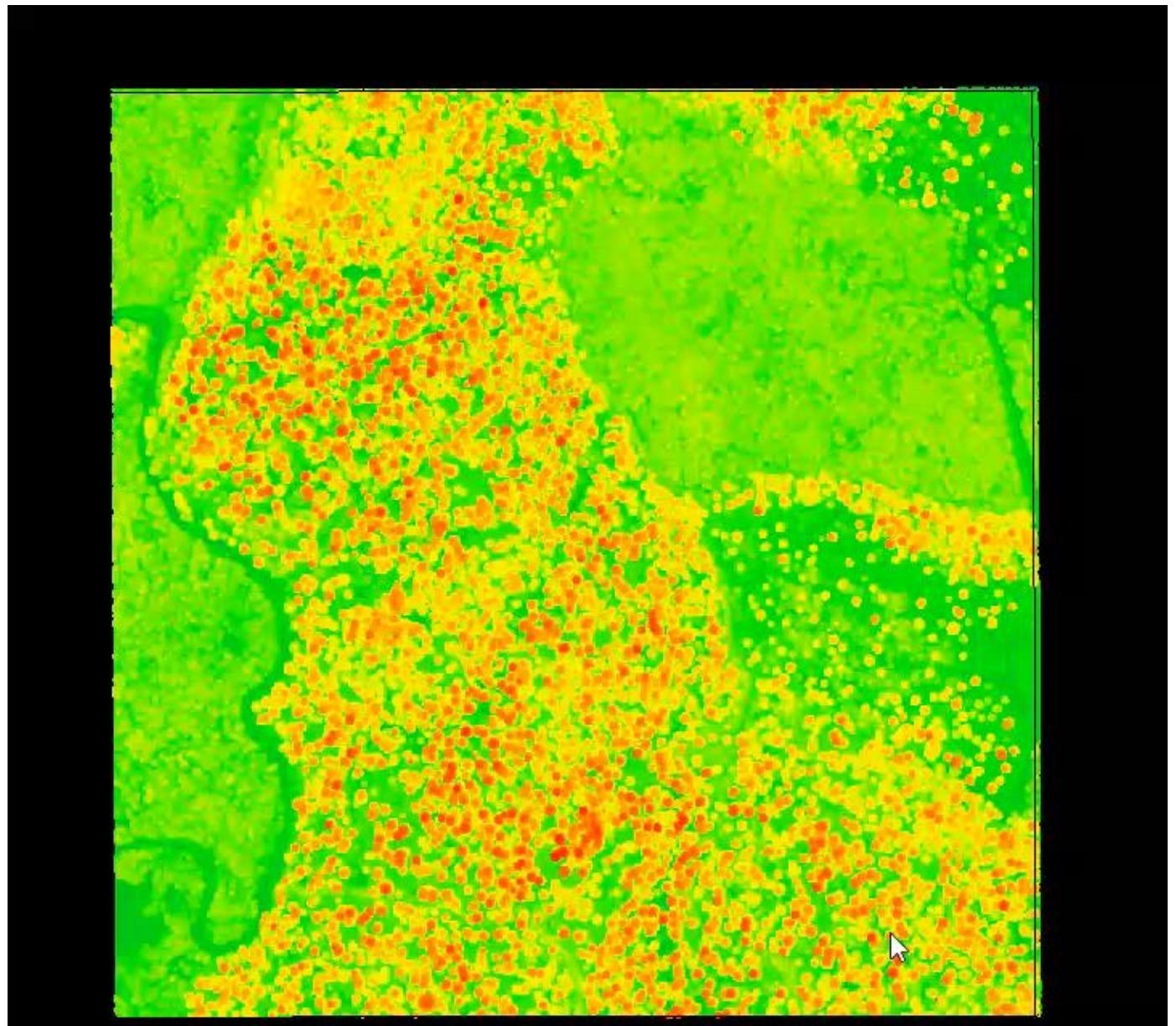
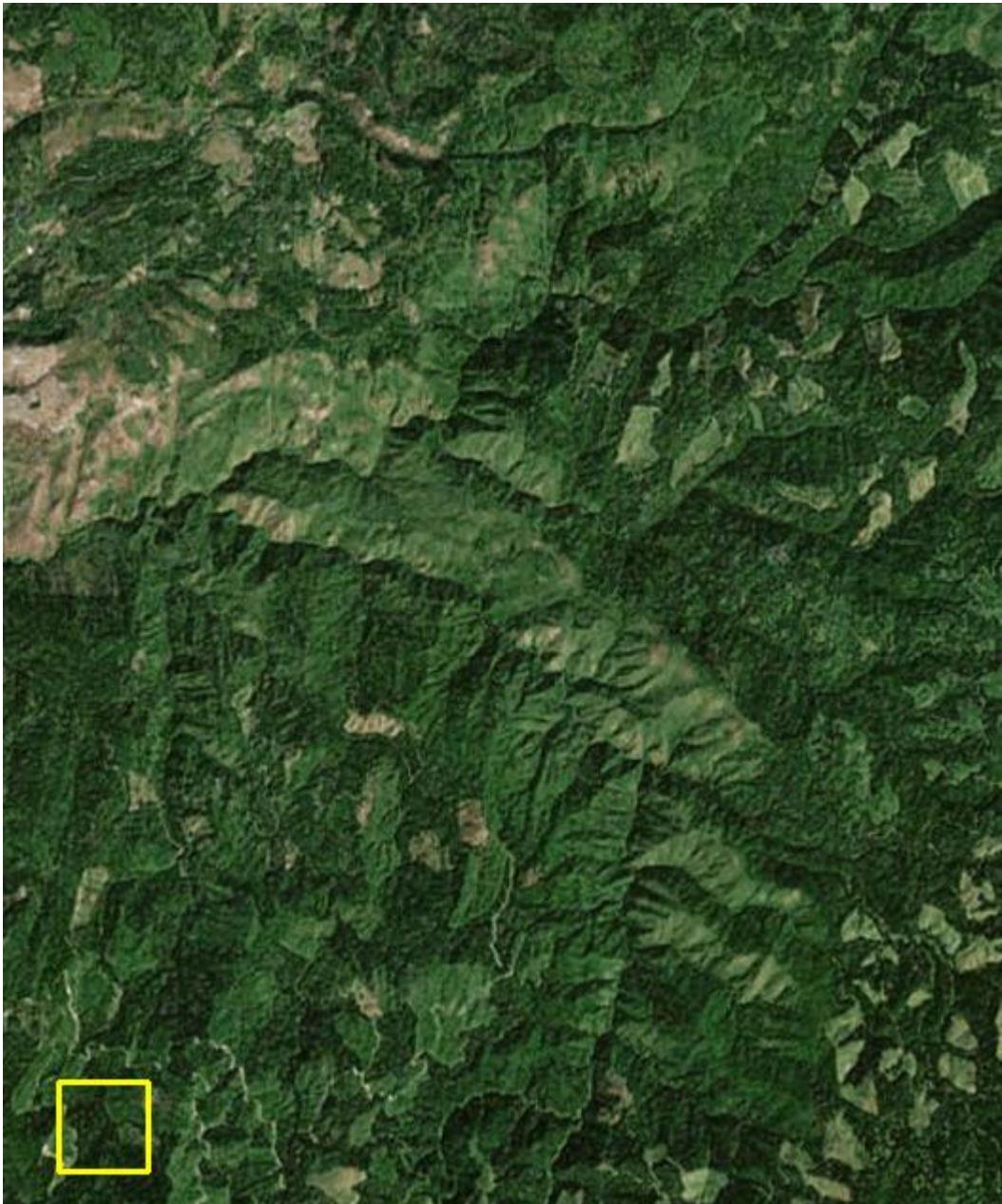


Tree level



Multi-scale analysis

LiDAR applications – wall to wall mapping



LiDAR applications – forest inventory

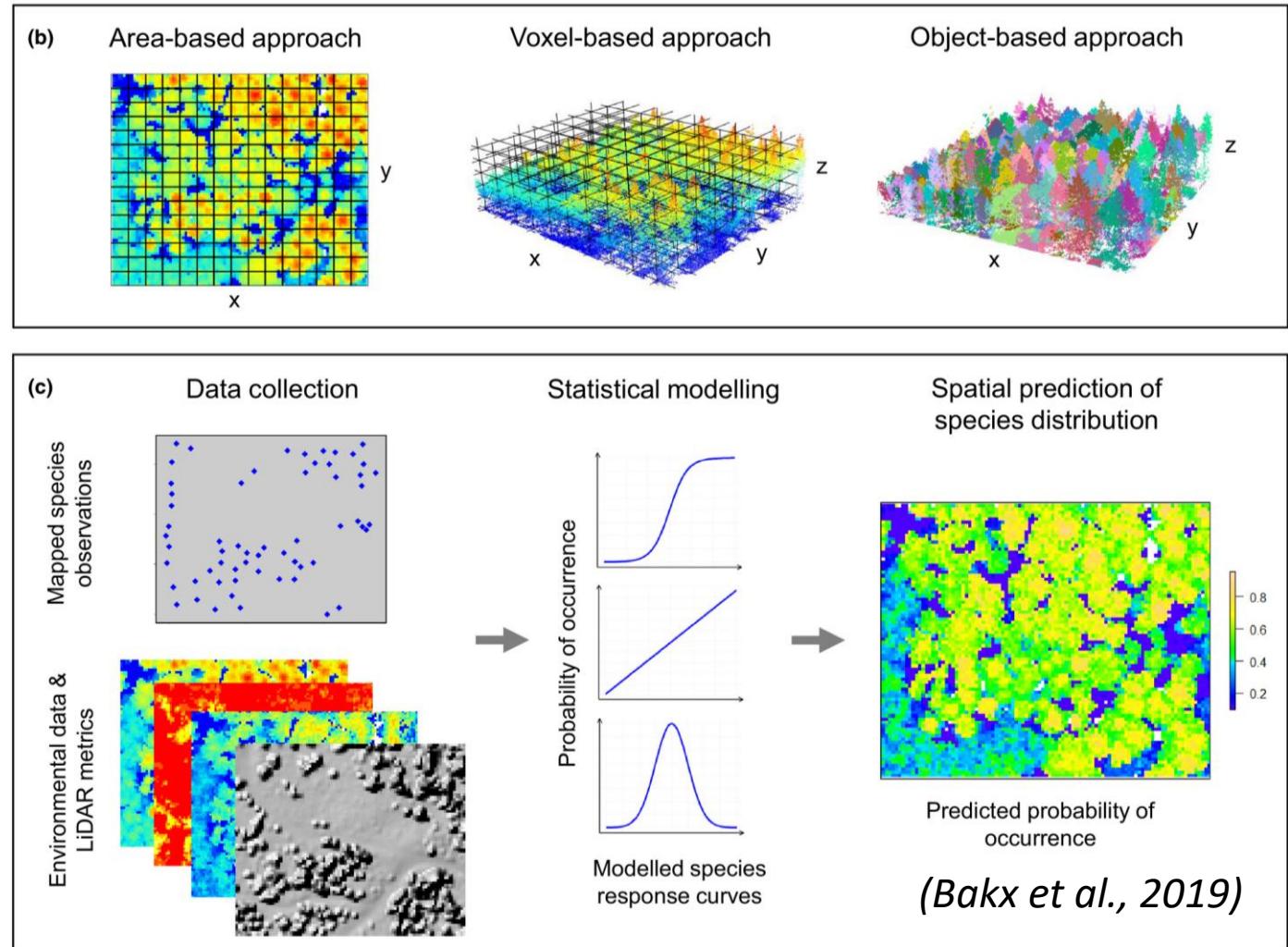
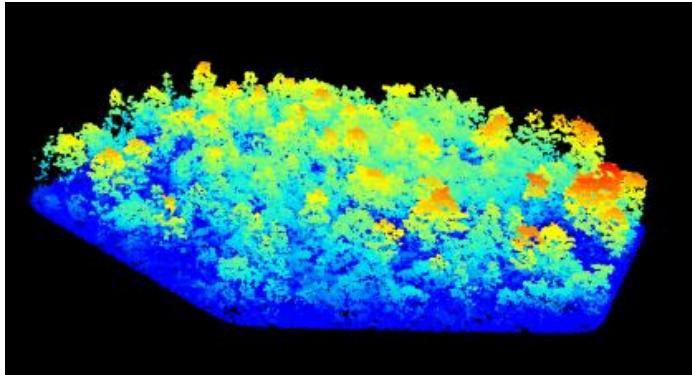


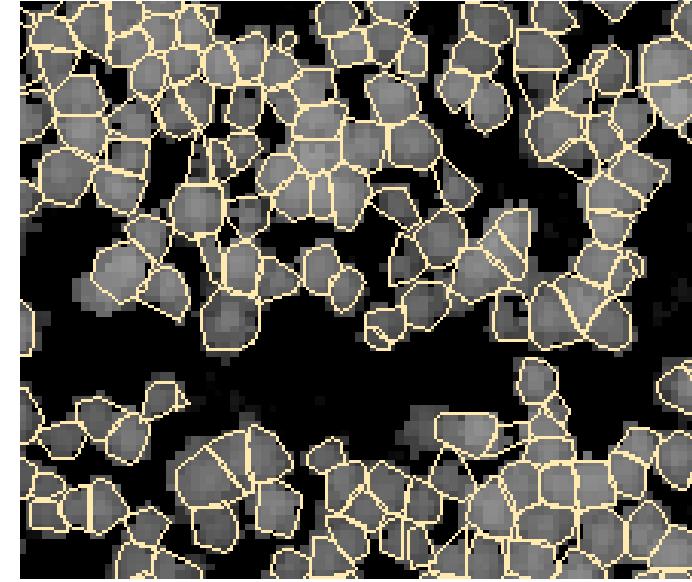
Image credit: Inacio Bueno

LiDAR applications – object level

Airborne lidar scanning (ALS)
data



Individual tree crown (ITC) map



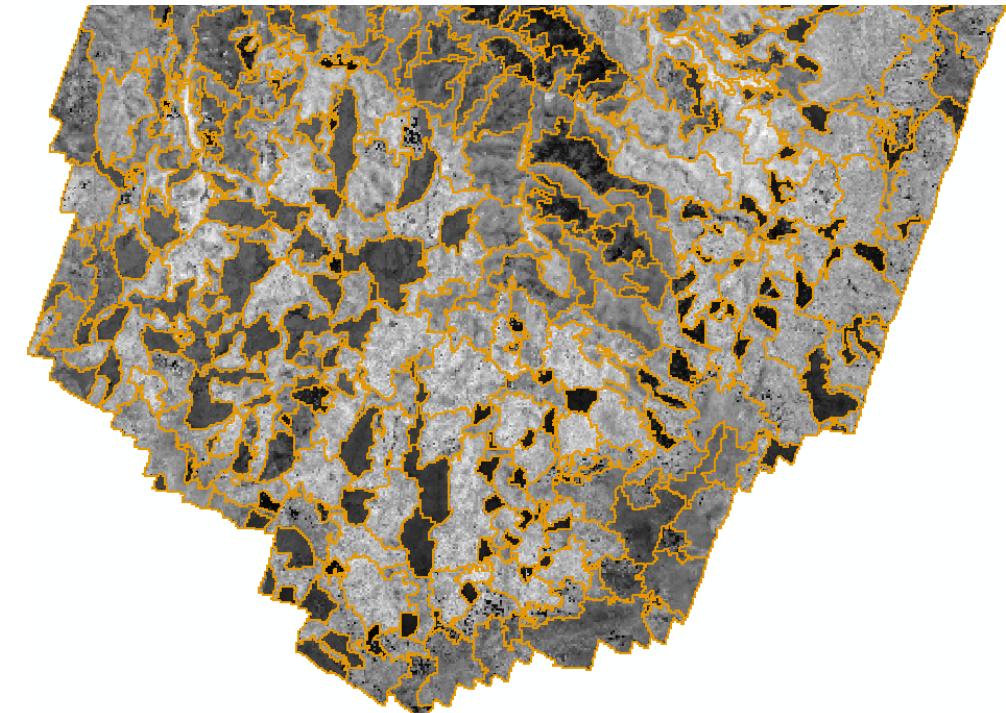
0 30 m

Delineation of individual trees

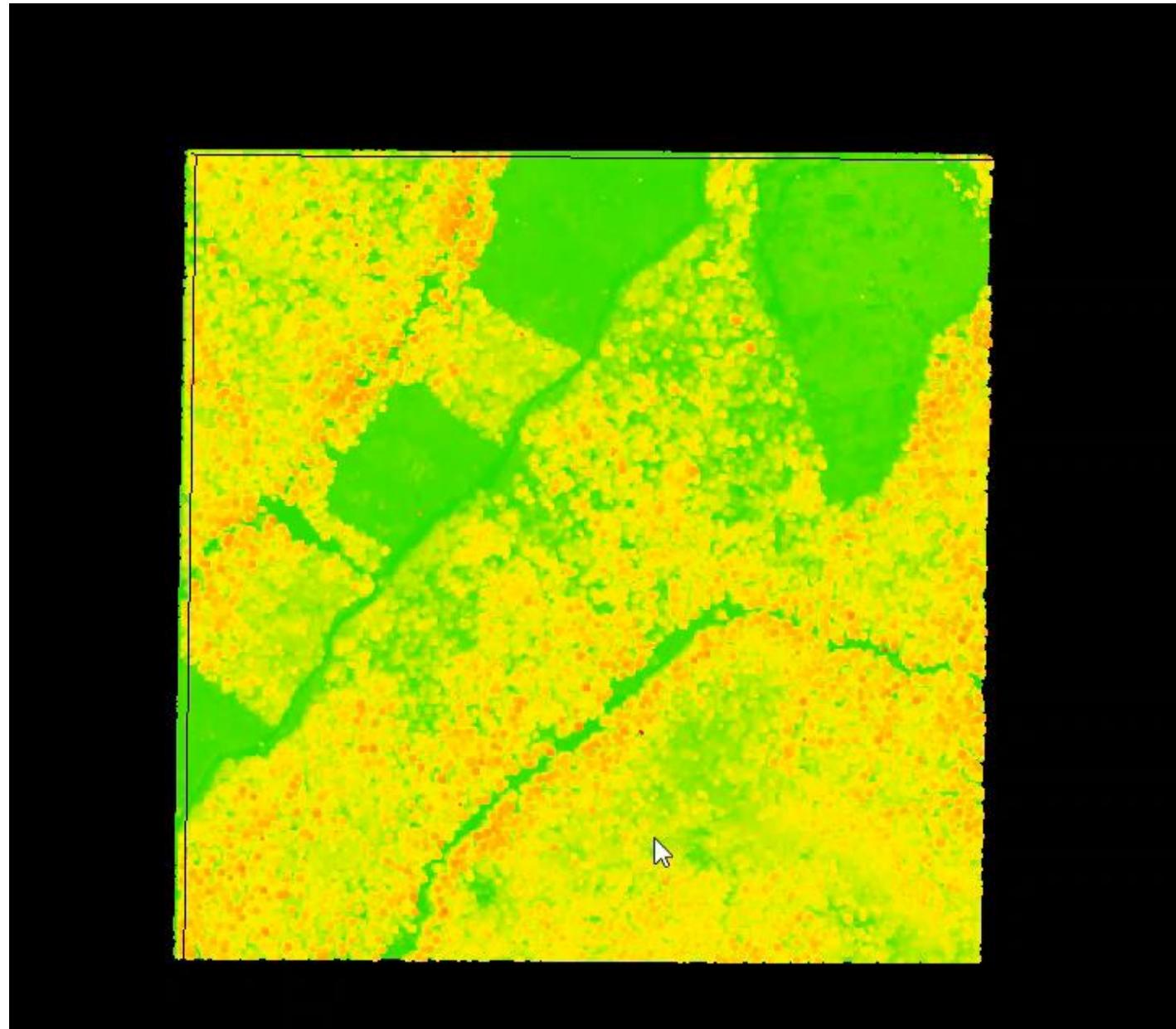
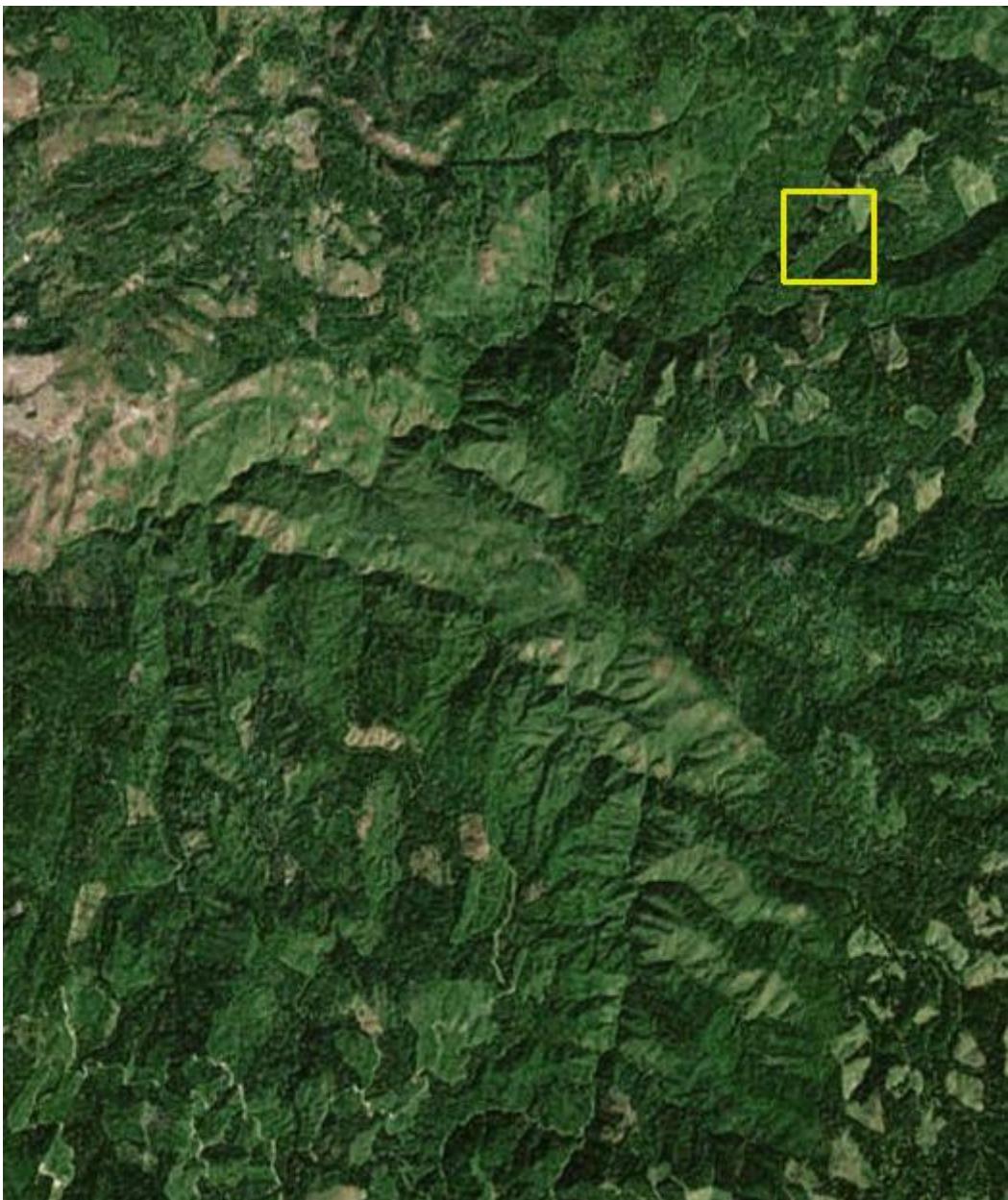
*Tree segmentation and foliage biomass
estimation through Random Forest*



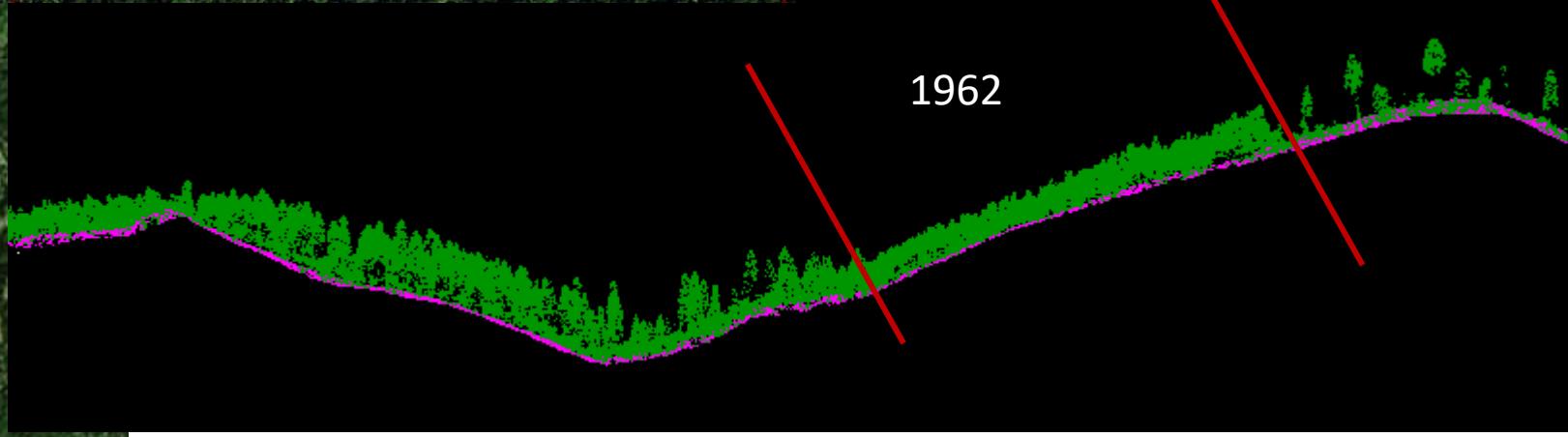
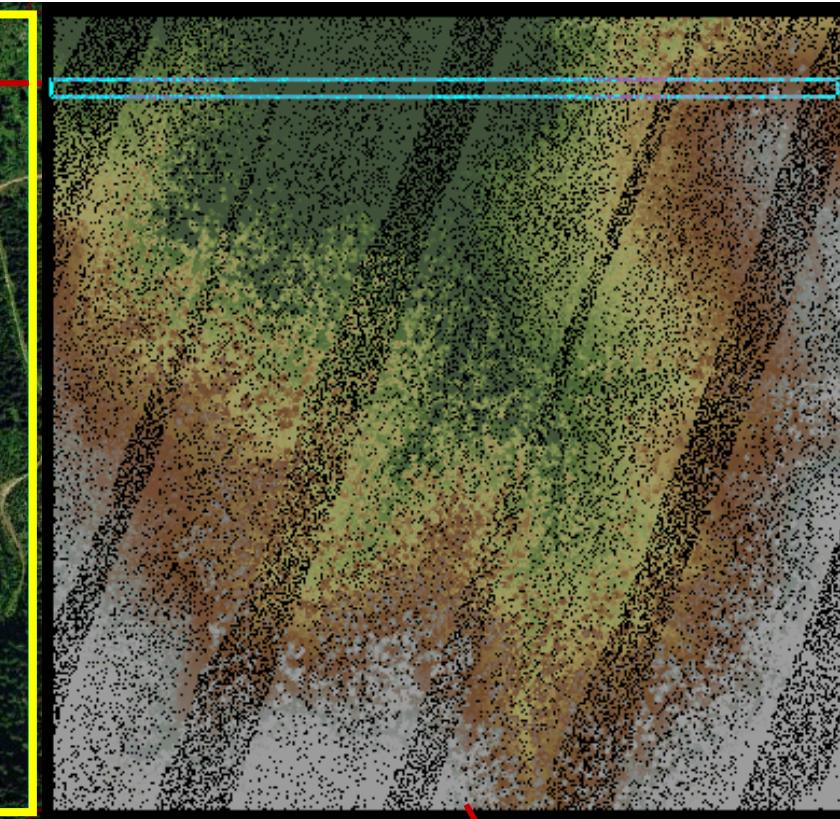
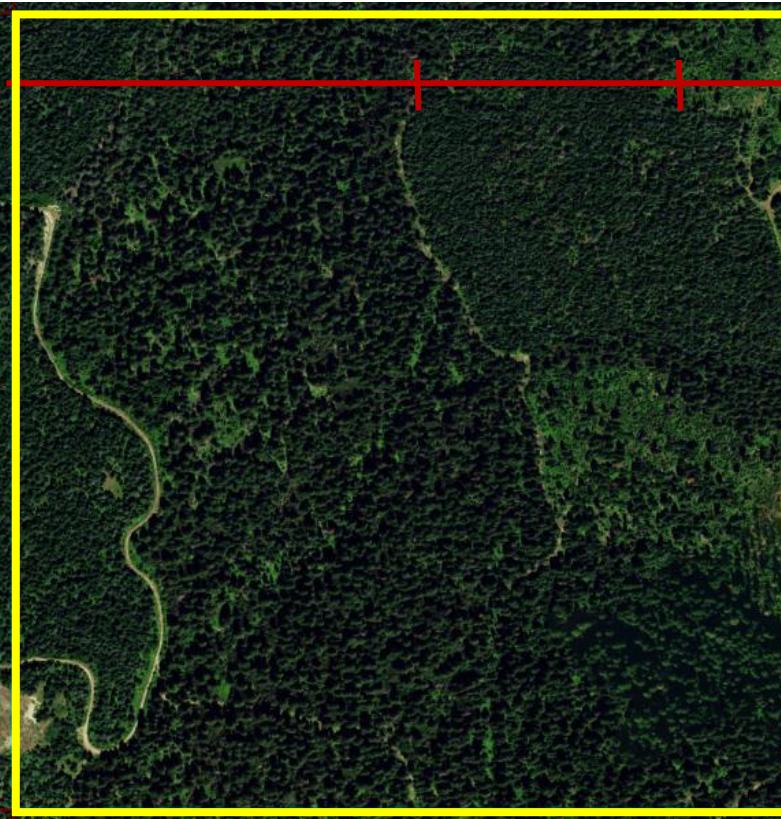
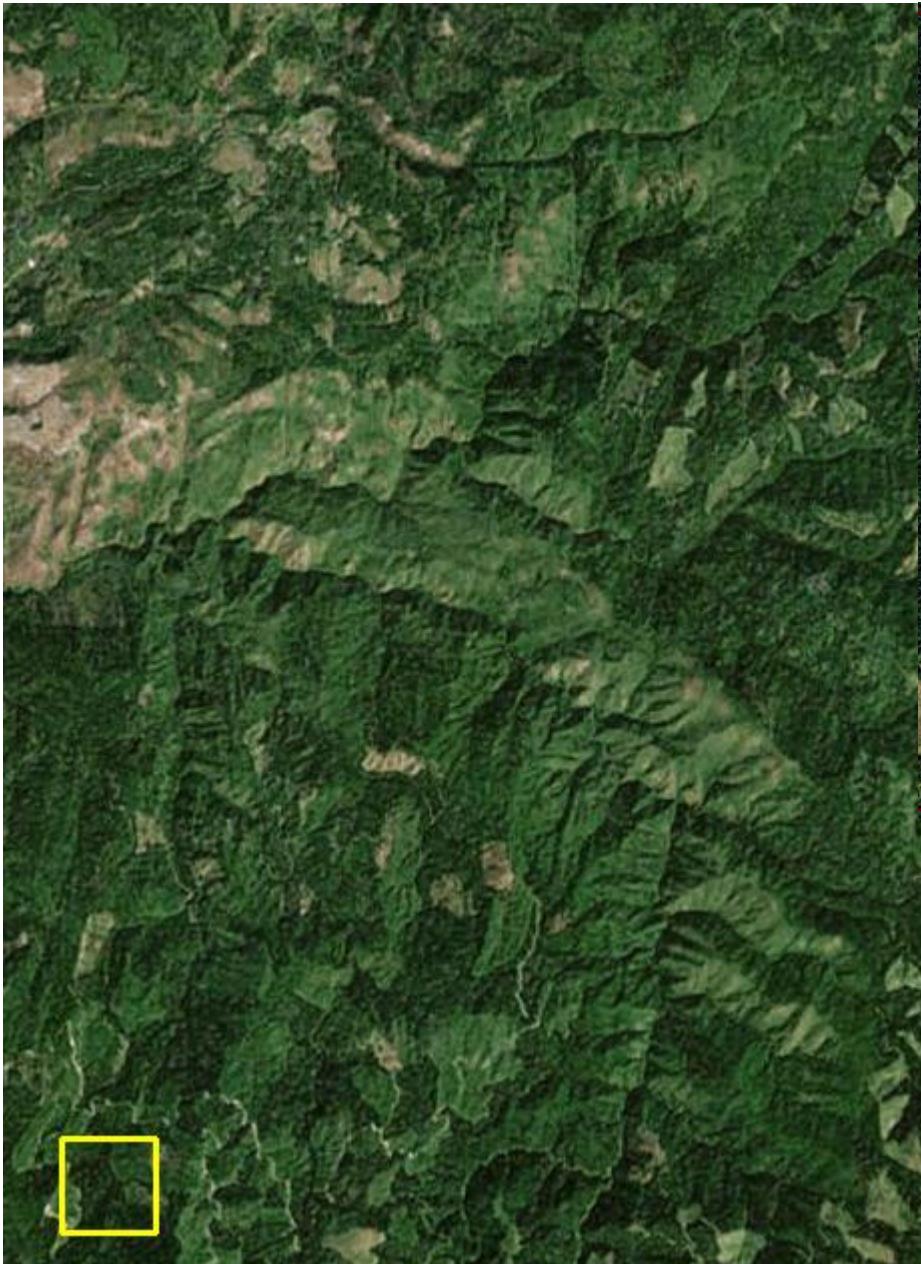
Delineation of forest stands

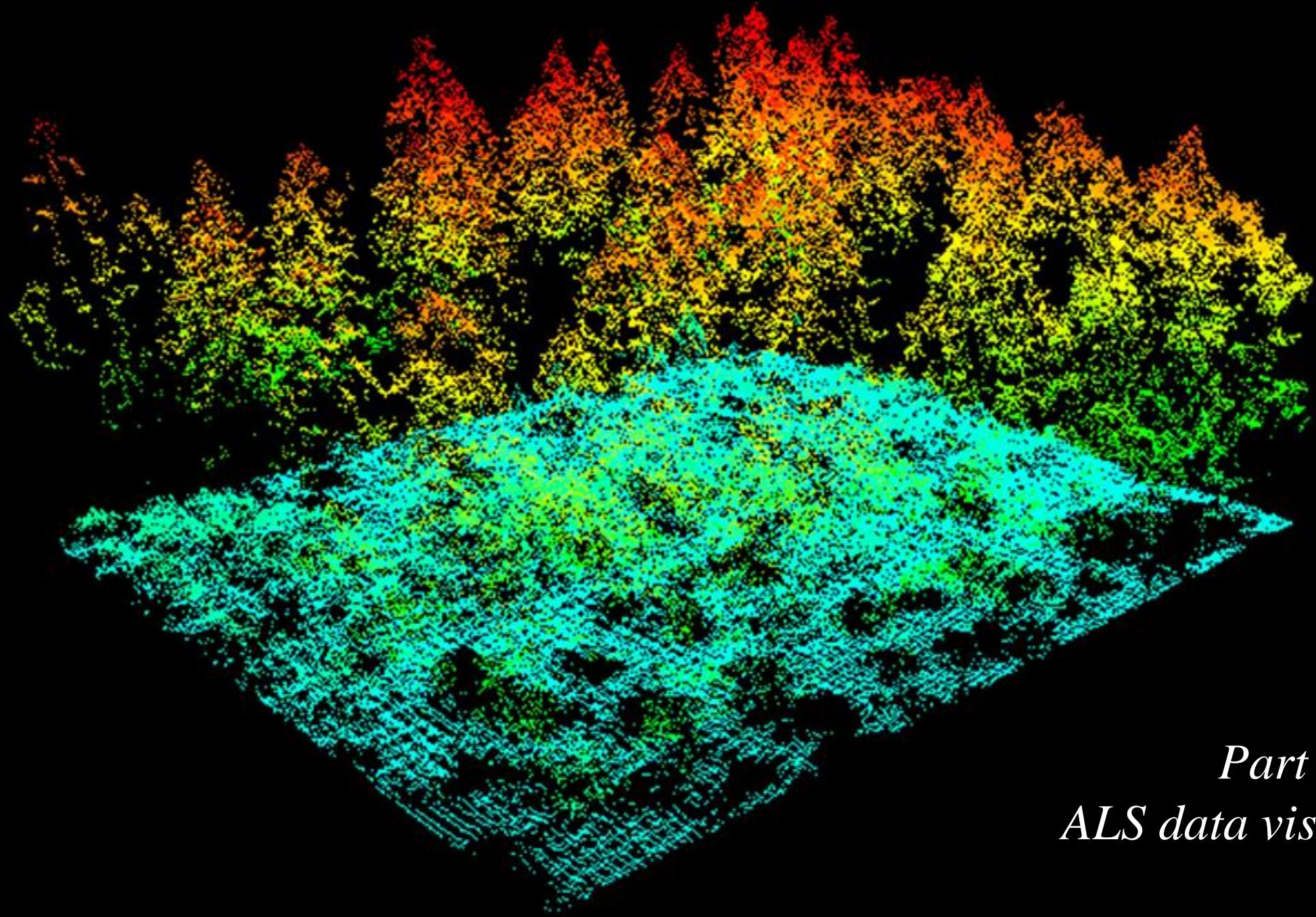


LiDAR applications – disturbance detection



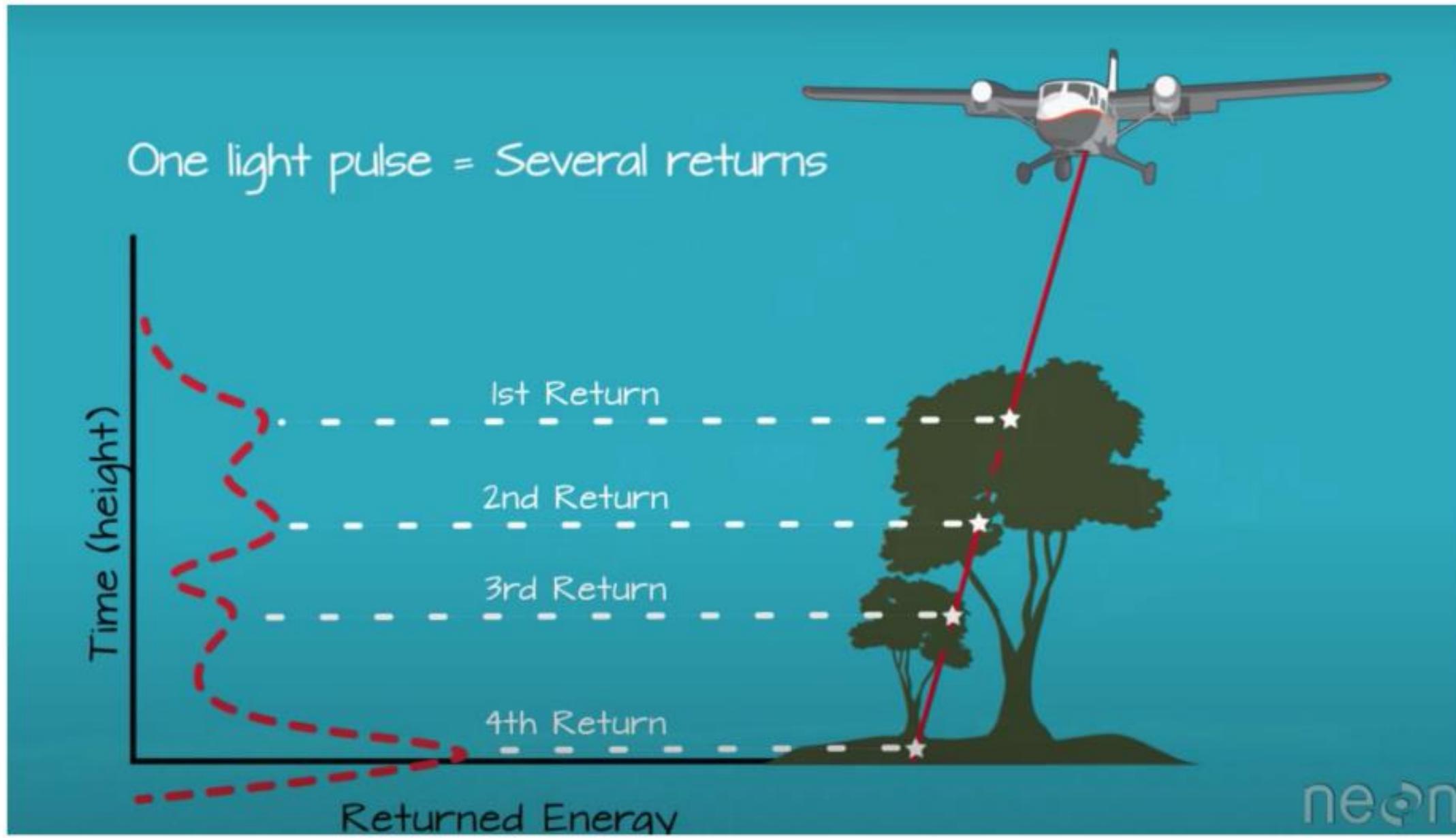
LiDAR applications – disturbance detection



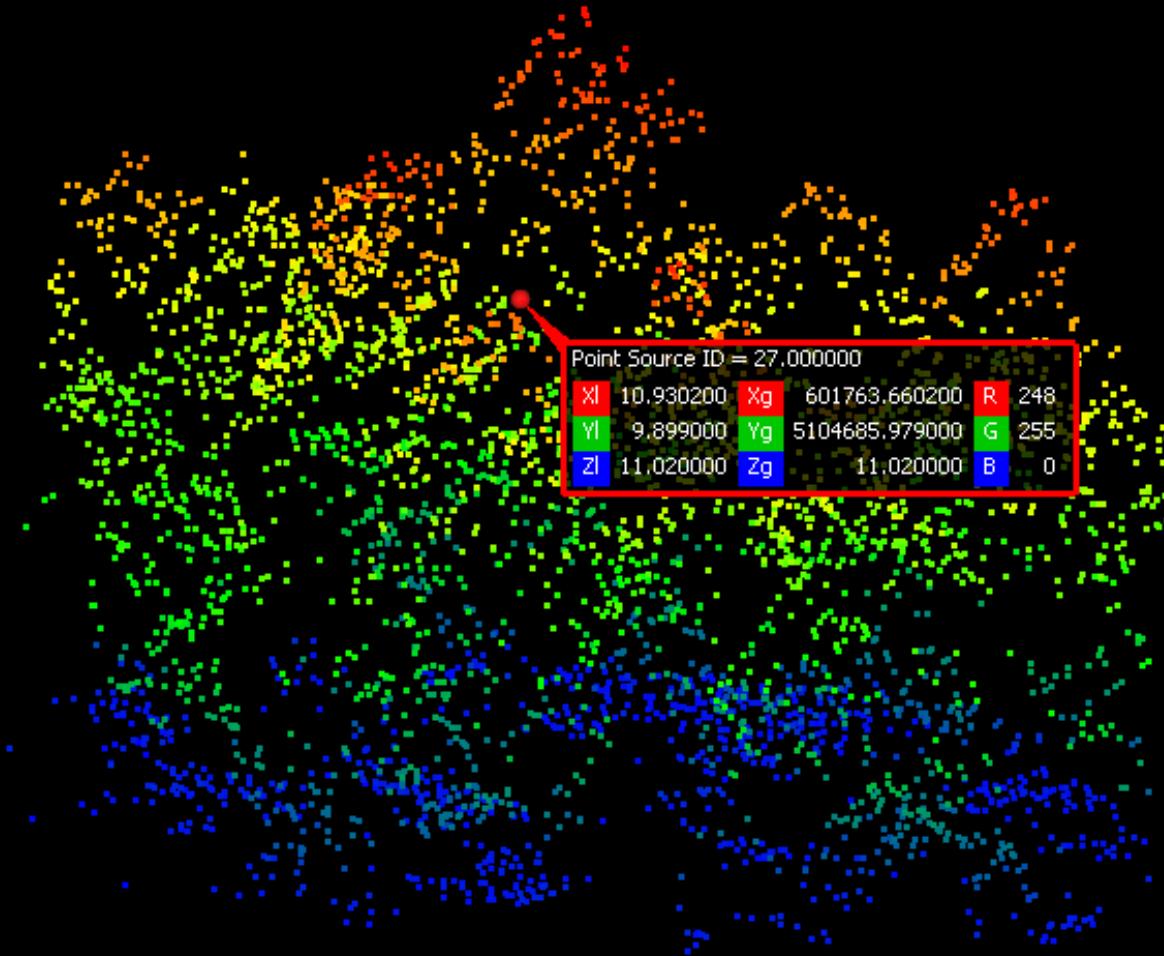


*Part 2:
ALS data visualization*

Airborne laser scanning (ALS)



Airborne laser scanning (ALS)



- 3D Point cloud
- X, Y and Z coordinates

**Structural information of
the vegetation**

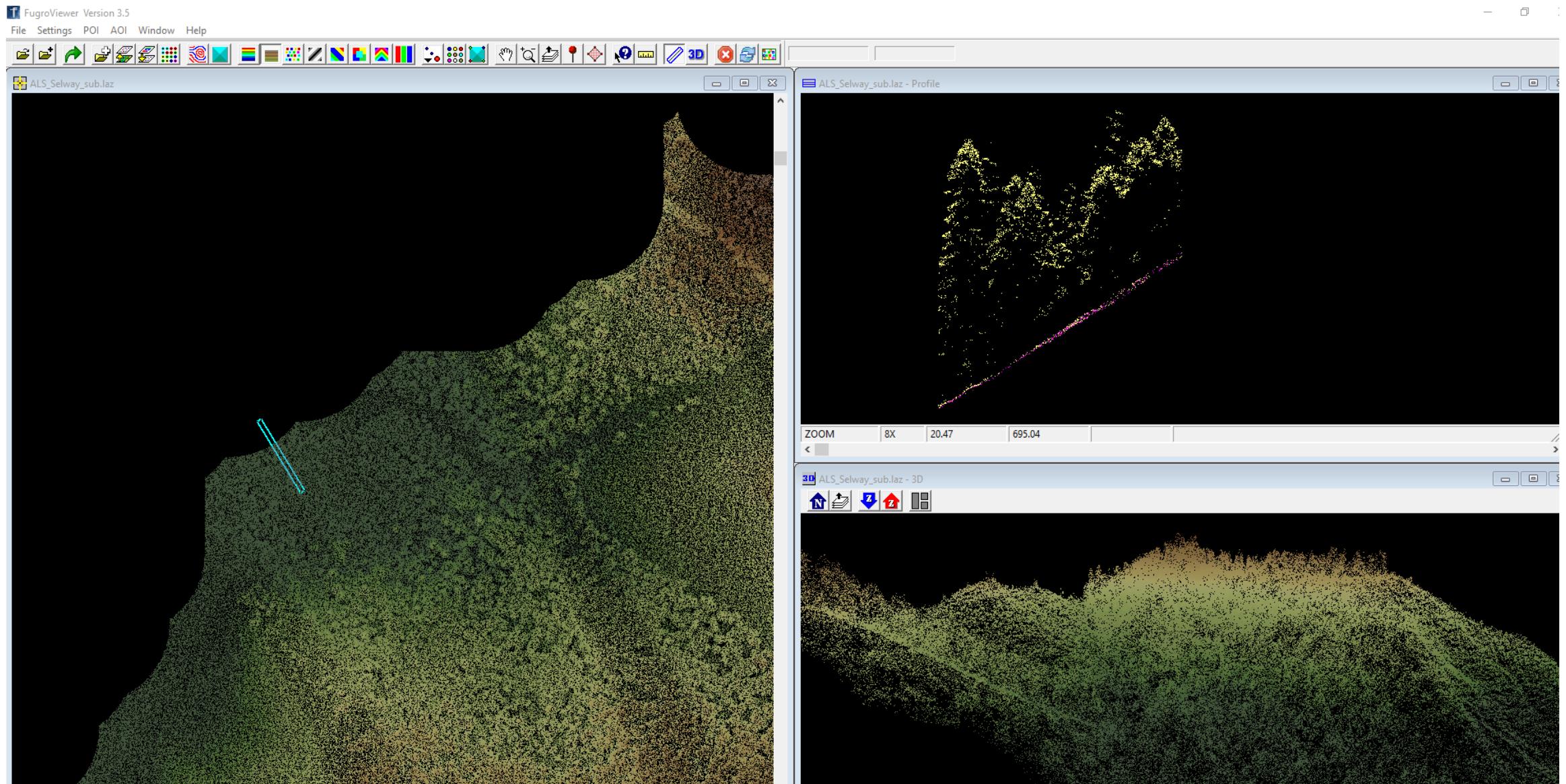
LAS/LAZ format

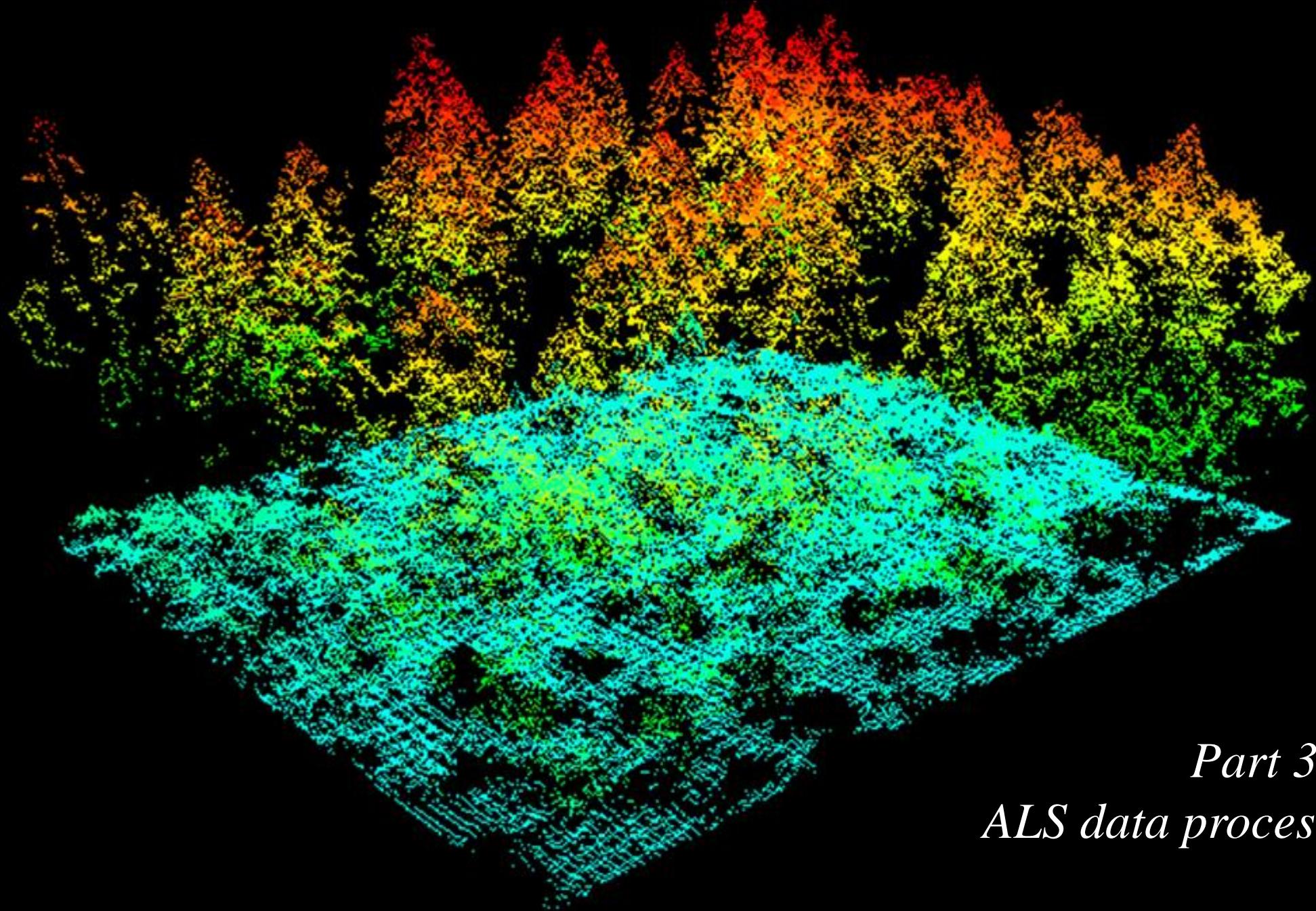
- LAS: LASer, LiDAR Aerial Survey
- 3D point cloud data – lidar data
- Binary file
- LAZ: compressed lidar data (LASzip). Can reduce considerably the size of the files.
- Some softwares can read LAS & LAZ format files. Some others (e.g., Arcmap) require transformation from LAZ files to LAS

Software:

- Fusion (http://forsys.cfr.washington.edu/fusion/fusion_overview.html)
- QGIS
- Cloud compare (<https://www.danielgm.net/cc/>)
- Lastools (<https://lastools.github.io/>)
- **Fugro viewer** (<https://www.fugro.com/expertise/other-expertise/fugroviewer>)
- R (**lidR package**)

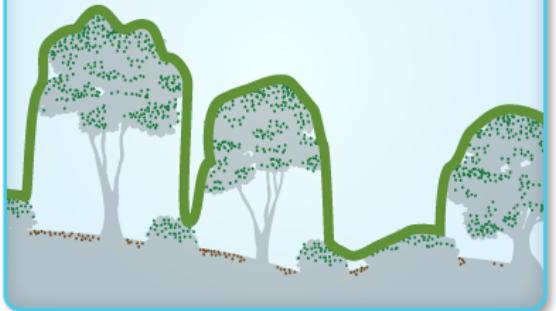
Fugro viewer - data visualization



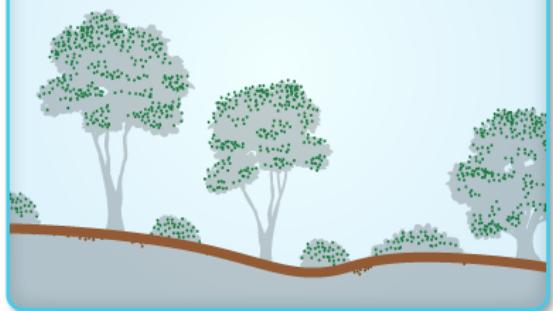


*Part 3:
ALS data processing with R*

Digital Surface
Model (DSM)



Digital Terrain
Model (DTM)



Canopy Height Model (CHM)



DSM (Digital Surface Model)

-DTM (Digital Terrain Model)

CHM (Canopy Height Model)



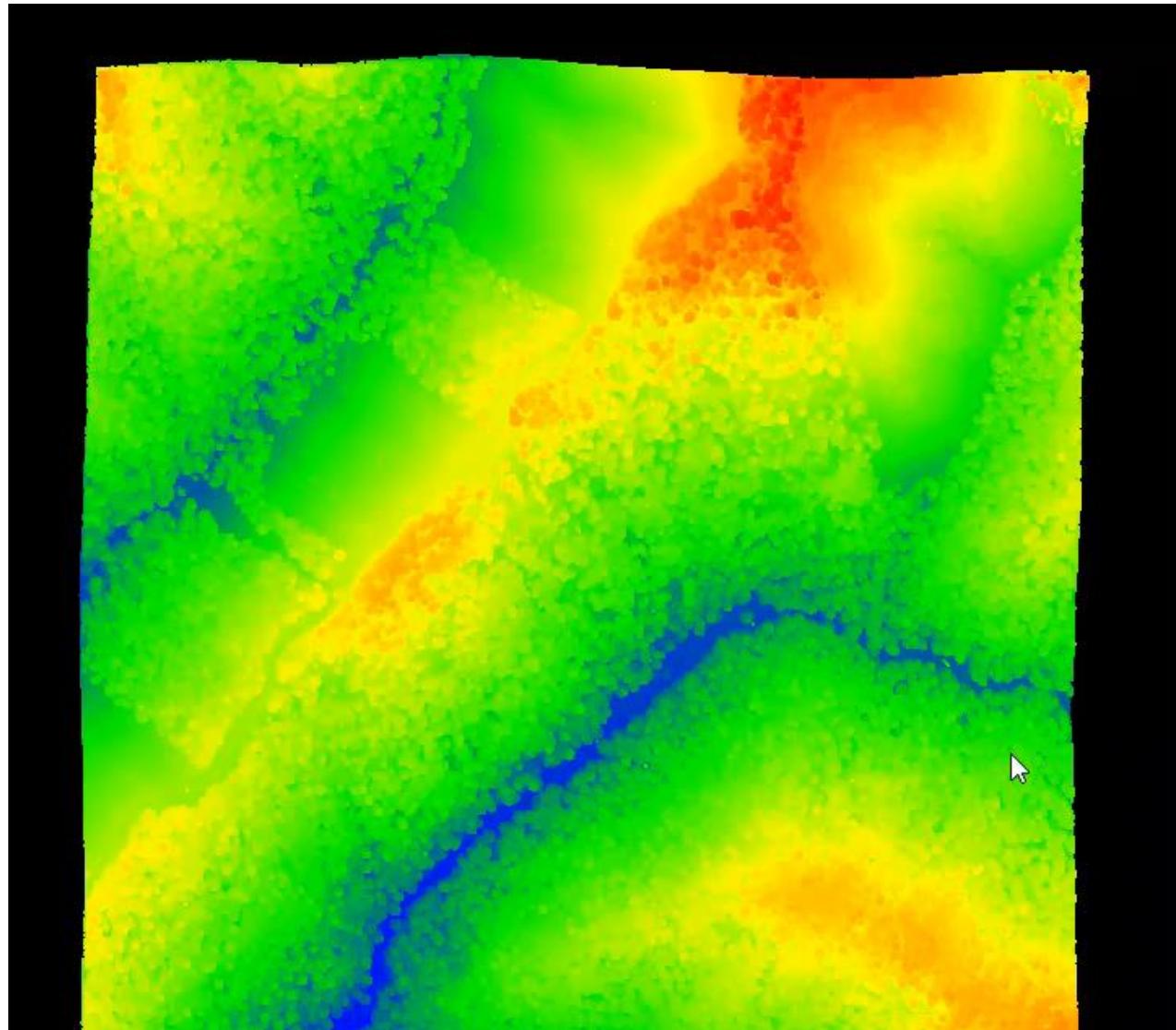
DTM: elevation of the ground

DSM: elevation of the tallest surface

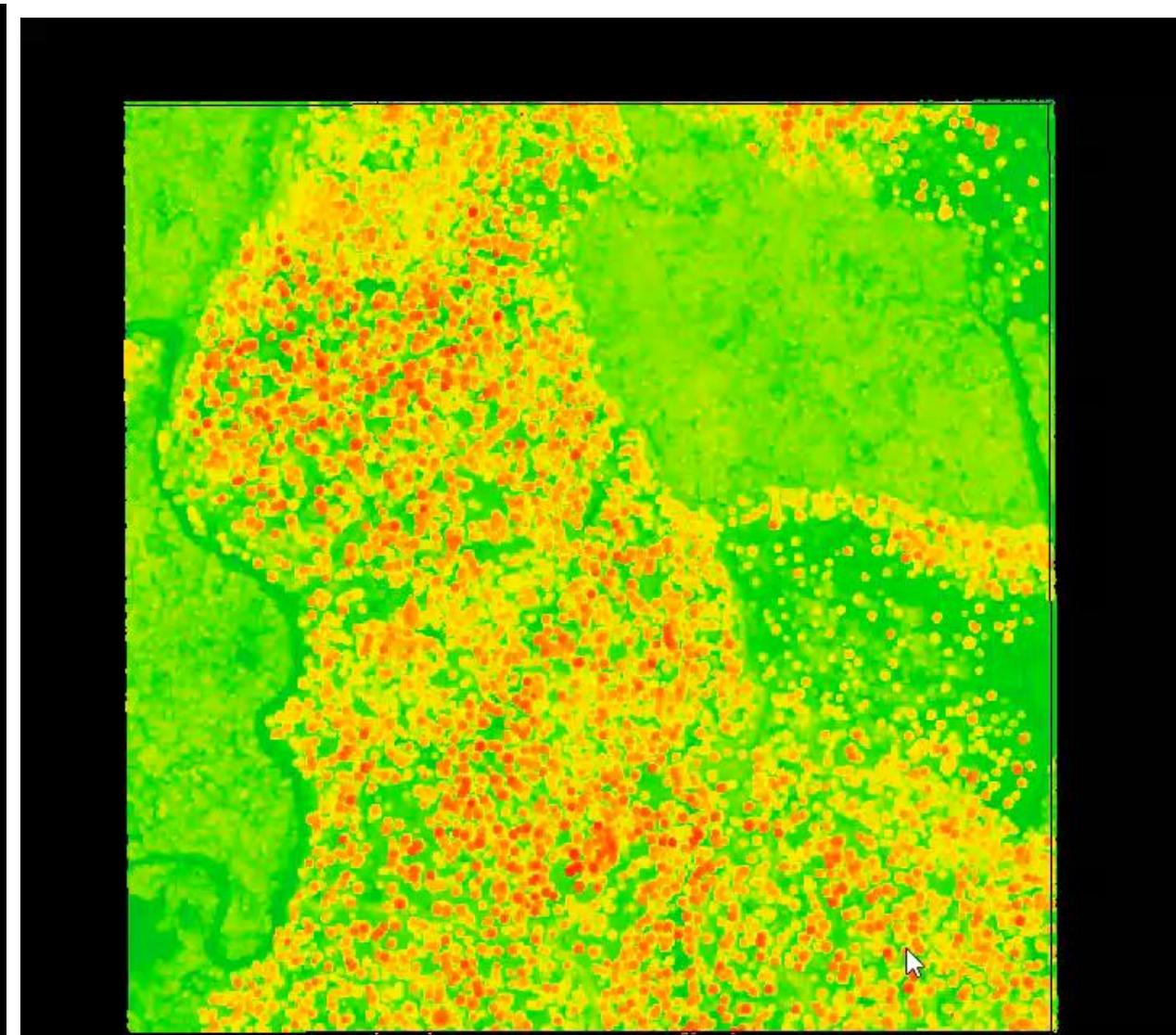
CHM: height of the tallest surface

Normalization of the point cloud

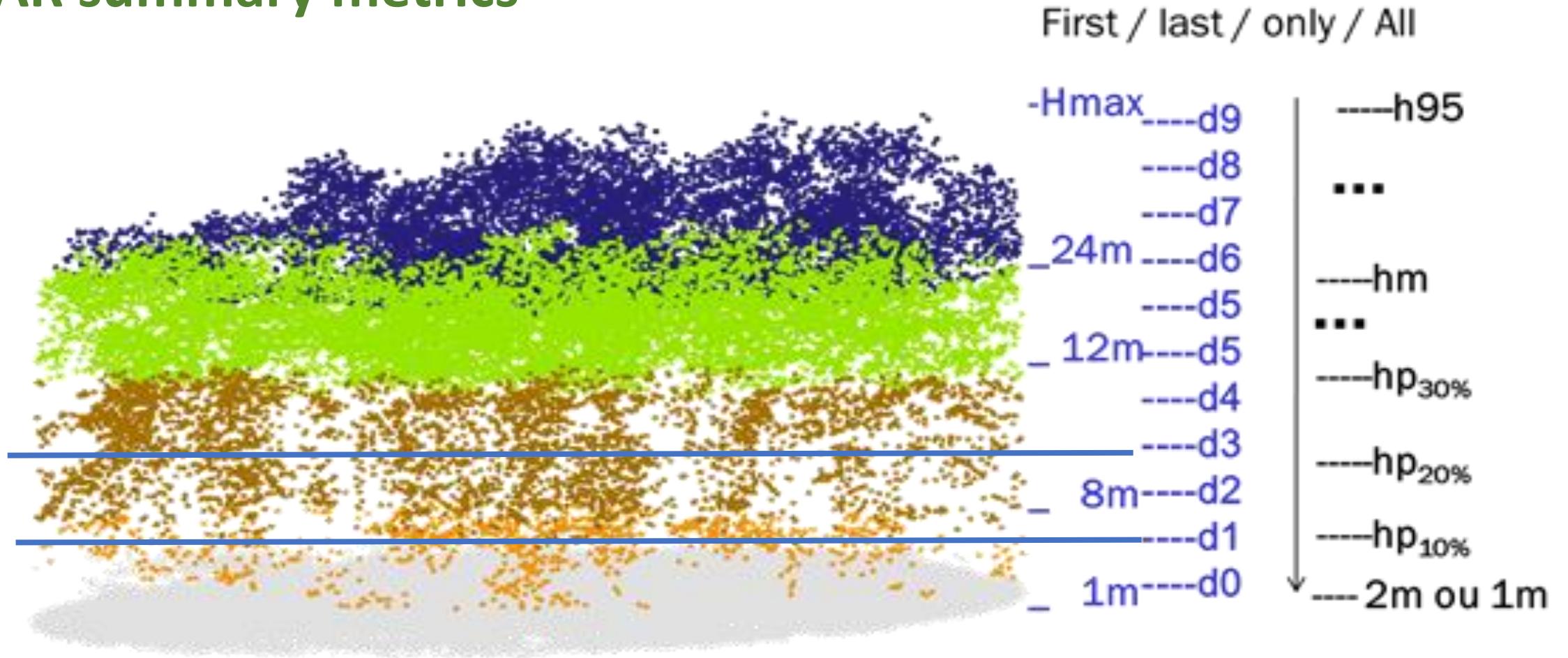
Raw point cloud



Normalized point cloud



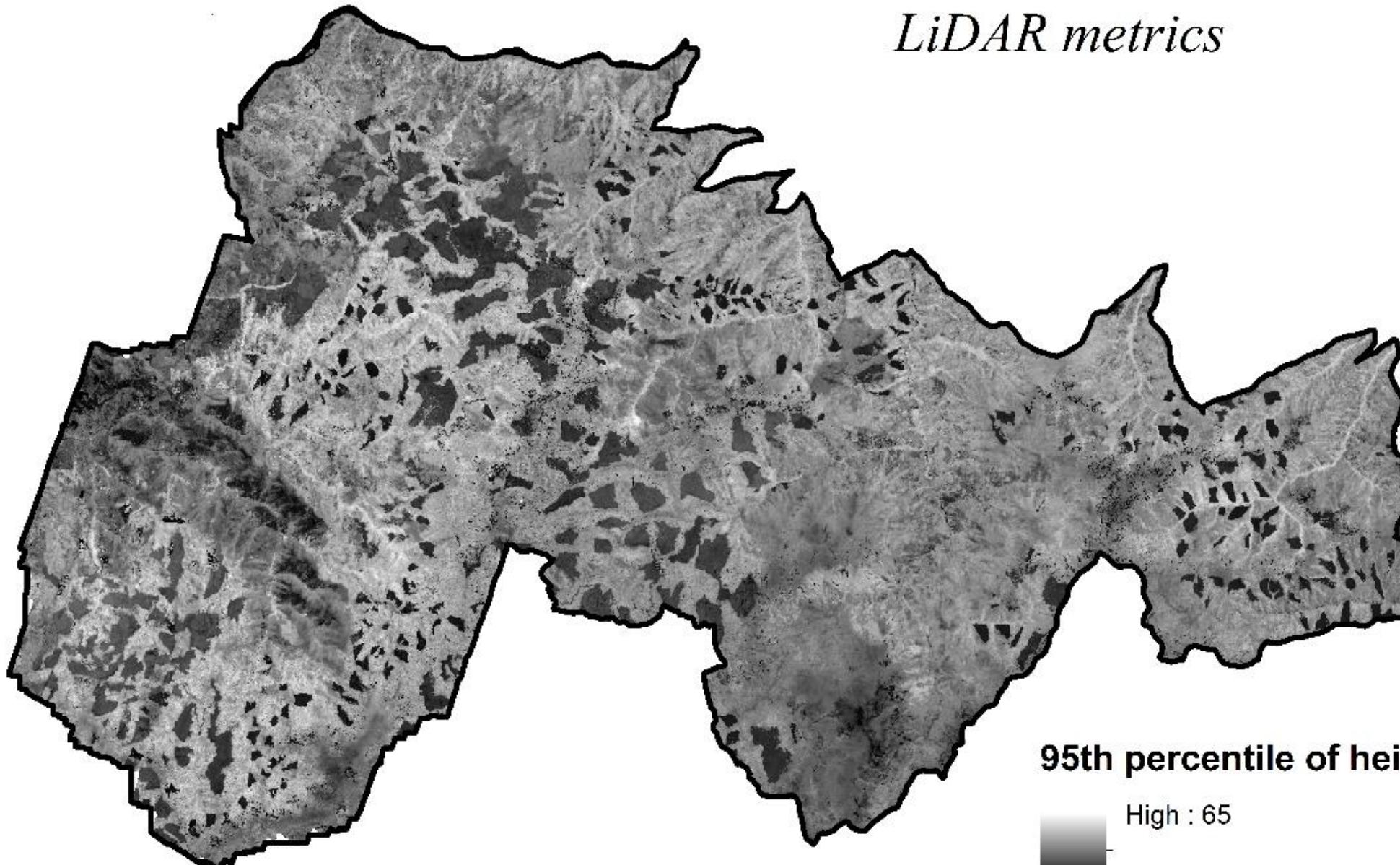
LiDAR summary metrics



Statistics summarizing the LiDAR point cloud

LiDAR summary metrics

LiDAR metrics



Additional information

<https://opentopography.org/>

<https://www.youtube.com/watch?v=EYbhNSUnIdU>

<https://www.neonscience.org/resources/learning-hub/tutorials/lidar-basics>

<https://www.neonscience.org/resources/learning-hub/workshops/work-lidar-derived-rasters-r>

<https://r-lidar.github.io/lidRbook/>



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