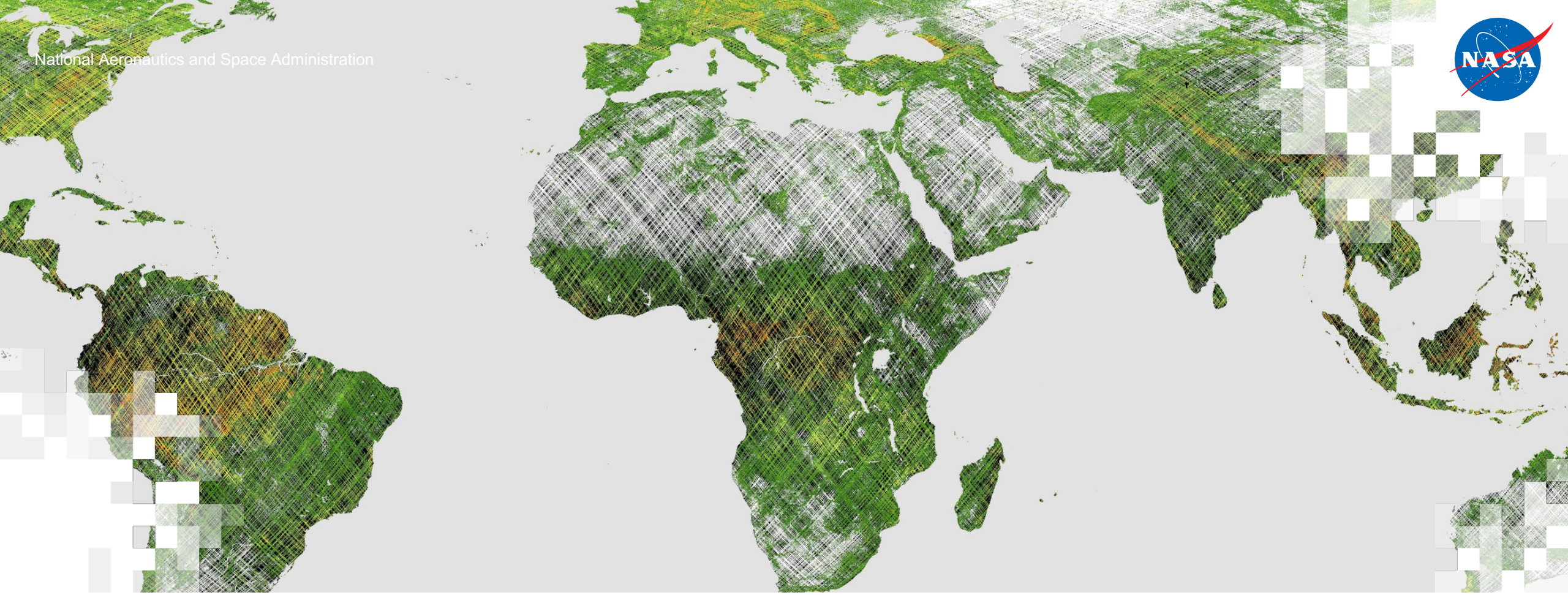


The Fundamentals of LiDAR

Erika Podest, Ph.D., Jet Propulsion Laboratory, California Institute of Technology

Mar. 16, 2021

Webinar Overview

- March 16 - Fundamentals of LiDAR and its Applications & Accessing and Analyzing ICESat-2 LiDAR Data
- March 18 - Accessing and Analyzing GEDI LiDAR Data
- March 23 - The Fundamentals of Solar Induced Fluorescence and its Applications
- March 25 - Accessing and Analyzing SIF Data for Vegetation Studies

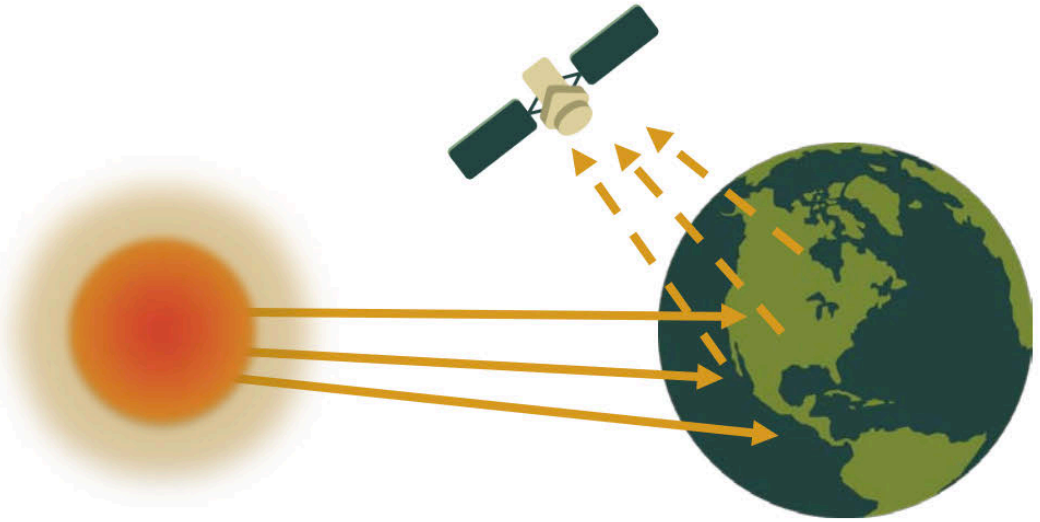
Learning Objectives

By the end of this session, you will understand:

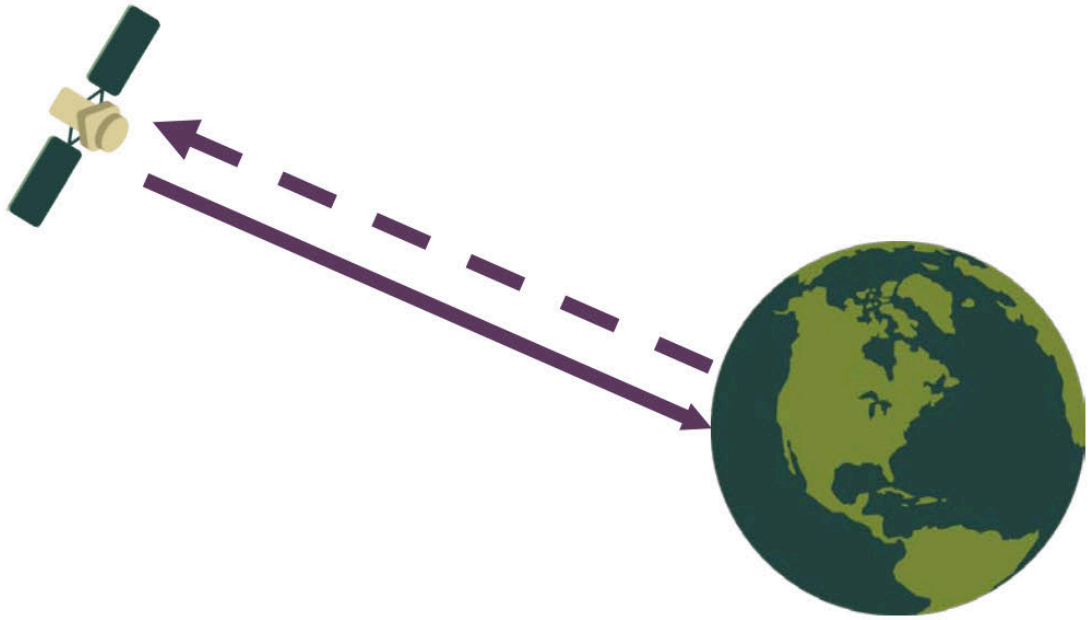
- Fundamental concepts of LiDAR
- Applications of LiDAR data
- Characteristics of ICESat-2 LiDAR data
- How to access and analyze ICESat-2 LiDAR data

Active and Passive Sensors

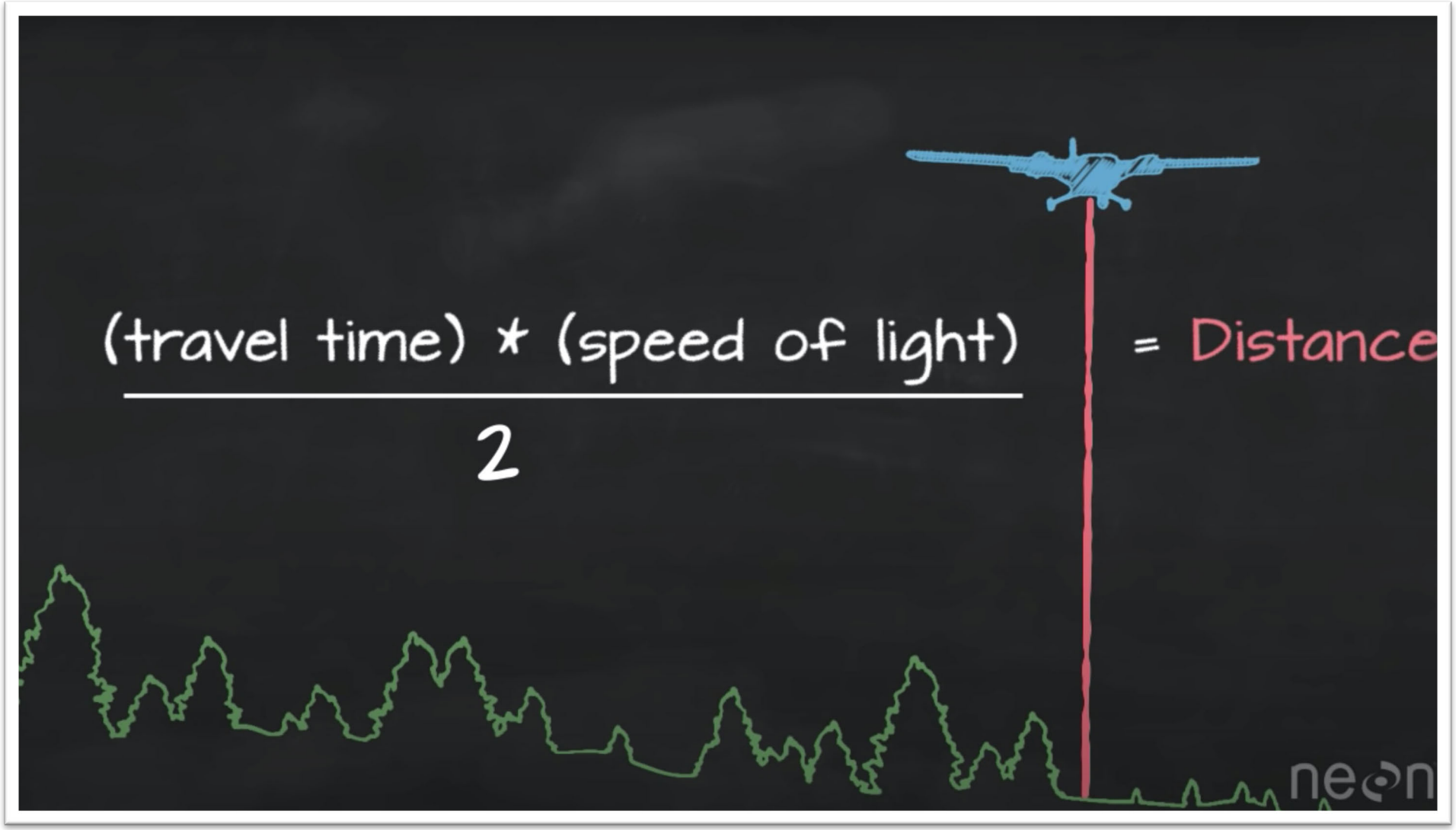
Passive Sensors



Active Sensors

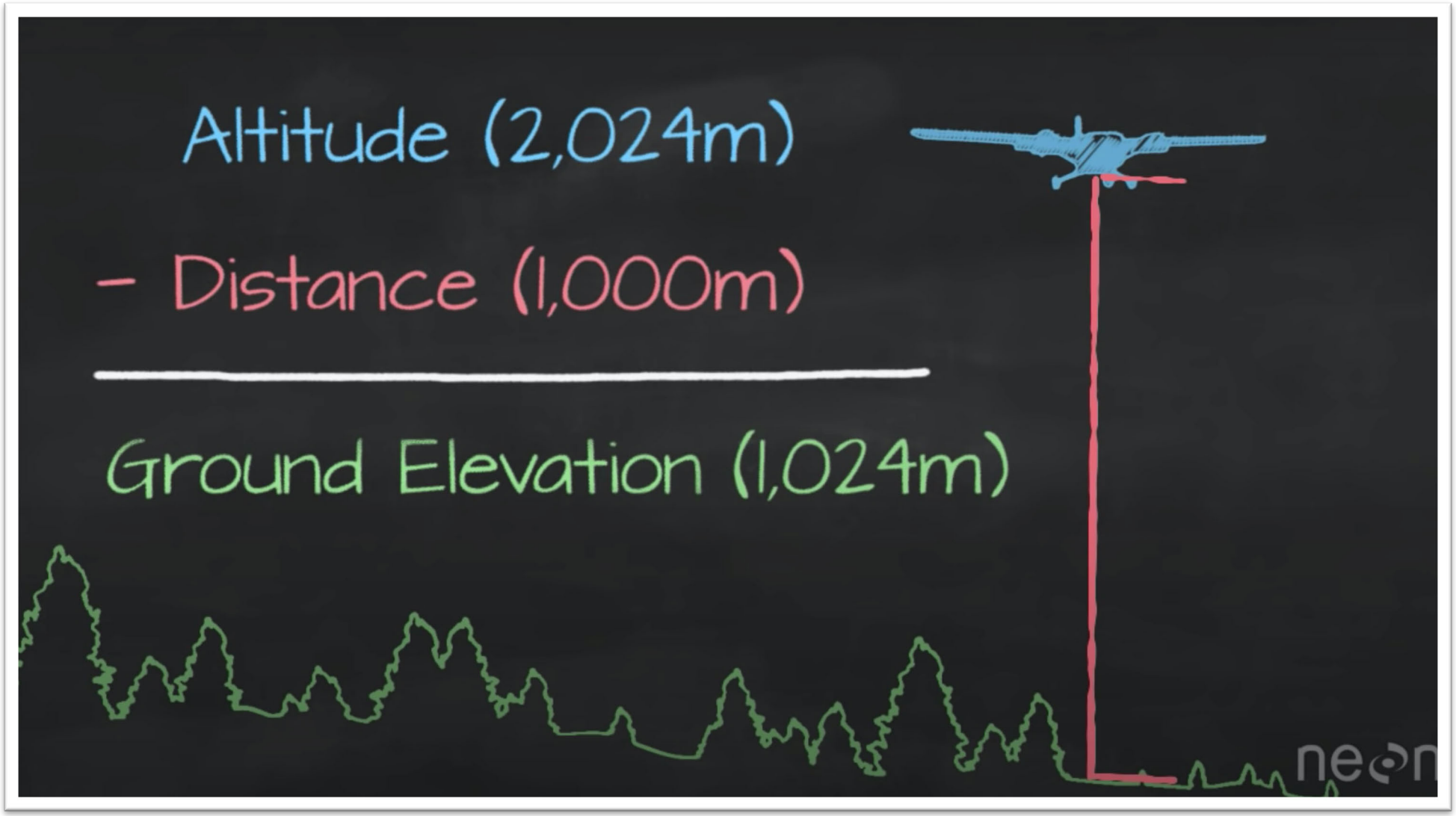


LiDAR - Determining Distance



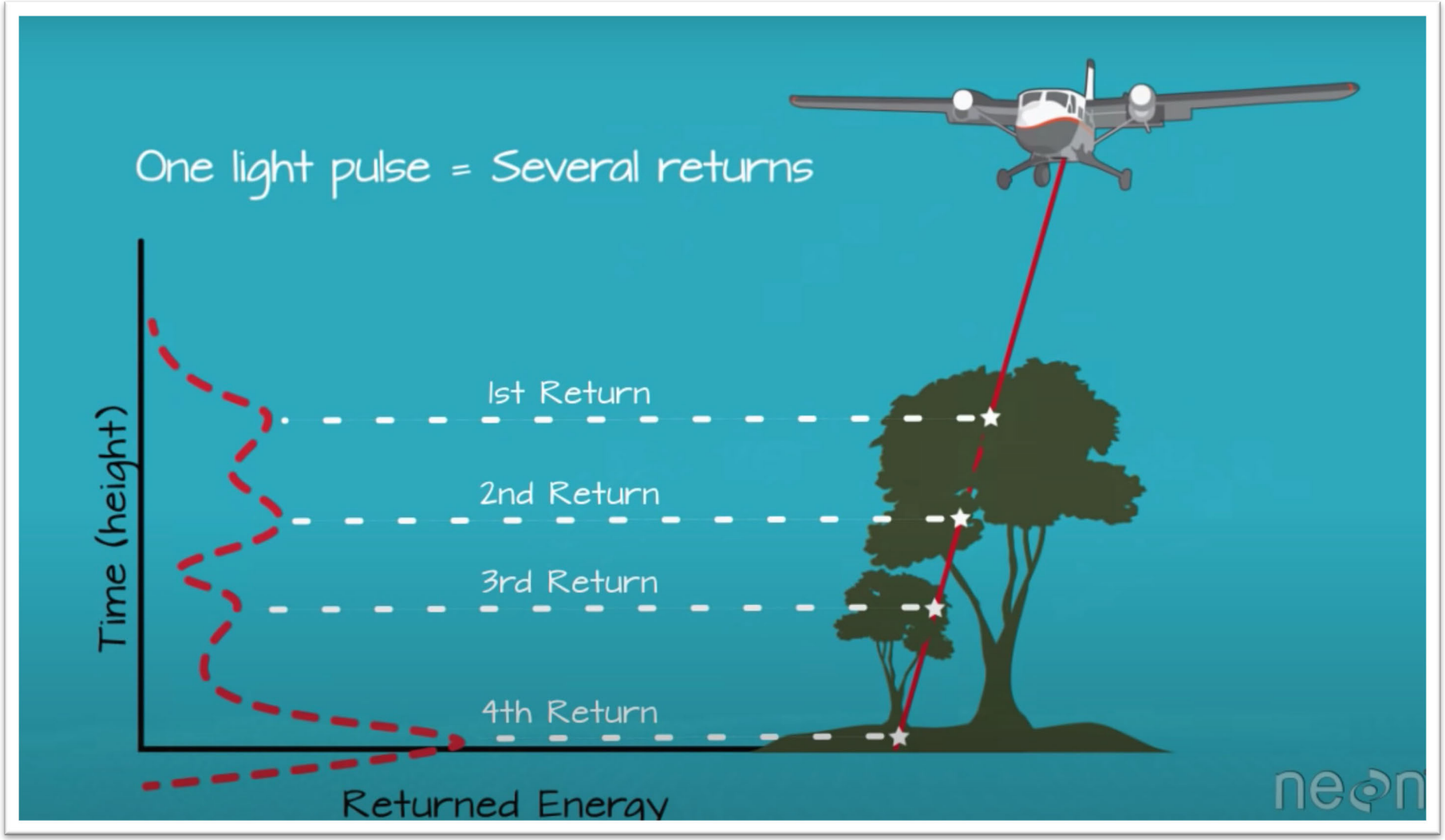
Source: NEON

LiDAR - Determining Elevation



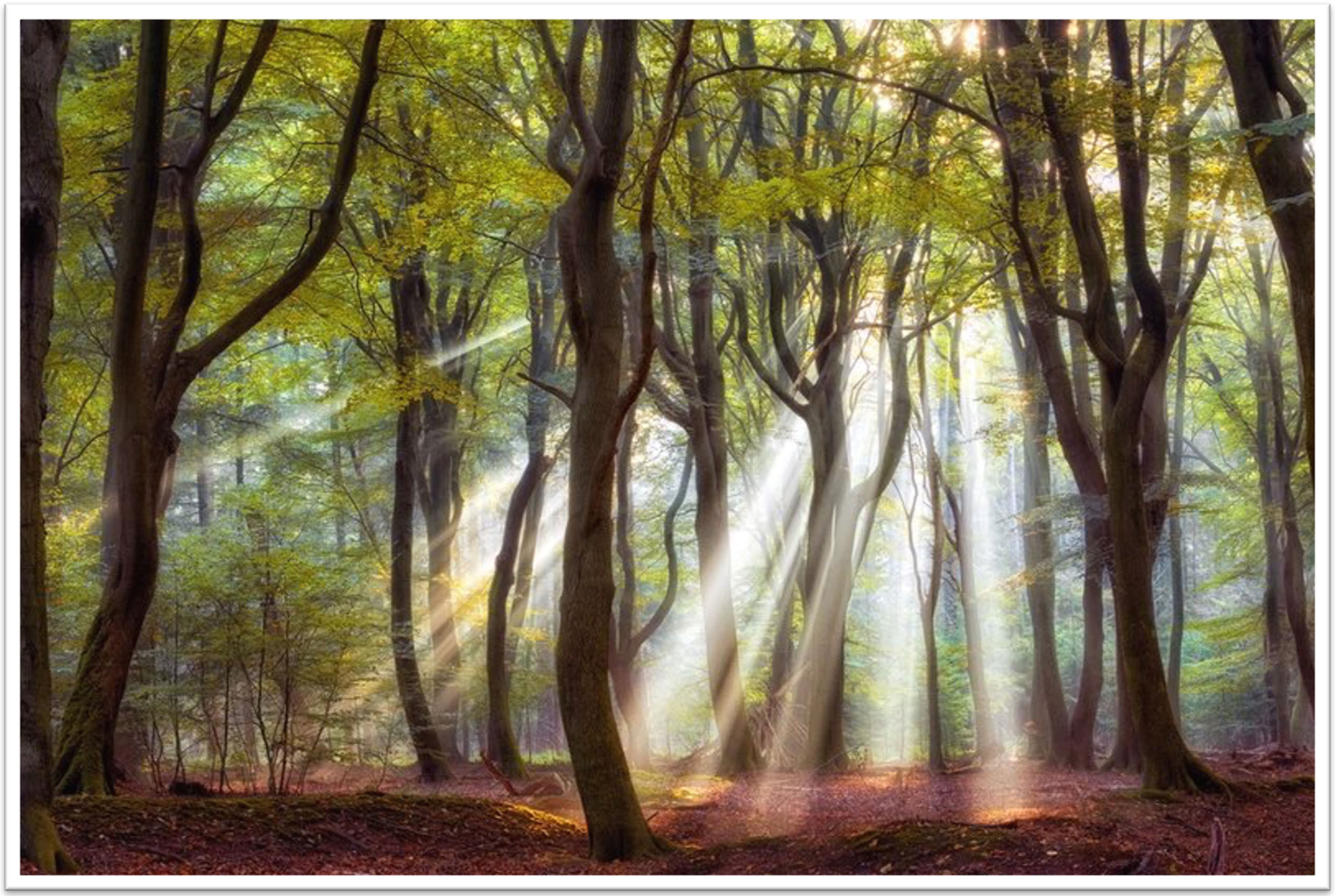
Source: NEON

Multiple Echoes



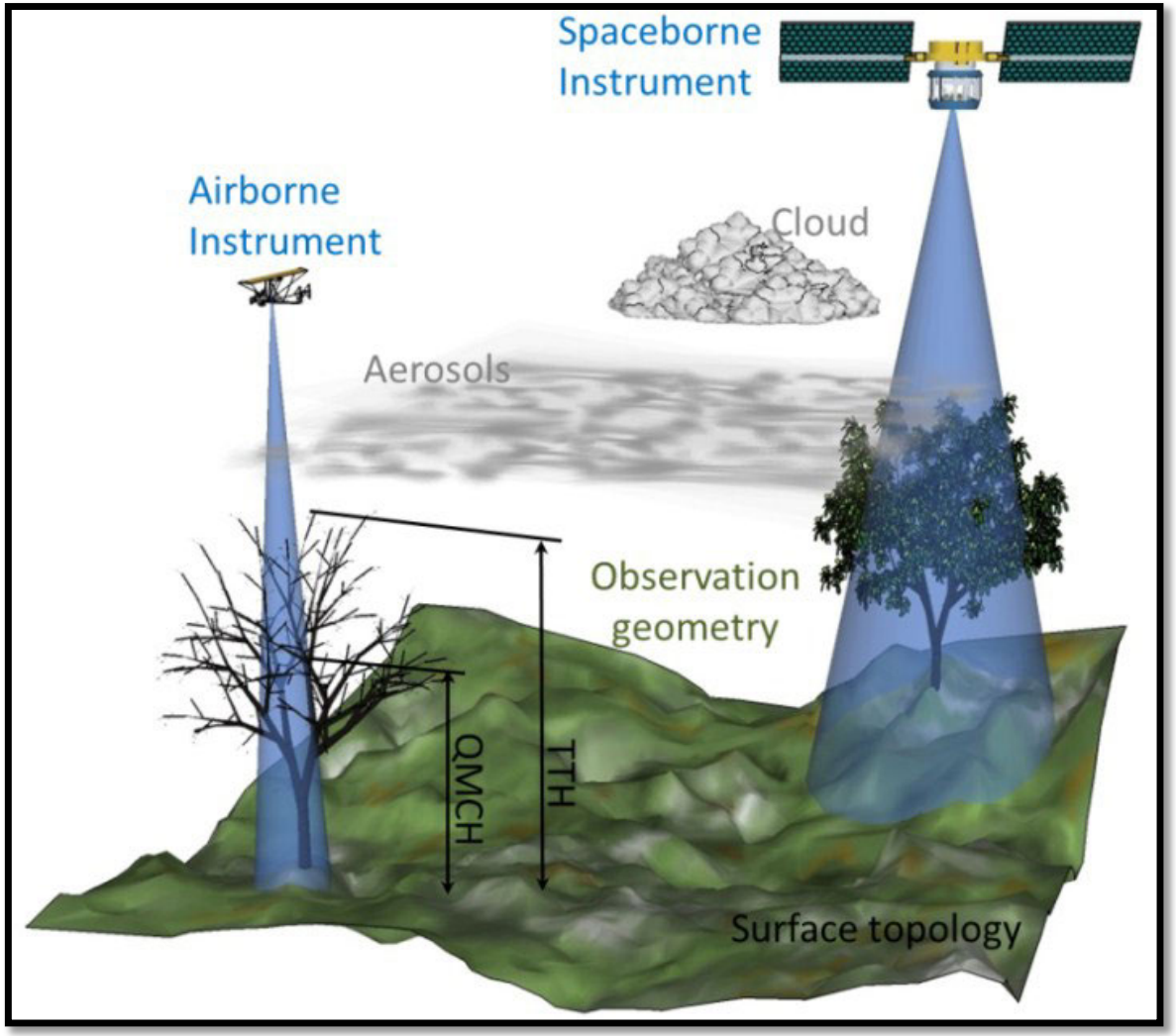
Source: NEON

Penetration Through the Canopy



Source: www.awatrees.com

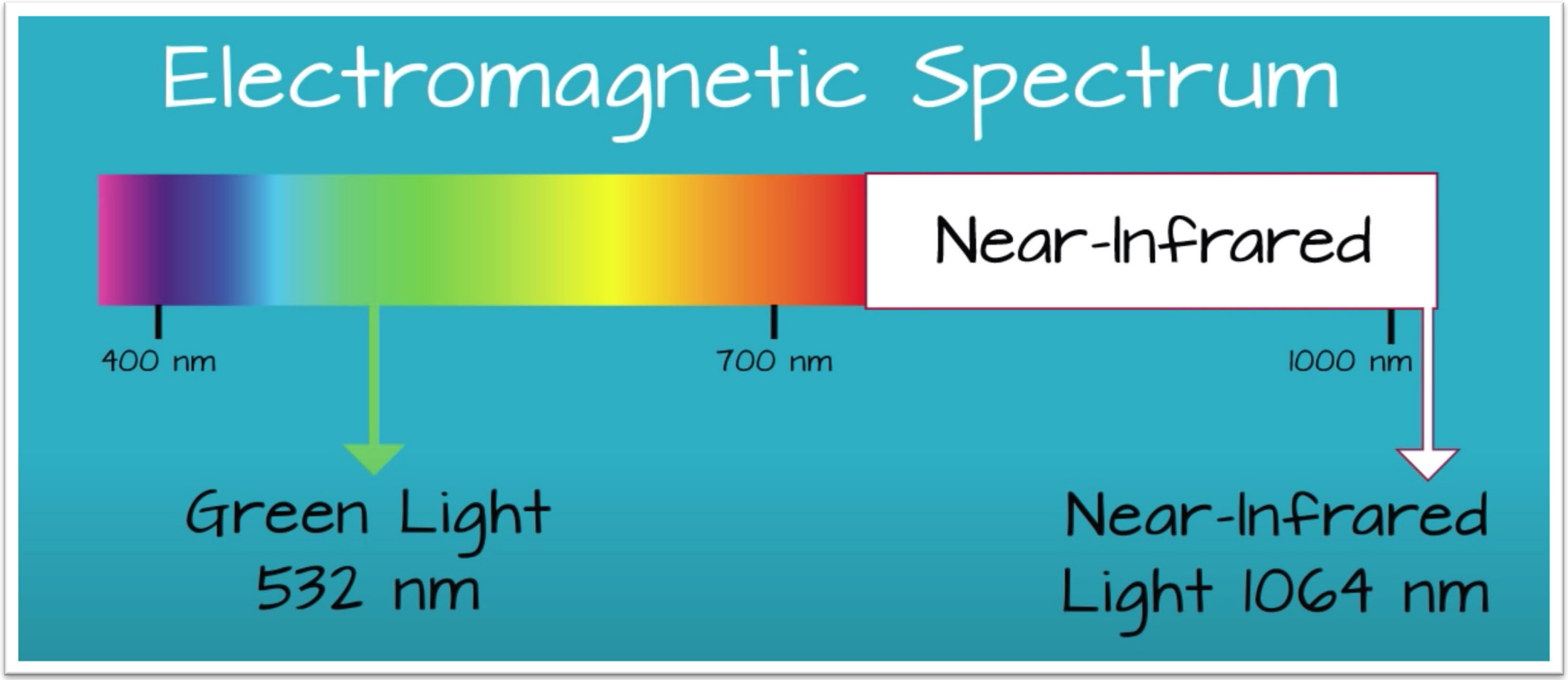
LiDAR Platforms



Source: Shang and Chazette, 2015

LiDAR Wavelength

- LiDARs focused on terrestrial studies operate at either Green or NIR wavelengths.



Source: NEON

LiDAR Detector Modalities

Discrete

- Records individual returns representing the peaks in the waveform curve.
- A discrete system may record 1-5 returns from each laser pulse. A collection of discrete return LiDAR points is known as a LiDAR point cloud.

Full Waveform

- Records the distribution of returned light.
- Data are more complex to process but can contain more information than discrete LiDAR sensors.

Photon Counting

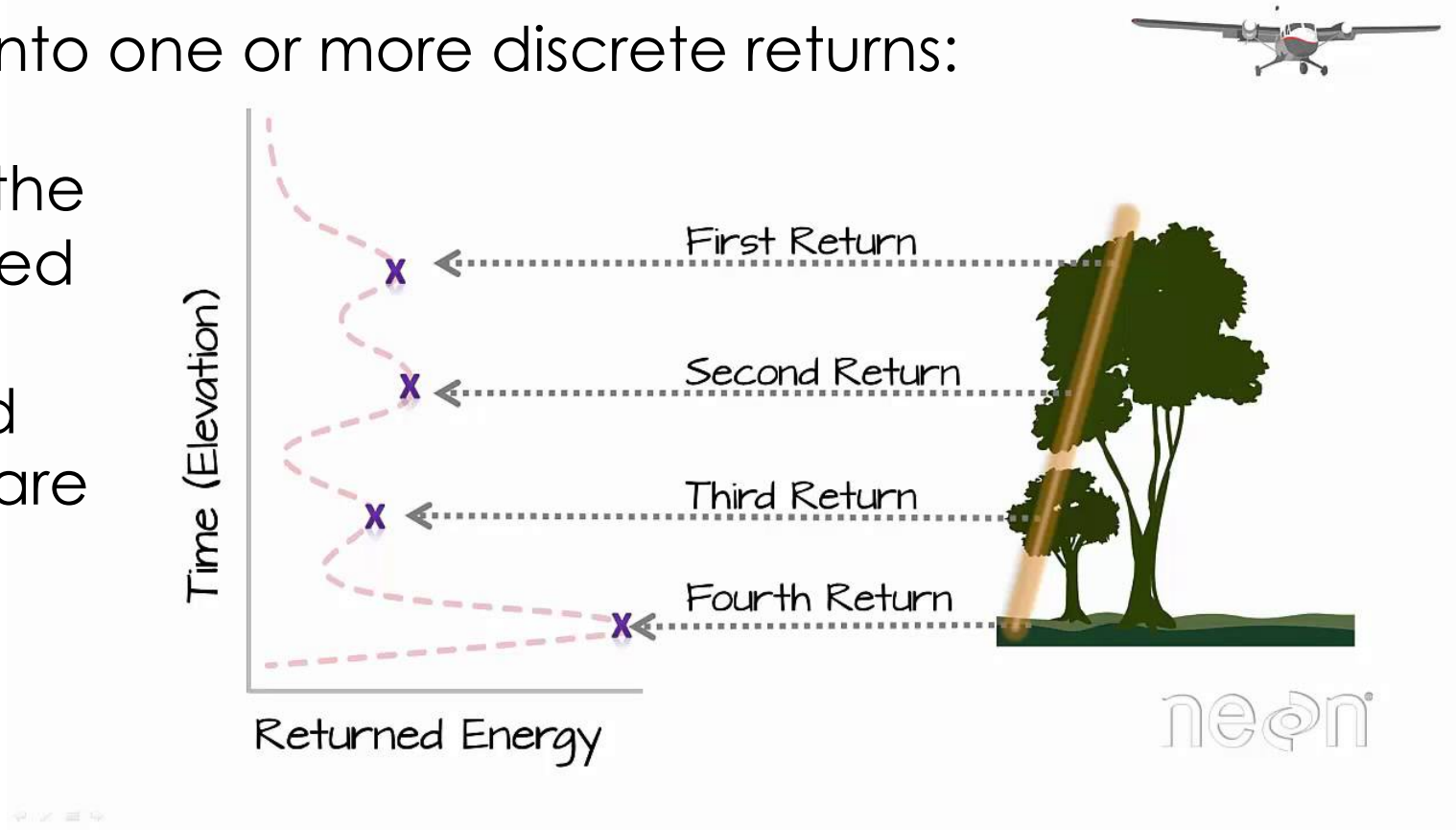
- Records the arrival time associated with a single photon detection occurring anywhere within the vertical distribution of the reflected signal.

Discrete LiDAR

-The pulse represents peaks in energy.

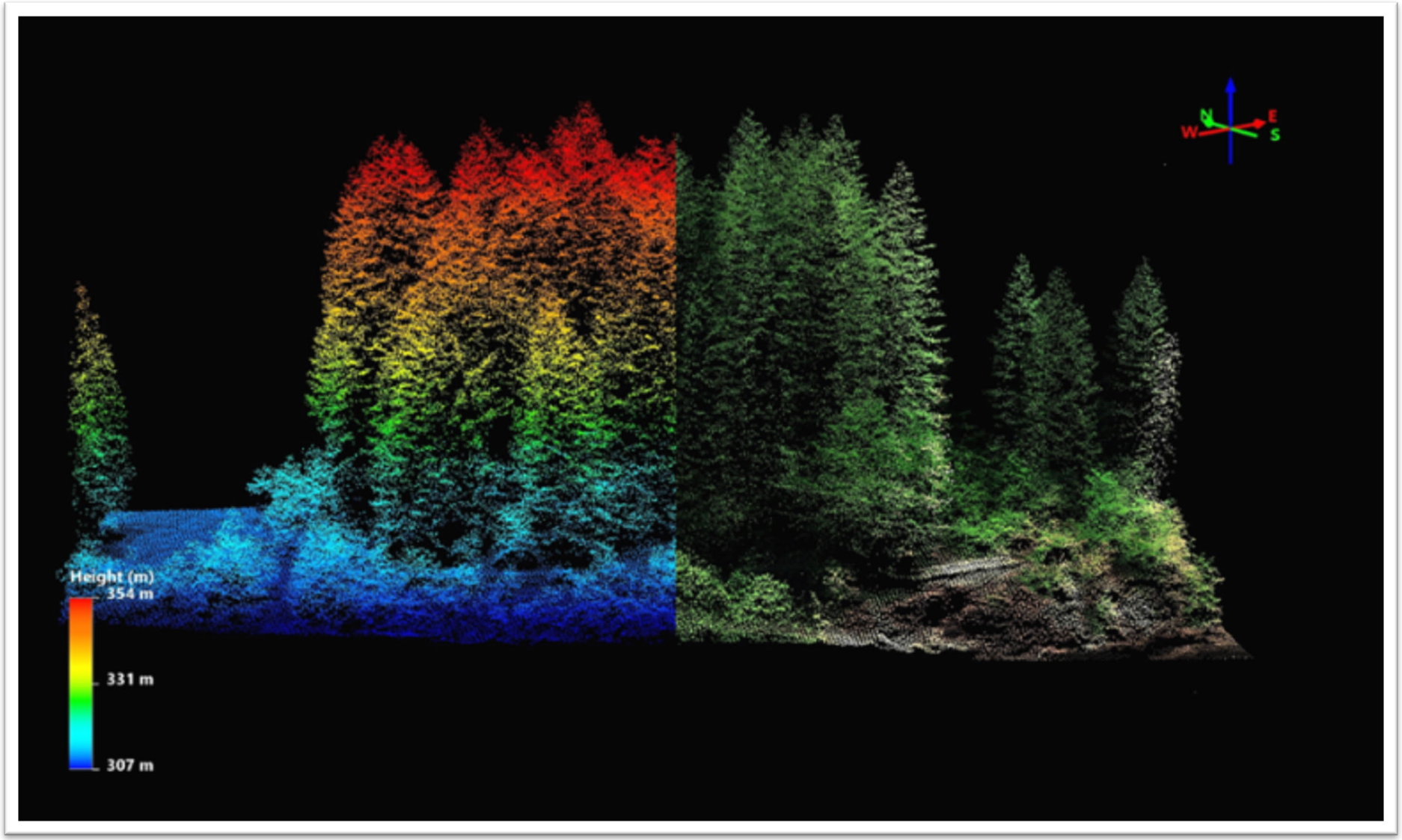
-The returned pulse is classified into one or more discrete returns:

- X, Y, Z intensity
- Returns are recorded when the intensity exceeds a predefined system threshold.
- Multiple returns are recorded (usually 1-5). The last returns are especially important for detecting the ground.



Source: NEON

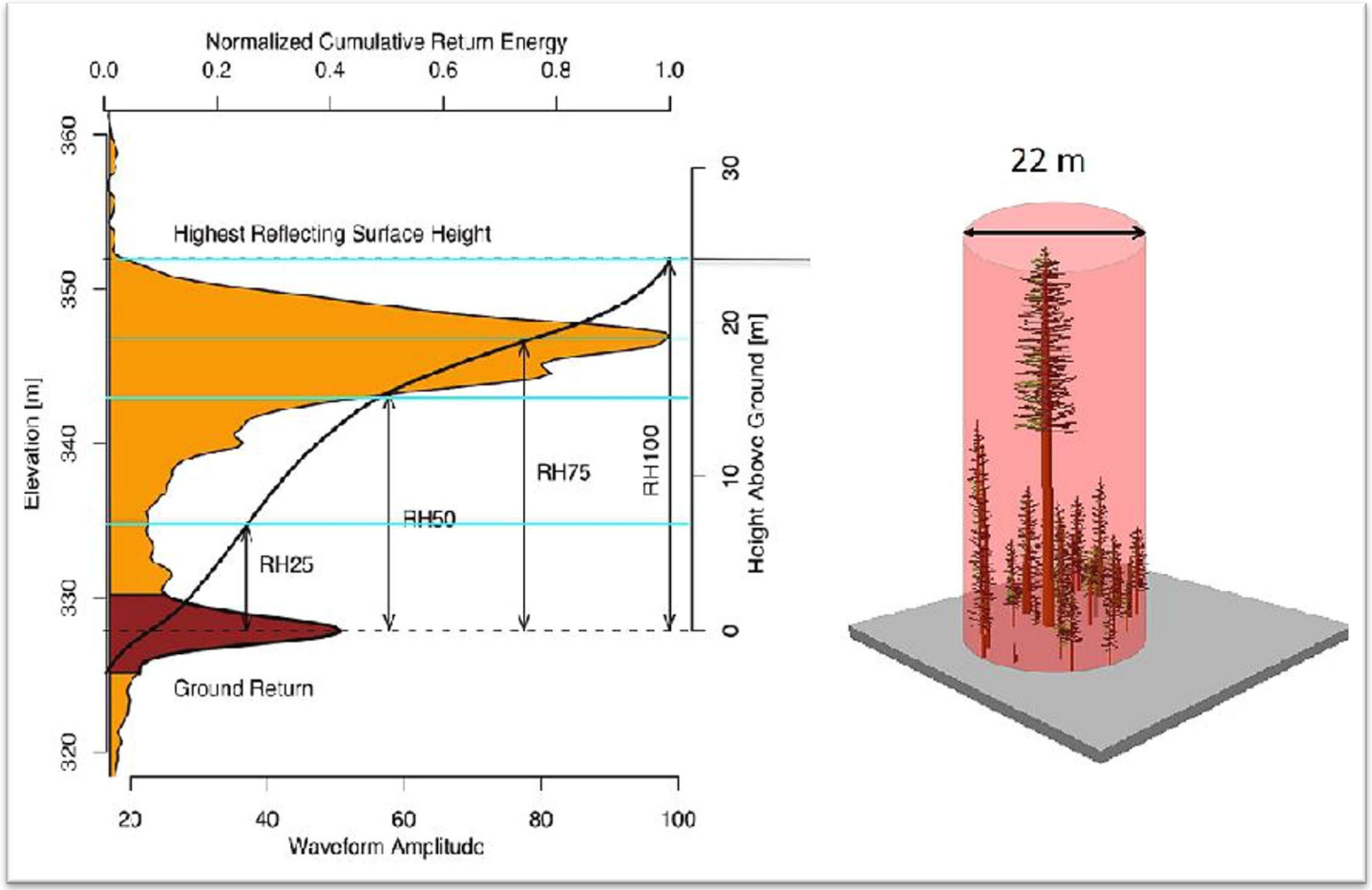
Discrete LiDAR (Cont.)



Source: NEON

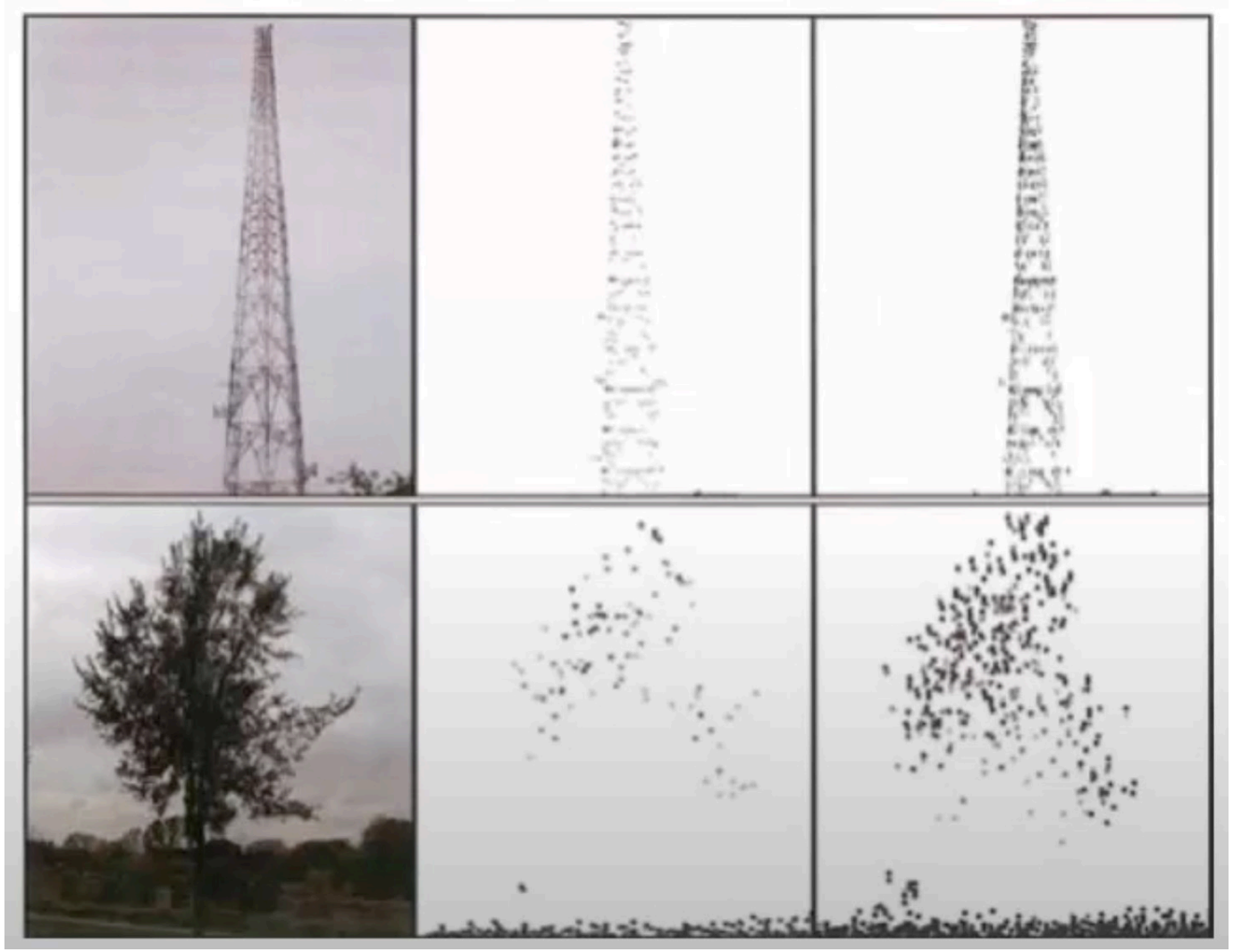
Full Waveform LiDAR

- The waveform is the distribution of the return.
- More useful information can be extracted from the entire waveform than from discrete returns.
- Data processing is complex. Need to apply algorithms to filter the data and extract useful information.



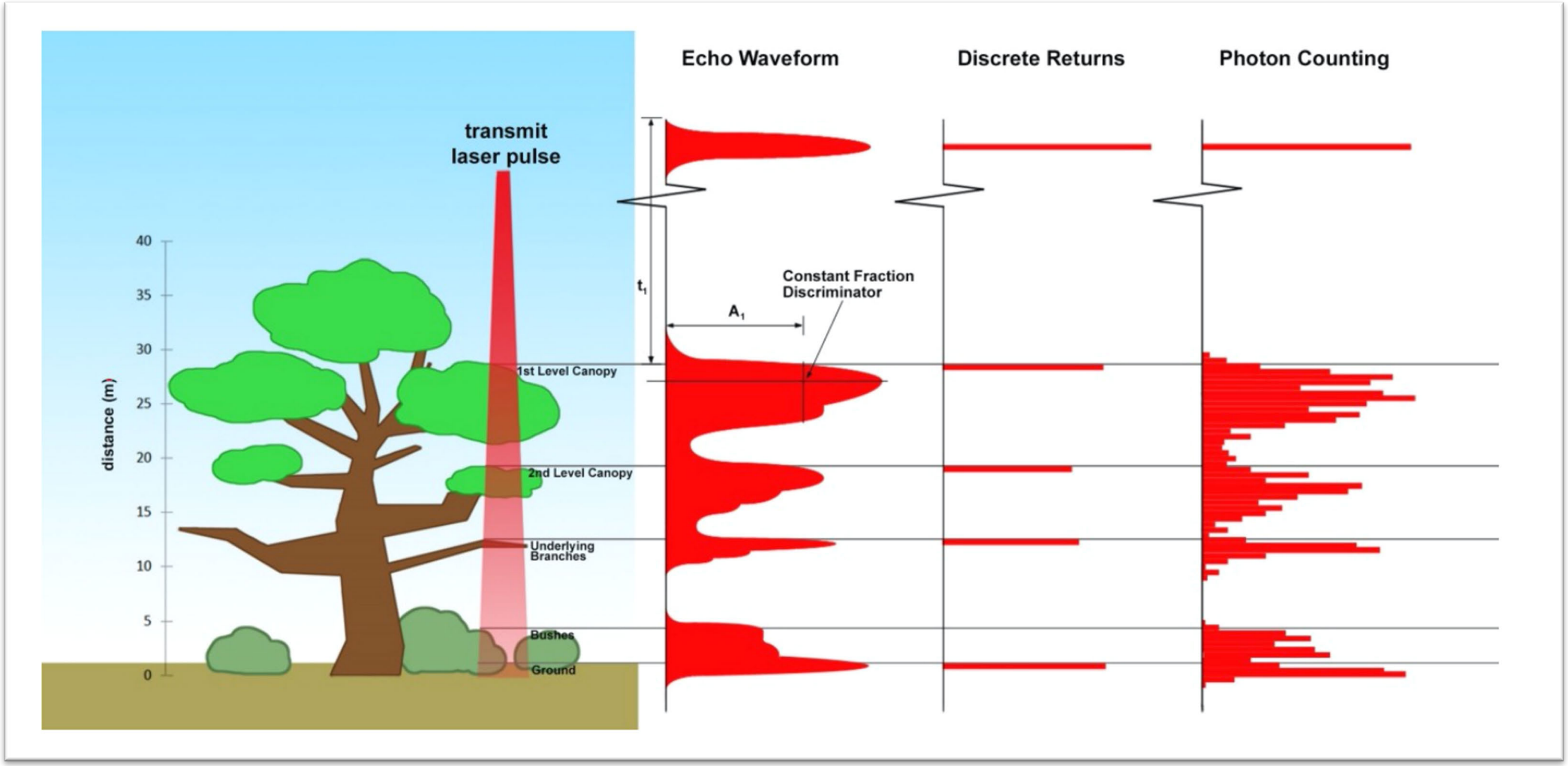
Source: Ralph Dubayah, University of Maryland, College Park

Comparison of Discrete and Full Waveform LiDAR



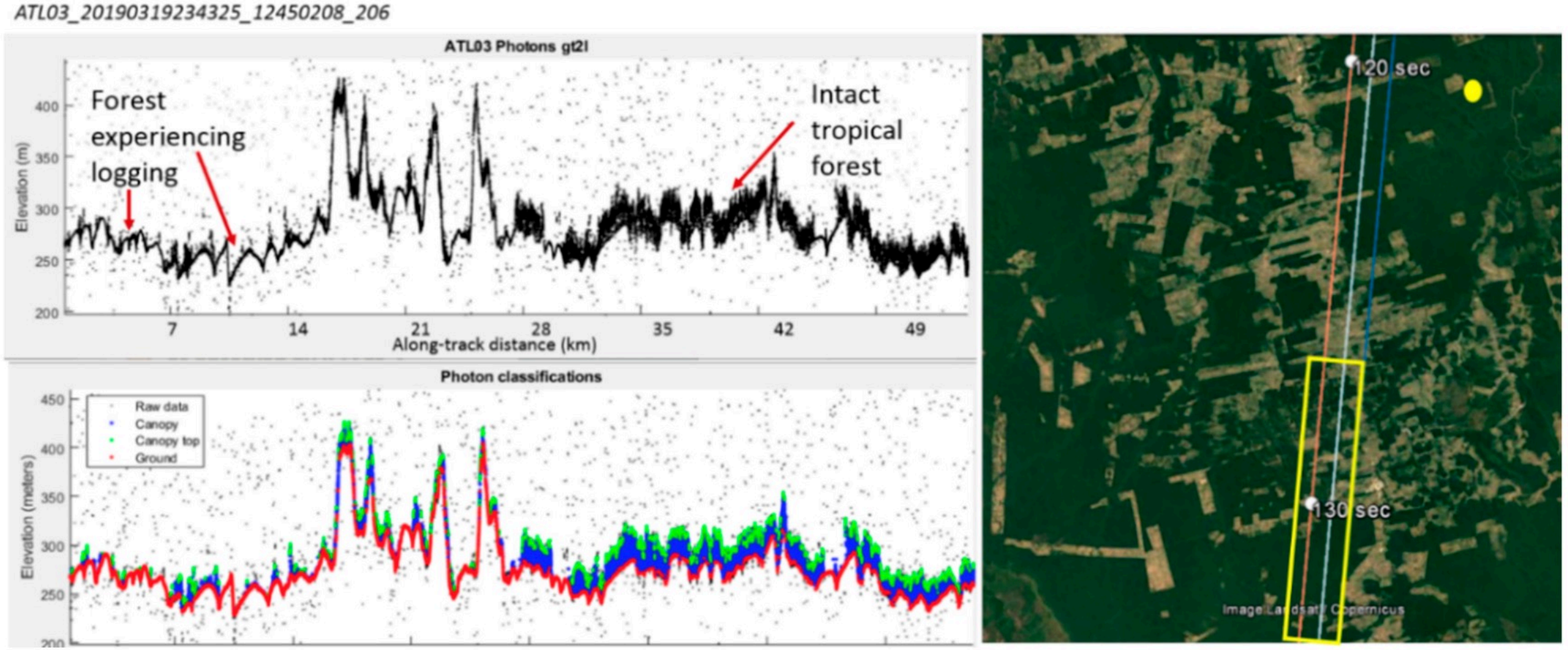
Source: Renslow, 2012

Photon Counting



Source: ICESat-2 ATBD - Adapted from Harding, 2009

Photon Counting (Cont.)



Source: Amy L. Neuenschwander and Lori A. Magruder, 2019.

Processing the Data: Estimating Surface and Canopy Height

- Identify the last hit for every pulse. Assume that the last hit is the ground, however, sometimes it is not (e.g., especially in dense forests).

- Identify the first point or those relevant to the vegetation.

- Calculate relative vegetation height by subtracting the vegetation hits from the ground hits.

- Extrapolate your samples to estimate surface height and canopy height for your region of interest.

Differences Between LiDAR and Radar

Lidar

- Optical Frequencies: Near IR and Green (wavelengths 532 and 1064 nm)

- High frequency and focused beam provide high spatial resolution

- Limited to clear atmospheric conditions. Can operate day/night.

Radar

- Microwave Frequencies: Wavelengths ~100,000 times longer than NIR

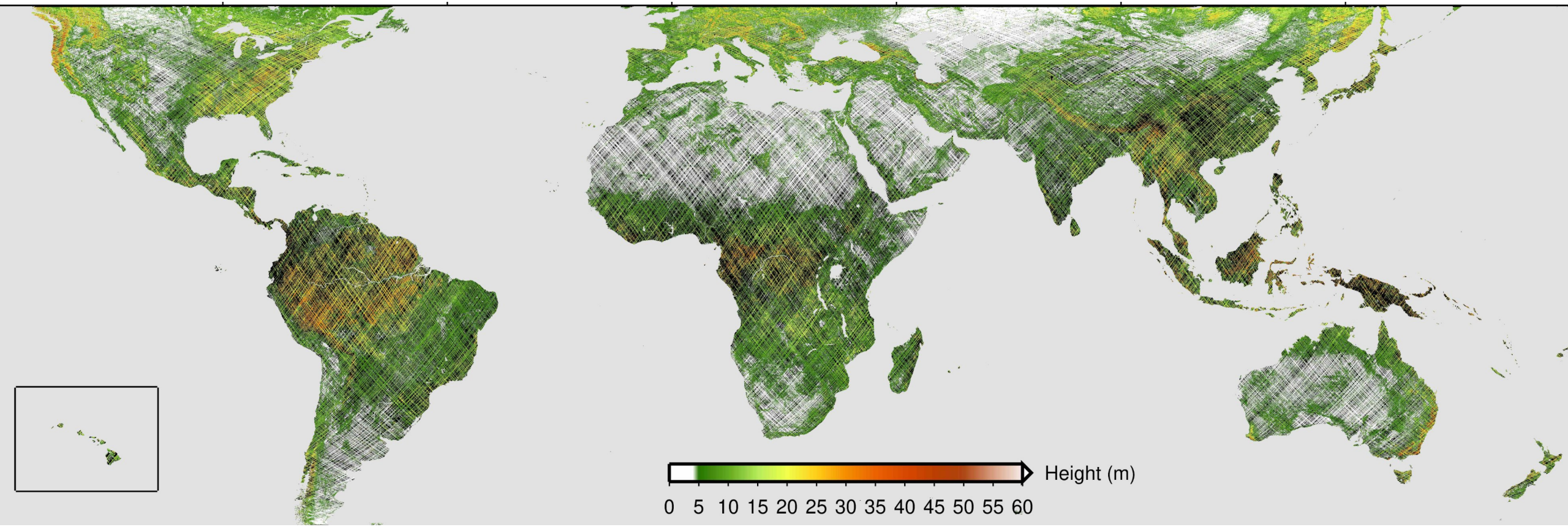
- Beam width and antenna size (even synthesized) limit the spatial resolution

- Can operate under almost any type of weather condition. Can operate day/night.

LiDAR Applications

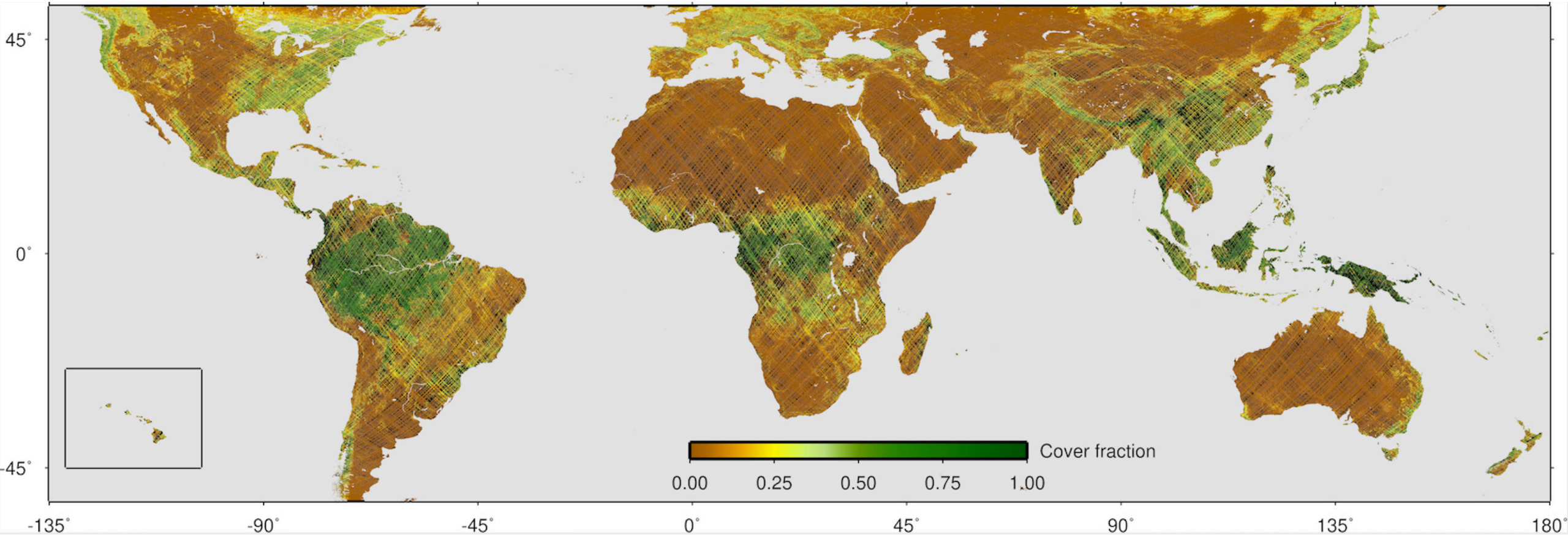
- Fires - Vegetation Loss
- Habitat Characterization (Structural and Vertical Components)
- Carbon Storage
- Forest Inventory
- Changes in Surface Deformation

Vegetation Height



Source: GEDI

Cover Fraction



Source: GEDI

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