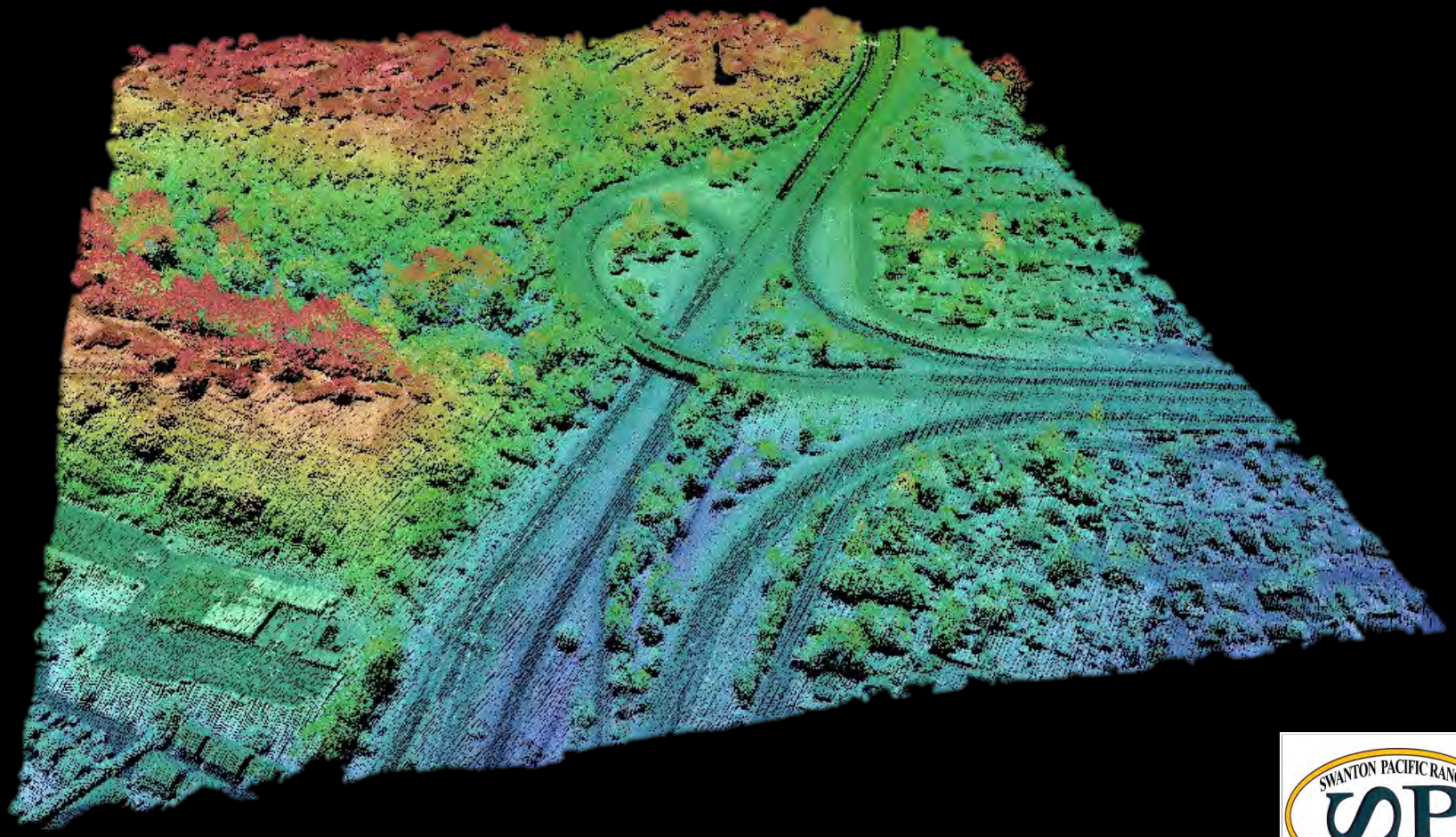
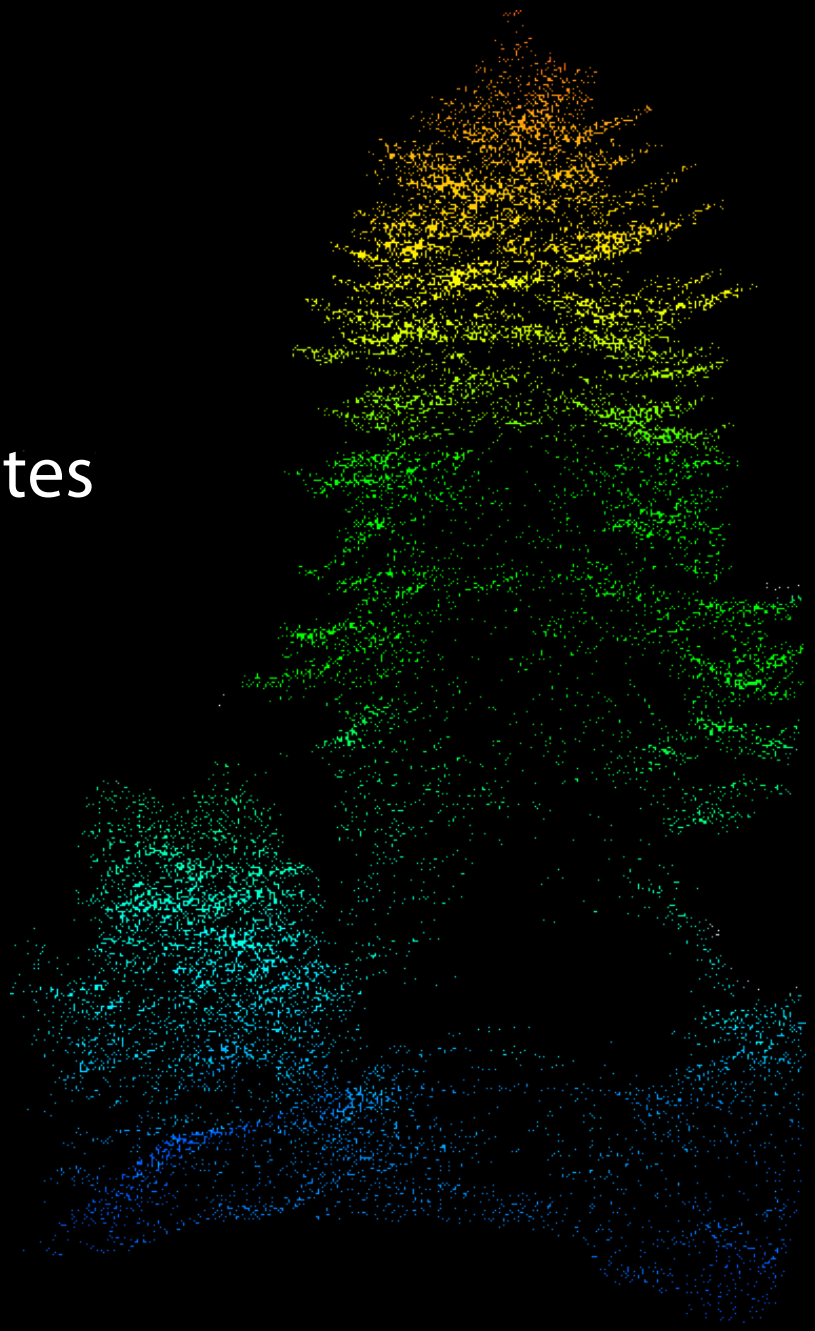
LiDAR Tools and Workflows



Russell White rwhite@calpoly.edu
Natural Resources Management Department

Overview

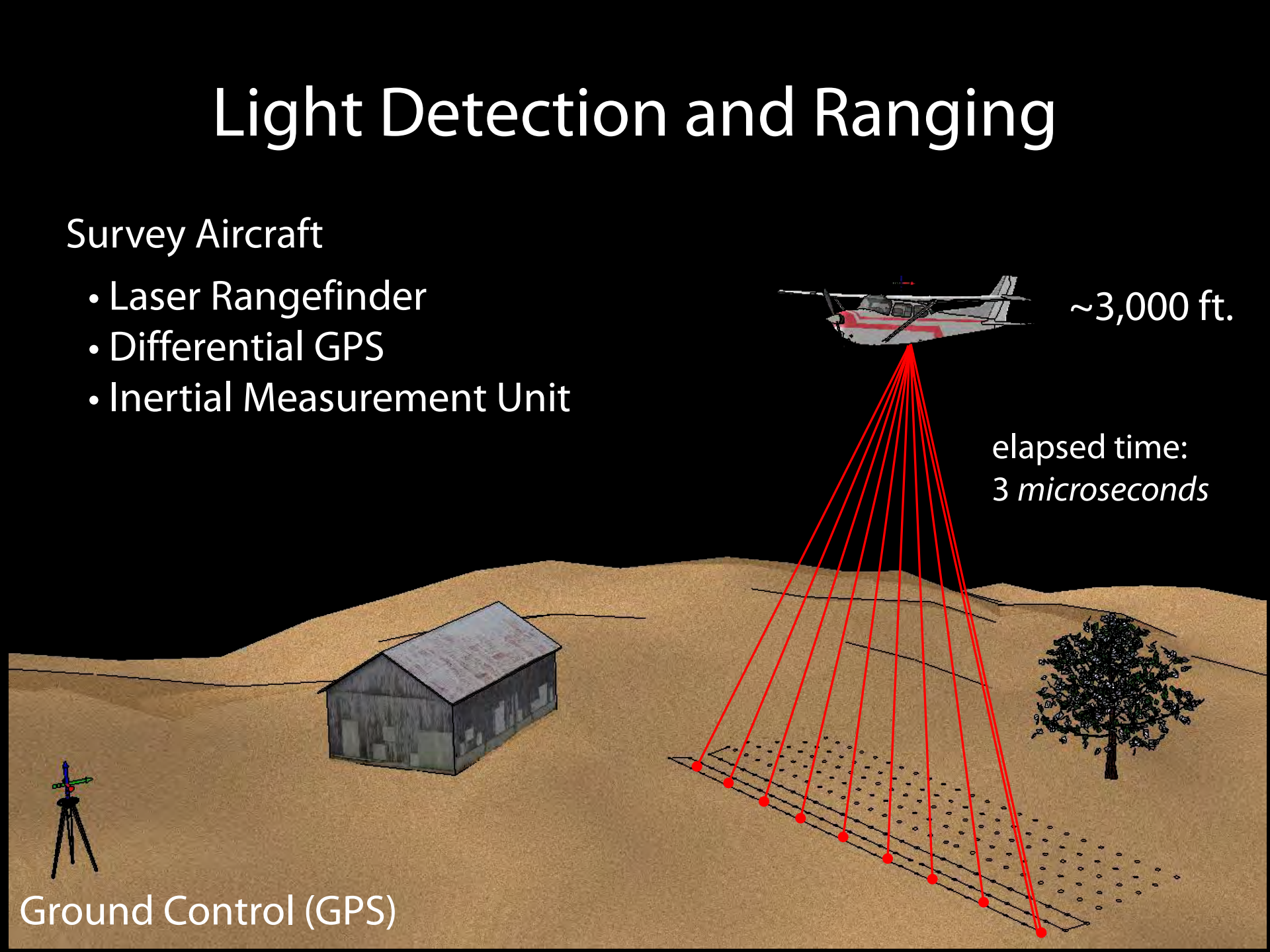
- LiDAR Data Collection
- LAS Data Format and Attributes
- Data Sources and Products
- Tools and Workflows



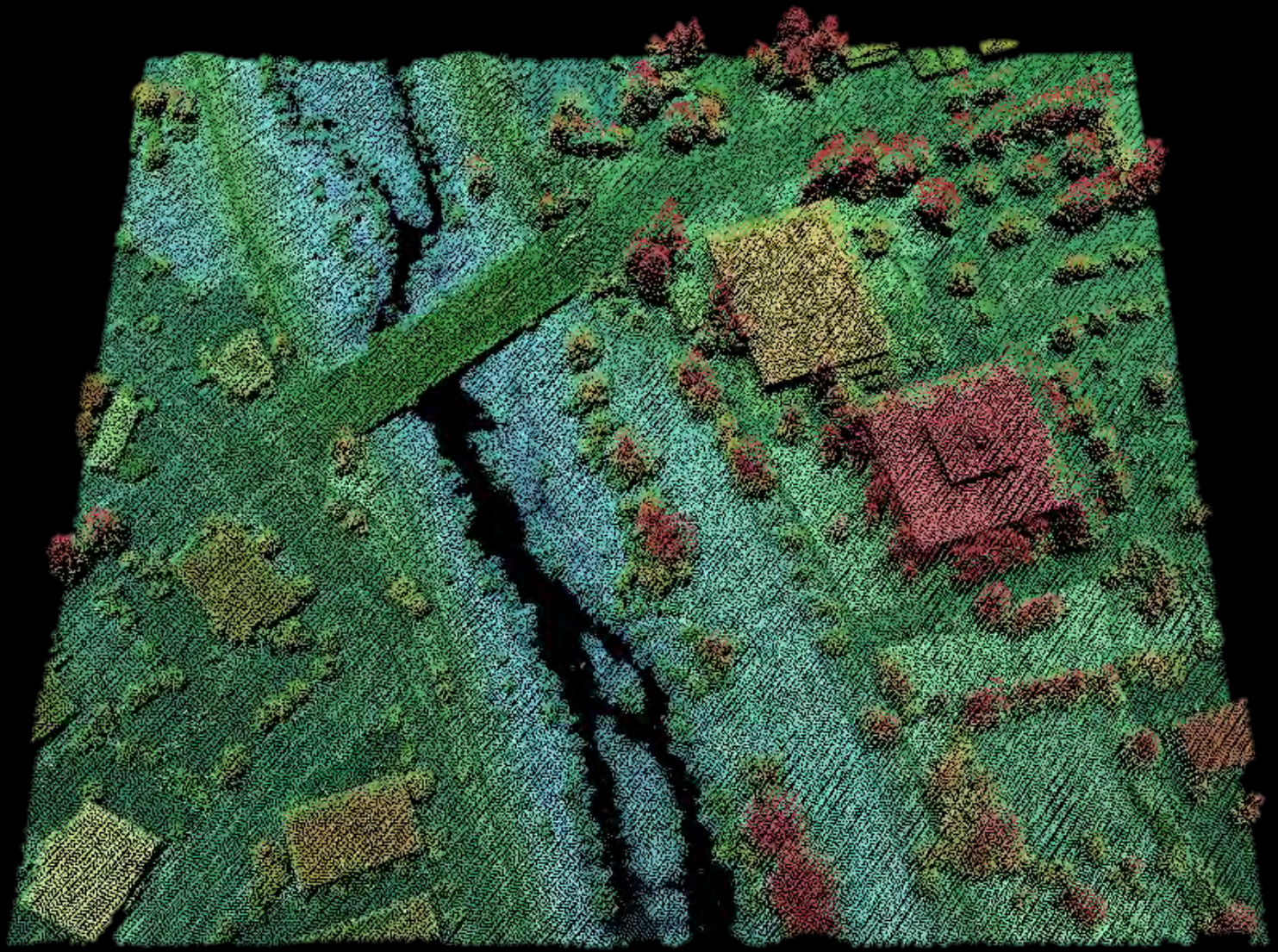
Light Detection and Ranging

Survey Aircraft

- Laser Rangefinder
- Differential GPS
- Inertial Measurement Unit



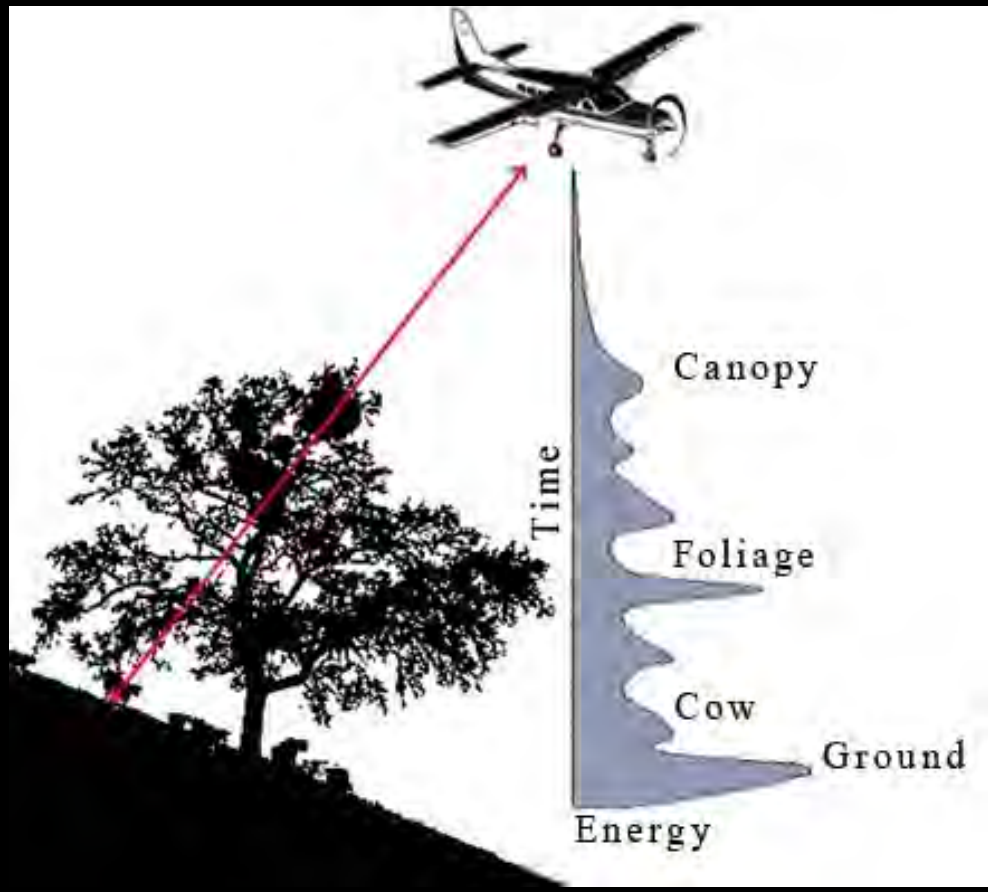
LiDAR Point Cloud



Multiple Returns

For each pulse, many returns

- Typically 1-4 returns per pulse
- Provides vertical profile
- Last returns used to determine the ground surface



http://www.ensisjv.com/Portals/0/lidarimage002.jpg

LAS Attributes

POINT DATA RECORD FORMAT 1:

Item	Format	Size	Required
X	long	4 bytes	*
Y	long	4 bytes	*
Z	long	4 bytes	*
Intensity	unsigned short	2 bytes	
Return Number	3 bits	3 bits	*
Number of Returns (given pulse)	3 bits	3 bits	*
Scan Direction Flag	1 bit	1 bit	*
Edge of Flight Line	1 bit	1 bit	*
(1.1) Classification	unsigned char	1 byte	*
Scan Angle Rank (-90 to +90) – Left side	unsigned char	1 byte	*
(1.1) User Data	unsigned char	1 byte	
(1.1) Point Source ID	unsigned short	2 bytes	*
GPS Time	double	8 bytes	*

http://www.asprs.org/Standards/LASer-LAS-File-Format-Exchange-Activities.html

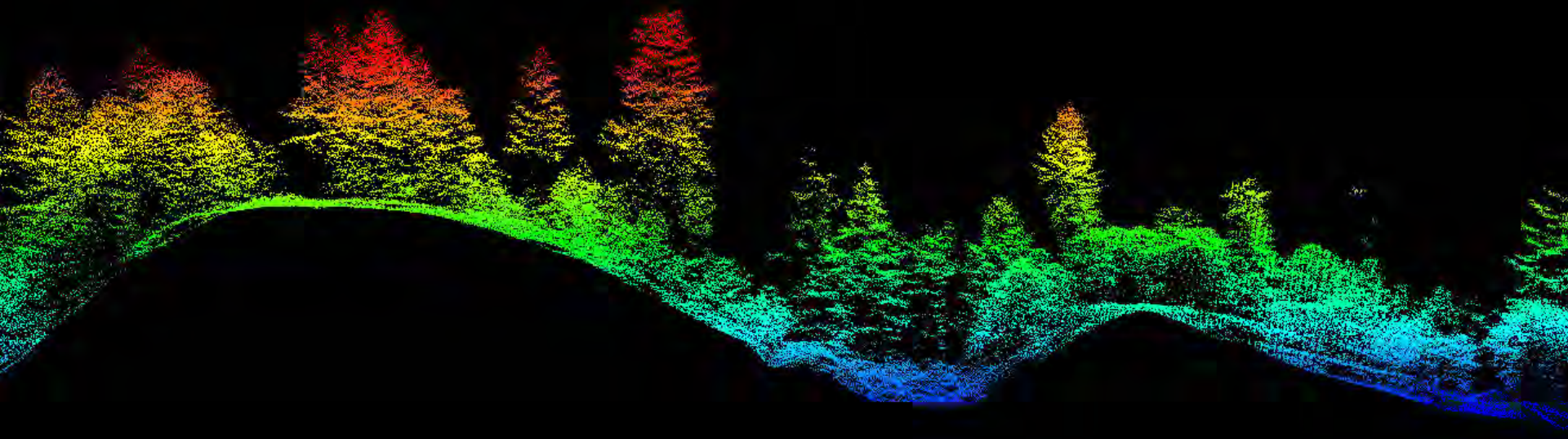
LAS Classification

ASPRS Standard LIDAR Point Classes

Classification Value (bits 0:4)	***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*

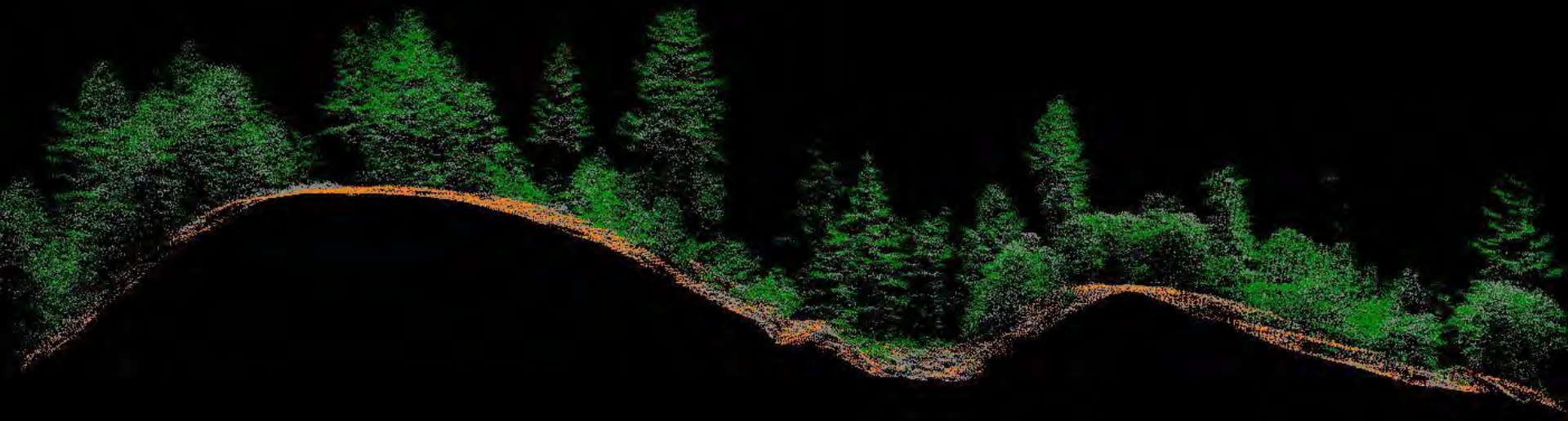
Point Cloud Profile

All Returns

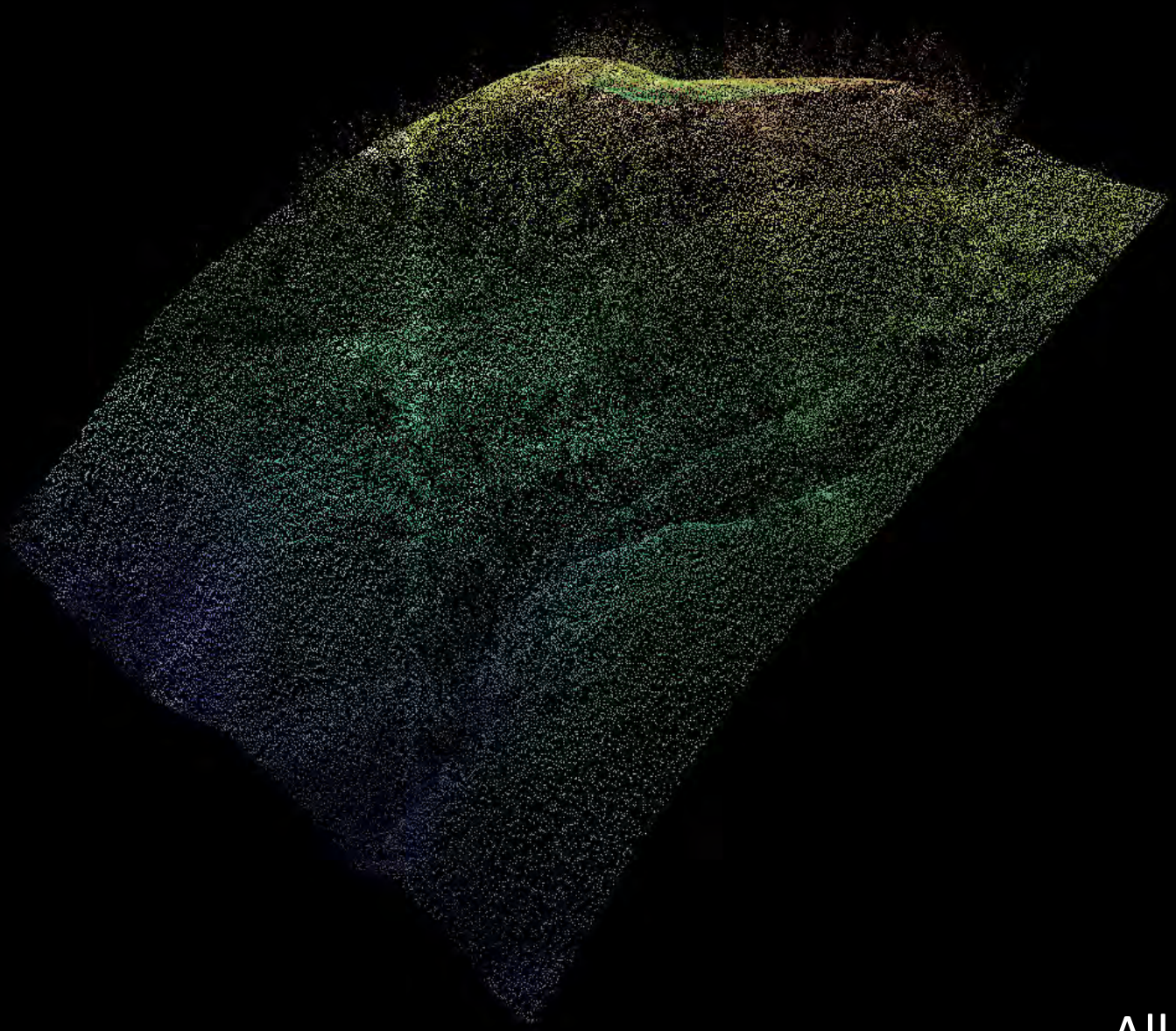


Point Cloud Profile

Classified



Point Cloud Perspective



All Returns

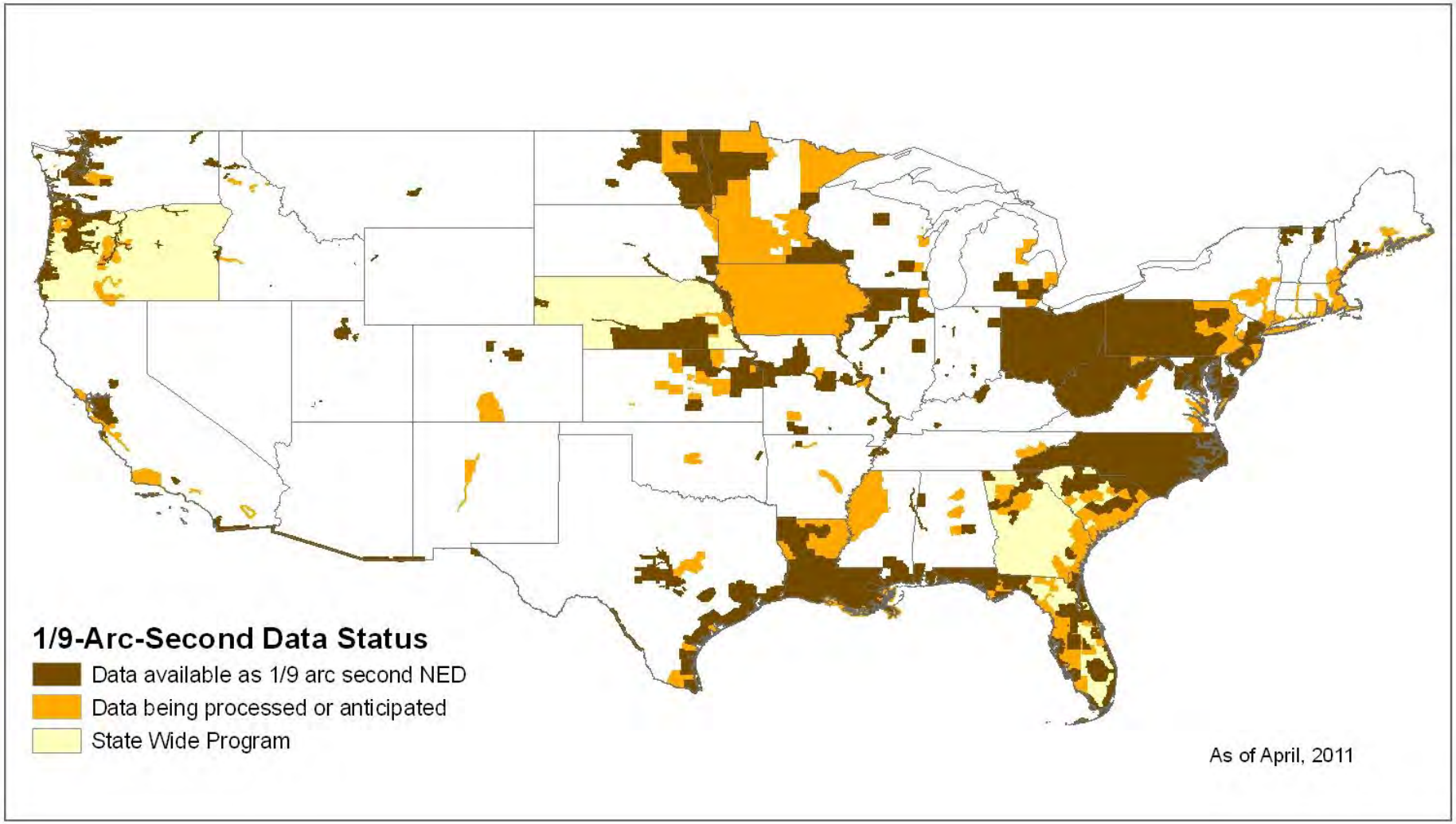
Point Cloud Perspective

Ground Interpolation

Data Sources and Products

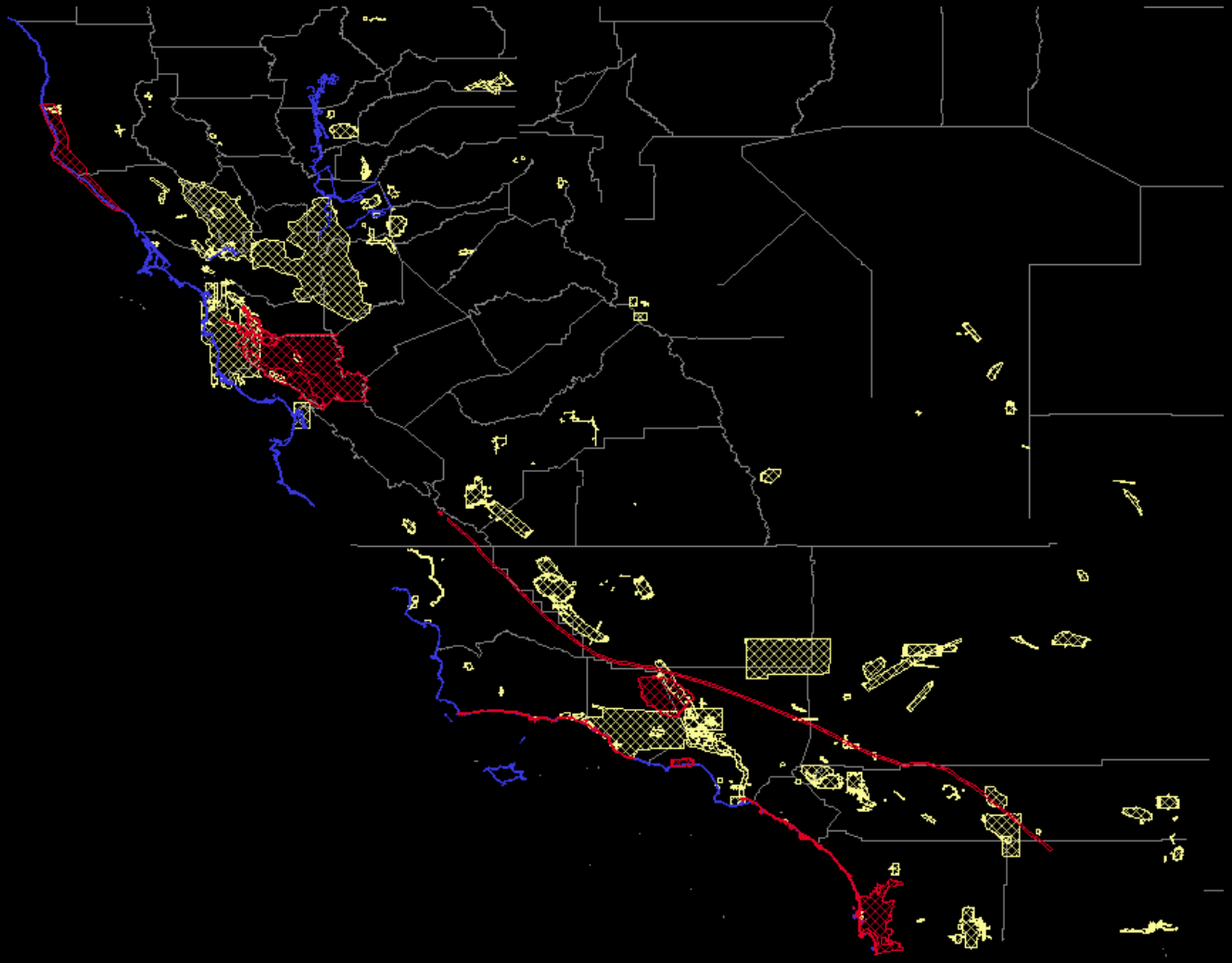
Source	Products
• Contract, Resale Data	LAS classified, DEM, …
• USGS Click	LAS unclassified
• Seamless NED, TNM	3m DEM

The National Map



http://nationalmap.gov/

USGS Click



http://lidar.cr.usgs.gov/

LiDAR Basemaps

Oregon Department of Geology

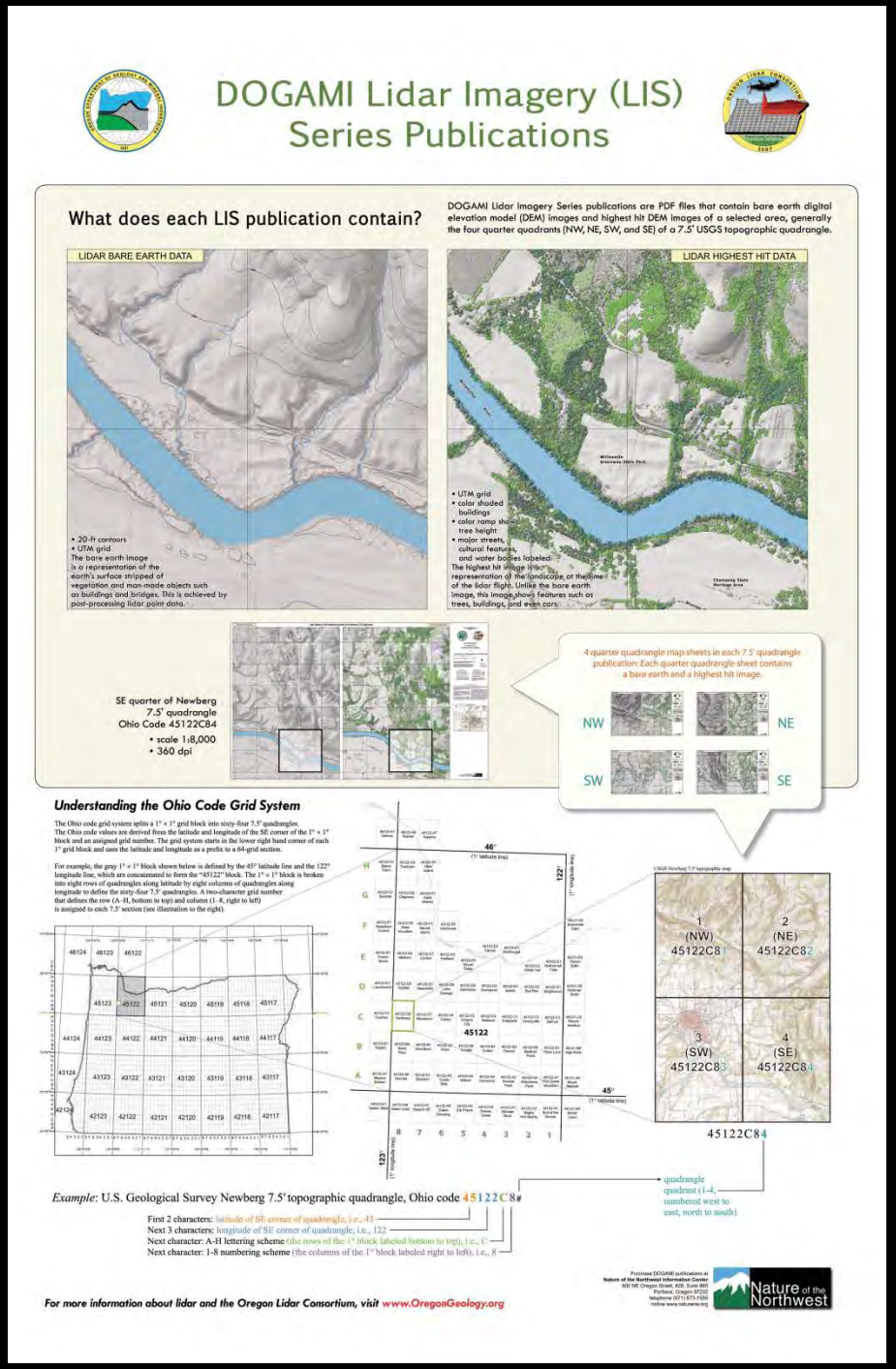
1 : 8000 map scale

Bare-Earth, Contours, Hydrography

Surface Height Hillshade with 4-tone tint

Can order print, .pdf, or data DVD

http://www.oregongeology.com/sub/pub&data/lidarpubs.htm



CCJDC 2010

http://www.ccjdc.org/projects/lidar.htm

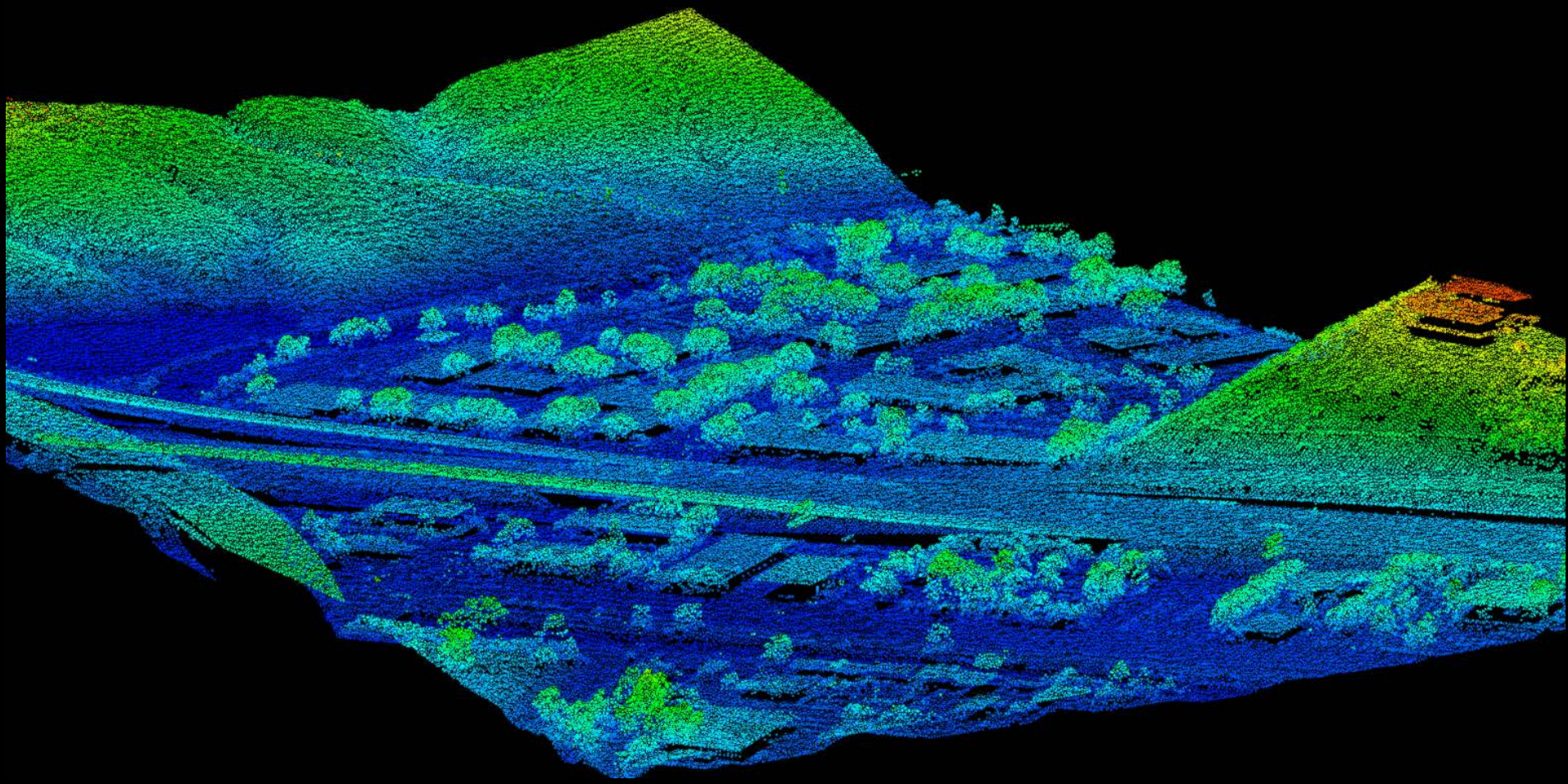
LiDAR .LAS data

- 683 Tiles
- 25 Million points ea.
- ~500 Mb ea.

3.4 Mi^2 ea

Name	Date modified	Type	Size
4BG-15.las	3/31/2011 8:09 AM	LAS File	441,915 KB
4BH-14.las	3/31/2011 8:09 AM	LAS File	38,425 KB
4BH-15.las	3/31/2011 8:09 AM	LAS File	549,728 KB
4BH-16.las	3/31/2011 8:09 AM	LAS File	603,909 KB
4BI-14.las	4/1/2011 7:29 AM	LAS File	126,098 KB
4BI-15.las	3/31/2011 8:09 AM	LAS File	590,930 KB
4BI-16.las	3/31/2011 8:09 AM	LAS File	616,355 KB
4BI-17.las	3/31/2011 8:09 AM	LAS File	603,956 KB
4BI-18.las	3/31/2011 8:09 AM	LAS File	612,503 KB
4BI-19.las	3/31/2011 8:09 AM	LAS File	613,137 KB
4BI-20.las	3/31/2011 8:09 AM	LAS File	591,898 KB
4BI-21.las	3/31/2011 8:09 AM	LAS File	603,141 KB

Layers from LAS data?



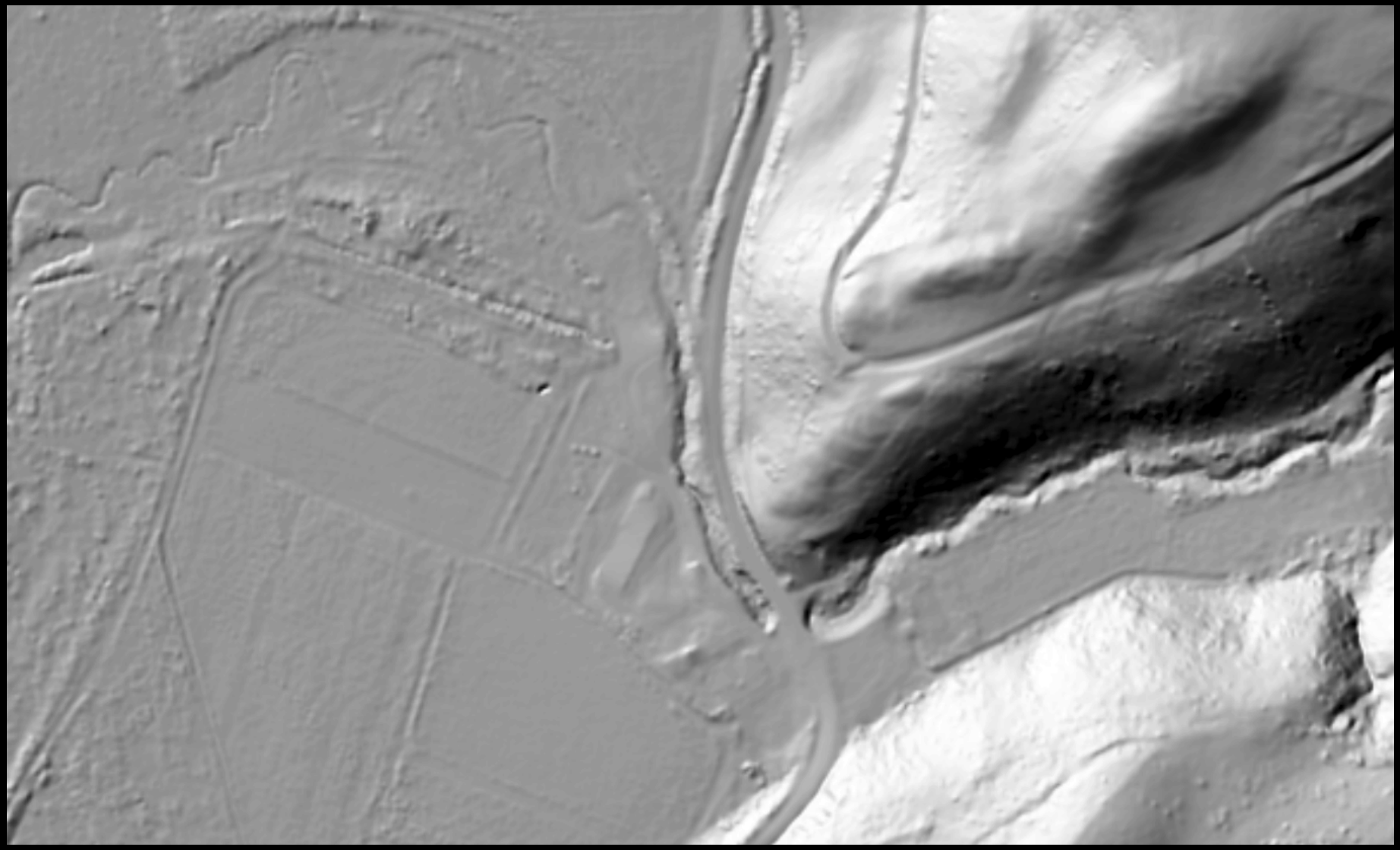
Grid Layers from LAS

- Bare Earth DEM
- Canopy Height Model
- Intensity Image
- % Canopy Cover, Bulk Density, Height to Crown Base, …
- Ground Point Density

Bare Earth DEM

data must already be filtered

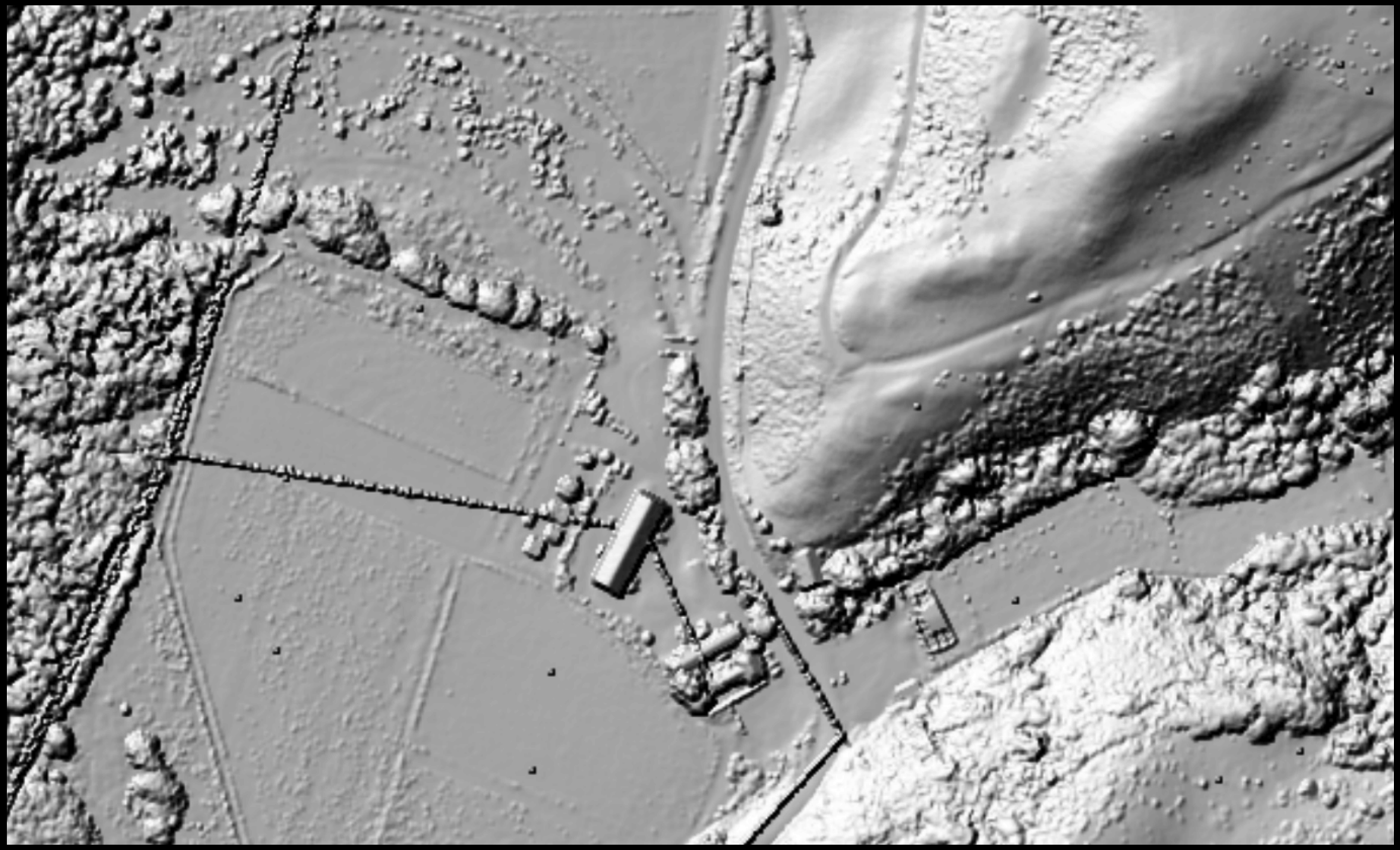
ArcGIS



Digital Surface Model (DSM)

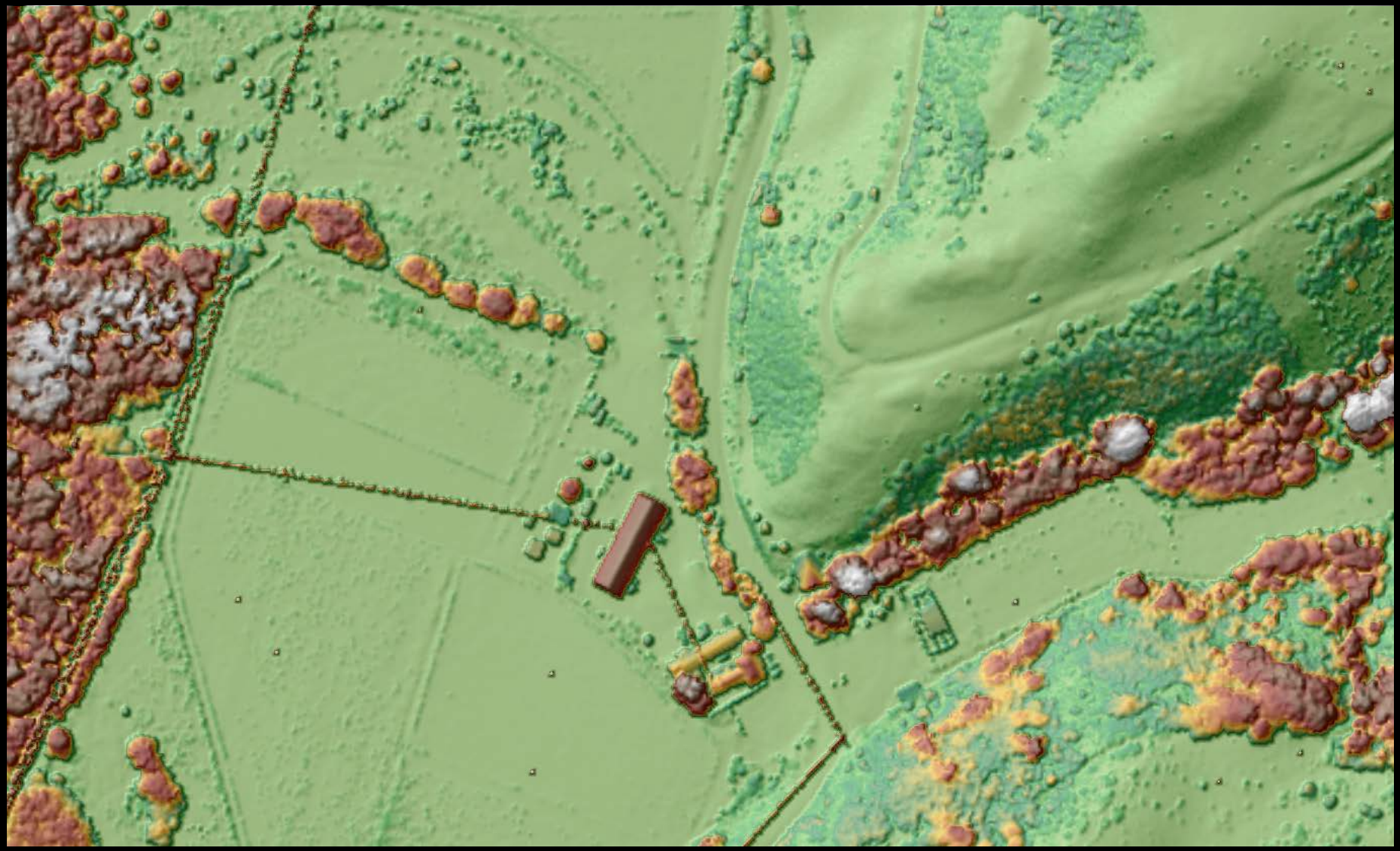
Highest hit elevations

USFS Fusion



nDigital Surface Model (nDSM)

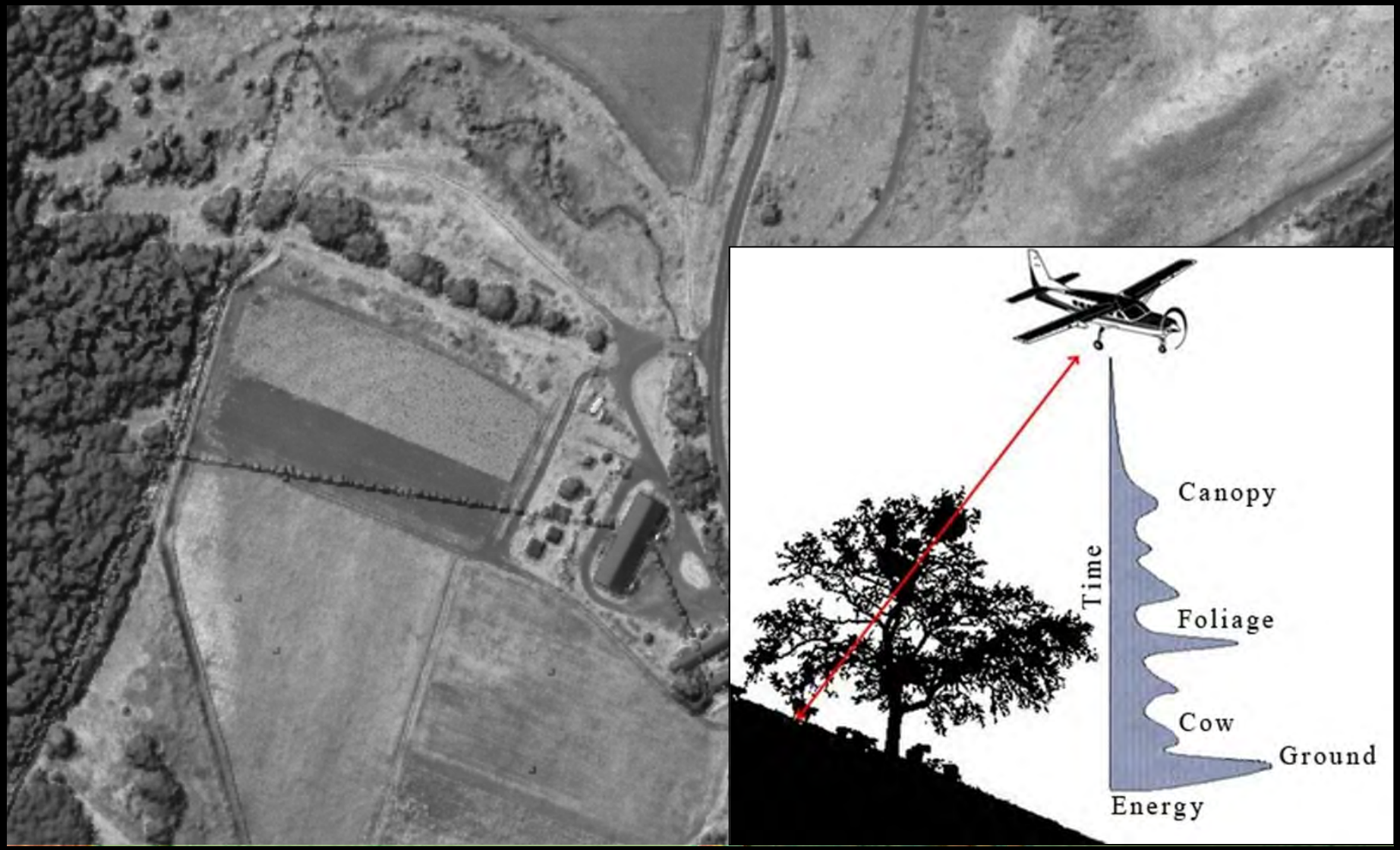
DSM – DEM = height above ground ArcGIS



Intensity Image

LiDAR reflectance

ArcGIS: Point to Raster*



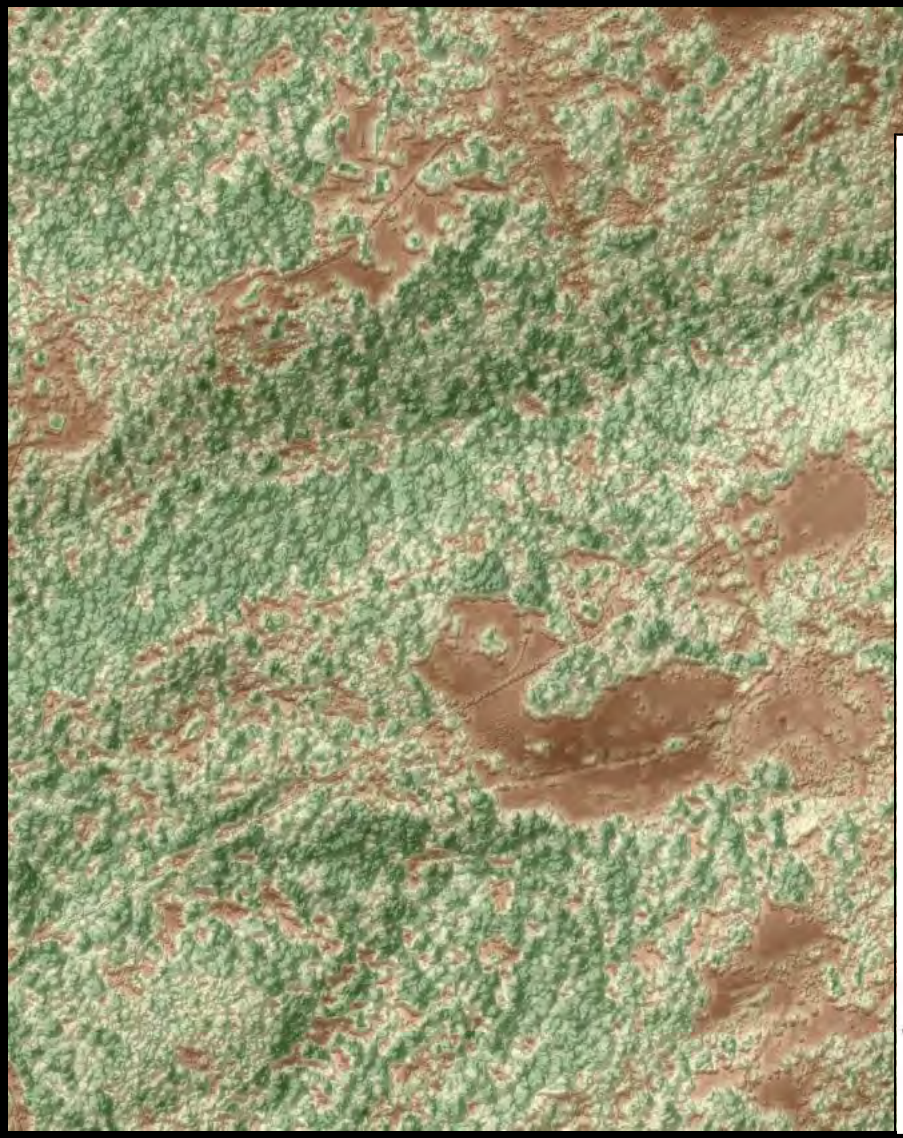
Hillshade and Imagery

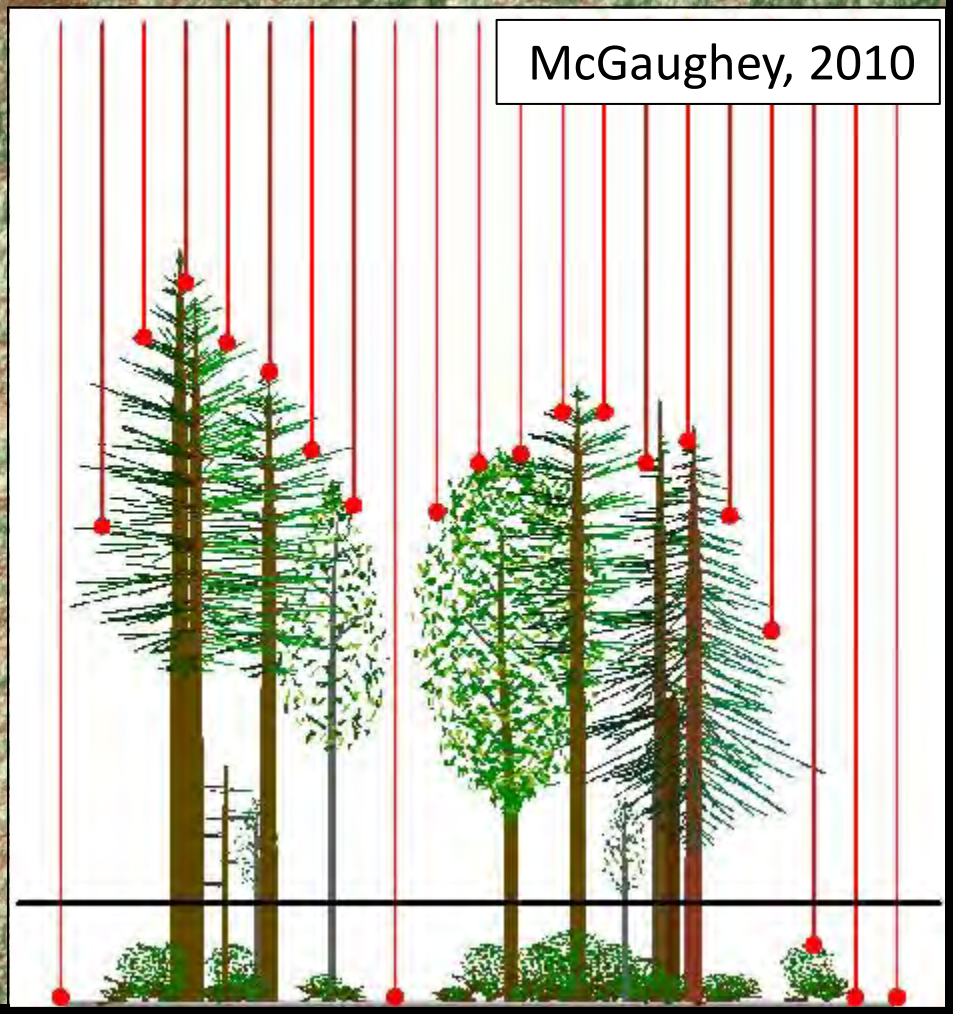
ArcGIS

Percent Canopy Cover

(# Canopy returns / Total # Returns)

USFS Fusion

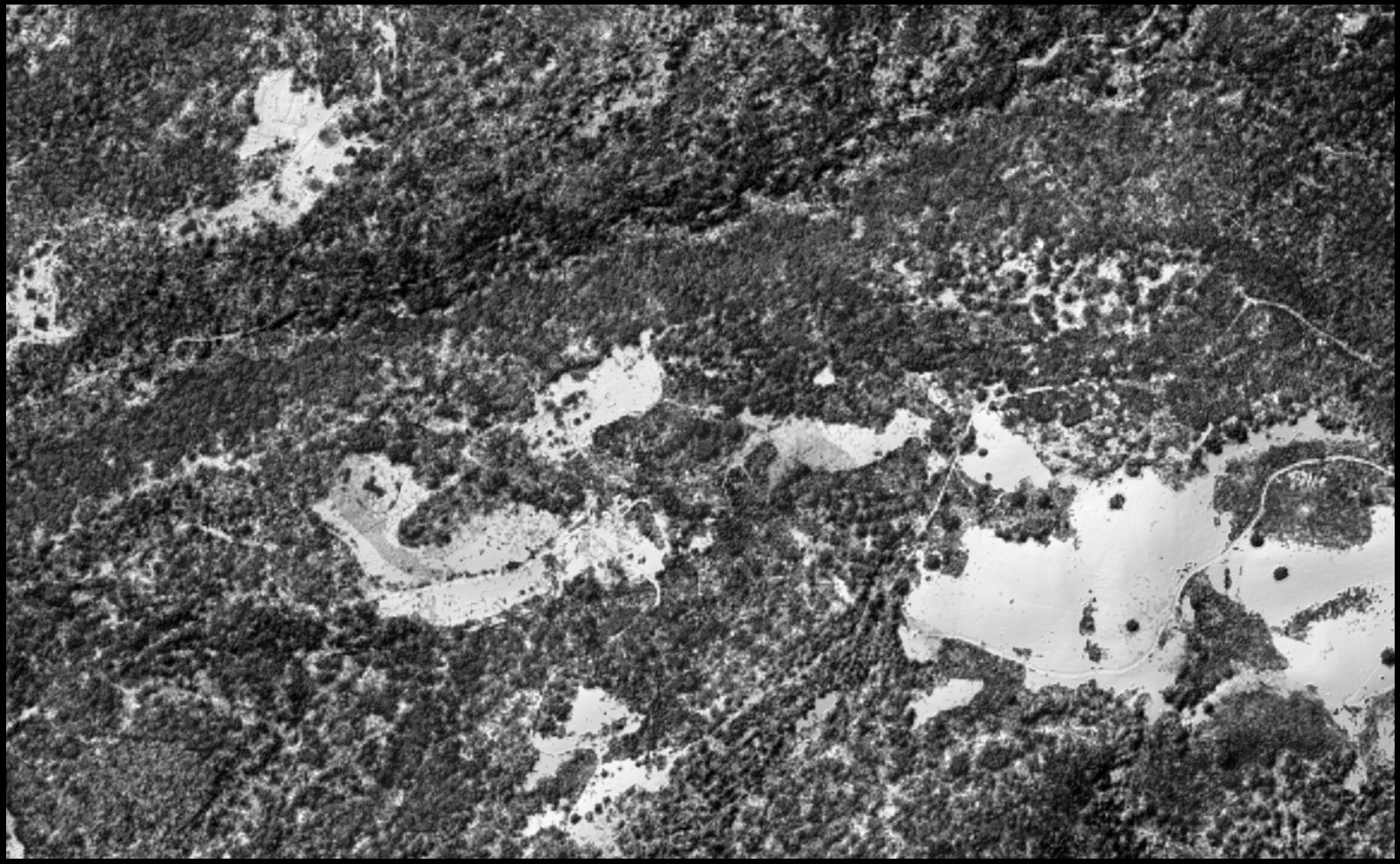




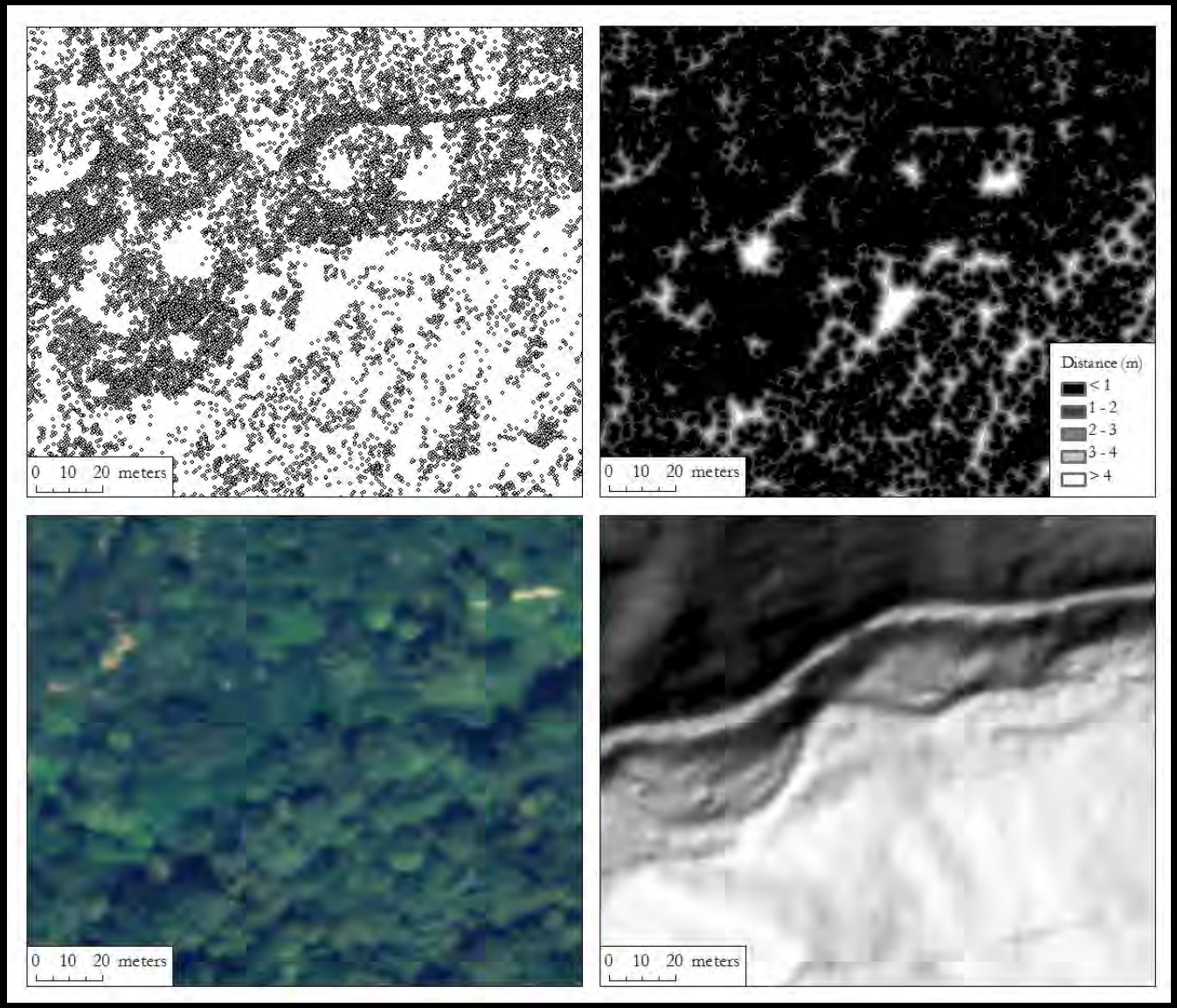
Ground Point Density

Ground Returns per m^2

Point to Raster



Irregular Point Spacing

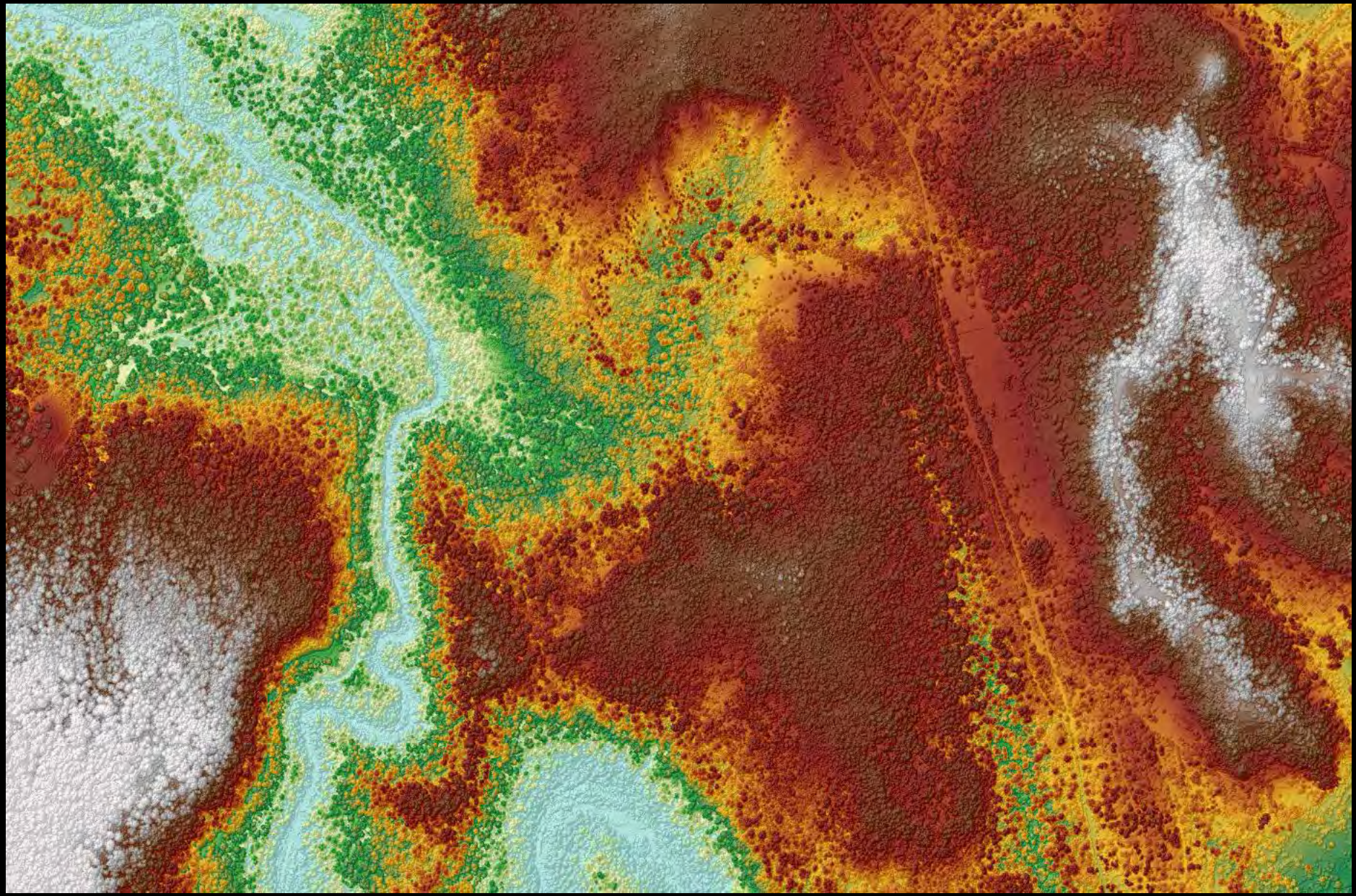


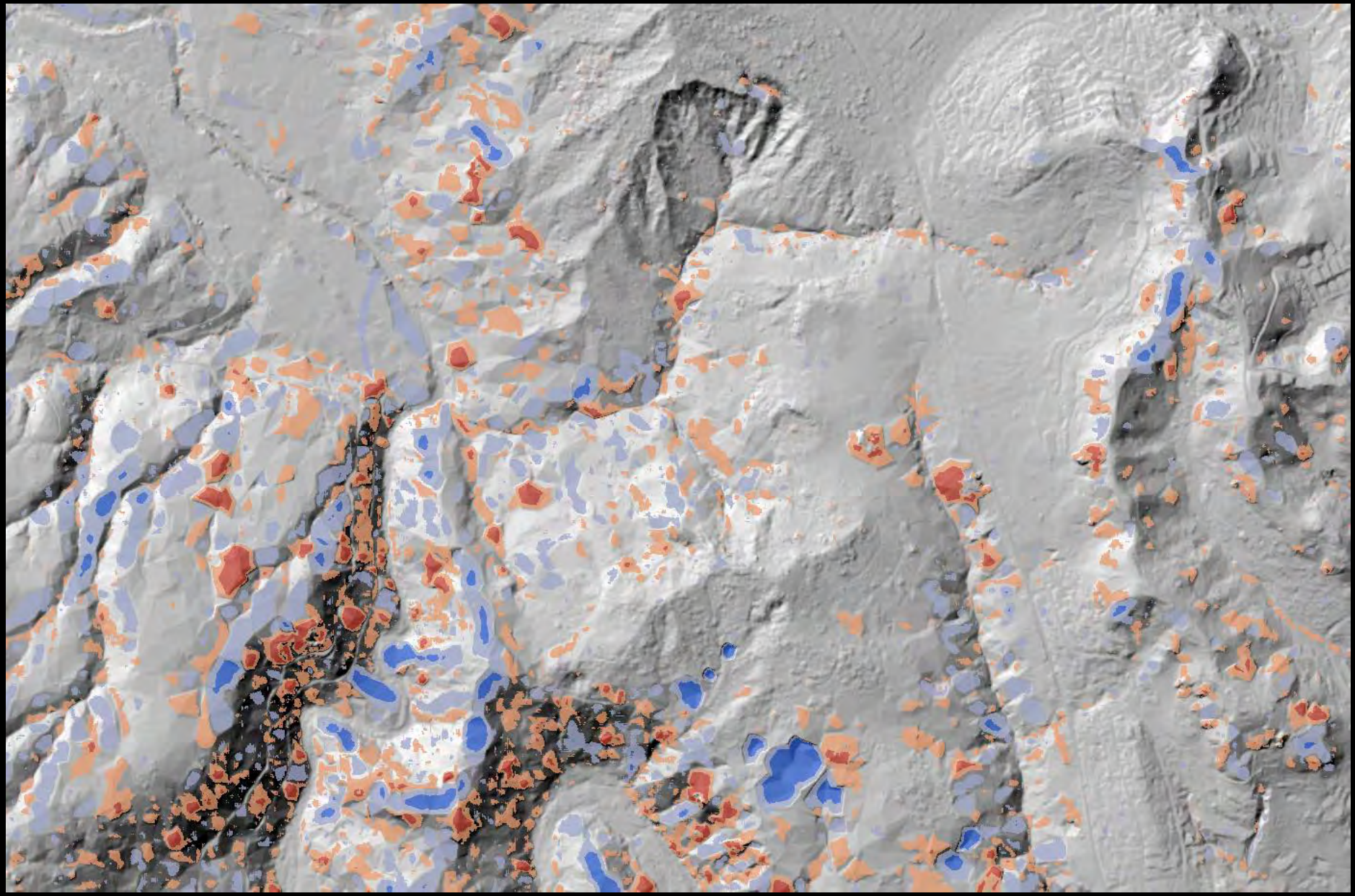
Mapping Forest Roads using LiDAR

CCJDC Example Data

- Tile 4BP-9.las
  - Bare Earth Hillshade
  - DSM
  - nDSM
  - Canopy Cover
  - Intensity

  - Original Bare-earth Filtering v.s. MCC re-filter





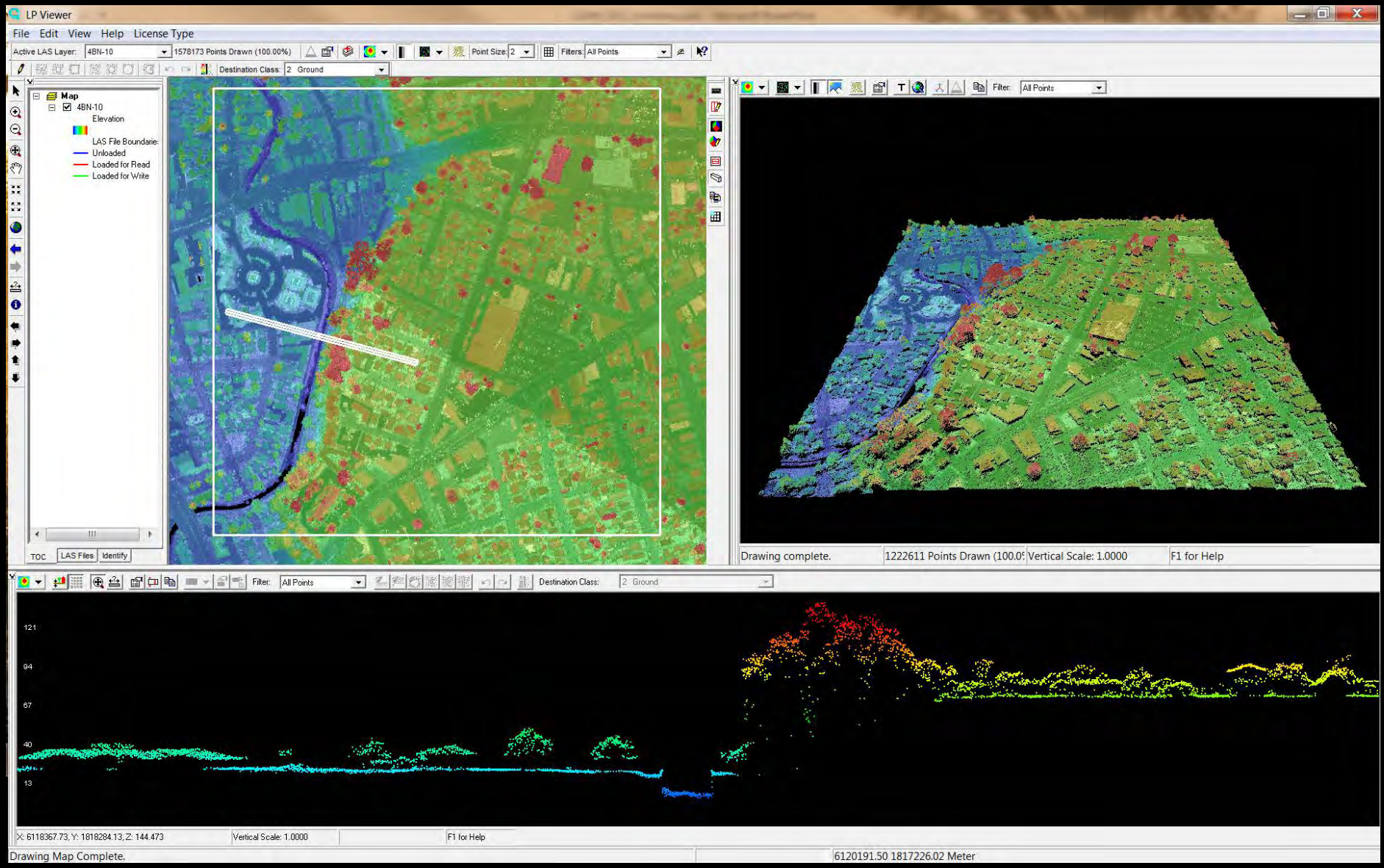
Elevation Difference from Original DEM- Refiltered DEM: +100 to – 100 ft.

Original Ground Point Density 0-2 pts./m^2

Visualization and Processing Tools

LP360	Point Cloud Viewer
LAS Tools	Clip, Merge, Convert…
MCC-LIDAR	Bare Earth Filtering
USFS Fusion	Canopy Surface, and more
ArcGIS	Build TIN, Terrain, DEM

Qcoherent LP360



LAS Tools

LasClip: extract points within polygon

- LasClip -i in.las -o out.las -poly mask.shp

Keep Only Ground Returns

- las2las -i in.las -o out.las -keep_class 2

Merge many tiles into one

- LasMerge -i list.txt -o merged.las

LAS Tools

laszip.exe	compresses the LAS files in a completely lossless manner
lasinfo.exe	prints out a quick overview of the contents of a LAS file
txt2las.exe	converts LIDAR data from ASCII text to binary LAS format
las2txt.exe	turns LAS into human-readable and easy-to-parse ASCII text
lasmerge.exe	merges several LAS files into one
lasgrid.exe	rasters very large LAS files into elevation or intensity grids
lastile.exe	tiles huge amounts of LAS points into square tiles

http://www.cs.unc.edu/~isenburg/lastools/

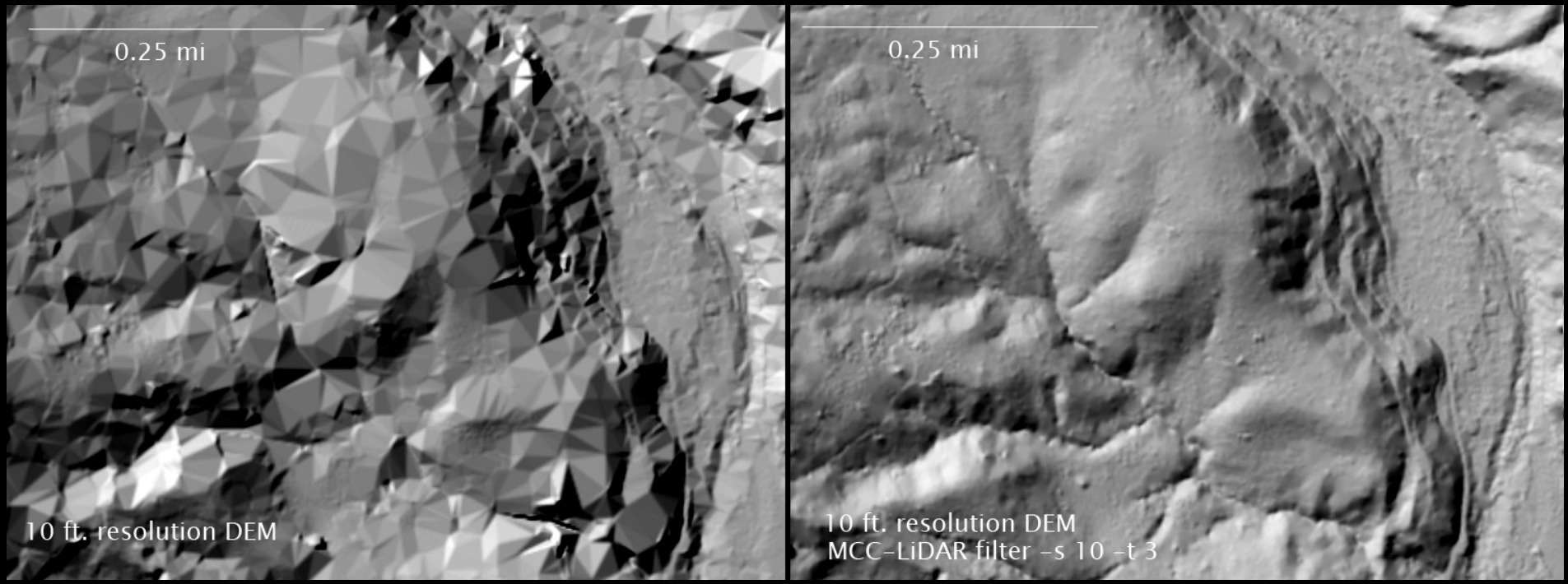
LAS Tools Continued

lasclip.exe	clips LAS points against building footprints / swath boundaries ...
las2las.exe	extracts last returns, clips, subsamples, translates, etc ...
lasboundary	extracts a boundary polygon that encloses the points
las2tin.exe	triangulates the points of a LAS file into a TIN
las2dem.exe	rasters a temporary TIN with hillshade/elevation/intensity
las2iso.exe	extracts, optionally simplified, elevation contours
las2shp.exe	turns binary LAS into ESRI's Shapefile format
shp2las.exe	turns an ESRI's Shapefile into binary LAS

http://www.cs.unc.edu/~isenburg/lastools/

MCC-LiDAR

Open Source Bare Earth Filtering



mcc-lidar -s 8 -t 3 sc.las sc_filtered.las

http://sourceforge.net/projects/mcclidar/

Multiscale Curvature Filter Publication

USFS Fusion

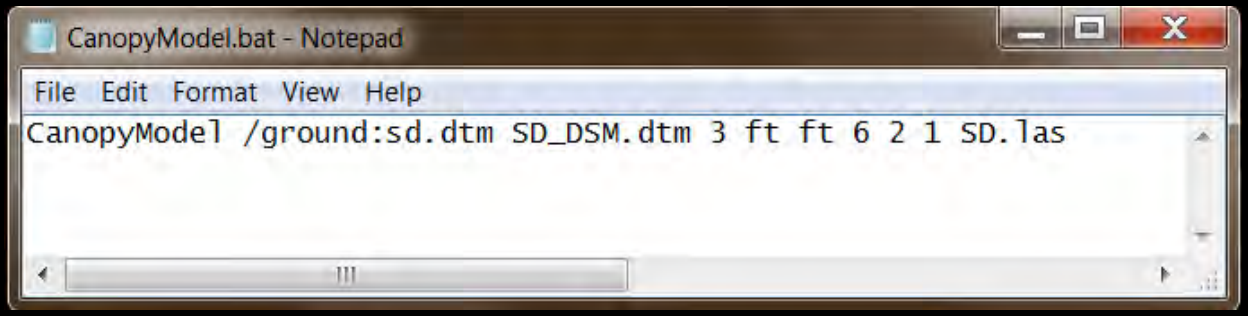
CanopyMaxima
CanopyModel
Catalog
ClipData
ClipDTM
CloudMetrics
Cover
DensityMetrics
FilterData
FirstLastReturn
GridMetrics
GridSurfaceCreate
GroundFilter
IntensityImage
MergeData
MergeDTM
PolyClipData

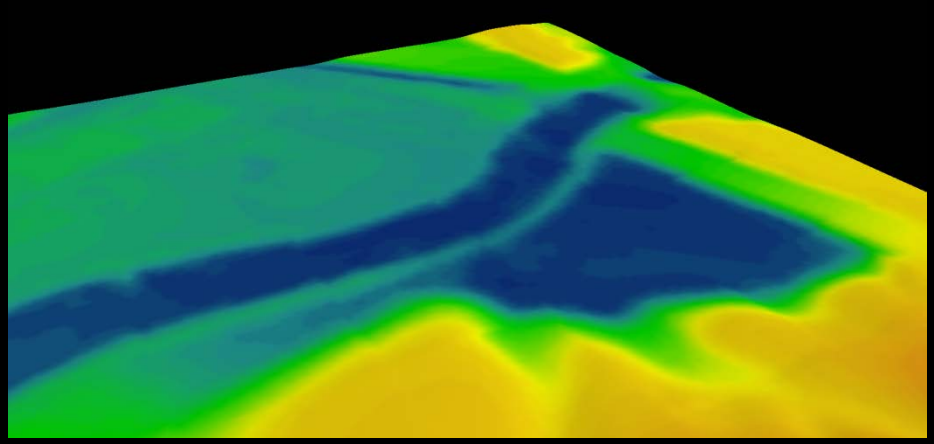
http://www.fs.fed.us/eng/rsac/fusion/

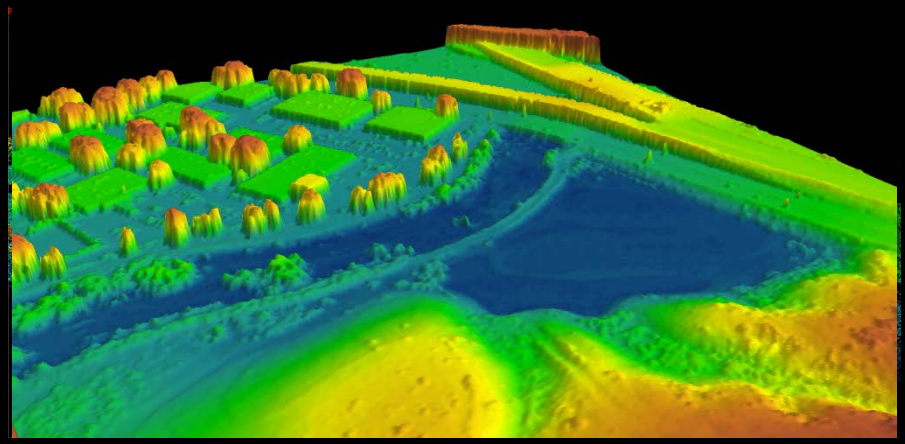
USFS Fusion: Canopy Surface Model

Syntax

CanopyModel [switches] surfacefile cellsize xyunits zunits coordsys zone horizdatum vertdatum datafile1 datafile2 …



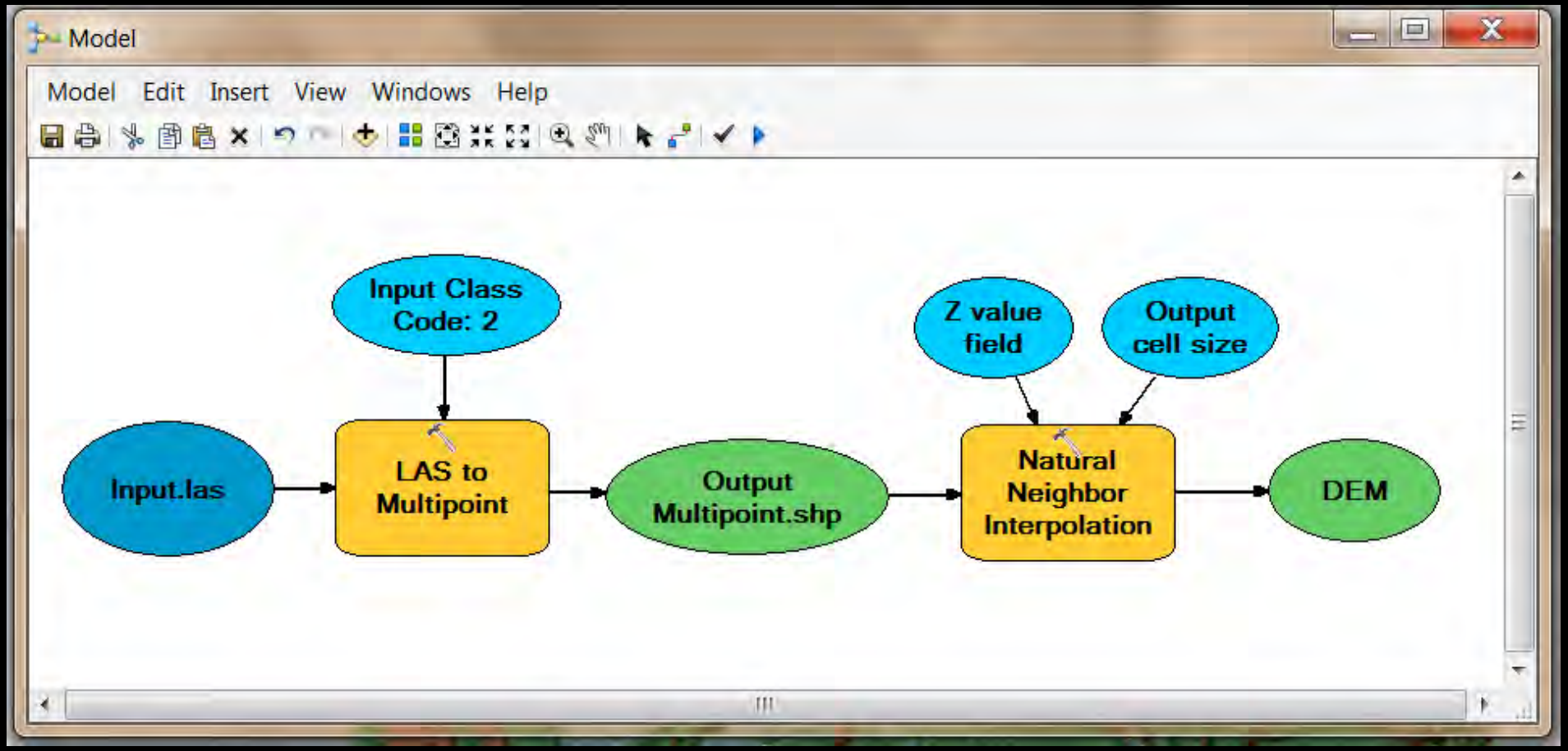




LAS and ArcGIS

- If LAS data are classified:
  - LAS to Multipoint
  - Build DEM
  - Incorporate Breaklines
  - Construct Intensity Image
  - Point Density

ArcGIS: LAS to Multipoint to DEM



ArcGIS Resource Center: LiDAR Solutions in 8 parts

http://blogs.esri.com/Dev/blogs/geoprocessing/archive/2008/11/06/Lidar-Solutions-in-ArcGIS_5F00_part-1_3A00_-Assessing-Lidar-Coverage-and-Sample-Density.aspx

LiDAR Software

- Several Open-Source Tools
  - Functionality for the Point Cloud
  - Stable, High performance, batch process

  - No Interactive Editing
  - No single All-purpose product
  - Data Conversion LAS → .asc → GRID
  - Some gaps in functionality

Data Considerations

- Potential value with raw LAS data
  - Also some issues: Negative Blunders, Birds…
- Processed DEMs may be suitable in the open…but
  - Inspect Hillshade
  - Evaluate Ground Point Spacing
  - Re-filter?
  - Where possible, verify with ground elevation checkpoints

GIS of the Future…today

thank you

…Questions?

Additional Links and Resources

- Opentopography
- NCALM
- NOAA Digital Coast
- LiDAR News Blog

Regional LiDAR Groups

- Oregon DOGAMI
- Pennsylvania LiDAR