World Geospatial Forum - Rotterdam, Netherlands 2023

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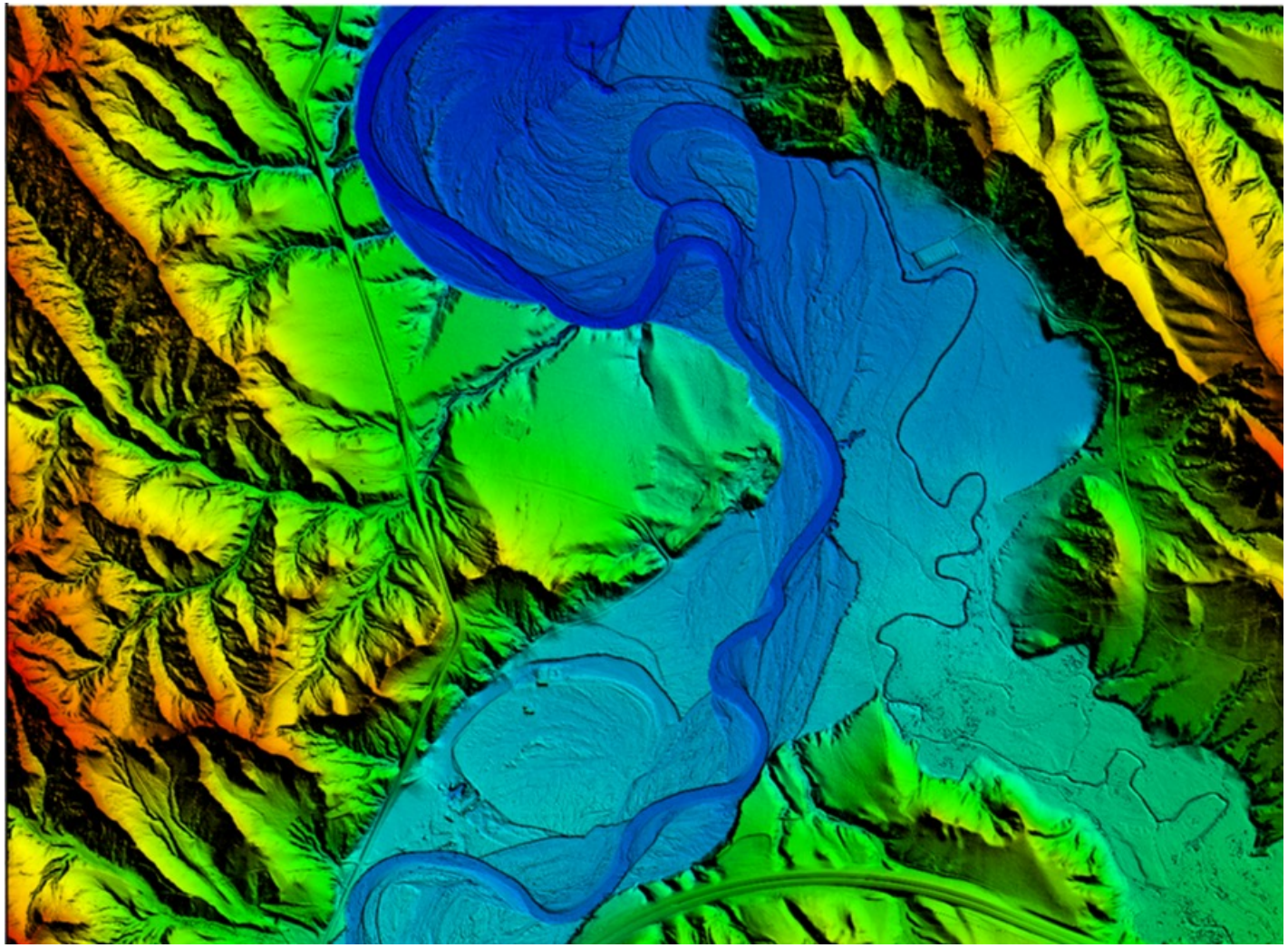
Application of Geiger Mode LiDAR Technology for Extracting Forest Attributes and Terrain Mapping



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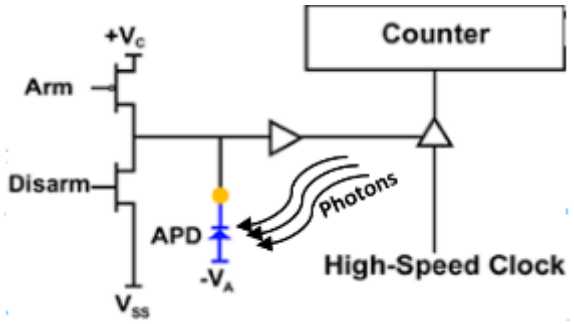
Introduction

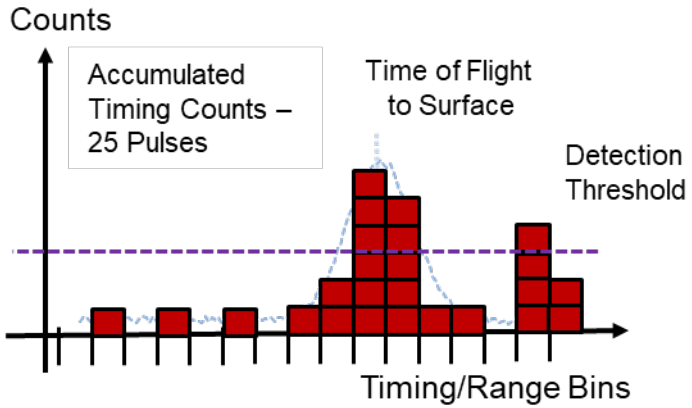
- Introduction to Geiger Mode LiDAR (GML) technology
- Visual example of Geiger Mode LiDAR data
- Discussion on the extraction of forest attributes and terrain mapping
- Deep Learning Model
- Summary

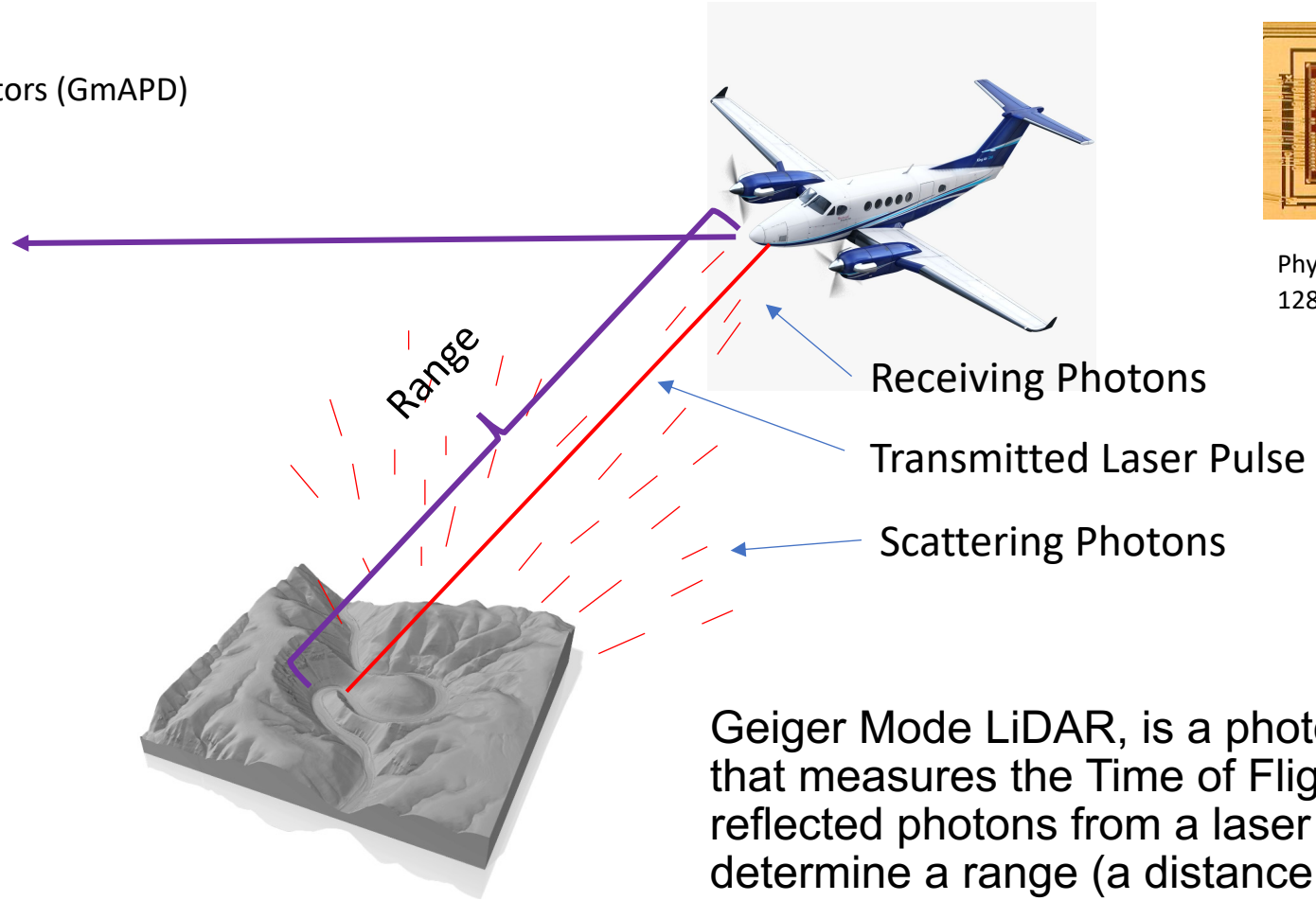
Introduction Geiger Mode LiDAR

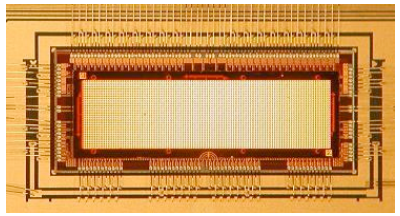
Receiving Photon Sensor

Geiger Mode Avalanche Photodiode Detectors (GmAPD)





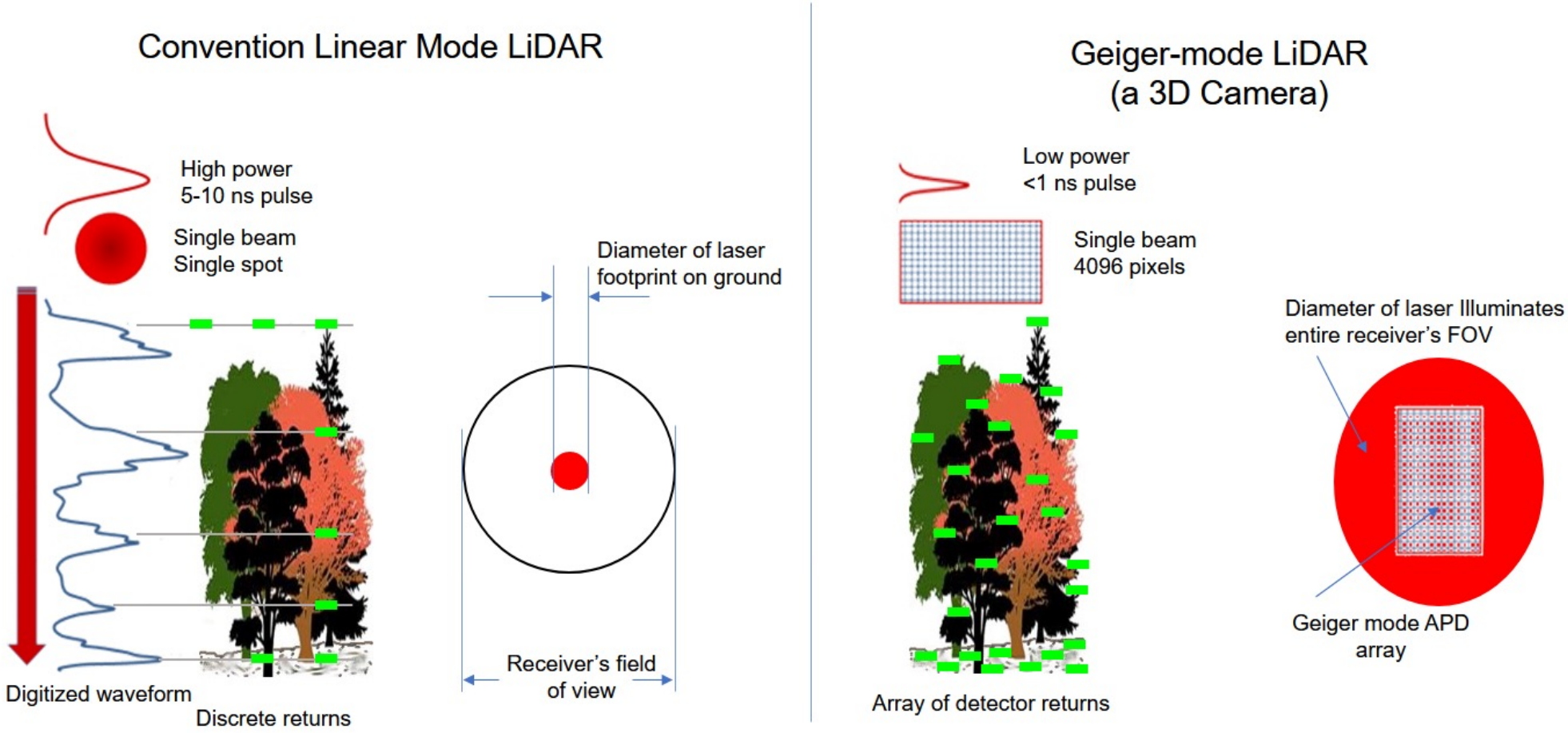




Physical Sensor
128 x 32 = 4,096 detectors

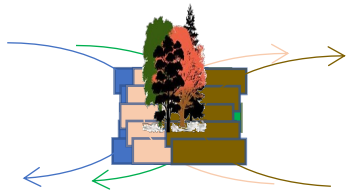
Geiger Mode LiDAR, is a photon base sensors that measures the Time of Flight (TOF) of reflected photons from a laser pulse to determine a range (a distance from aircraft to ground)

Receiving Photons



Spot size Linear LiDAR @ 4,300 AGL' and Geiger Mode @ 12,000' MSL

Introduction Geiger Mode LiDAR

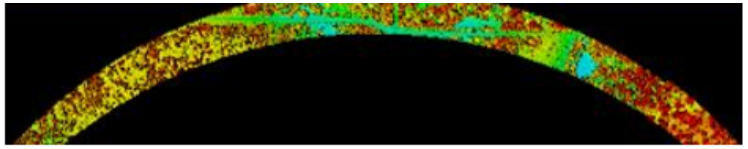


Palmer Scanner & Look diversity

- 4,096 measurements per laser flash or for each frame
- 50,000 flashes per second creating overlapping frames

  (Approximately 205 million elevation measurement per second)
- Rotating Palmer Scanner Creates Overlaps in Flight Direction of frames in direction of the Flight path
- Forward and Aft Looks for Each Rotation of Scanner at 15° angle

Introduction Geiger Mode LiDAR

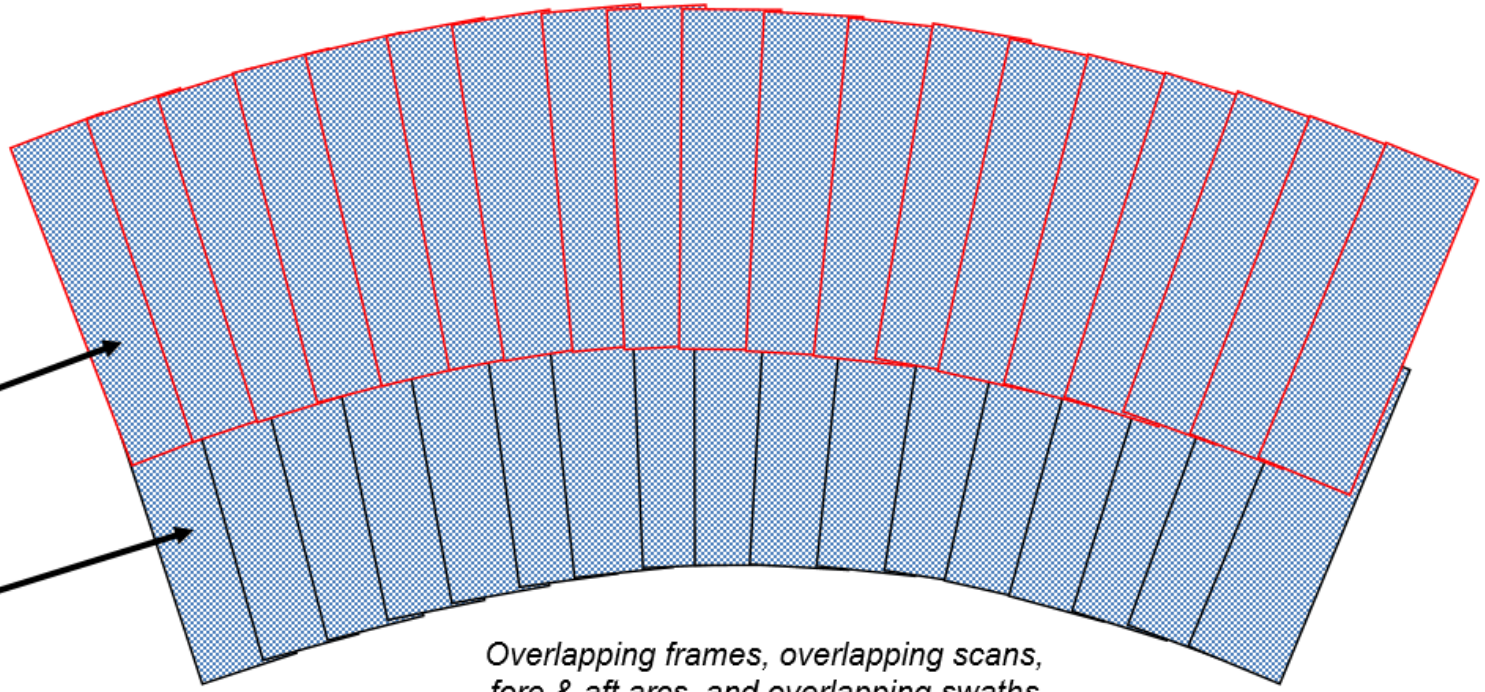


Data built from multiple frame samples

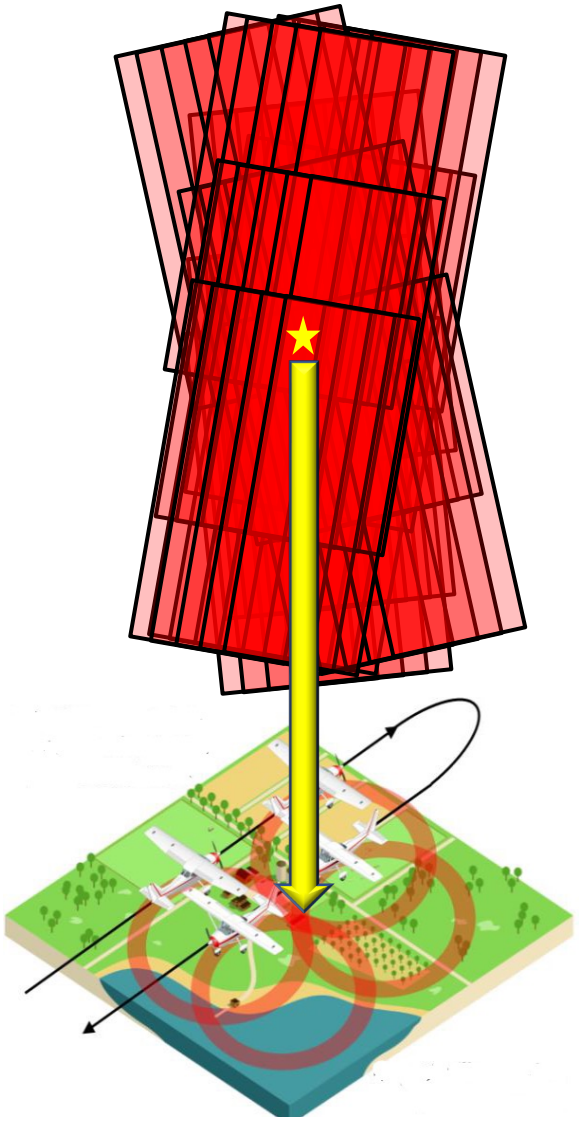
Flight direction

Scan 2 Frames

Scan 1 Frames



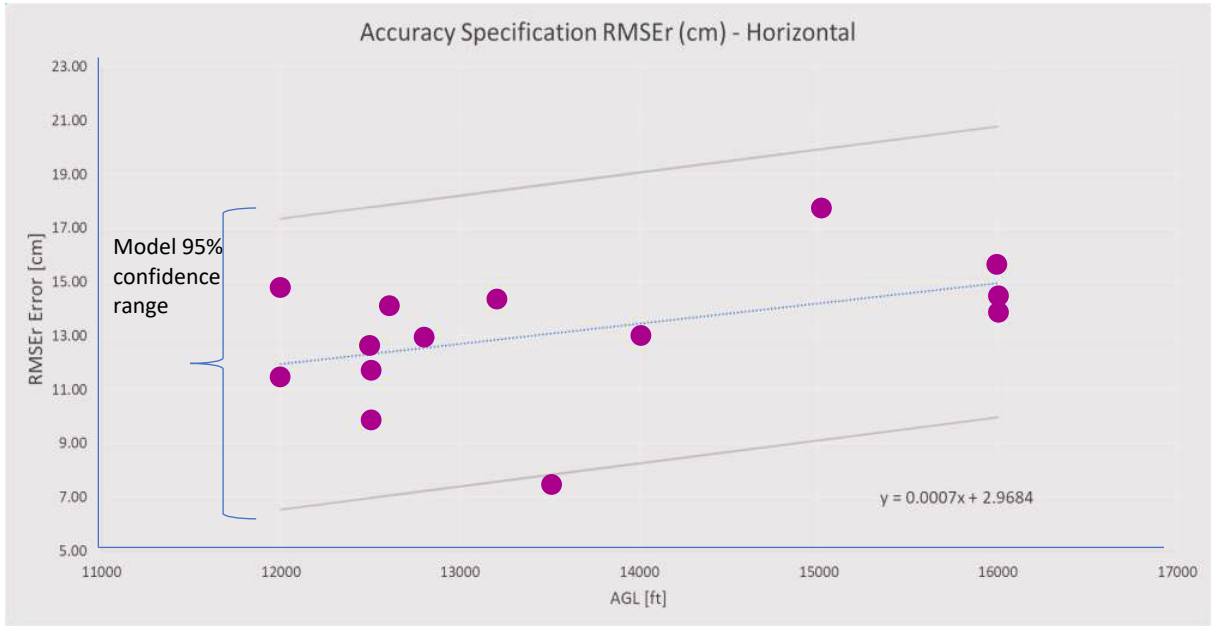
Overlapping frames, overlapping scans, fore & aft arcs, and overlapping swaths

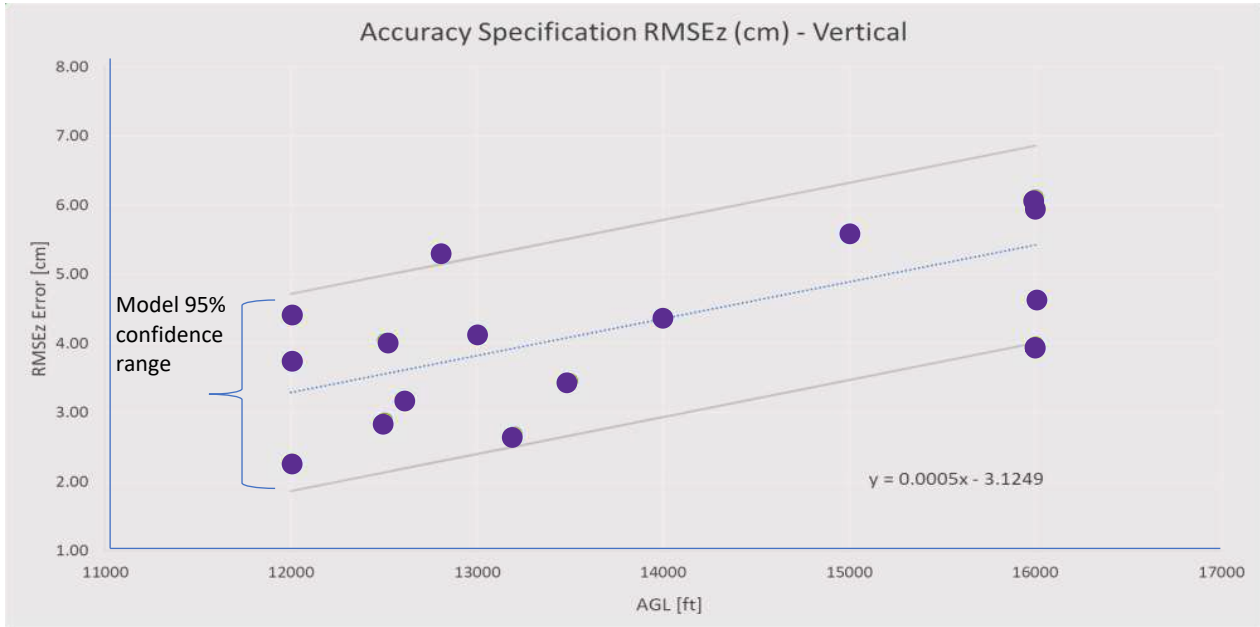


Visual Examples of Geiger Mode LiDAR Data

Accuracy

Actual horizontal and vertical accuracy results are displayed below from project collections





Mean/STDEV Horizontal Accuracy (RMSEr)
13.4cm +/- 2.6cm from 15 projects

Mean/STDEV Vertical Accuracy (RMSEz)
4.3 cm +/-1.2cm from 19 projects

Accuracy – Multi-Project Empirical RMSE values
VeriDaaS has collected over 520,000 km²

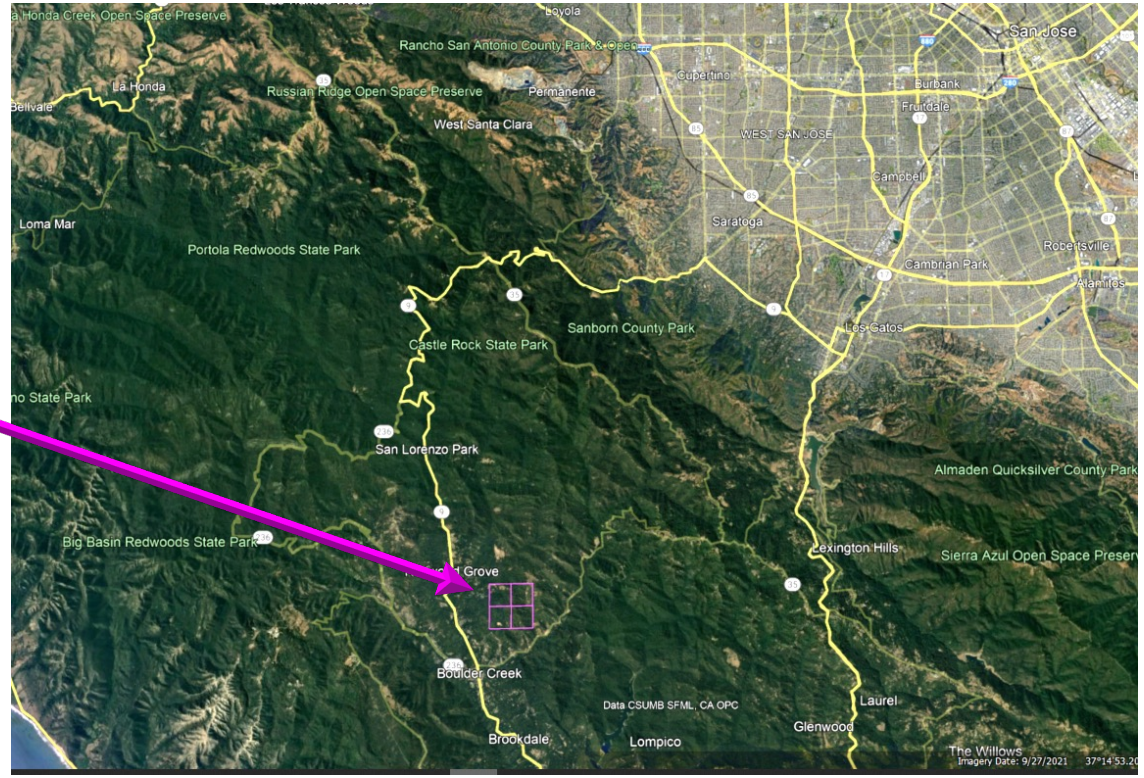
Extracting Forestry Attribute and Terrain Mapping

Geiger Mode LiDAR data is well suite for applications related to forestry/tree attributes and under canopy terrain mapping to support for the following reasons:

- Narrow pixel size to acquire terrain measurements through the gaps of the tree.
- Ultra high data density up to 140 ppms
- Multi-look angle for optimizing structural mapping
- Uniform data distribution
- Accurate data

Forestry Use Case
Boulder Creek in Redwood Forest area of California

- Forest/tree area delineation
- Tree top location
- Crown delineation

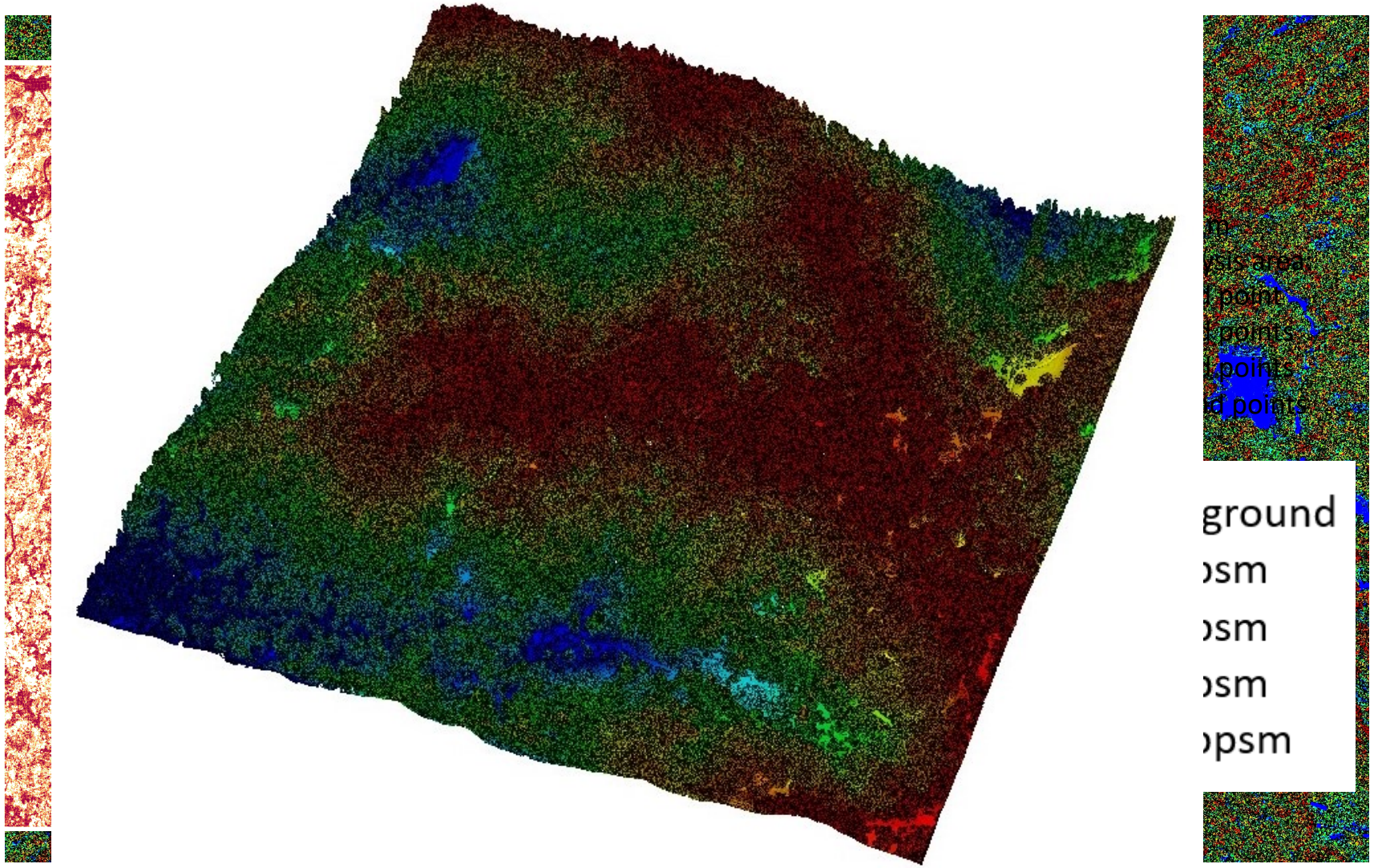


Boulder Creek California Data Collection

Collection Details

- May 2021
- ~ 50 ppms
- Acquisition 12,800ft AGL (3.9km AGL)
- 50+ % overlap
- 27° Field of View

Example area is 1 sq mile (2.6 km^2)

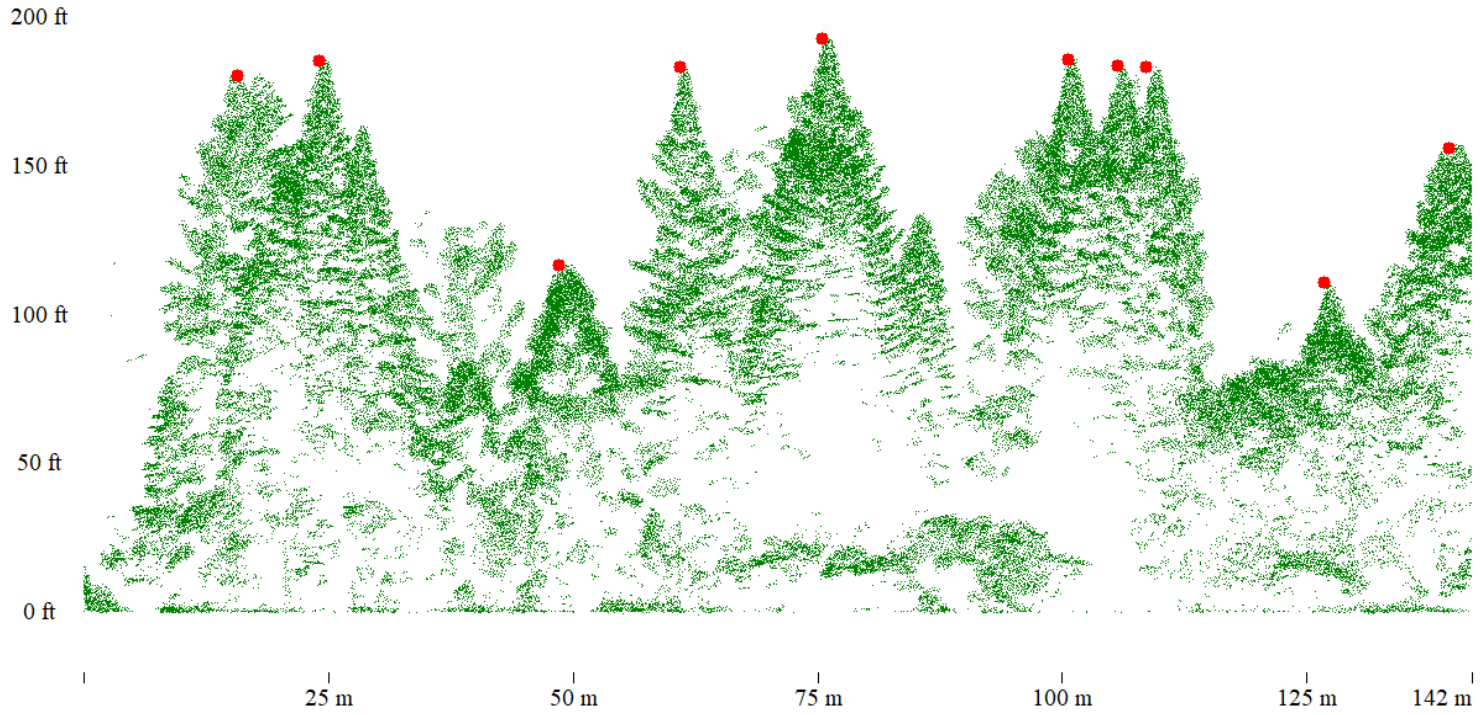


Forestry Attributes

- Tree height – Above Ground Level (AGL)
- Forest/tree area delineation
- Individual tree top detection
- Individual tree crown segmentation

Tree density distribution
Tree height distribution
Tree lean
Tree volume

Biomass/Carbon Quantification
Fallen Tree Risk
Timber Yield
Vegetation Encroachment
Forest Fuel Assessment



Forest Attributes and Terrain Layer Data Stack

Bare Earth DEM

Hillshade DEM

Drainage Network

Forest Delineated

Forest Delineated Area

Canopy Height Model (C

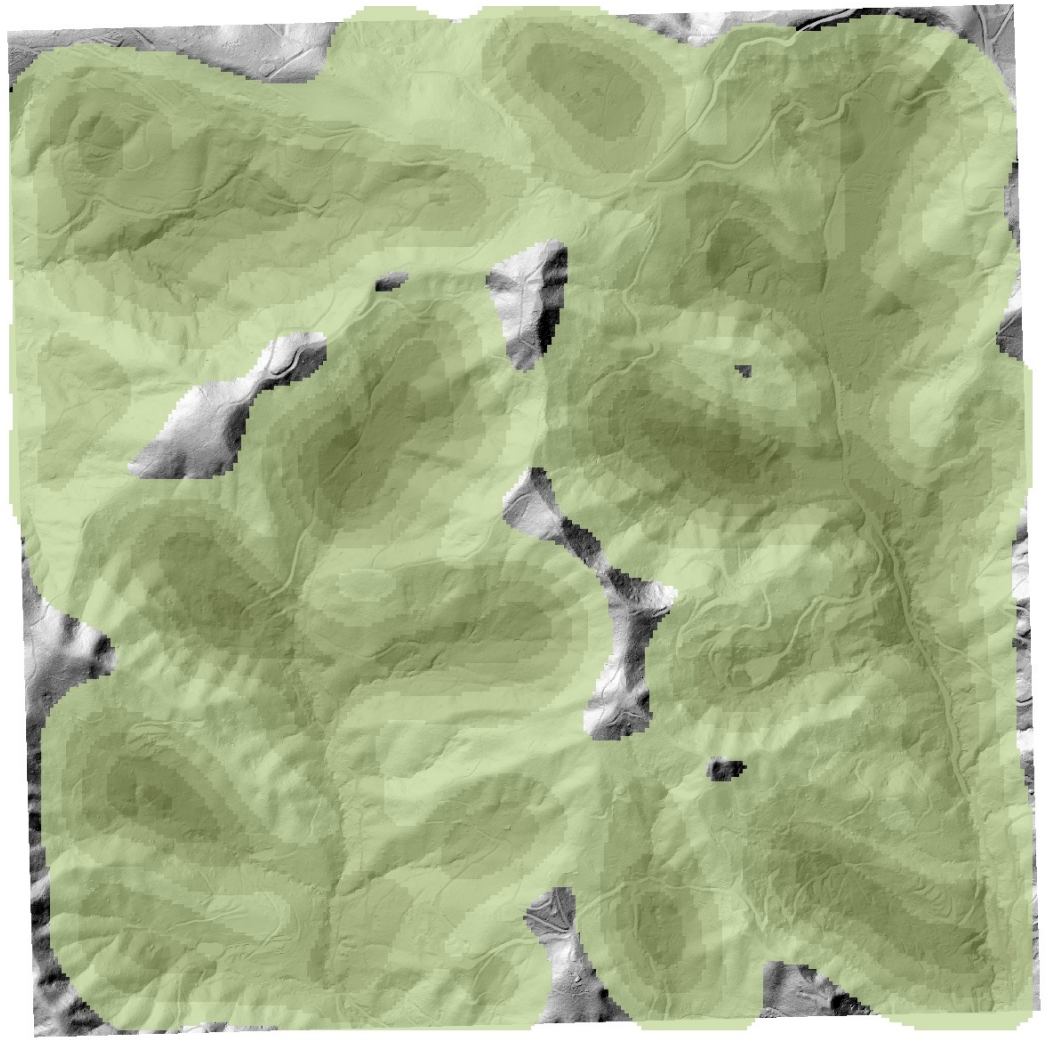
Crown Area

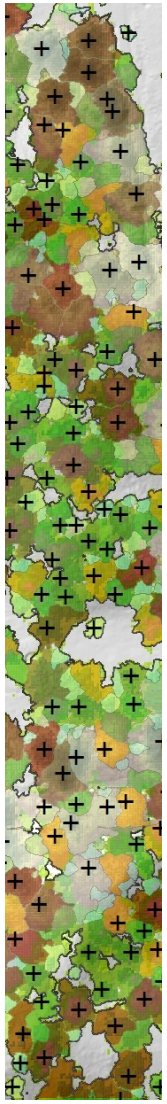
Tree Top

Tree Top Density (Hectare <1,2,3,4,5,6>)

CHM Tree Top

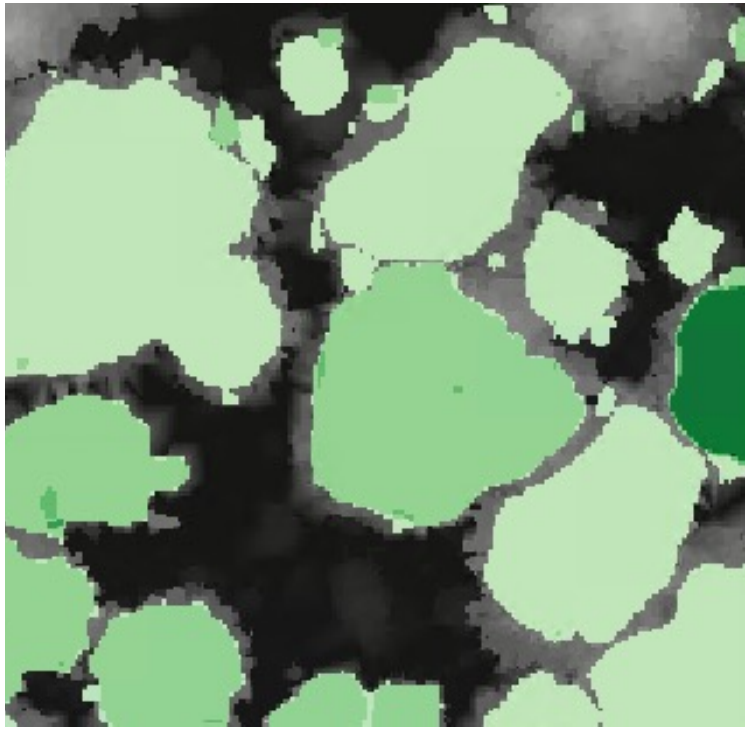
CHM, Tree Top, Crown Ar



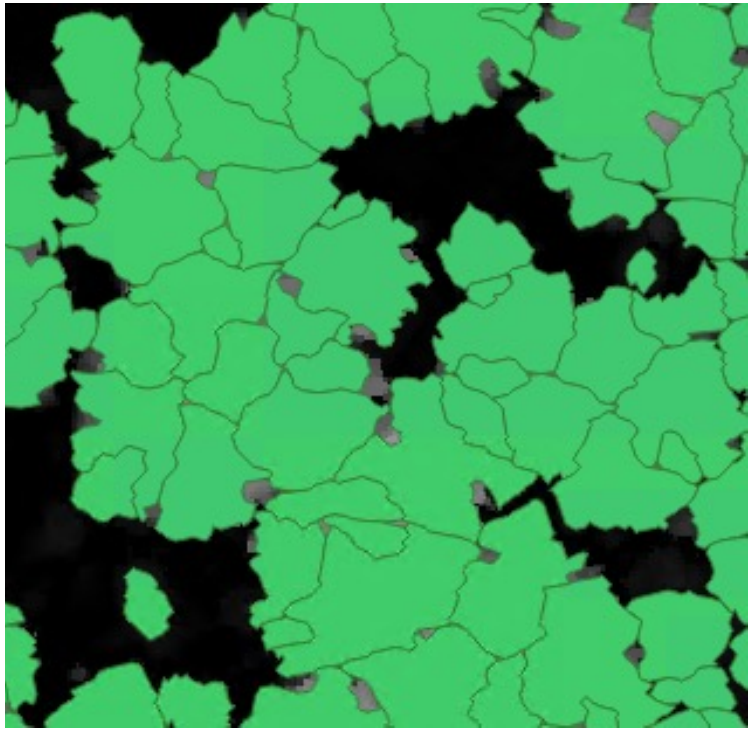


Vision Transformer Deep Learning Models

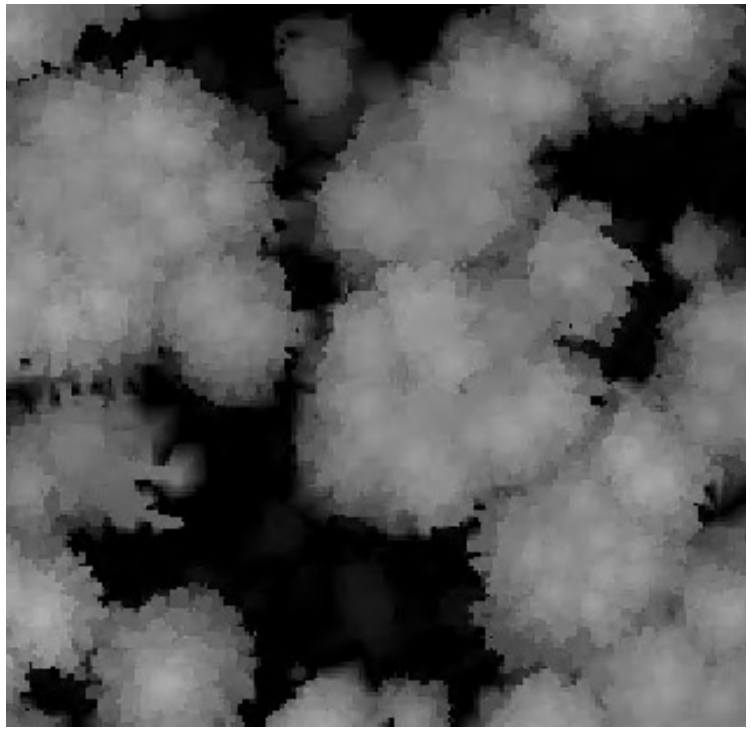
Vision Transformer DLMs are the state-of-art for image recognition in computer vision tasks due rate of accuracy and computational efficiency



Vision Transformer (ViT) Model



Watershed Segmentation

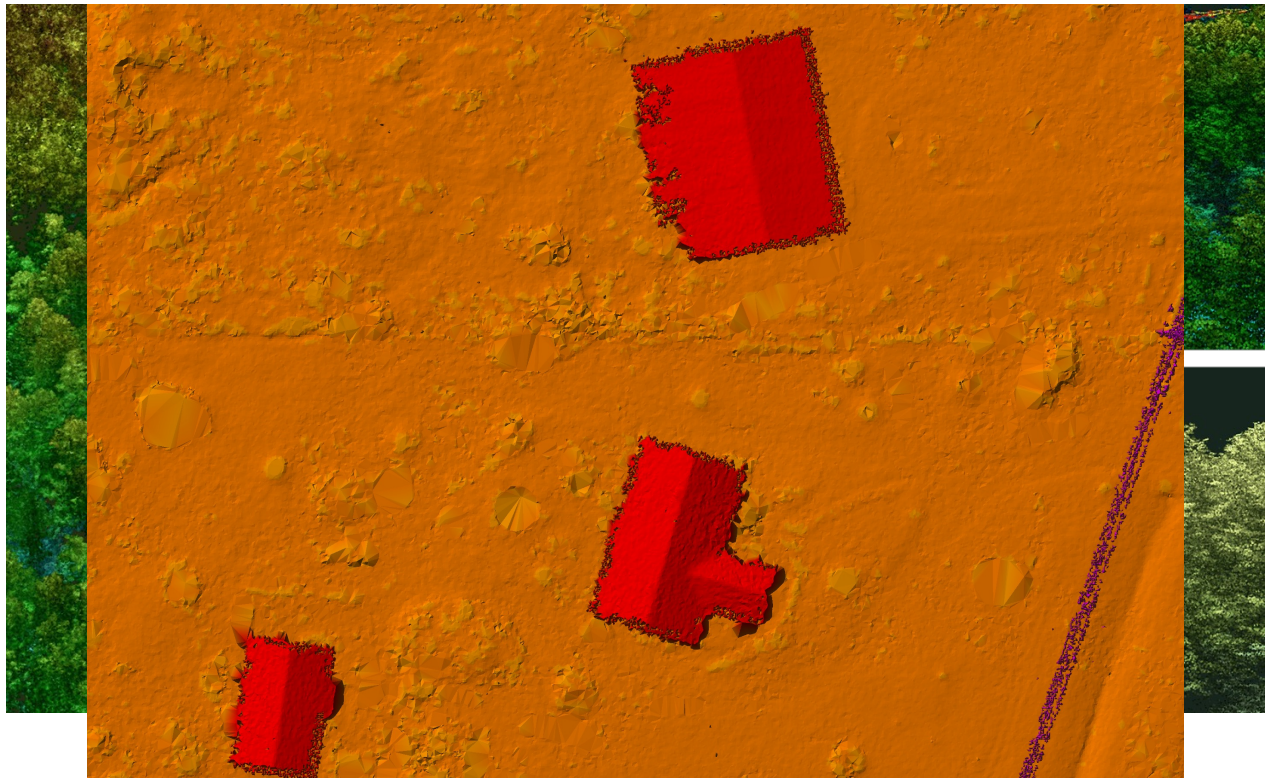


Canopy Height Model

Summary

Geiger Mode LiDAR data bring to the geospatial community the following:

- Powerful technology for building foundation data for Digital Twinning initiative in any environment
- Accurate data to build confidence in 3D models and knowledge content
- Rapid wide area collection, with high-definition and uniform data, to identify fine features
- Multi-look, oblique angles enables superior foliage penetration and 360-degree capture of structures
- Narrow pixel size for penetrating through tree gaps to identify structures and ground measurements



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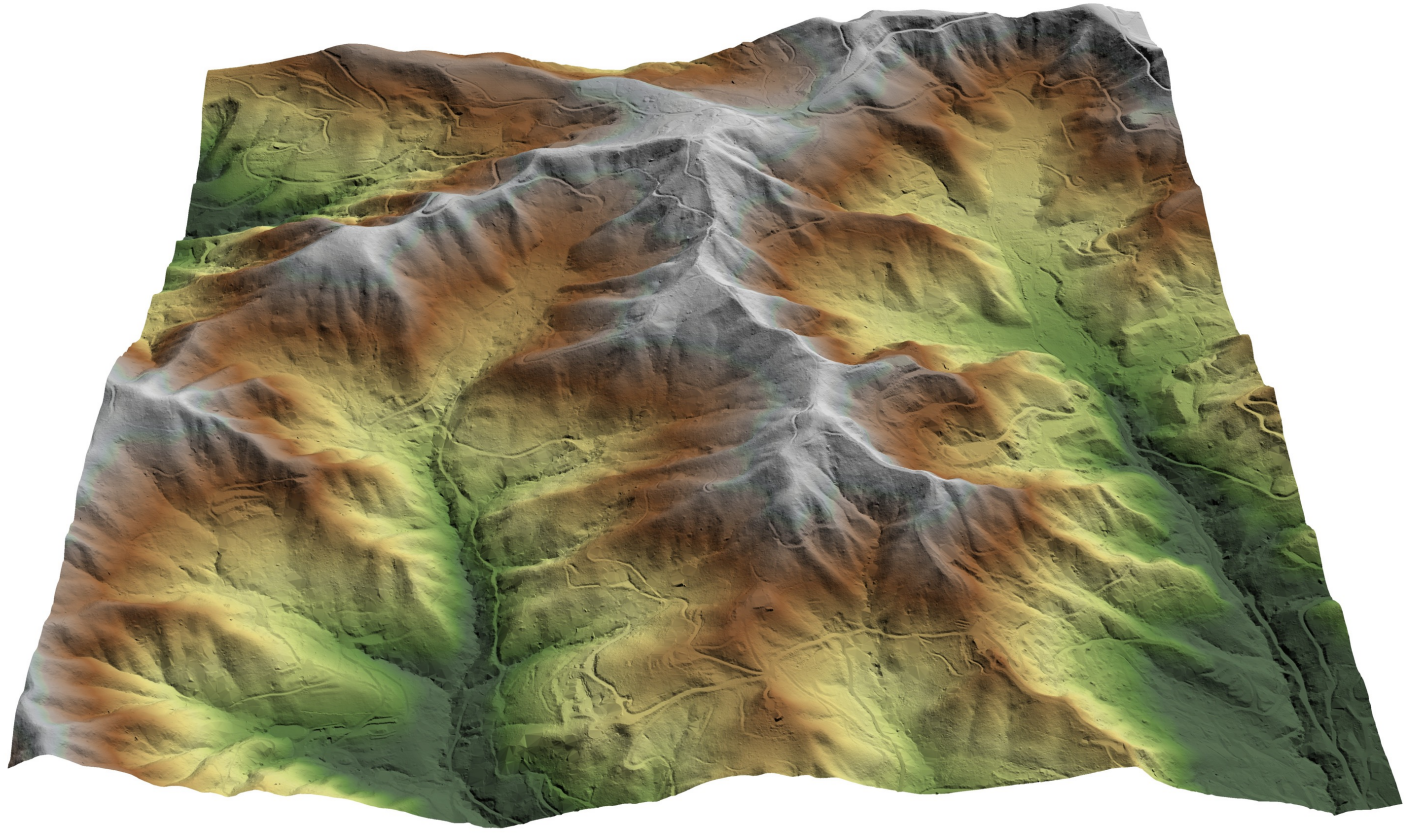

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Questions