LIDAR and Terrain Models: In 3D!

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http://www.esri.com/library/whitepapers/pdfs/lidar-analysis-forestry.pdf

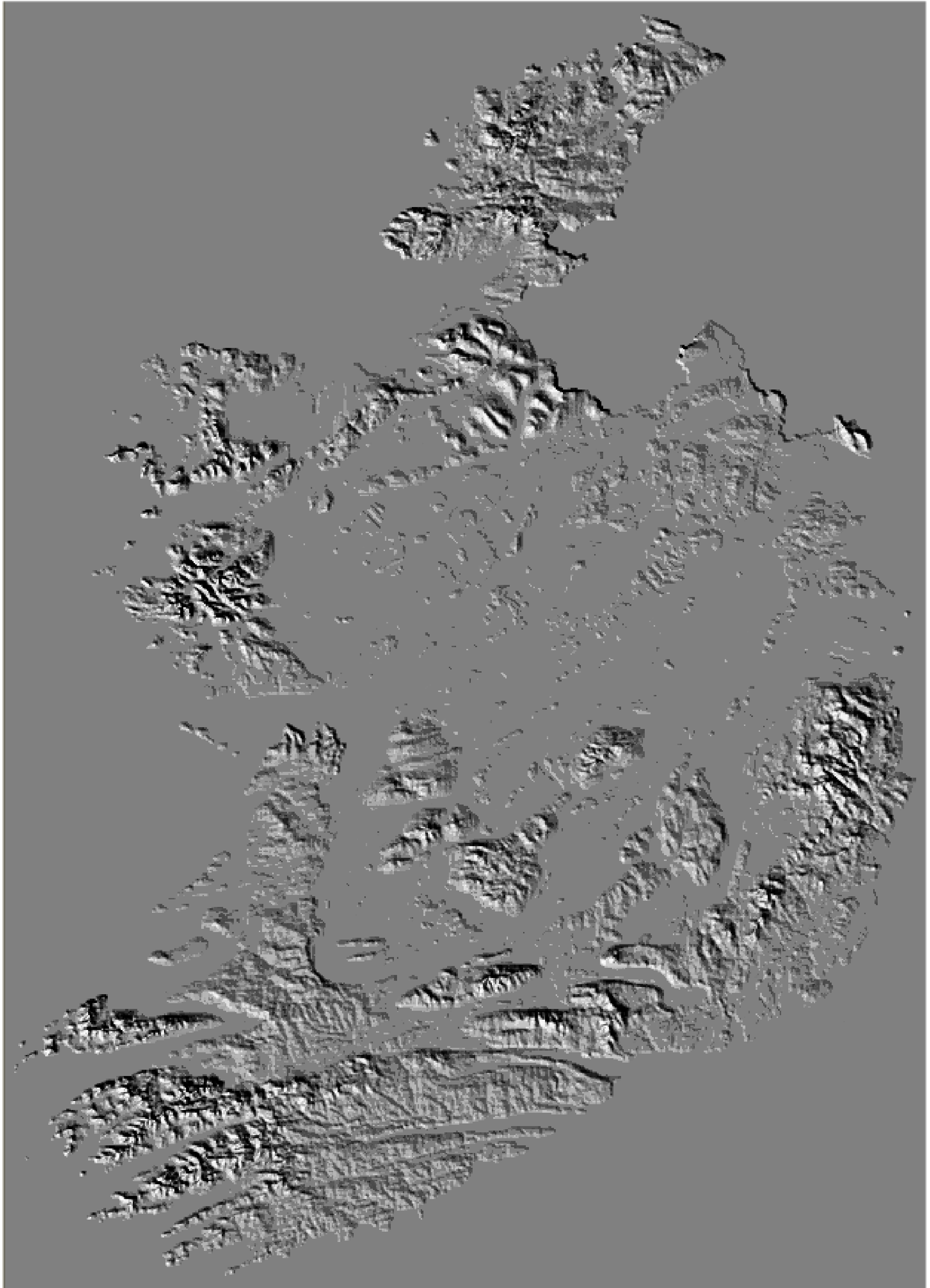
http://www.csc.noaa.gov/digitalcoast/_/pdf/Refinement_of_Topographic_Lidar_to_Create_a_Bare_Earth_Surface.pdf

https://www.e-education.psu.edu/lidar/

- **Digital Elevation Model:**

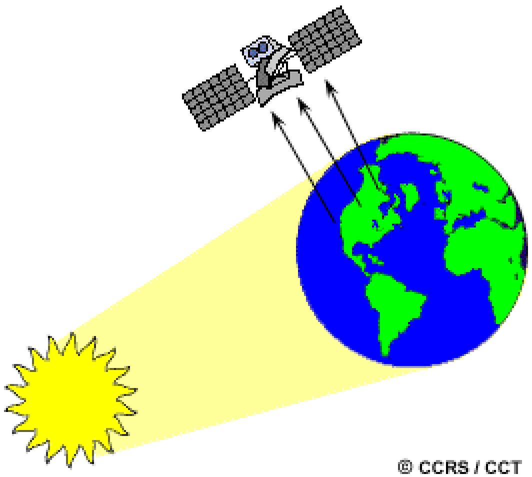
A model of the continuous variation of relief over a geographic area.

An “image” where all the pixel values (digital numbers) represent
The elvation above sea level of the piece of land represented by
The pixel

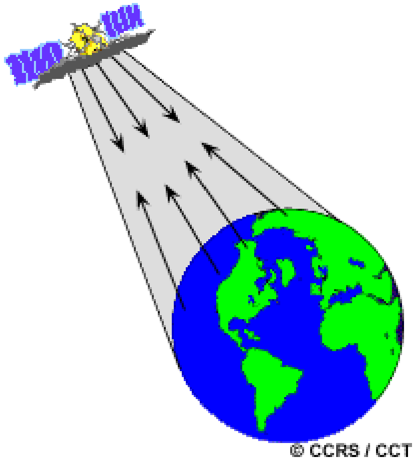


Used to visualise landscape

- There are many ways to produce elevation data (we saw in lecture 3 how we could use overlapping aerial photography to get height information).
- We are going look at using Active Sensors to probe the environment and creat measurements in 3D



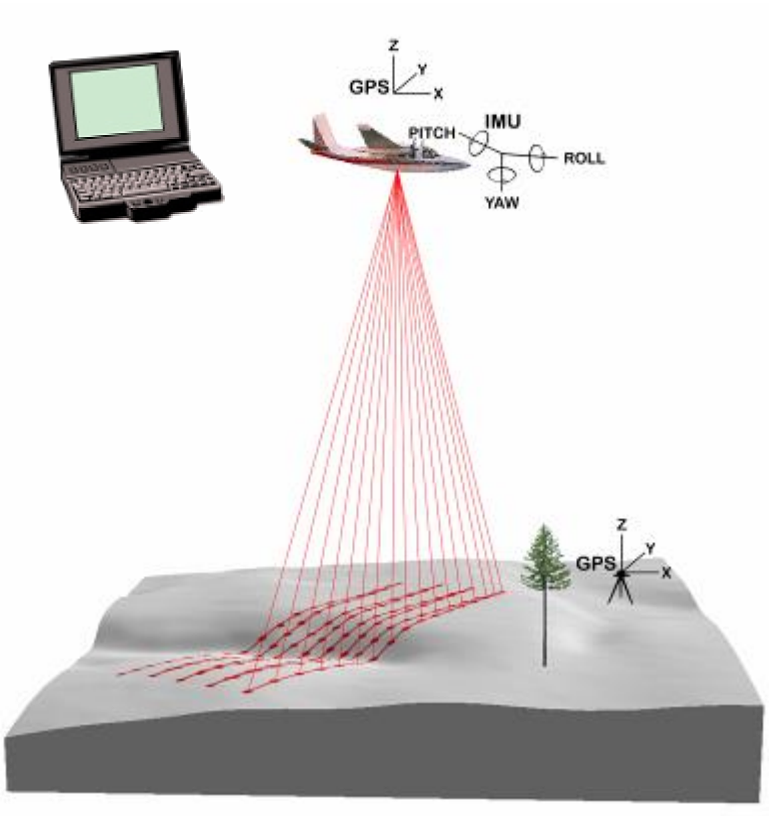
Passive sensors can only be used to detect energy when the naturally occurring energy is available. For all reflected energy, this can only take place during the time when the sun is illuminating the Earth. There is no reflected energy available from the sun at night. Energy that is naturally emitted (such as thermal infrared) can be detected day or night, as long as the amount of energy is large enough to be recorded.

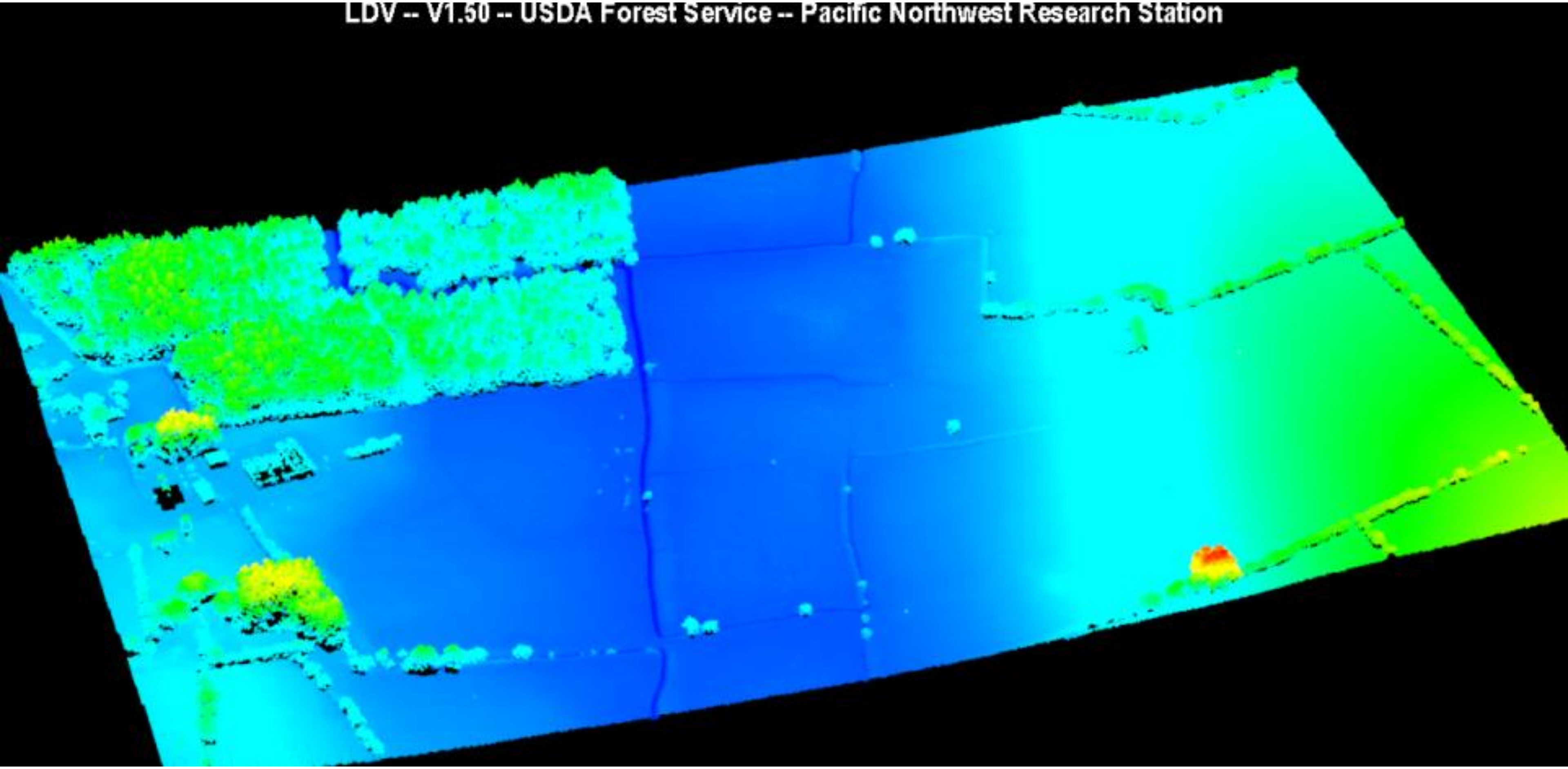


Active sensors, on the other hand, provide their own energy source for illumination. The sensor emits radiation which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor. Advantages for active sensors include the ability to obtain measurements anytime, regardless of the time of day or season. Active sensors can be used for examining wavelengths that are not sufficiently provided by the sun, such as microwaves, or to better control the way a target is illuminated. However, active systems require the generation of a fairly large amount of energy to adequately illuminate targets. Some examples of active sensors are a laser fluorosensor and a synthetic aperture radar (SAR).

Airborne Laser Scanning (LIDAR) System Components

- Active sensor emits 40,000 – 150,000 infrared laser pulses per second
- Differentially-corrected GPS
- Inertial measurement unit (IMU)
- Computer to control the system monitor mission progress
- Interesting targets

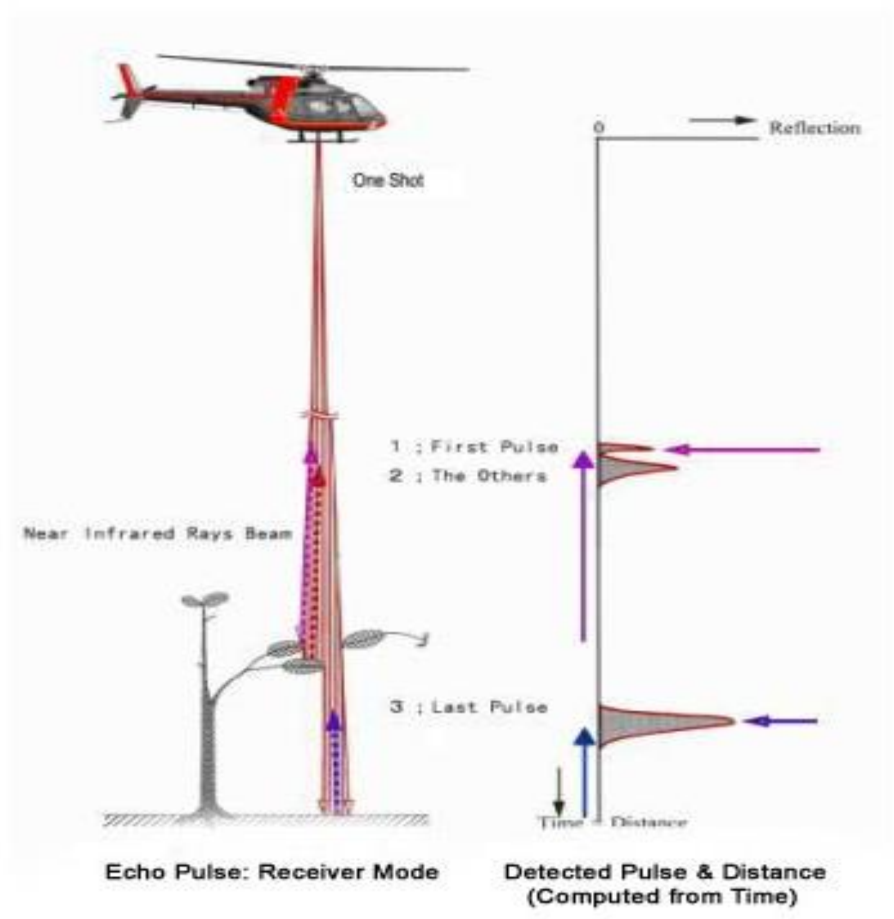



LDV -- V1.50 -- USDA Forest Service -- Pacific Northwest Research Station

Laser Scanning: Simplest scenario

- The scanner sends out laser pulses and record the length of time it takes to return. Knowing the speed of light and the location of the scanner (from GPS) the software can calculate where the object the pulse reflected of must be.

In practice systems today measure multiple returns from the same pulse. This allows us to get an idea of when we are hiting soemthing hard or something porous. It alos allows us to distinguish, in a forest between trees and the ground



LiDAR Data

All returns

1st return

2nd return

3rd return

4th return

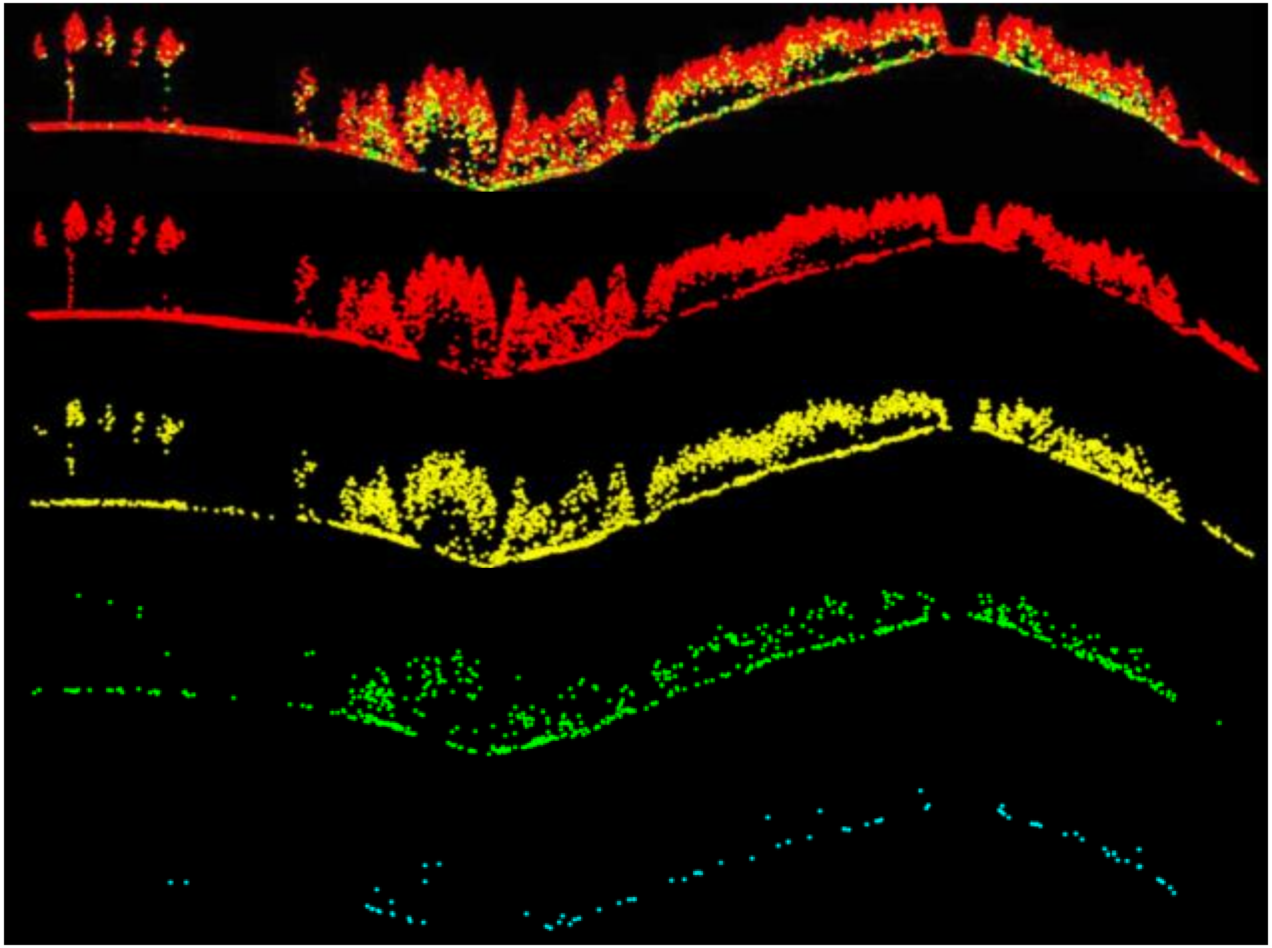
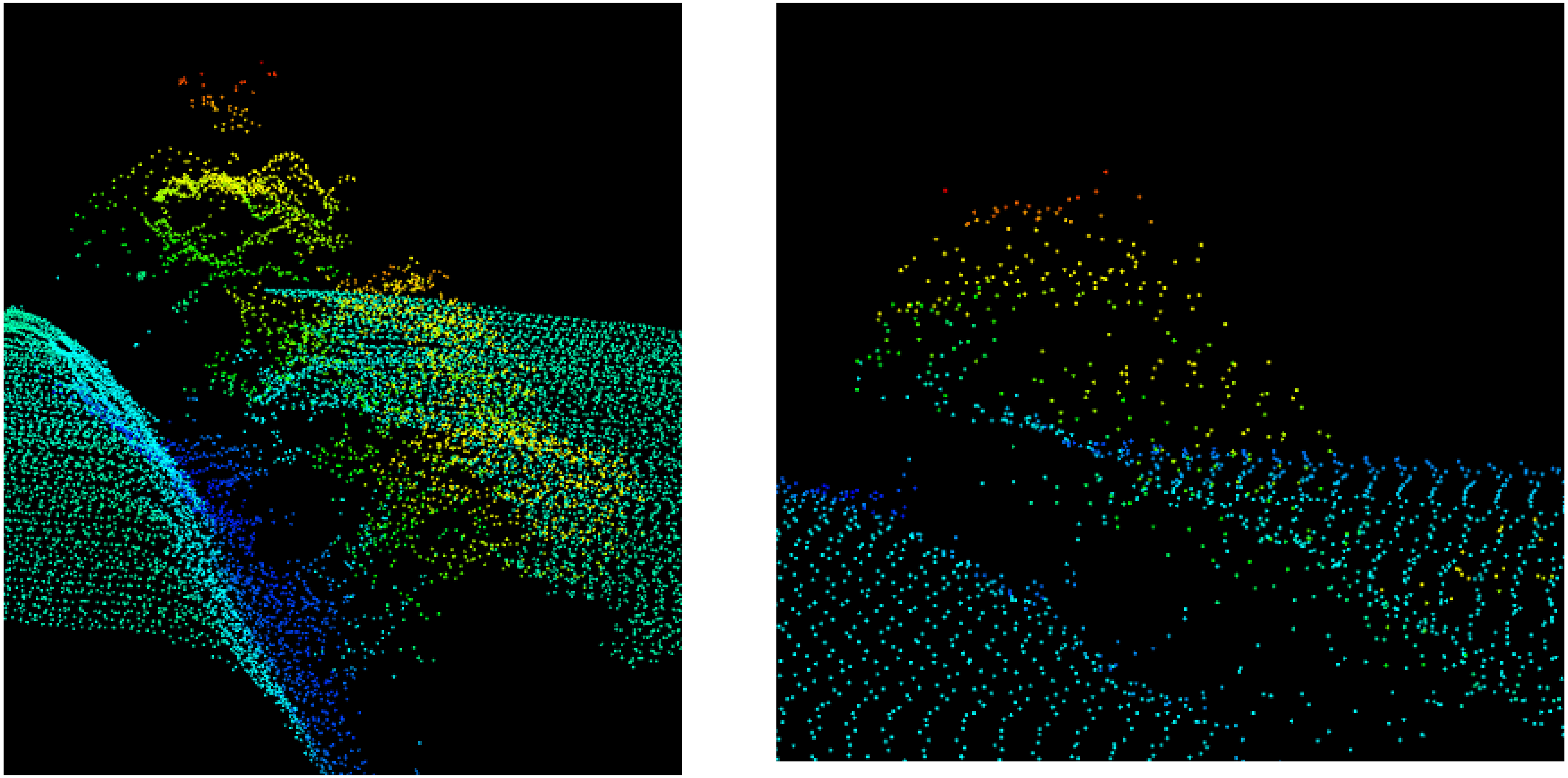
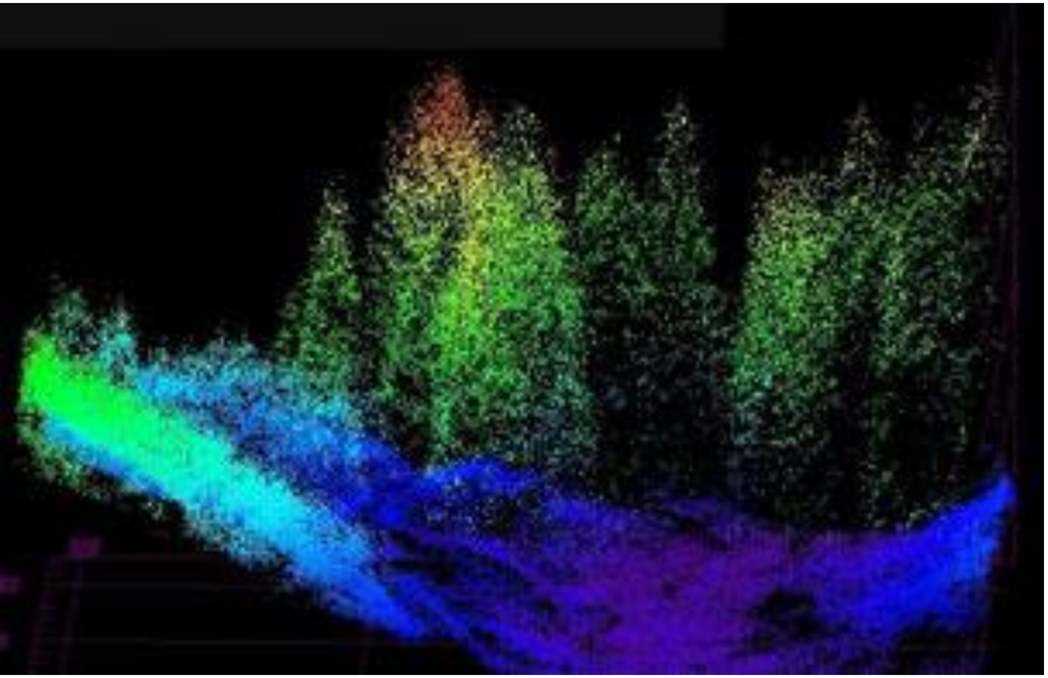


Image from Lidar Technology Overview, presentation by USGS, June 2007



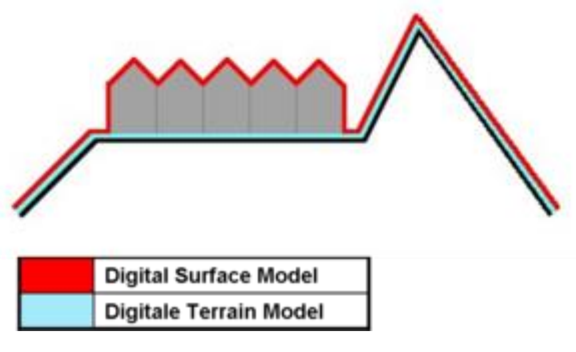
- The data format is typically very simple: .las files
- X,y,z values for each return pulse



A 'point cloud' of multiple LIDAR returns…a topic for on-going research… estimating forest stand volume for example

3D models of earths surface are called: elevation models

- There are two principle type of DEM:
- Digitial Surface model: DSM
- Digital Terrain Model: DTM



The DTM is sometimes called the "Bare Earth Model" to create it we have to Identify only those points that come from the ground and not objects like houses or trees etc

Create a bare earth model (dependent on software)

- Essentially you are classifying the lidar points based on return value and intensity.
- Identify targets that you know are bare earth to refine classifciation.
- Apply a spatial filter to fill in gaps. Interpolate between points the software is sure is ground. Chose the resoltuion of the DTM you want.

Classifying

- Creating a DTM is essentially a process of classifying lidar points. So you need training areas- point you can identify as ground or buildings or trees etc. And usually manual editing of the final product.
- There is a standardised classifcication scheme:
-

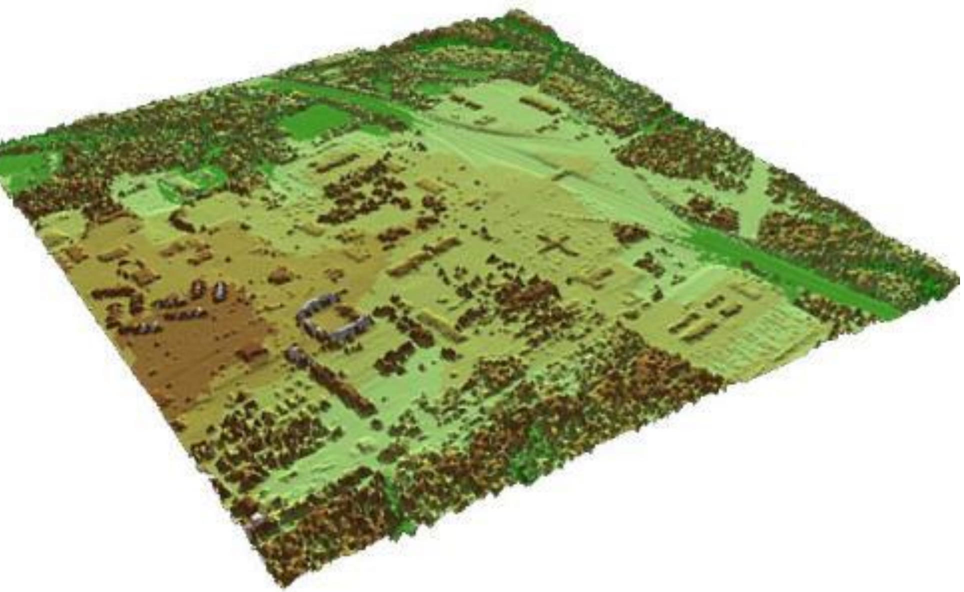
ASPRS Standard LIDAR Point Classes

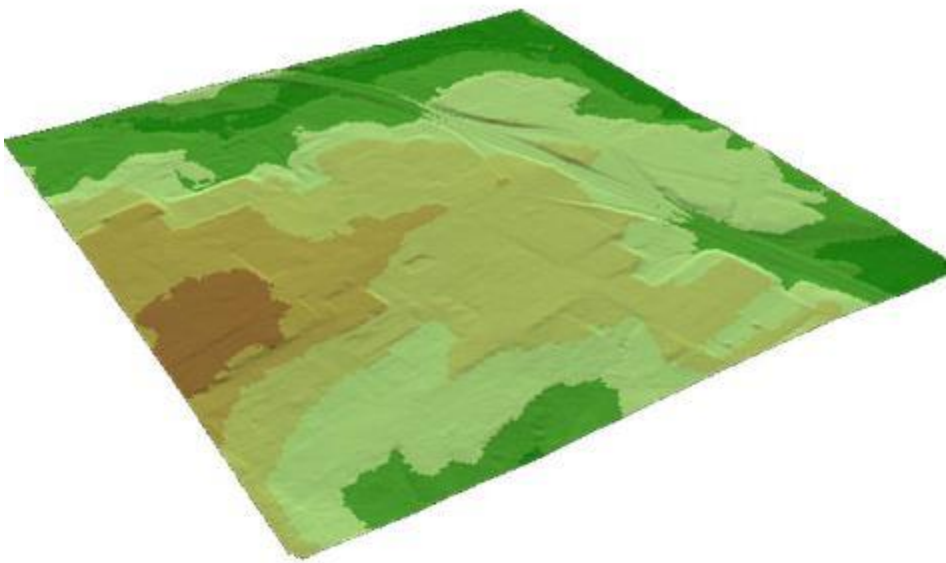
Classification Value	*Meaning*
0	Created, never classified
1	Unclassified[1]
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Point (noise)
8	Model Key-point (mass point)
9	Water
10	*Reserved for ASPRS Definition*
11	*Reserved for ASPRS Definition*
12	Overlap Points[2]
13-31	*Reserved for ASPRS Definition*

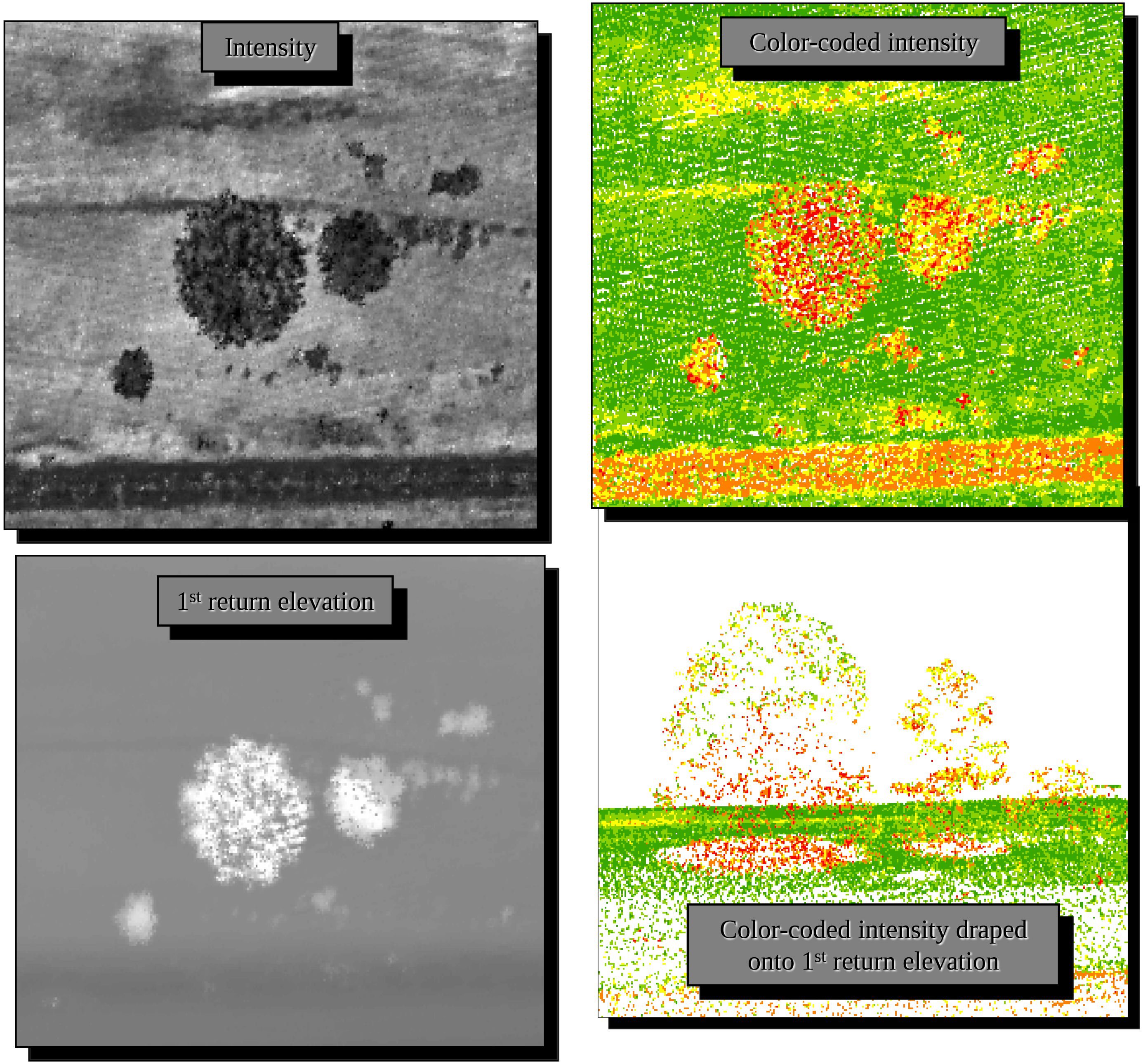
Classification

- Usually done automatically using a decsion tree using return intensity, number, angle- and sometimes other data sets.

The parameters and threholds for the classifcation rely on expert judgement.



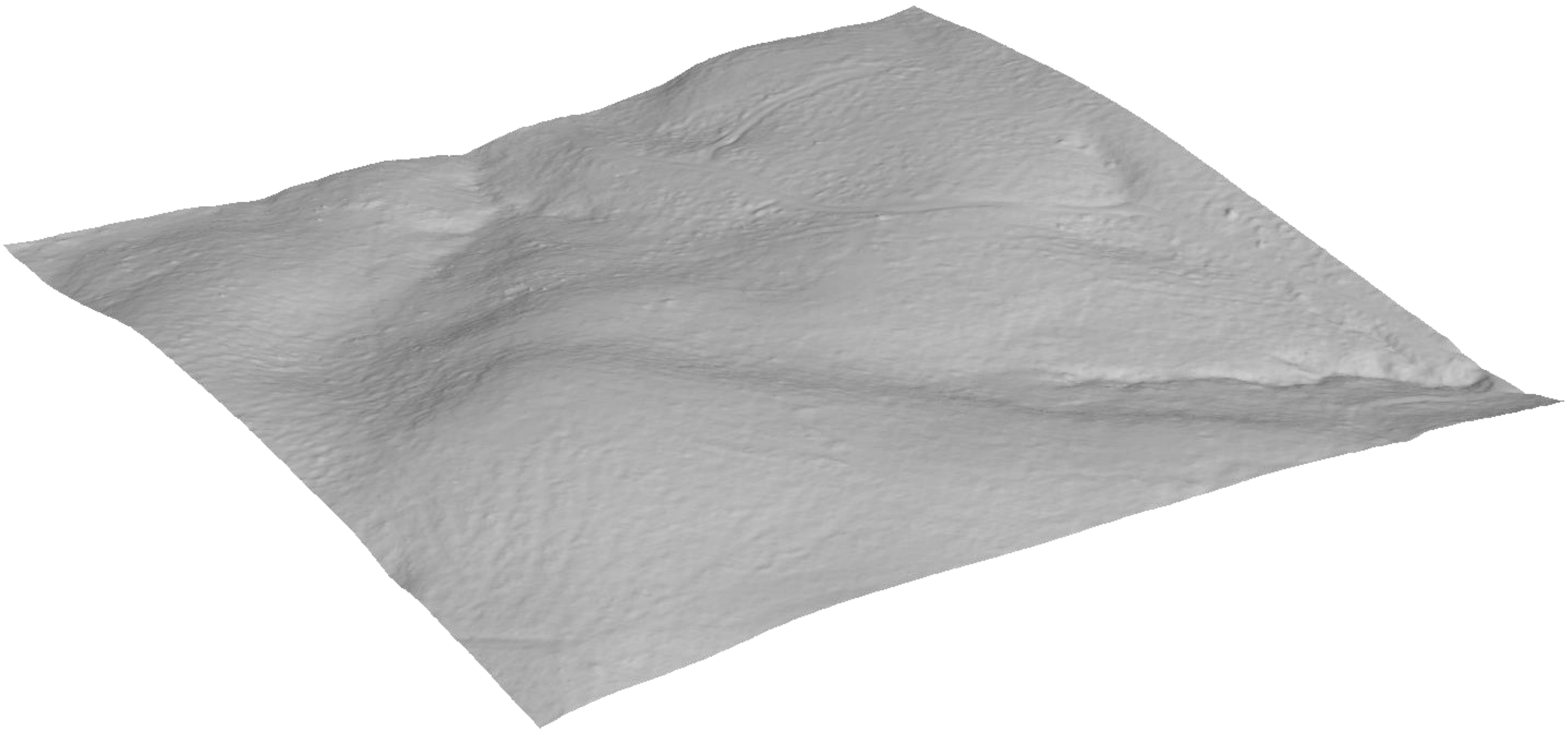



Intensity
Color-coded intensity
1st return elevation
Color-coded intensity draped onto 1st return elevation

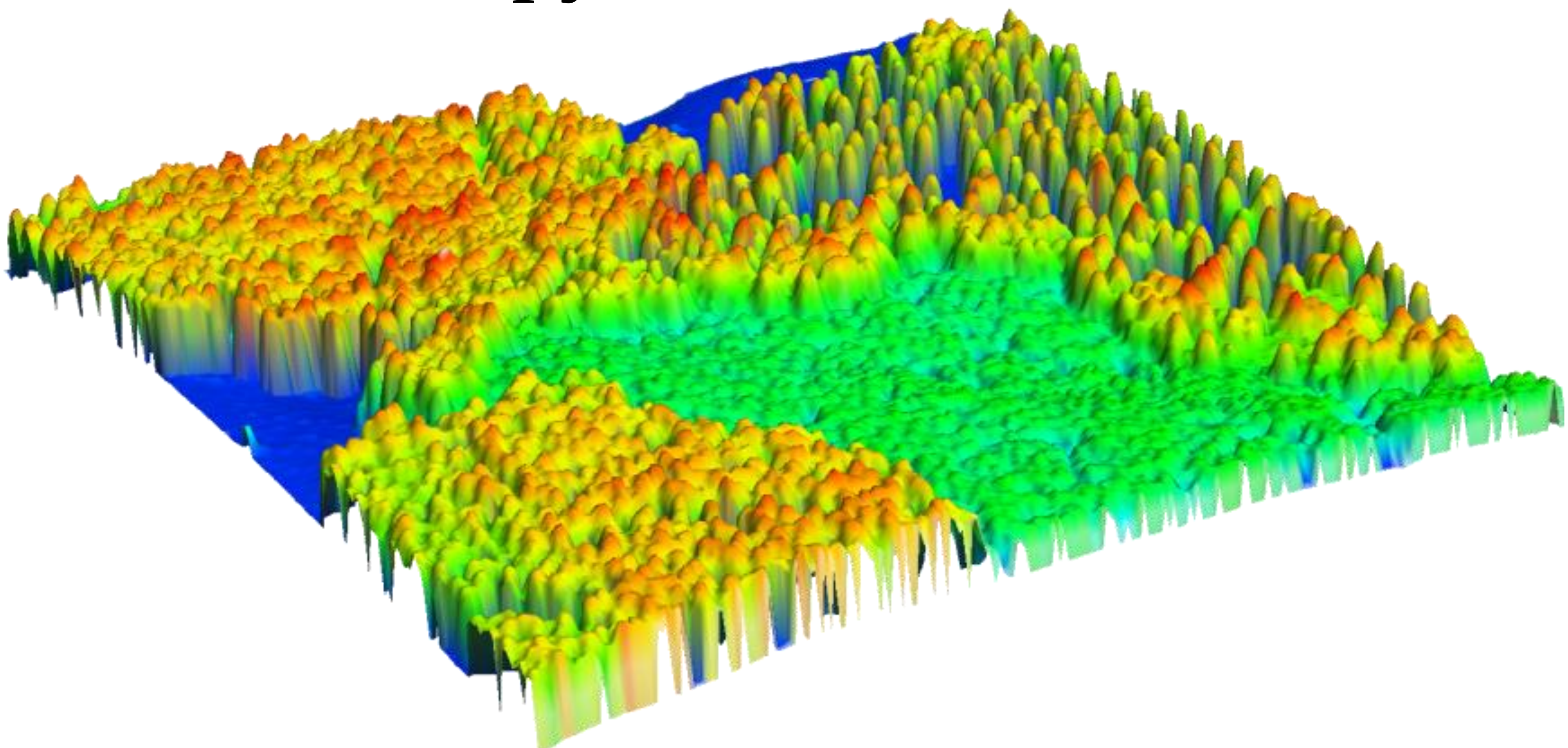
The intensity of return is important in helping us classify the lidar point

- The return intensity relies on the property of the material and angular effects.
- Flat, dry, bright rough material will reflect back the most.
- Dark wet material the least.
- Obviously if the target if perpendicular to the laser pulse direction it will relfect back more than if its at an angle/

LIDAR-derived
Bare-Earth Surface Model



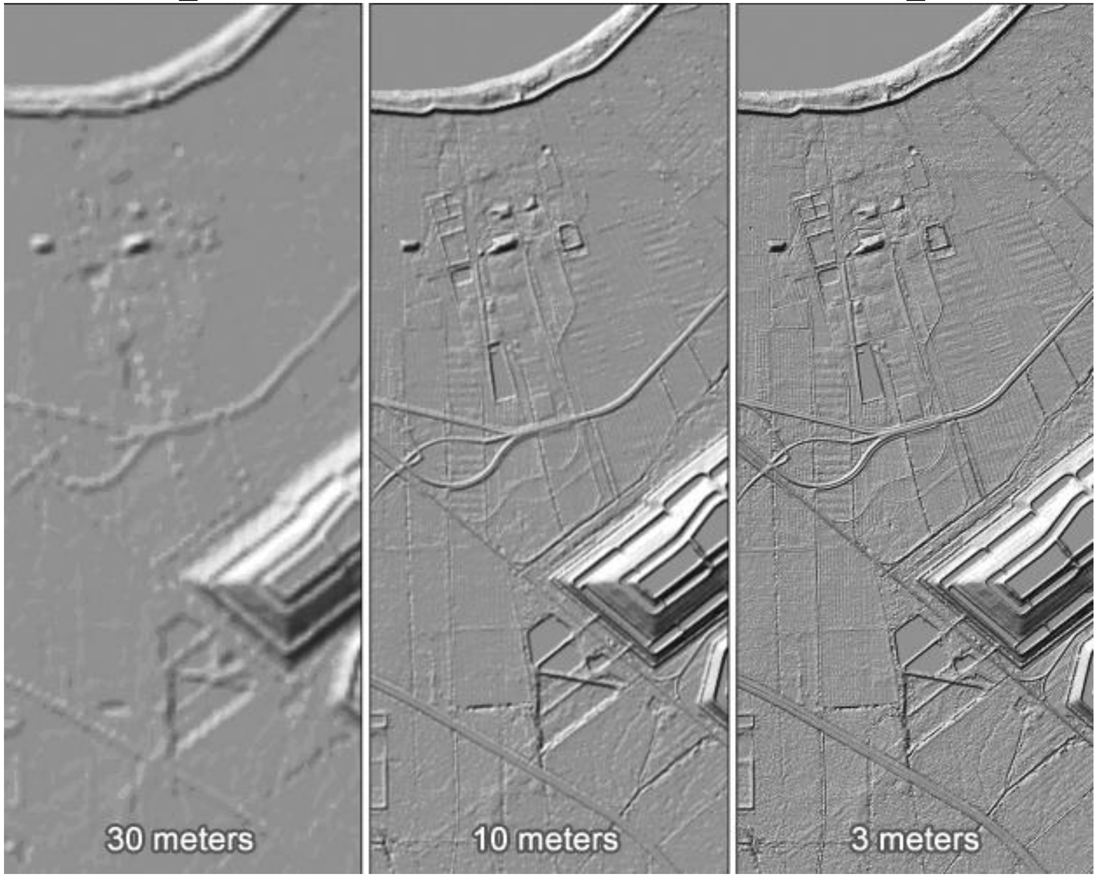
LIDAR-derived Canopy Surface Model



A canopy height model is a continous interpolated surface representing the top of the vegetation.

How do we turn points into surfaces?

- A DTM or DEM is a pixel ratsre image- but each pixel value has the avarge height value of the points that fall in the pixel



- The level of detail in your final DTM depends on the level of detail of aquistion.

Usual defined in terms of points/m2.

Commonly 1-2 point/m

Good hydrographic quality 5-10/m

Micro topographic surveys ~30/m

Why LIDAR?

- Potential exists for highly accurate Elevation data sets….
- Forestry, construction, even modeling radio reception for cell towers depend on very accurate elevation data
- Many areas are too large (or difficult) to manually survey, river flood plains, coastal mudflats or sediment deposits

DEM Use

- Hydrological modelling
- Erosion models
- Viewshed analysis
- Planning, visulaisation
- Wind resoource mapping
- Soil Modelling
- Civil Engineering
- Flood risk asseemnt
- Agriculutral productivity monitoing
- Meterolgy