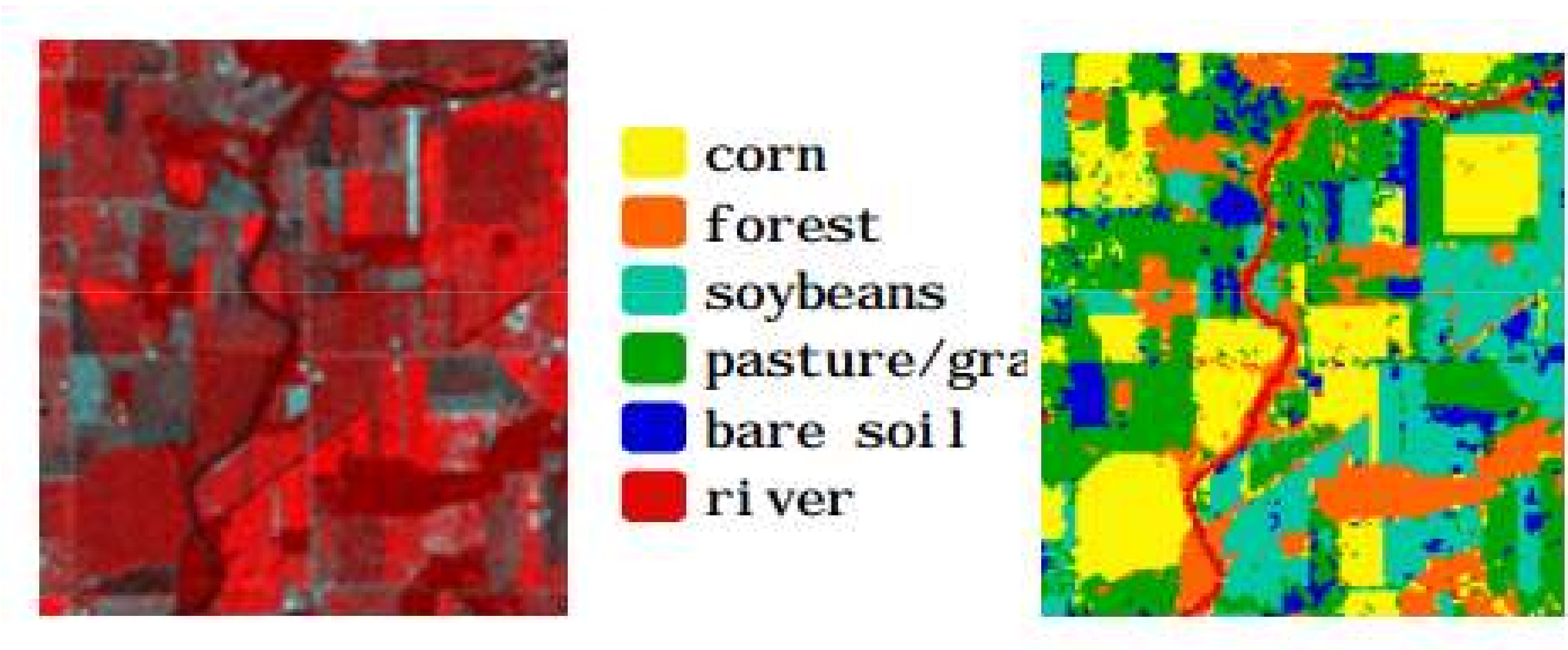
Hyperspectral Image Analysis

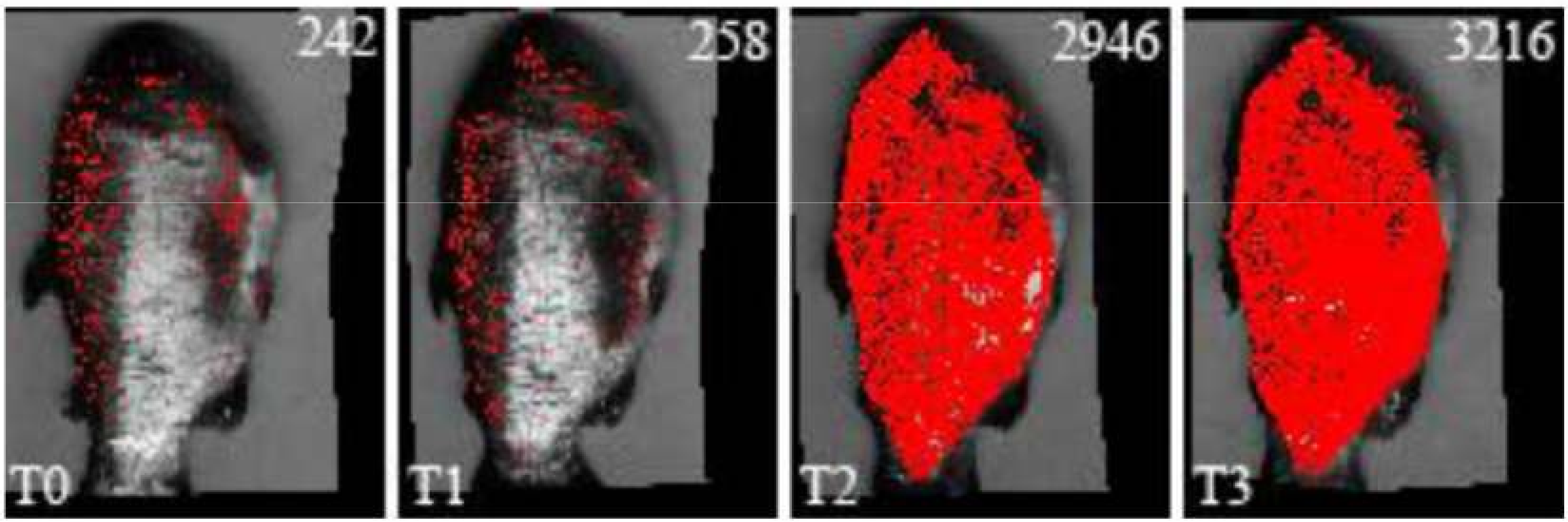
An outline of the process of extracting useful information from a hyperspectral cube is as follows:

- Acquisition of raw hyperspectral cube.
- Data preprocessing, including normalization, image calibration, and correction for scattering by the atmosphere.
- Dimensionality reduction (e.g., principal components analysis).
- Feature extraction.
- Spectral signature analysis (e.g., comparison to a database of known signatures).

Thematic map derived from the image

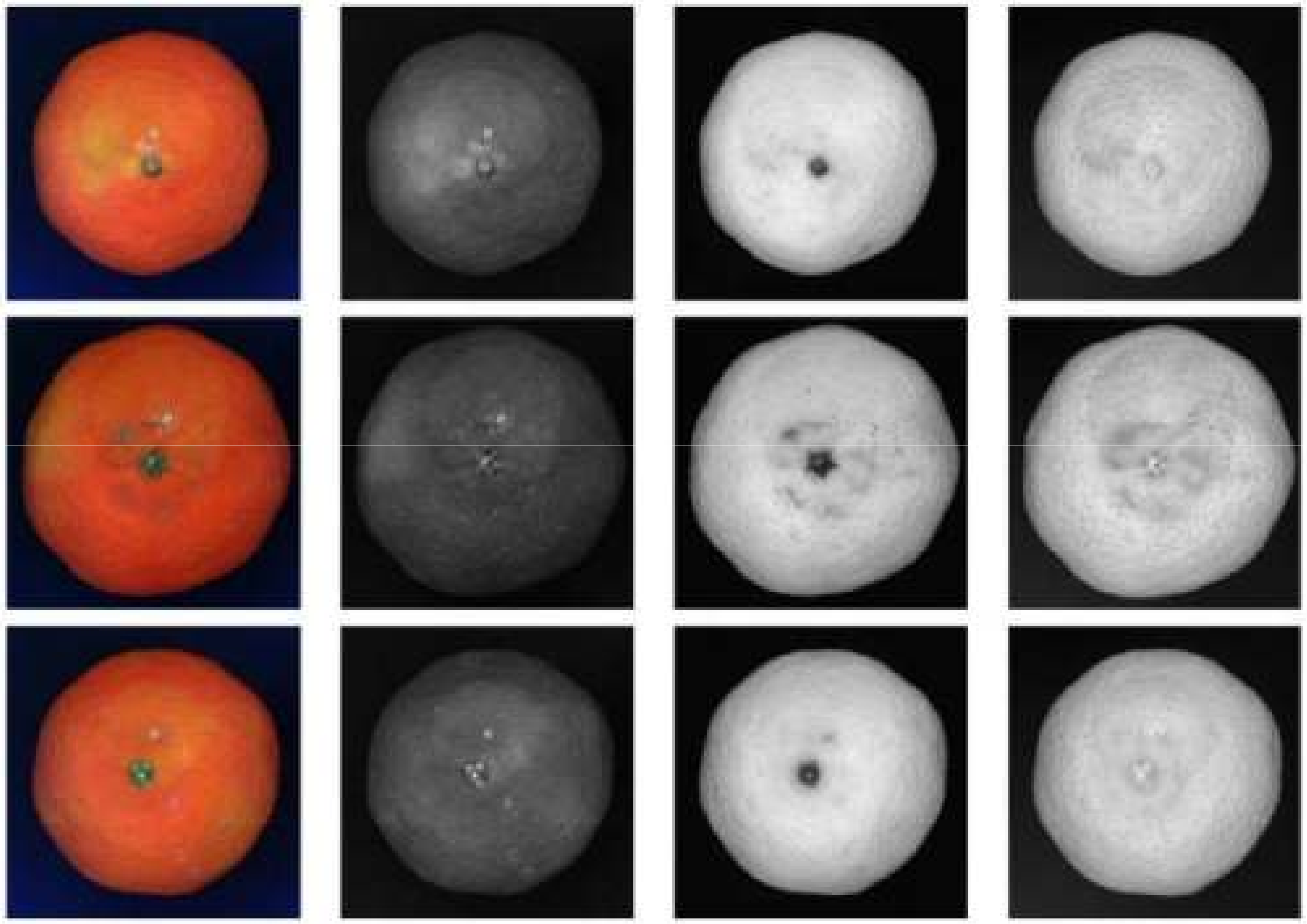


Using Hyperspectral Images as a method to provide quantitative evaluation of the fresh of food.



Example of Fish freshness classification: Pixels in red are those classified as "non-fresh".

Fruit Inspection



RGB =550 nm =660 nm =950 nm

RGB and monochromatic images (550 nm, 660 nm and 950 nm) of various mandarins

LiDAR: What and Why?

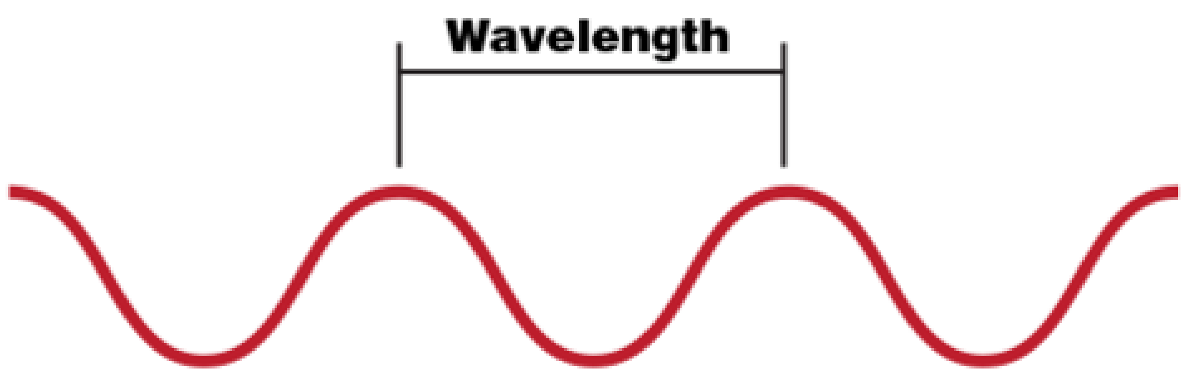
- LiDAR stands for Light Detection and Ranging, commonly known as ***Laser Radar***
- LIDAR refers to a remote sensing technology that emits intense, focused beams of light (laser) and measures the time it takes for the reflections to be detected by the sensor. This information is used to compute ranges, or distances, to objects.

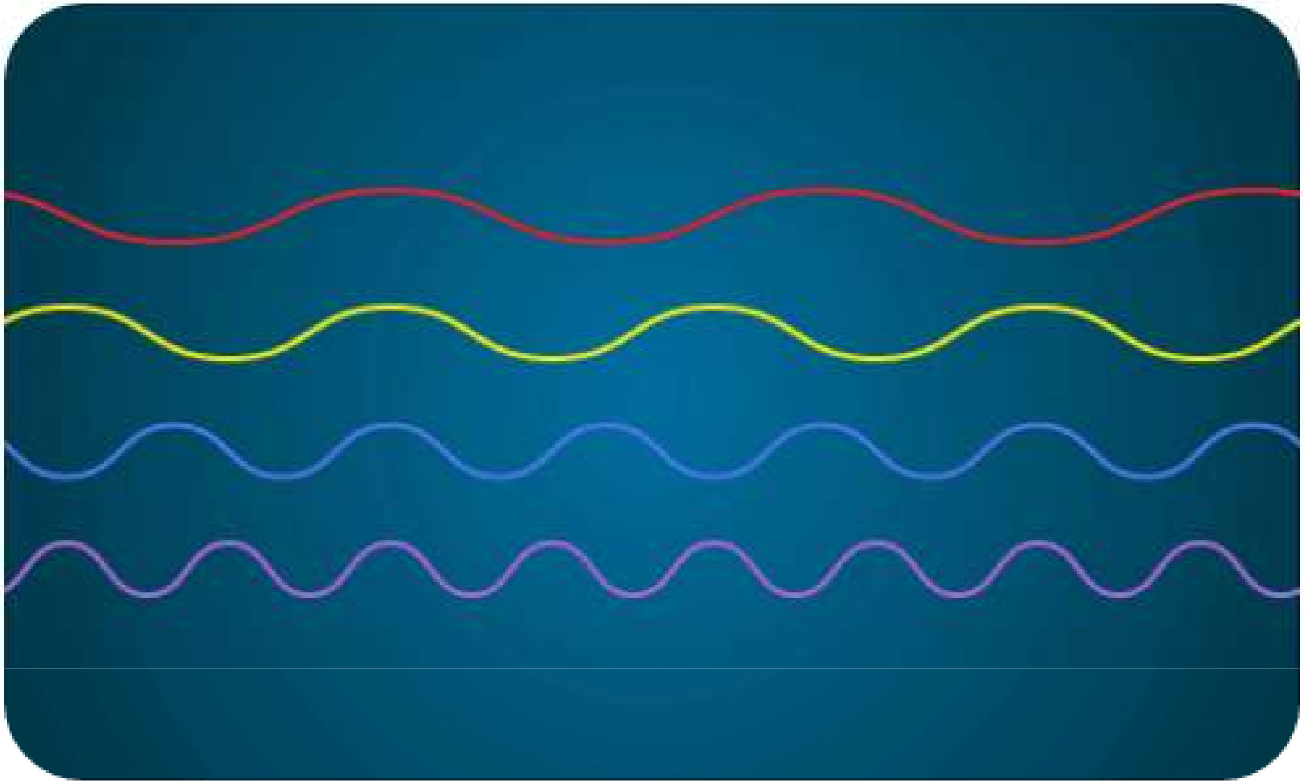
Laser

- Laser stand for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. A laser is an unusual light source. It is quite different from a light bulb or a flash light. Lasers produce a very narrow beam of light. This type of light is useful for lots of technologies and instruments—even some that you might use at home!

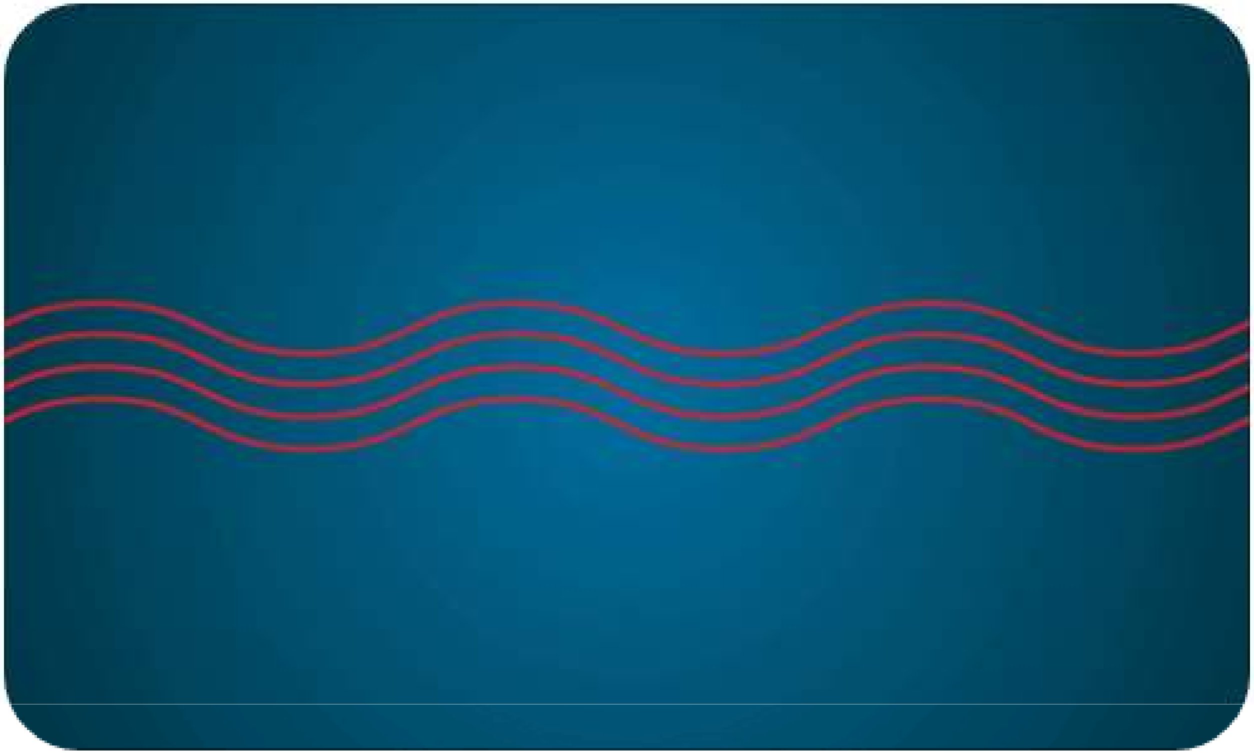
Laser

- Light travels in waves, and the distance between the peaks of a wave is called the **wavelength**.

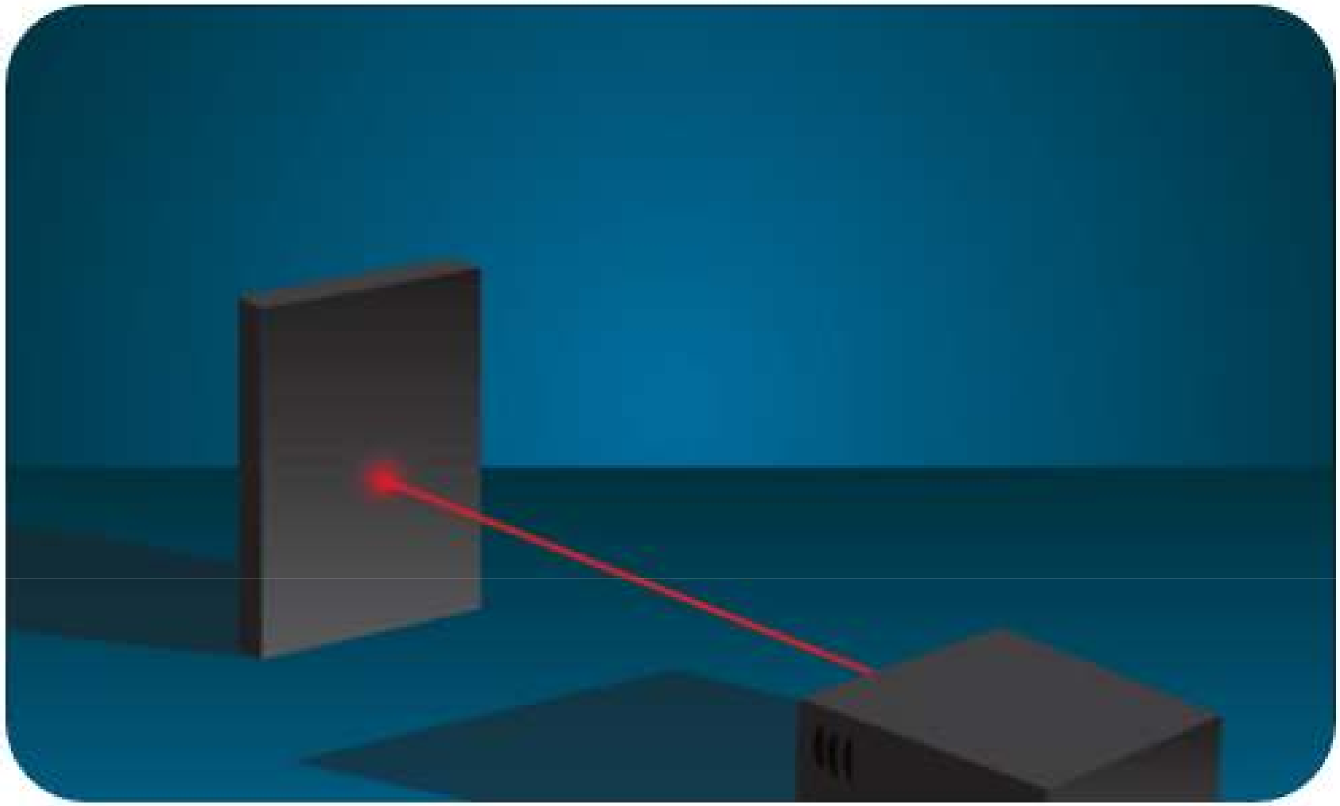




Each color of light has a different wavelength. For example, blue light has a shorter wavelength than red light. Sunlight—and the typical light from a lightbulb—is made up of light with many different wavelengths. Our eyes see this mixture of wavelengths as white light.

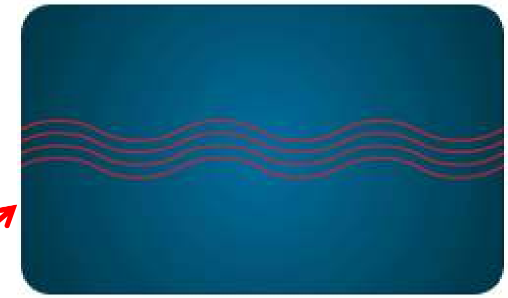


- A laser is different. Lasers do not occur in nature. However, we have figured ways to artificially create this special type of light. Lasers produce a narrow beam of light in which all of the light waves have very similar wavelengths. The laser’s light waves travel together with their peaks all lined up, or **in phase**. This is why laser beams are very narrow, very bright, and can be focused into a very tiny spot.
- The laser technology was invented by **Charles Towne**s and **Arthur Schawlow** in Bell Labs in 1958.



Because laser light stays focused and does not spread out much (like a flashlight would), laser beams can travel very long distances. They can also concentrate a lot of energy on a very small area.

LiDAR: How?

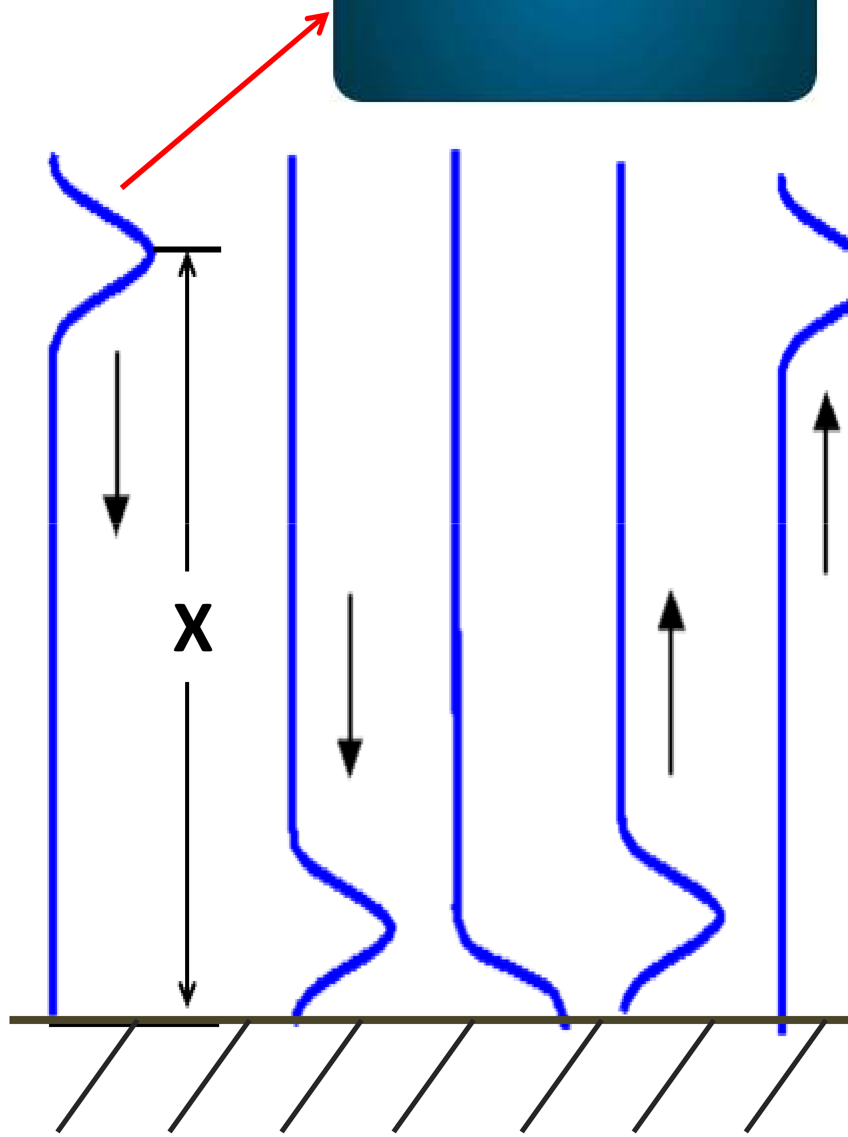


Each time the laser is pulsed:

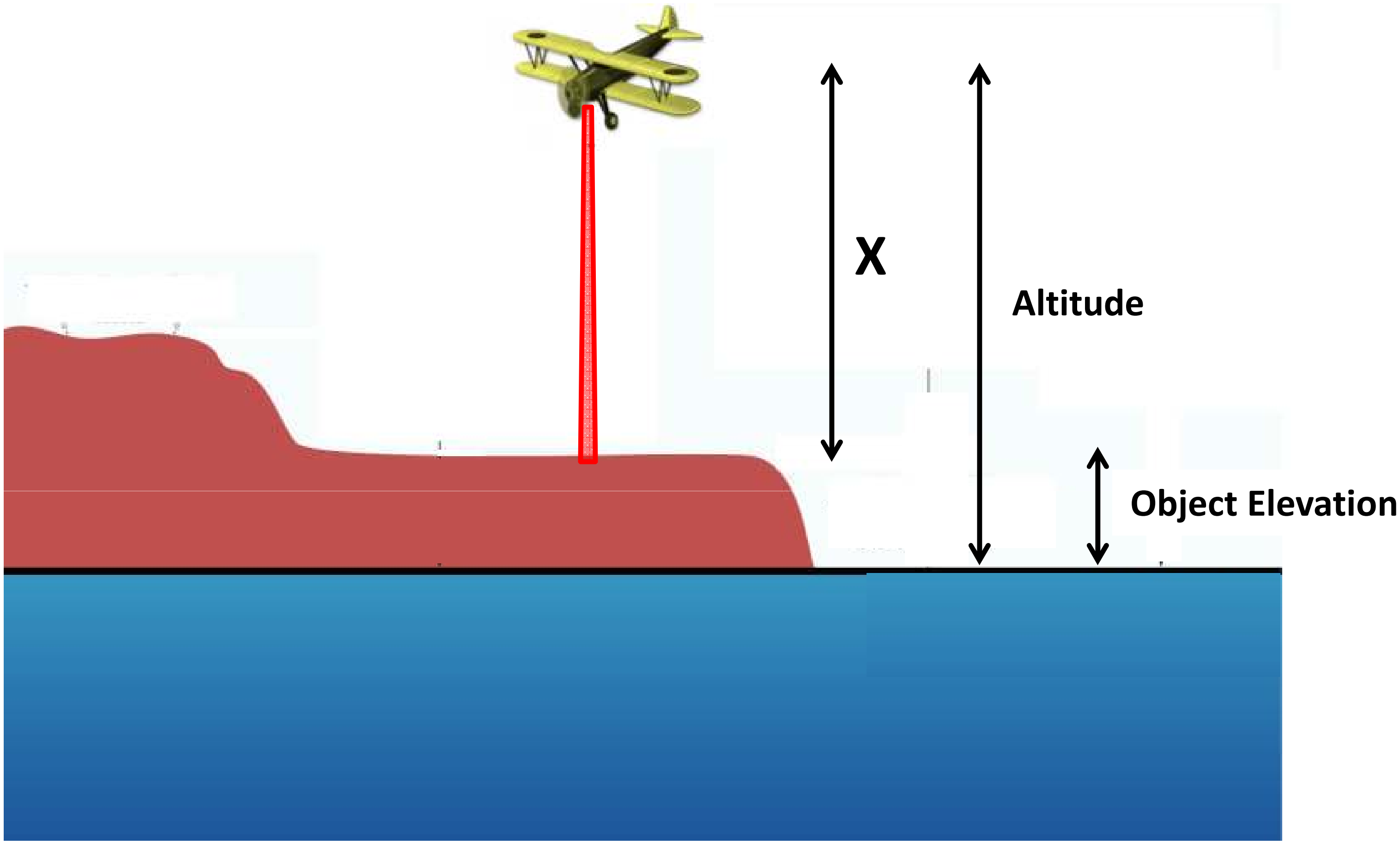
- Laser generates an optical pulse
- Pulse is reflected off an object and returns to the system receiver
- High-speed counter measures the time from the start pulse to the return pulse
- Time measurement is converted to a distance

$$X = C * \frac{T}{2}$$

T: Total travel time
X:Distance from sensor to object
C: Light Speed

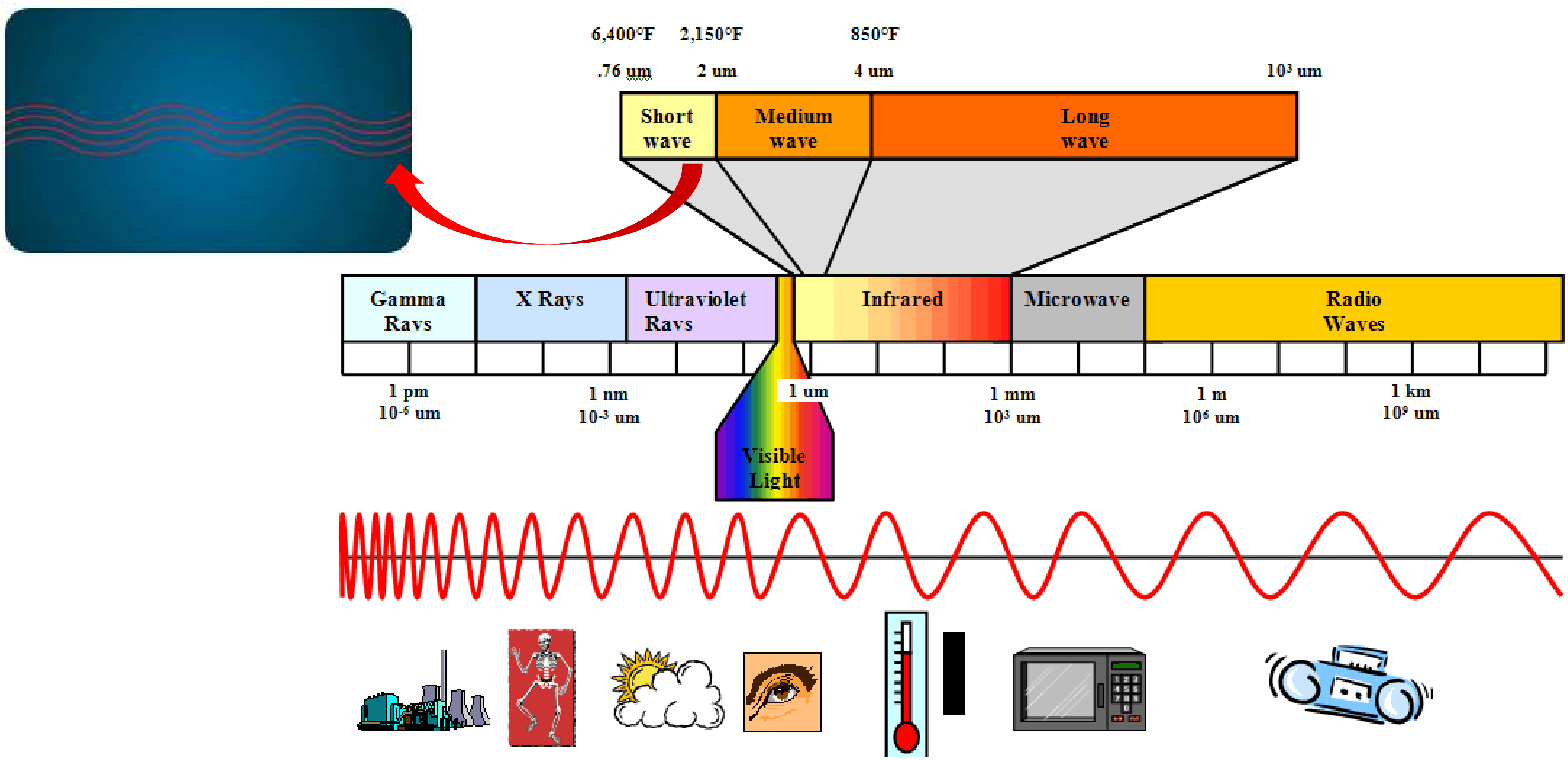


LiDAR: How?



$$X = C * \frac{T}{2} \qquad Object\ elevation = Alttitude - Dis\tan ce$$

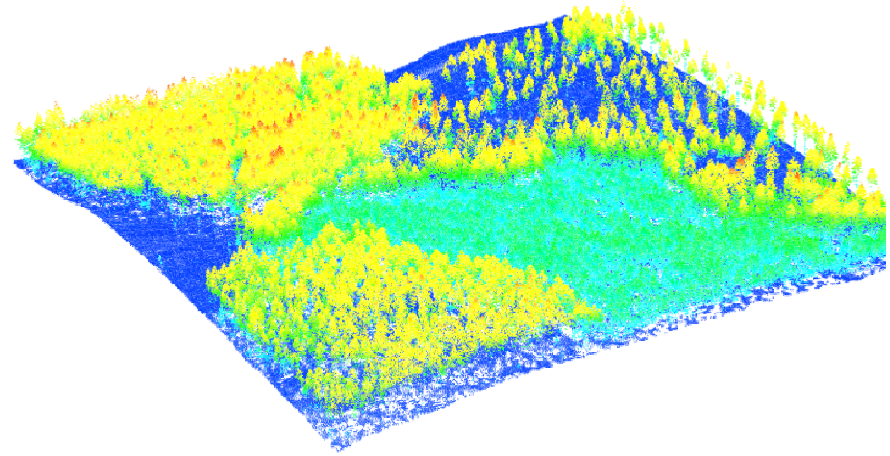
T: Total travel time
X:Distance from sensor to object
C: Light Speed



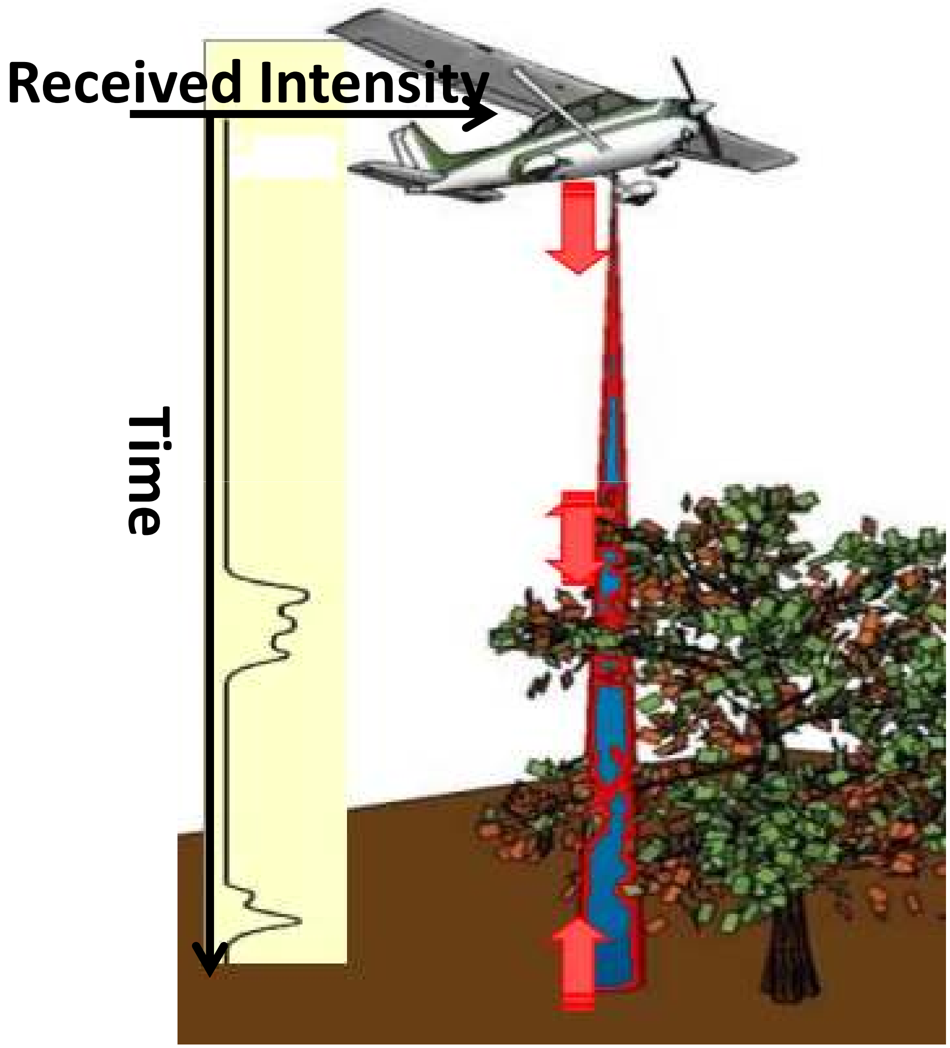
- In theory, any light source can be used to create a LIDAR instrument.

  Near-Infrared wavelength is used by most airborne terrestrial LIDAR systems . The most common laser is the solid-state laser which can produce radiation at an IR wavelength of 1064 nm (Easily absorbed at the water surface).

-Combination of scanning mirror and moving platform produces a 2D field of range measurements to recover a 3D surface.

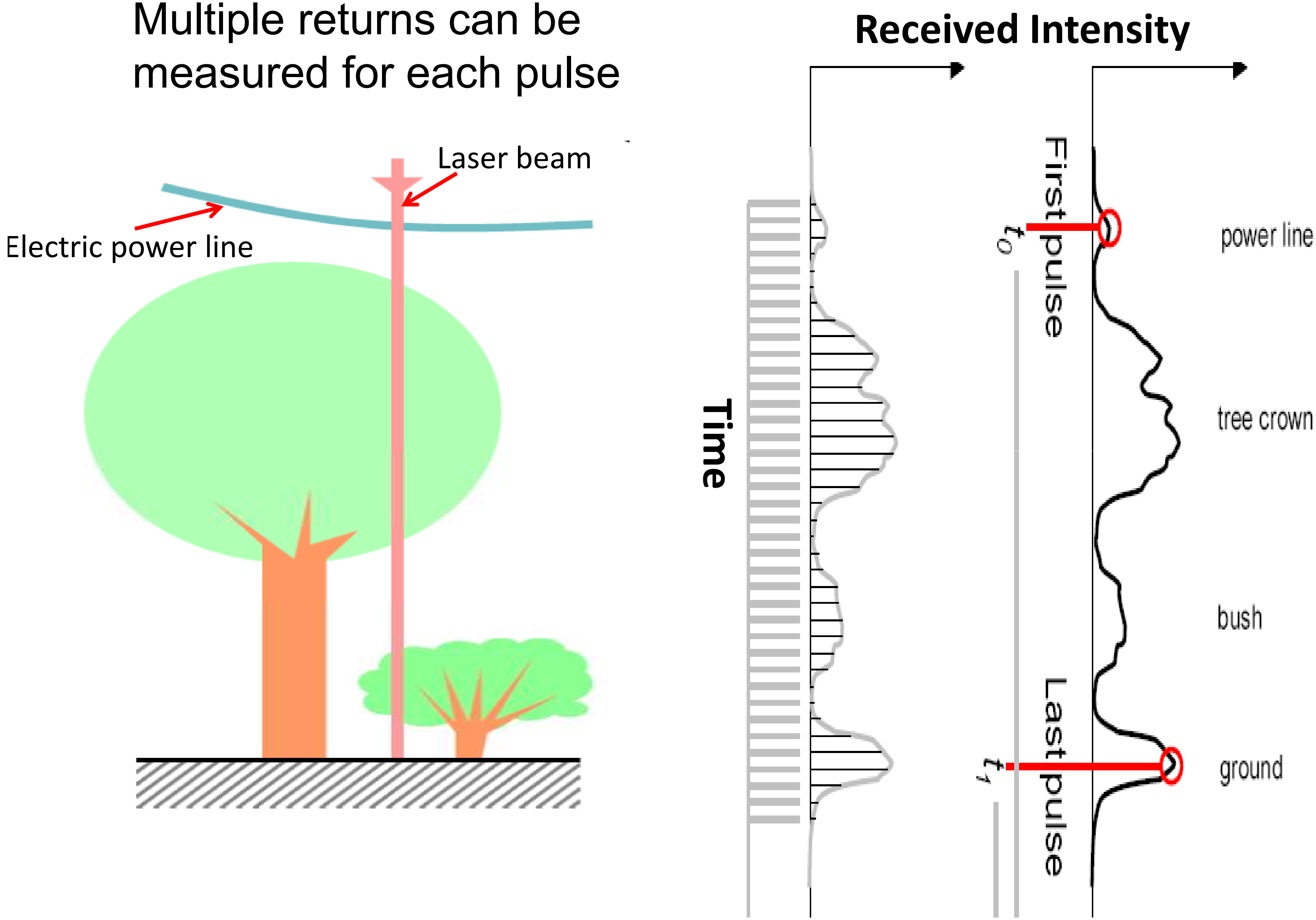


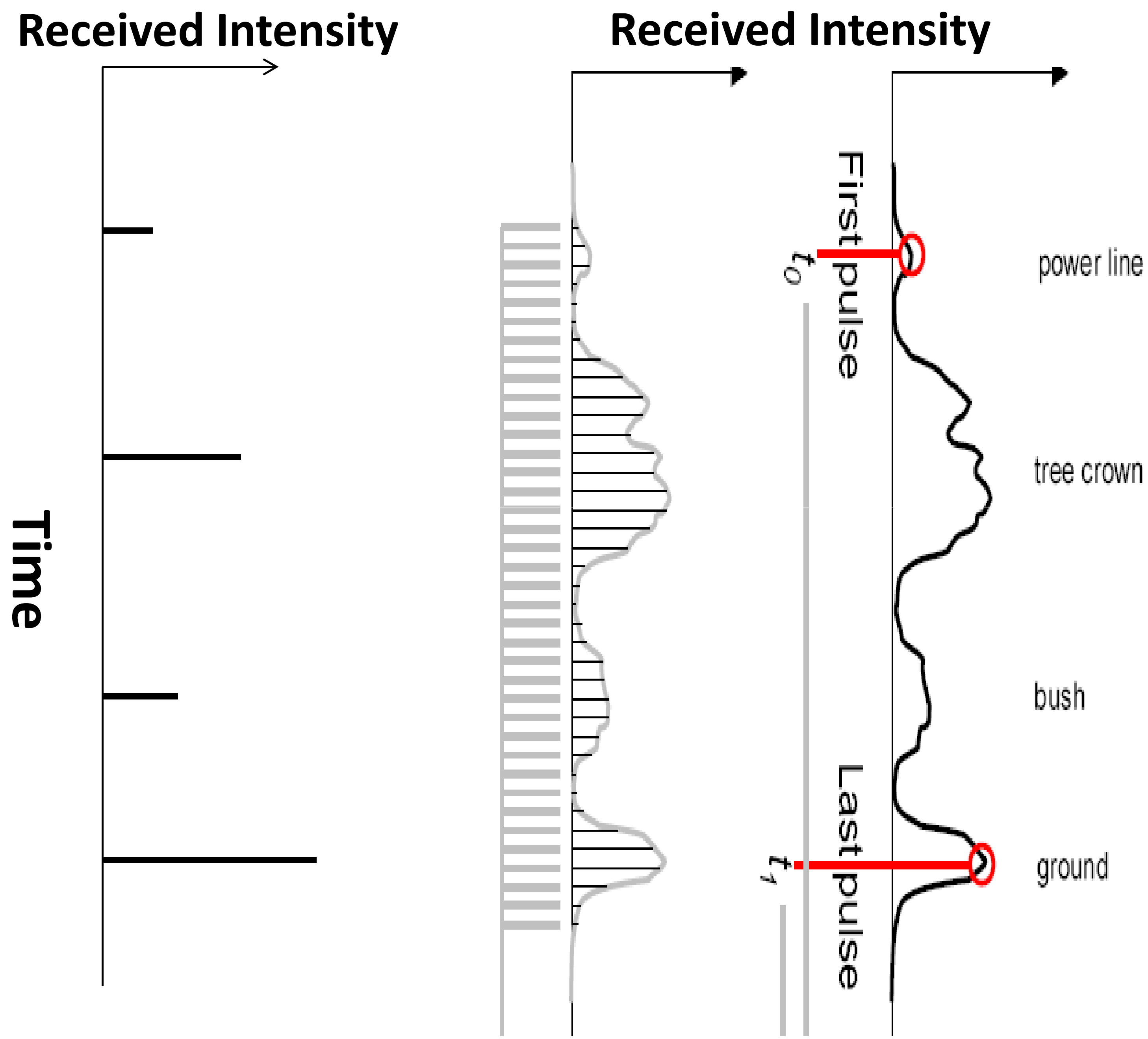
-The resulting measurements are represented as a point cloud with information of land surface altitude.



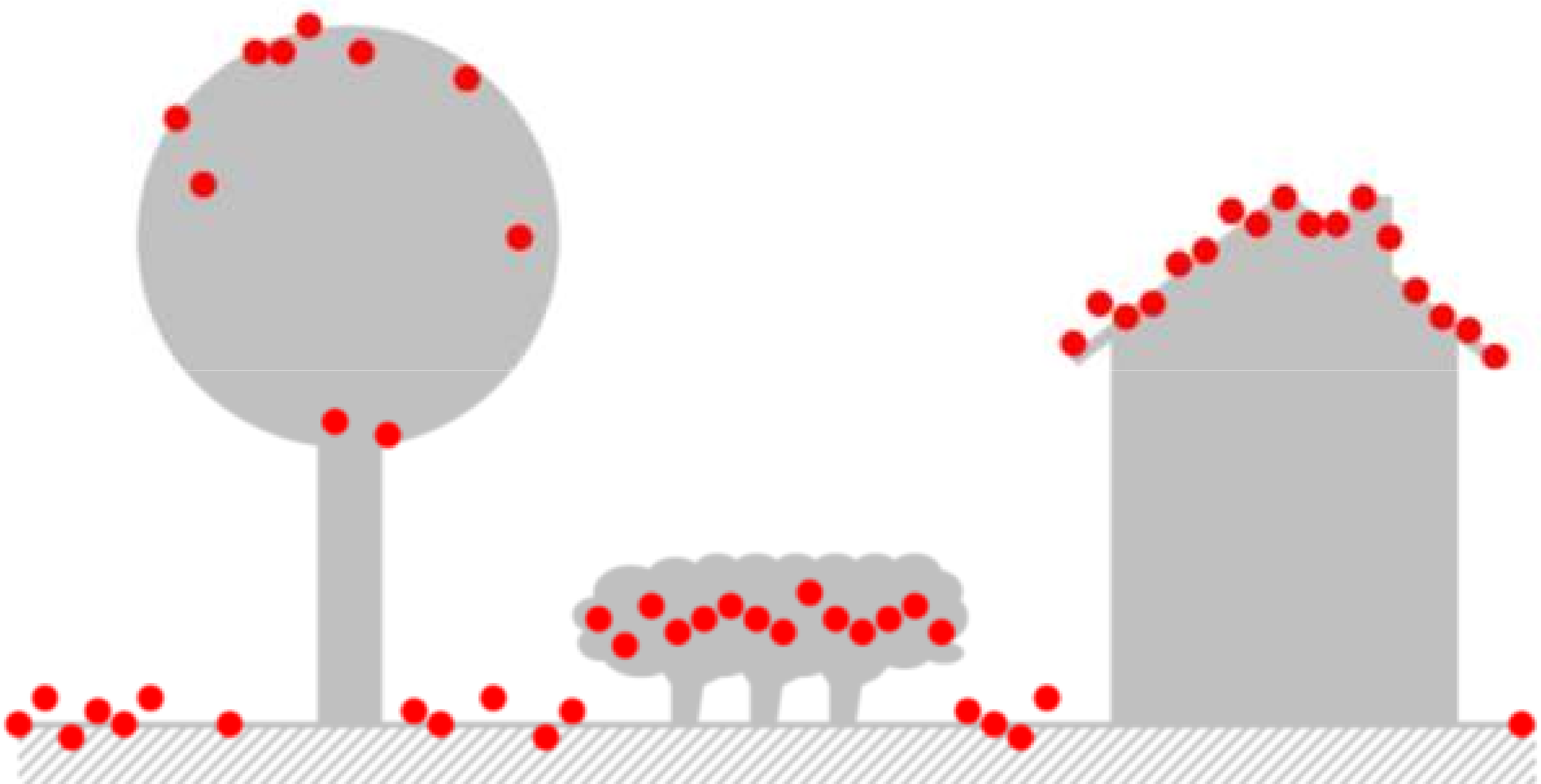
Multiple returns can be measured for each pulse

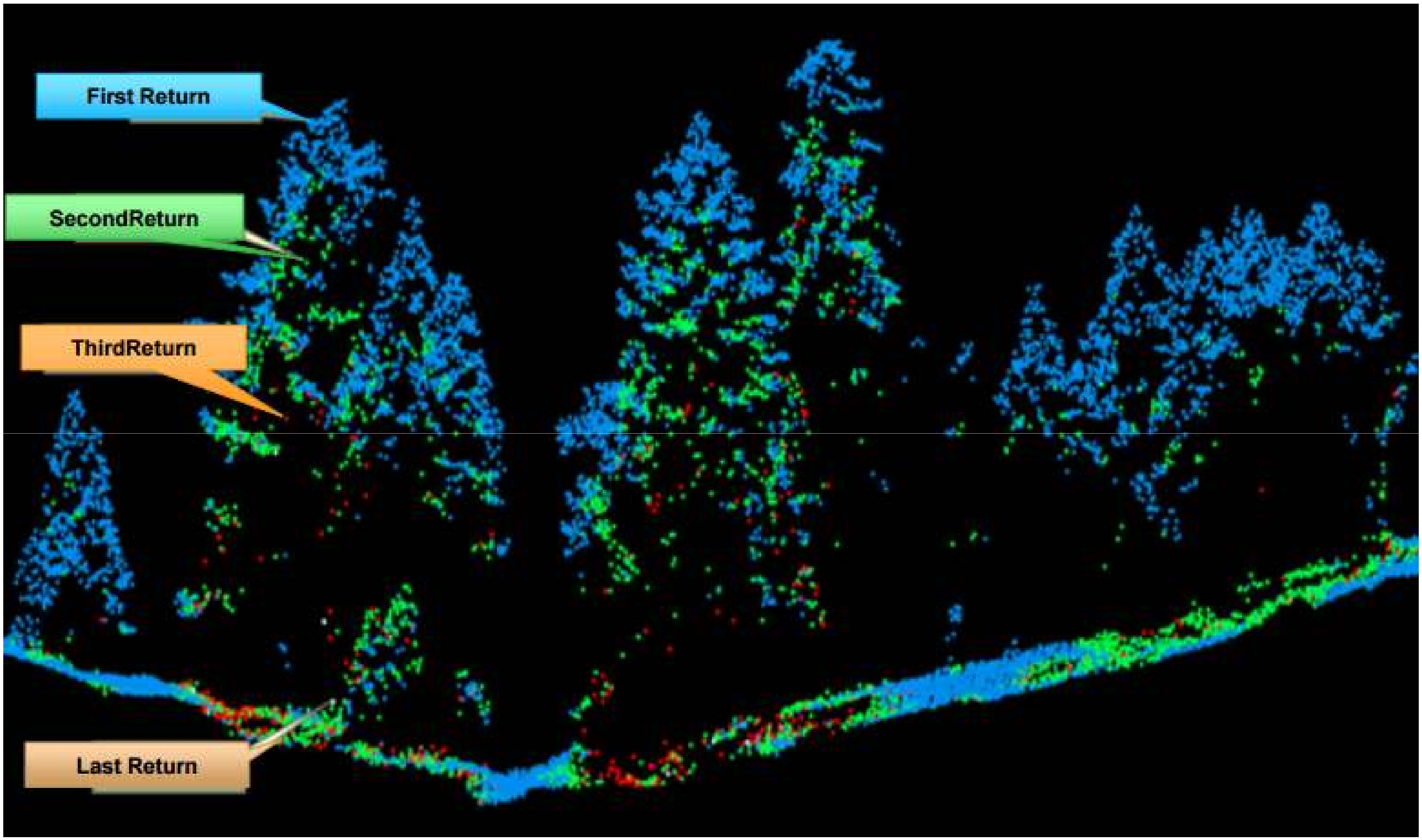
Multiple returns can be measured for each pulse

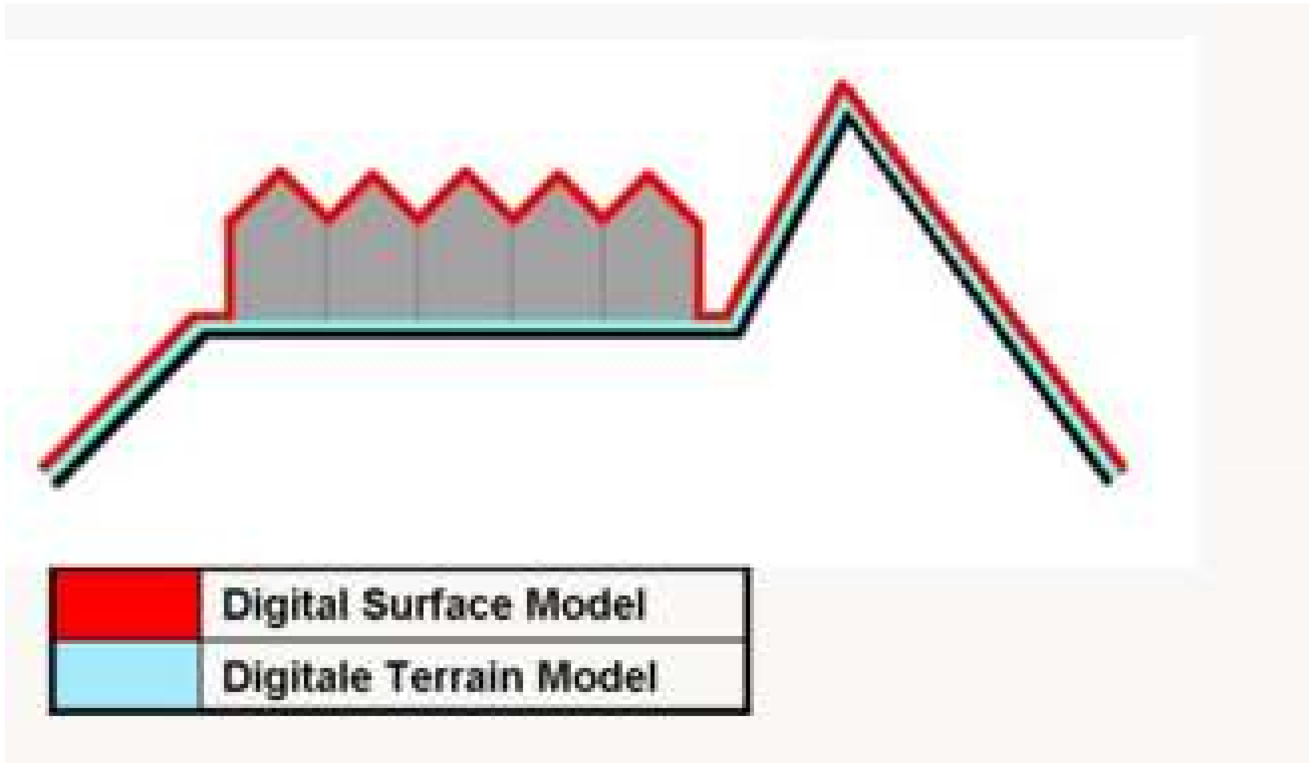




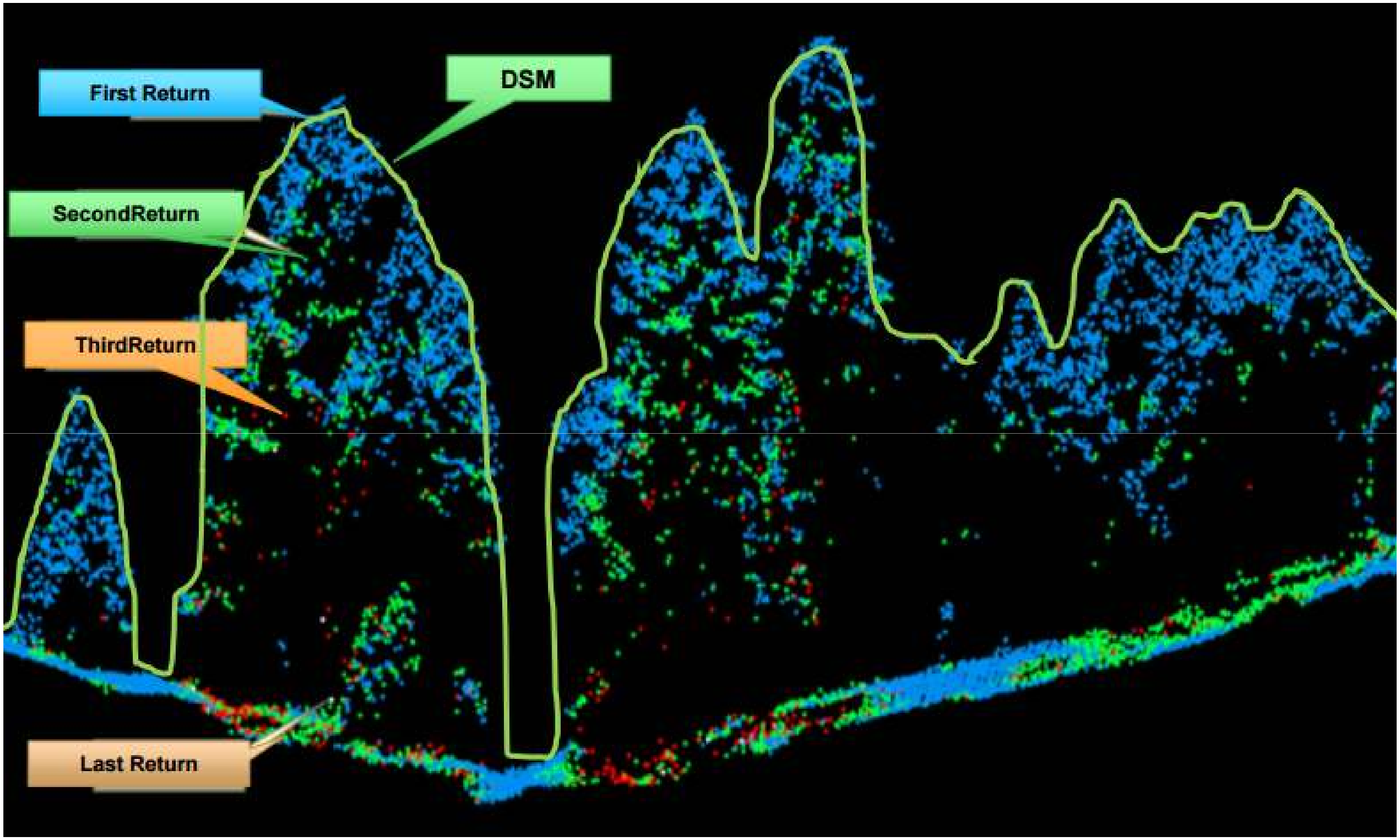
Received Intensity
Received Intensity
Time
First pulse
t_0
Last pulse
t_1
power line
tree crown
bush
ground



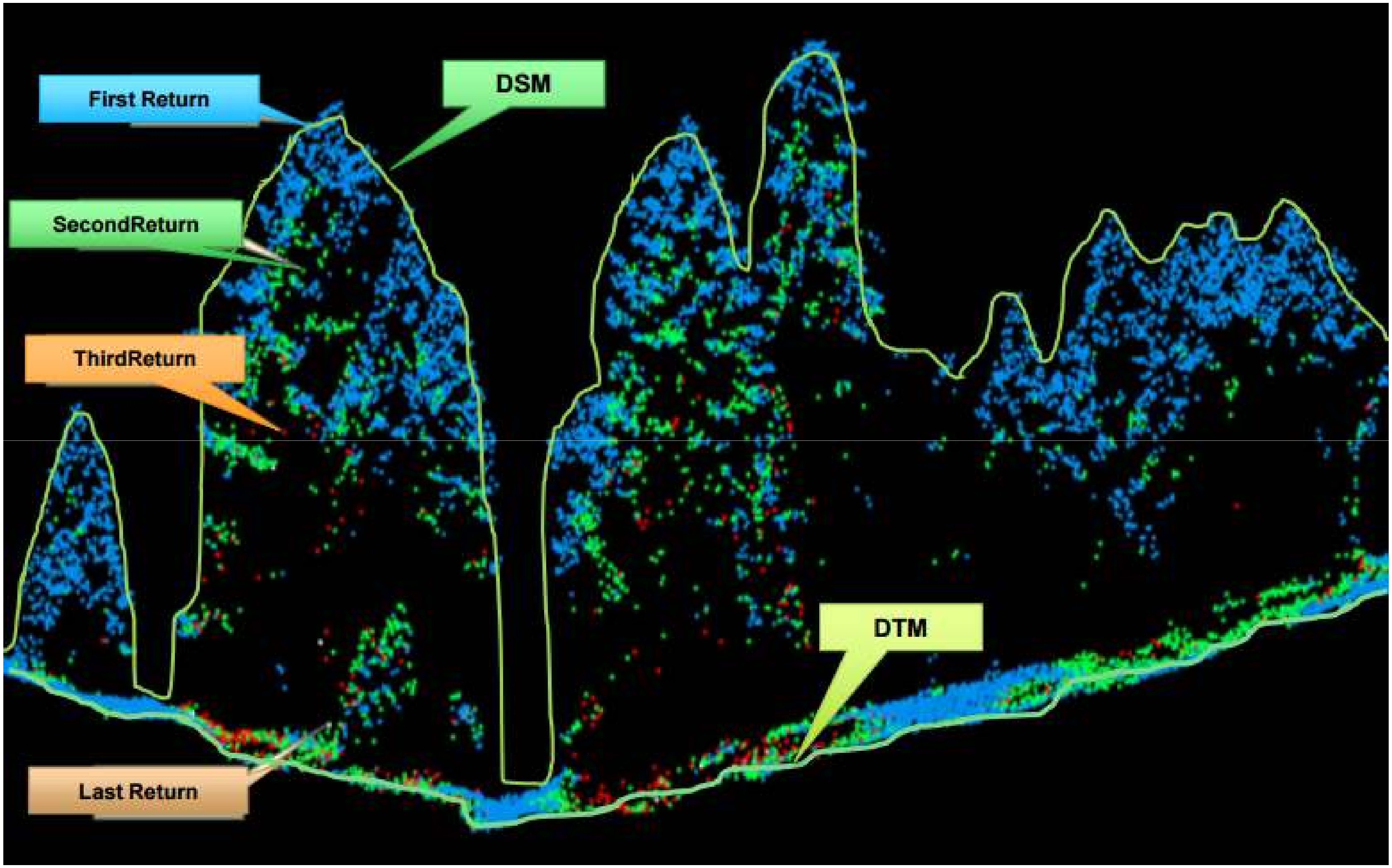

First Return
SecondReturn
ThirdReturn
Last Return



DSM=(earth) surface including objects on it.
DTM=(earth) surface without any objects.

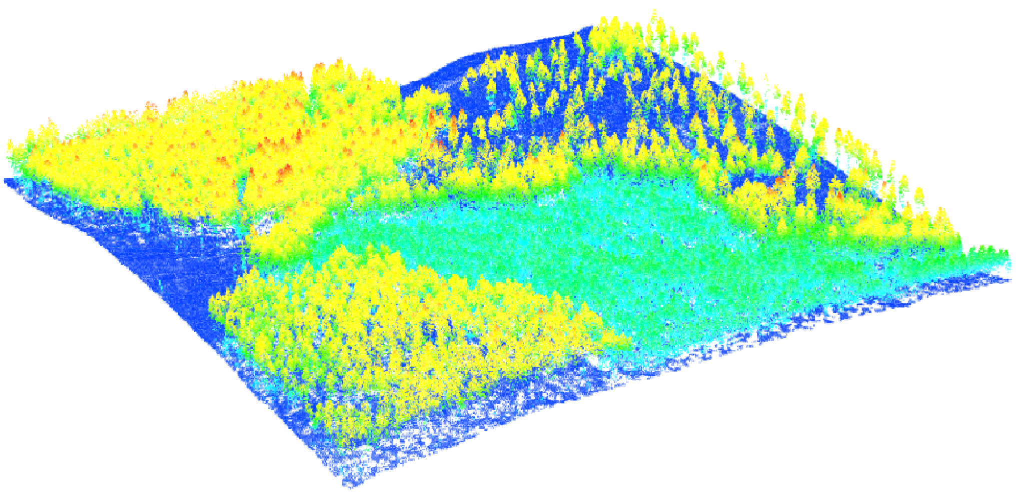


First Return
DSM
SecondReturn
ThirdReturn
Last Return

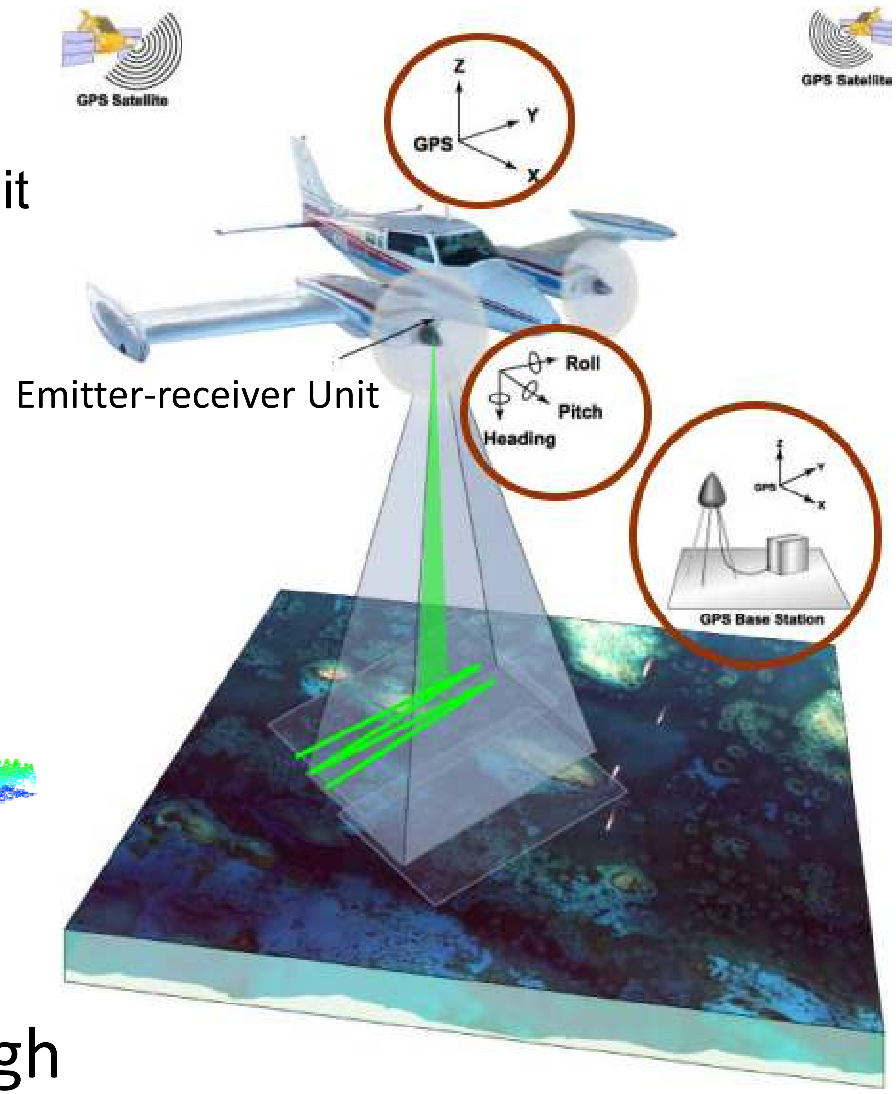

First Return
DSM
SecondReturn
ThirdReturn
DTM
Last Return

Aerial LiDAR System Components

- Aircraft
- Scanning laser emitter-receiver unit
- Differentially-corrected GPS
- Inertial measurement unit (IMU)
- Computer



LiDAR point data colored by heigh



LiDAR Data Characteristics

Raw return data are XYZ points

X: Longitude

Y: Latitude

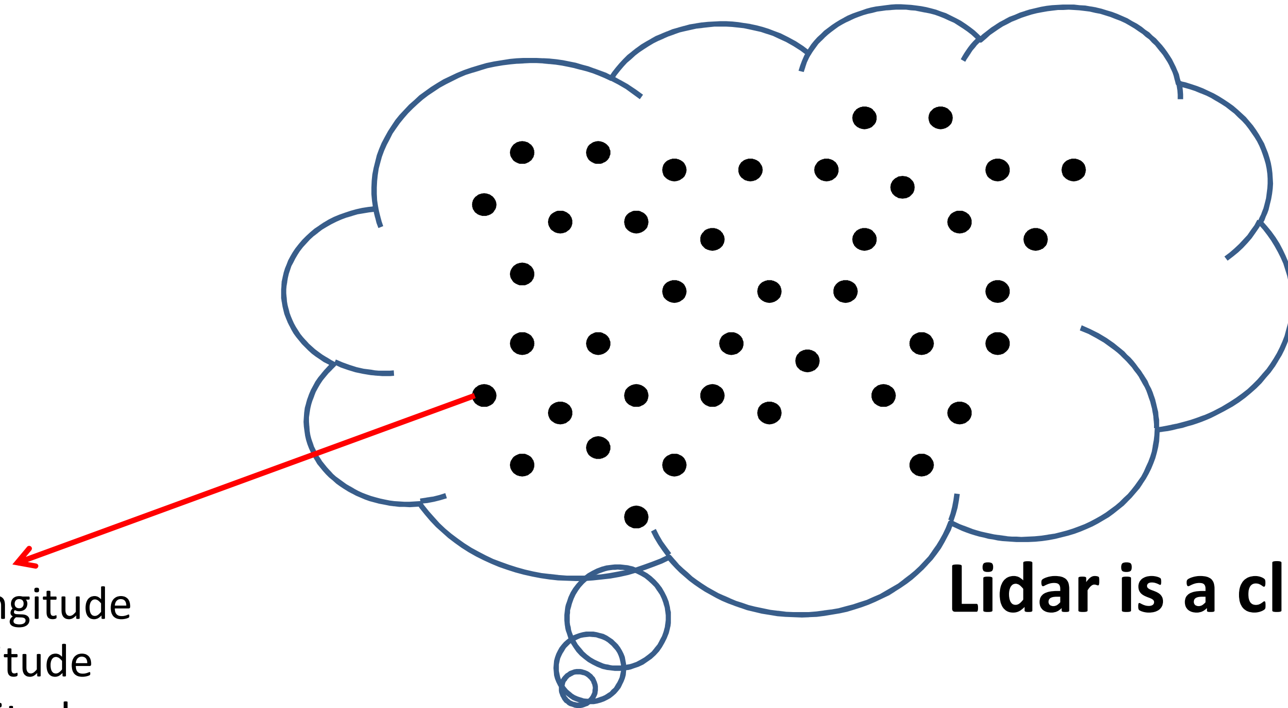
Z: Altitude

The spatial resolution of LIDAR is measured in points per square meter (PPM).

Spatial resolution:

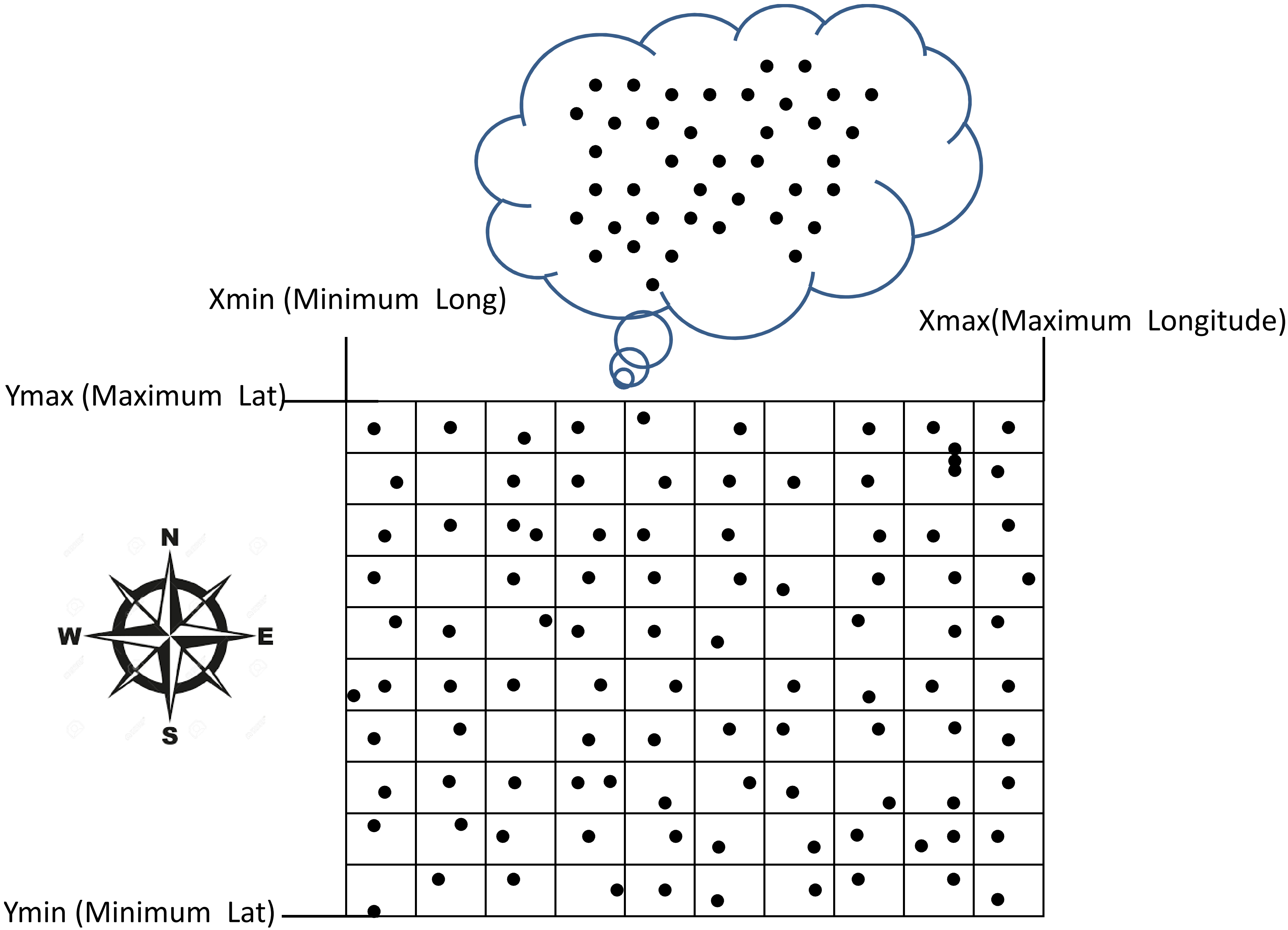
- Typical density is 0.5 to 20+ ppm
- 2 to3 returns/pulse
- Surface/canopy models typically 1 to 5m grid

Lidar can also capture intensity values from pulse returns.



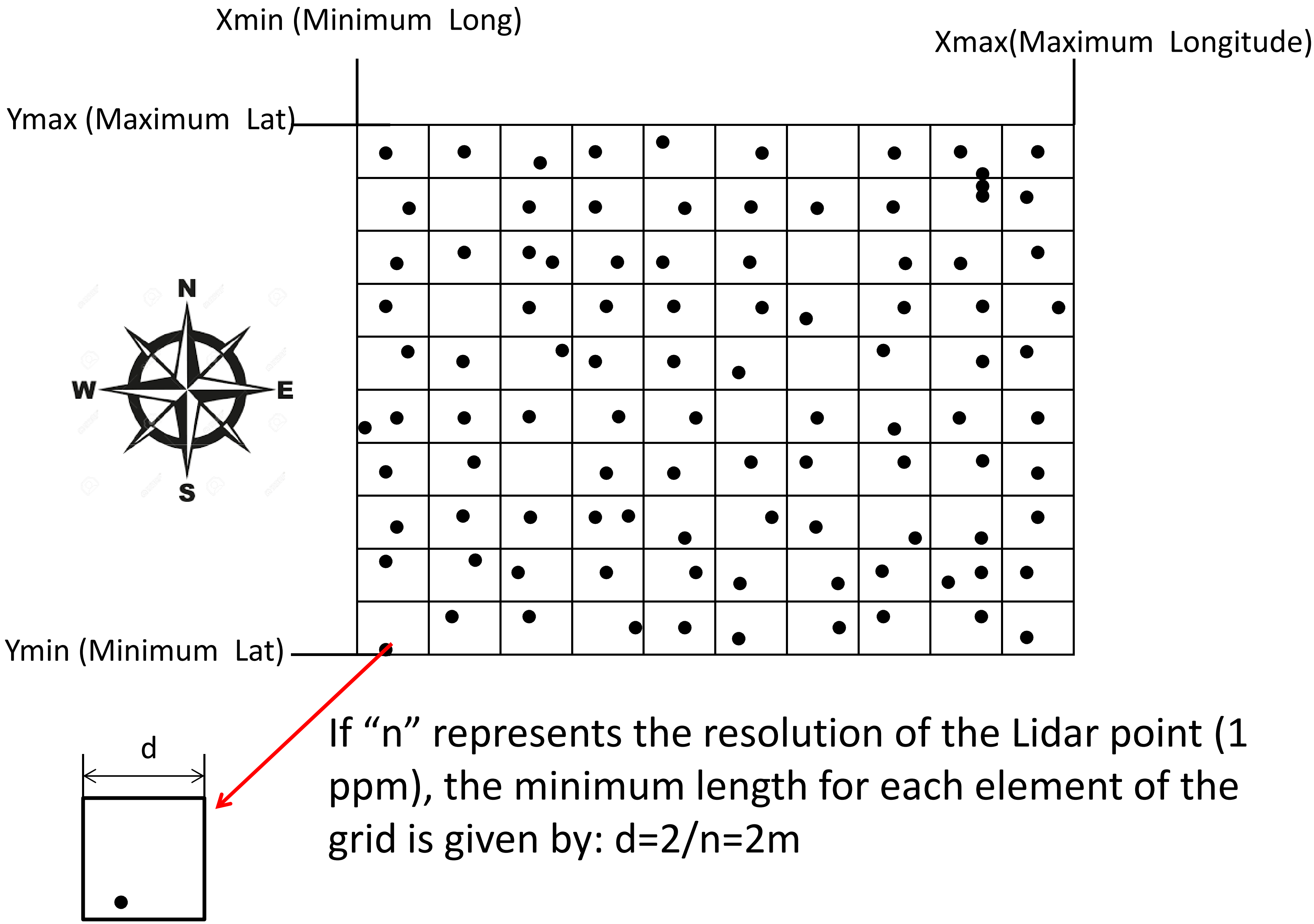
Lidar is a cloud of points

X: Longitude
Y: Latitude
Z:Alttitude
Intensity: The return strength of the laser pulse that generated the lidar point.
Return number: An emitted laser pulse can have up to five returns depending on the features it is reflected from and the capabilities of the laser scanner used to collect the data. The first return will be flagged as return number one, the second as return number two, and so on.
Number of returns: The number of returns is the total number of returns for a given pulse. For example, a laser data point may be return two (return number) within a total number of five returns.
Point classification: Every lidar point that is post-processed can have a classification that defines the type of object that has reflected the laser pulse. Lidar points can be classified into a number of categories including bare earth or ground, top of canopy, and water.

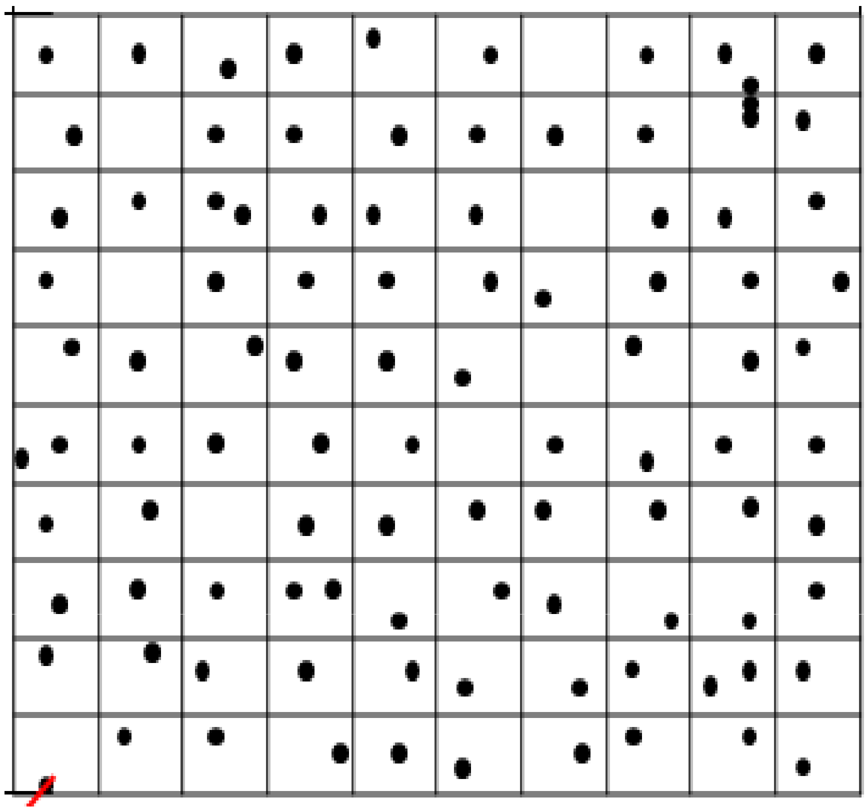

Xmin (Minimum Long)
Xmax(Maximum Longitude)
Ymax (Maximum Lat)
Ymin (Minimum Lat)
N
W
E
S

- **Nyquist sampling theory requires at least two samples per resolution element.**

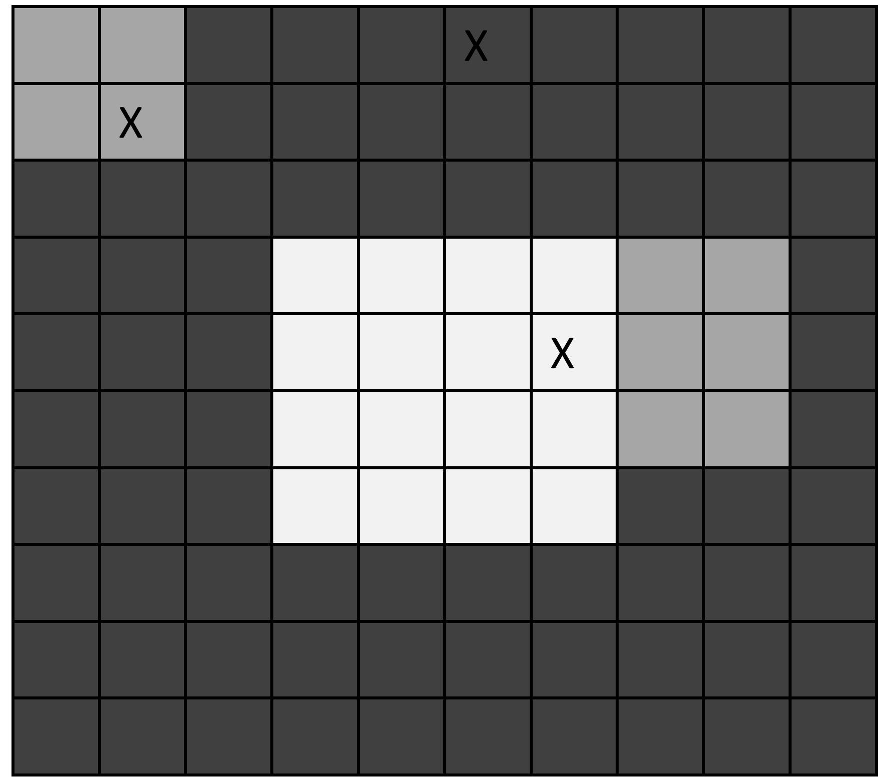
  To be able to “see” a feature in the terrain, it must be sampled by at least two lidar samples. For example, seeing a 2m wide pit in the bare earth lidar requires average point spacing of 1 sample every meter (1 ppm).



If “n” represents the resolution of the Lidar point (1 ppm), the minimum length for each element of the grid is given by: d=2/n=2m



Lidar points organized into a grid



Raster or image where each pixel represents an altitude value