Point clouds and DEMs

J Ramón Arrowsmith
School of Earth and Space Exploration
Arizona State University

Christopher J. Crosby
UNAVCO

Tutorial notes (April 2016)

OpenTopography
High-Resolution Topography Data and Tools

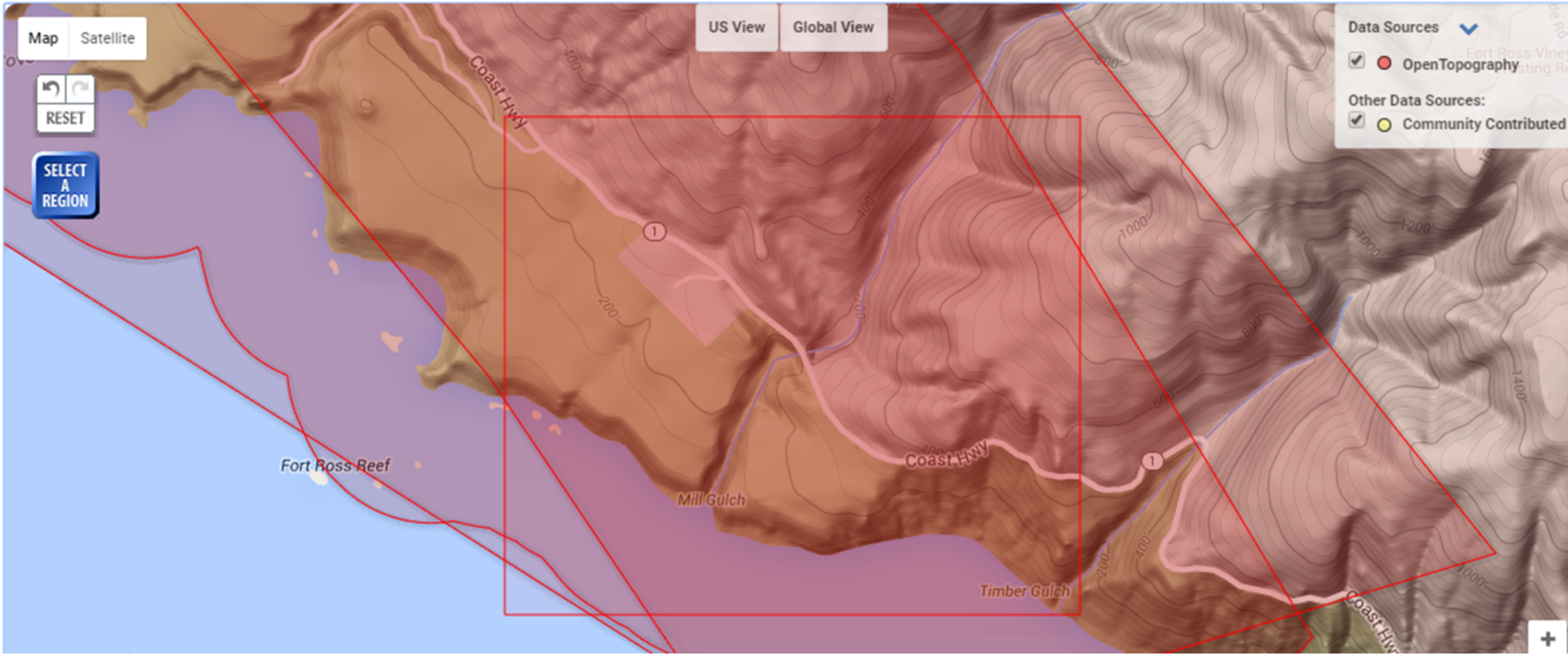
Demo Source Data

Find Lidar Topography Data

OpenTopography
High-Resolution Topography Data and Tools

Instructions

US Interagency Elevation Inventory



Datasets listed below are hosted by OpenTopography and are available in point cloud format for download and processing (e.g., creating custom DEMs). In some cases derived data products such as raster and Google Earth Image overlays are also available. Click the button to the right of the dataset name to access the available data products.

1	UMD-NASA Carbon Mapping /Sonoma County Vegetation Mapping and LiDAR Program	Raster Data · Point Cloud Data
2	Shuttle Radar Topography Mission (SRTM) Global	SRTM 30m · SRTM 90m
3	EarthScope Northern California LiDAR Project	GE Hillshades · Raster Data · Point Cloud Data
4	Northern San Andreas Fault, CA	Point Cloud Data

Demo Source Data

Northern San Andreas Fault, CA

Overview

This page offers access to lidar data acquired along the Northern San Andreas fault and associated marine terraces in coastal Sonoma and Mendocino counties, California. This dataset covers approximately 418 square kilometers and includes approximately 1.2 billion data points. Point density is 1.2 points per square meter.

These data were acquired by NASA, in collaboration with the United States Geologic Survey and the Puget Sound Lidar Consortium, with funding provided by NASA's Earth Surface and Interior Focus Area. The data was collected and processed by Terrapoint. The data are in the public domain with no restrictions on their use.

Platform: Airborne Lidar
Full Metadata

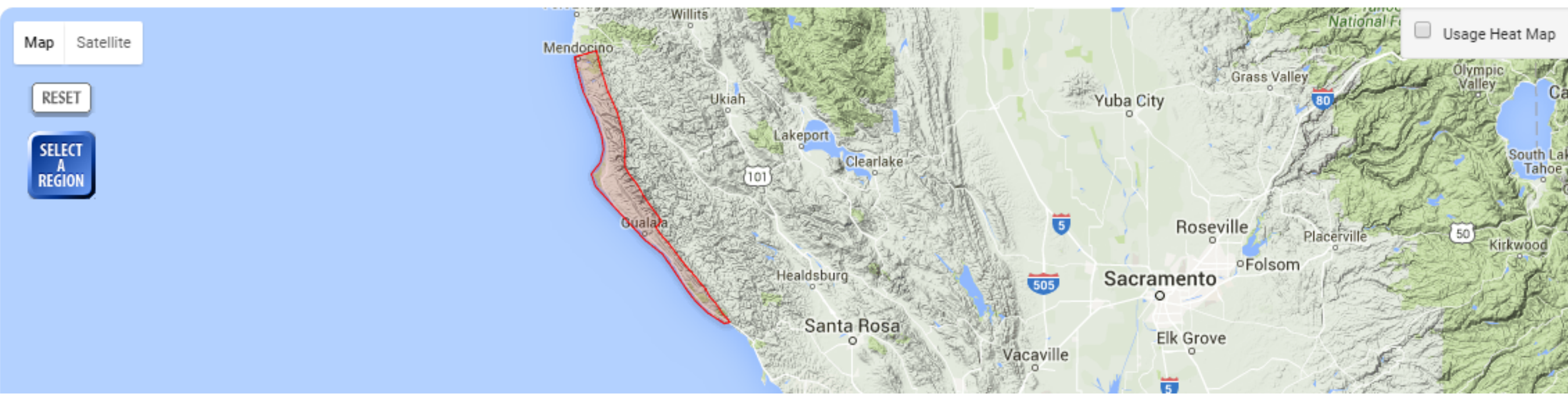
Survey Area: 767.00 km^2
Dataset Acknowledgement

Point Density: 1.47 pts/m^2
Funder: NASA *Partners*: USGS, PSLC

Survey Date: 02/01/2003
Collector: Terrapoint

Select Other Available Data Products: Point Cloud Bulk Download

1a. Select area of data to download or process



Demo Source Data

1. Coordinates & Classification

Horizontal Coordinates: California State Plane Zone II US Survey Feet [EPSG: 2871]
Vertical Coordinates: NAVD88

Data Selection Coordinates: ☐ Manually enter selection coordinates (in the horizontal coordinate system listed above)

X_{min} = 6211604.418 Y_{min} = 1946923.876 X_{max} = 6213674.873 Y_{max} = 1949335.955

Demo Source Data

X_{min} = 6211604.418 Y_{min} = 1946923.876 X_{max} = 6213674.873 Y_{max} = 1949335.955

The selection area contains approximately 223,000 points.

Choose Return Classification ☑ Ground ☑ Unclassified

2. Point Cloud Data Download

☐ Point cloud data in LAS format ☑ Point cloud data in LAZ format ☐ Point cloud data in ASCII format

3A. DEM Generation (Streaming TIN)

Gridding Method
☑ Calculate TIN

Gridding Parameters
Grid Resolution (Default = 6 ft) 6
Max. triangle size (Default 50 units) 50

Grid Format
GeoTiff

Demo Source Data

Job Id	Dataset	Title	Submission	Completion	Duration	Num points	Final Status
pc1462030452569	NSAF	NSAF demo for CGS	2016-04-30 08:34:12	2016-04-30 08:34:34	22 secs	636,201	Done ✔

Download Job Results

Point Cloud Results

- Download point cloud data in LAZ format points.laz (3 MB)

DEM Results

- Download DEM (TIN) dems.tar.gz (381.2 KB)

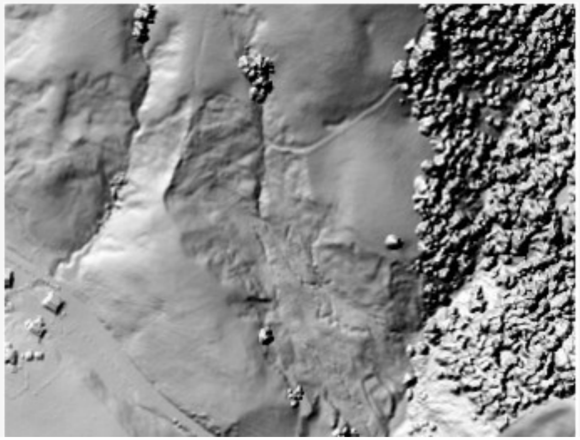
Derivative Products

- Download Hillshade & Slope Products (TIN) viz.tar.gz (599.7 KB)

Visualization Products

Ztin DEM

- Download KMZ file viz.tin.hs.kmz
- View with Google Map



Demo Source Data

OpenTopography
High-Resolution Topography Data and Tools

UMD-NASA Carbon Mapping /Sonoma County Vegetation Mapping and Lidar Program

Overview

This survey covers all of Sonoma County as well as two small portions of southern Mendocino County. Data were provided by the University of Maryland and the Sonoma County Vegetation Mapping and Lidar Program under grant NNX13AP69G from NASA's Carbon Monitoring System (Dr. Ralph Dubayah, PI). The Sonoma County Vegetation Mapping and Lidar Program is NASA/UMD's local partner in this project- its members are as follows: the Sonoma County Agricultural Preservation and Open Space District, the Sonoma County Water Agency, the California Department of Fish and Wildlife, the United States Geological Survey, the Sonoma County Information Systems Department, the Sonoma County Transportation and Public Works Department, the Nature Conservancy, and the City of Petaluma.

University of Maryland 1856

NASA

SONOMA VEG MAP
SONOMA COUNTY VEGETATION MAPPING & LIDAR PROGRAM
High-Quality Data for Planning, Conservation and Resource Management

These data will be used for various research projects throughout Sonoma County. They are critical to assessing climate mitigation and adaptation strategies and benefits provided by the landscape, such as the amount of carbon sequestration in forests or the degree to which riparian areas, floodplains, and coastal habitats may buffer extreme weather events. Other research applications include groundwater, ecosystem services valuation, ecosystem resiliency, and wildlife habitat connectivity. Finally, these data sets are key to facilitating good planning and management for watershed protection, flood control, fire and fuels management and wildlife habitat conservation.

The data was collected between September 28 and November 26, 2013 by Watershed Sciences, Inc. (WSI). Lidar was collected at high density greater than 8 pulses per square meter. WSI used two airplanes, one carrying a Leica ALS50 and the other a Leica ALS70; systems were flown at 900 meters above ground level, capturing a scan angle of 15 degrees from nadir (30 degree field of view). 4-band, 6-inch resolution aerial photography was collected simultaneously with the Lidar data.

Platform: Airborne Lidar
Full Metadata

Survey Area: 4,374.00 km^2
Dataset Acknowledgement

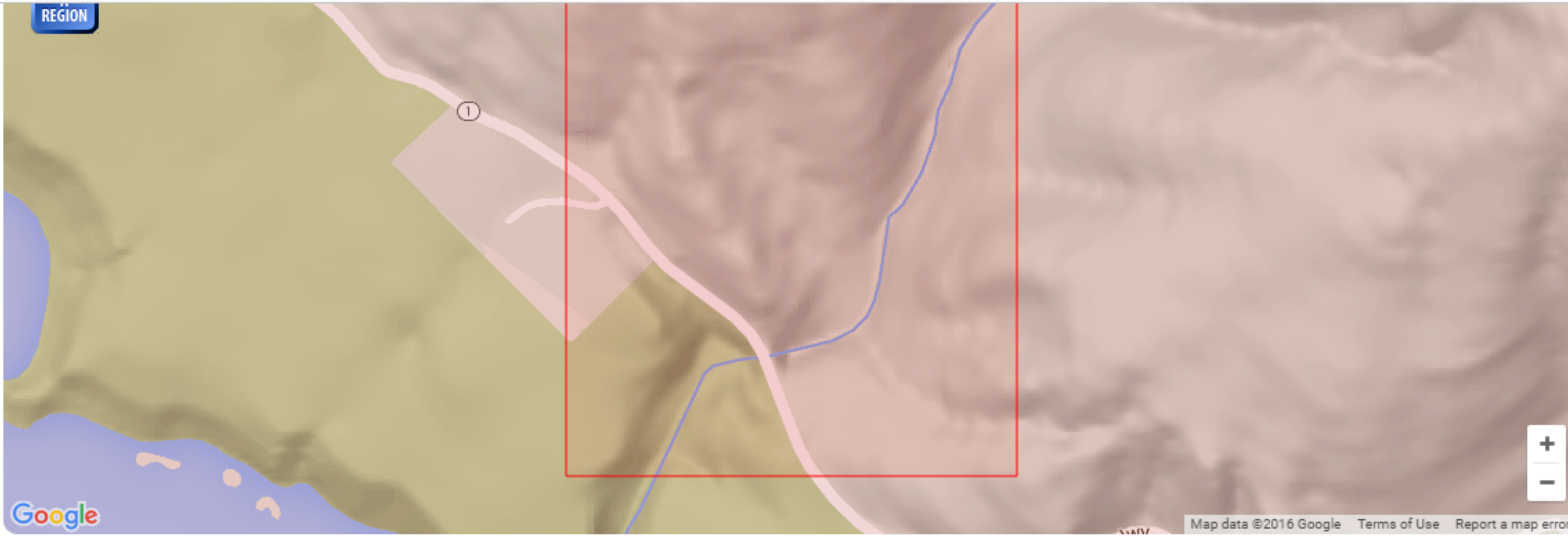
Point Density: 13.73 pts/m^2
Funders: NASA, Sonoma Veg Map, UMD
Collector: WSI

Survey Date: 09/28/2013 - 10/28/2013
Partners: NASA, Sonoma Veg Map, UMD

Demo Source Data

OpenTopography

HOME | ABOUT | DATA | TOOLS | LEARN | COMMUNITY



1. Coordinates & Classification

Horizontal Coordinates: State Plane, California Zone II, FIPS Zone 0402, (NAD83) 2011 [EPSG: 2871]
Vertical Coordinates: North American Vertical Datum 1988 (NAVD88), GEOID 12a, US Survey Feet

Data Selection Coordinates: ☑ Manually enter selection coordinates (in the horizontal coordinate system listed above)

X_{min} = 6211604.41 Y_{min} = 1946923.87 X_{max} = 6213674.87 Y_{max} = 1949335.95

Validate coordinates and estimate point count

The selection area contains approximately 4,453,000 points.

Demo Source Data

The selection area contains approximately 4,453,000 points.

Choose Return Classification ☑ Ground ☑ Unclassified ☑ Vegetation

2. Point Cloud Data Download

☑ Point cloud data in LAS format ☑ Point cloud data in LAZ format ☐ Point cloud data in ASCII format

3A. DEM Generation (Streaming TIN)

Gridding Method
☑ Calculate TIN

Gridding Parameters
Grid Resolution (Default = 6 ft) 6
Max. triangle size (Default 50 units) 50

Grid Format
GeoTiff

Demo Source Data

OpenTopography

HOME ABOUT DATA TOOLS LEARN COMMUNITY

Job Id	Dataset	Title	Submission	Completion	Duration	Num points	Final Status
pc1462030828460	SONOMA_LIDAR	Sonoma lidar for CGS demo	2016-04-30 08:40:28	2016-04-30 08:41:30	62 secs	4,735,481	Done ✔

Download Job Results

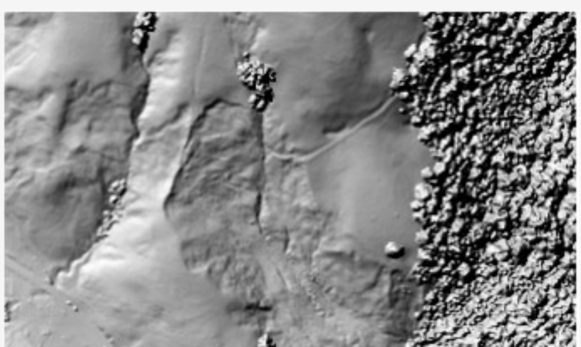
Point Cloud Results
- Download point cloud data in LAS format points.las (153.5 MB)
- Download point cloud data in LAZ format points.laz (25.7 MB)

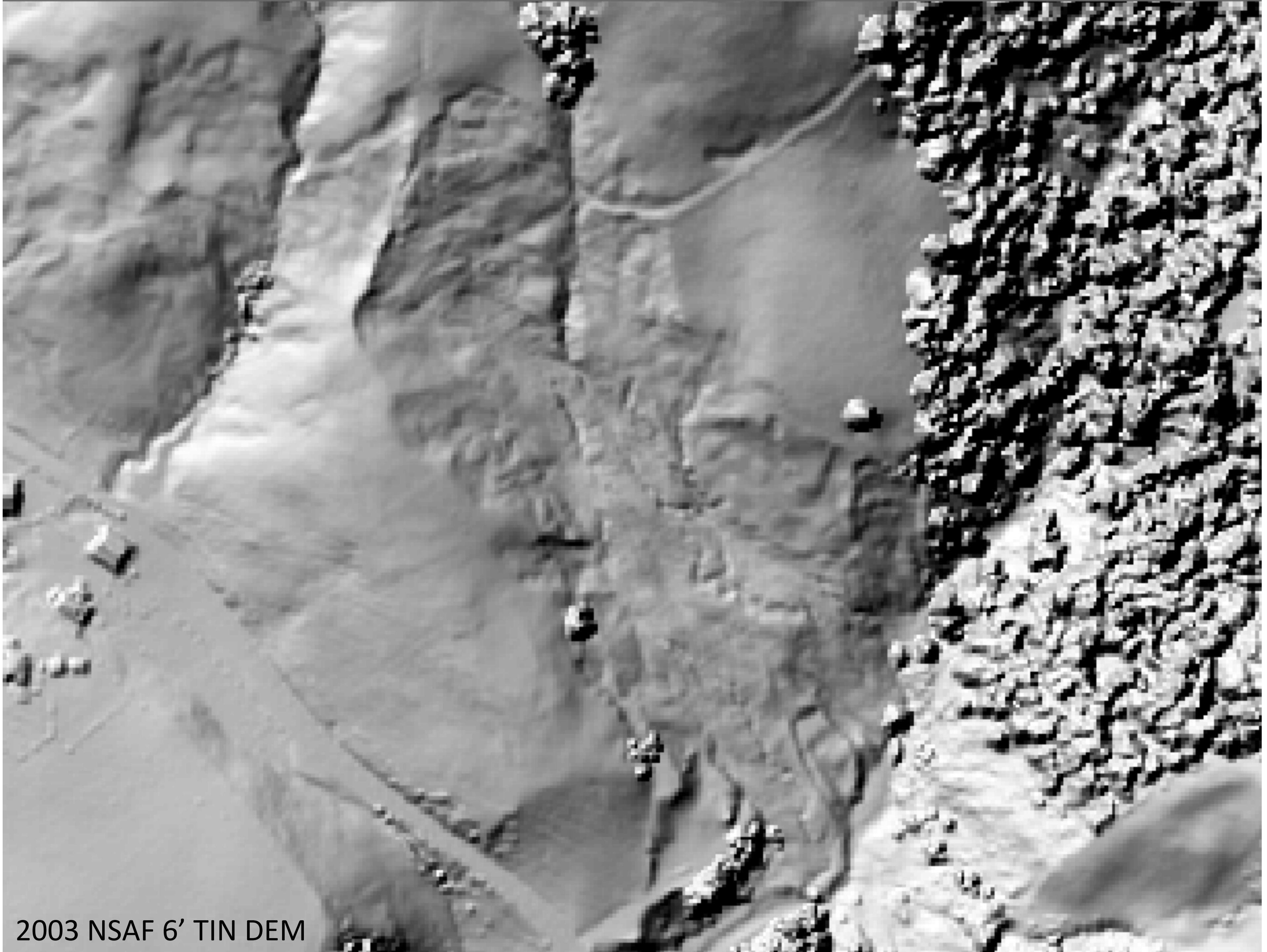
DEM Results
- Download DEM (TIN) dems.tar.gz (381.1 KB)

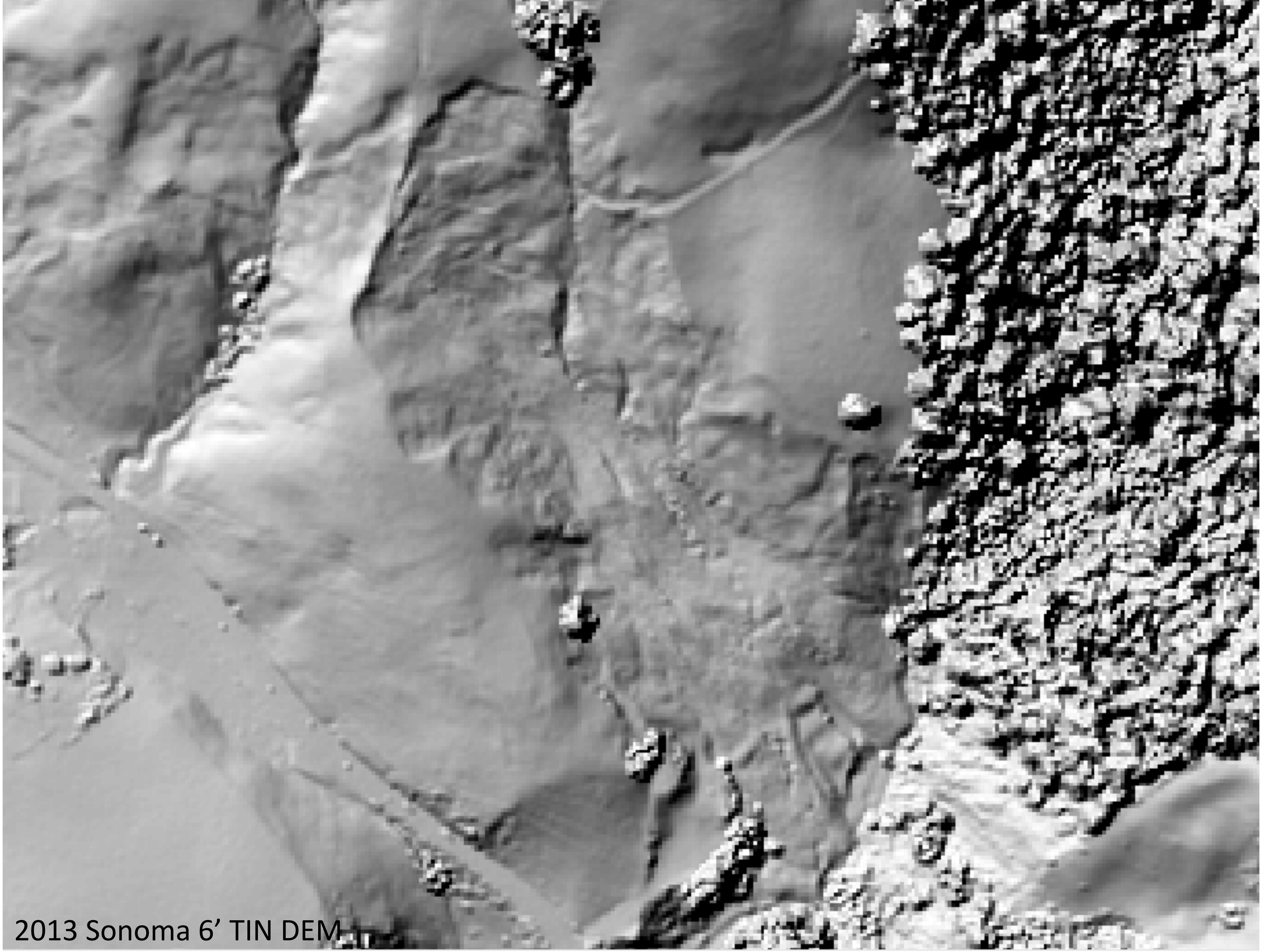
Derivative Products
- Download Hillshade & Slope Products (TIN) viz.tar.gz (600.6 KB)

Visualization Products

Ztin DEM
- View with Google Map




2003 NSAF 6’ TIN DEM


2013 Sonoma 6’ TIN DEM

LAStools: https://rapidlasso.com/lastools/

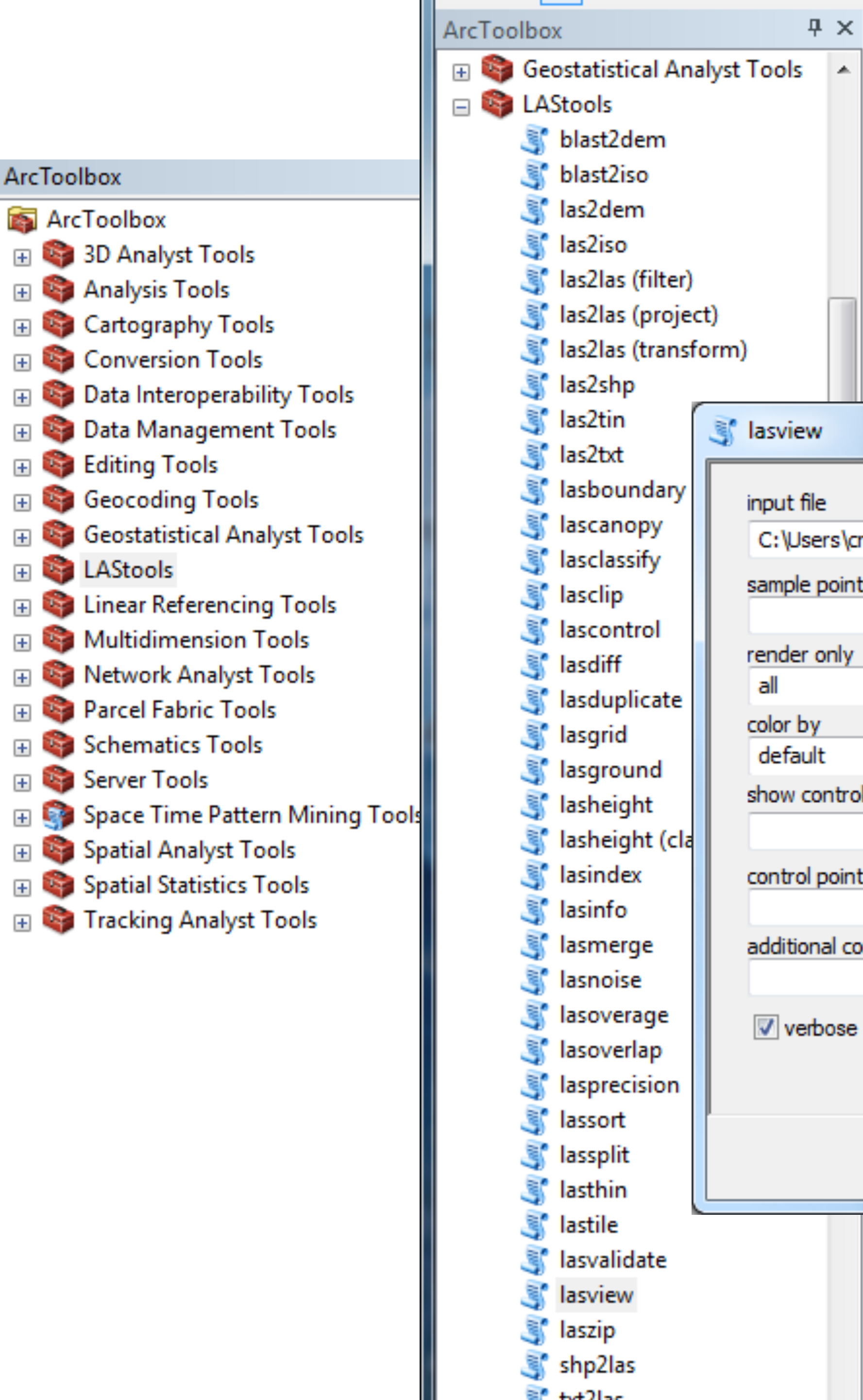
Combination of open source and commercial software.

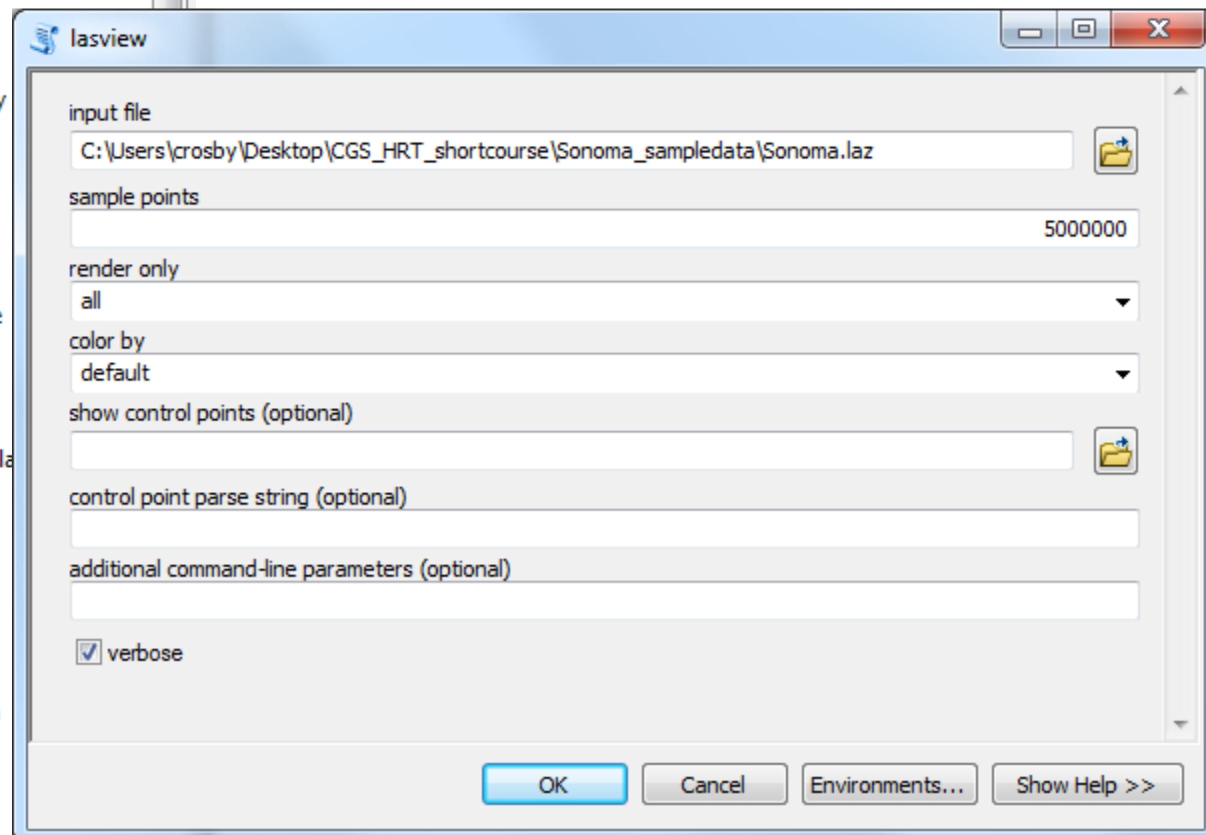
Stand alone GUIs, command line tools, **ArcGIS**, QGIS, ERDAS Image toolboxes

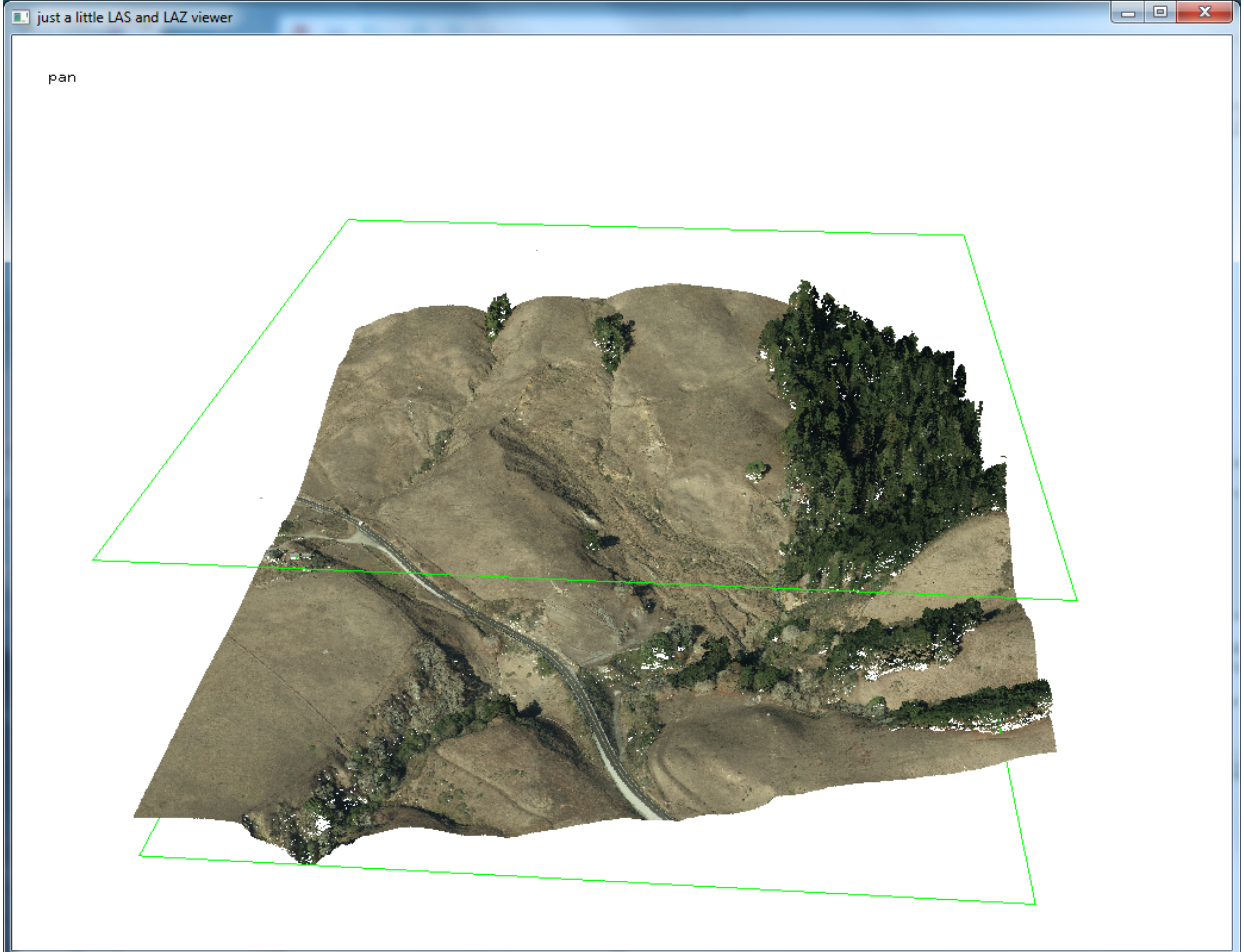
Point clouds and DEMs

1. Download 2013points.laz
2. Lasview (right click to change functions)
3. Lasinfo (lasinfo -i "C:\Users\ramon\Desktop\Tahoepoints.las" -odir "C:\Users\ramon\Desktop" -o "tahoe.txt“)
4. Lasboundary (output file format kml)
5. Las2txt
6. LAS2LAS - filtering (-keep_class); projections
7. LASground

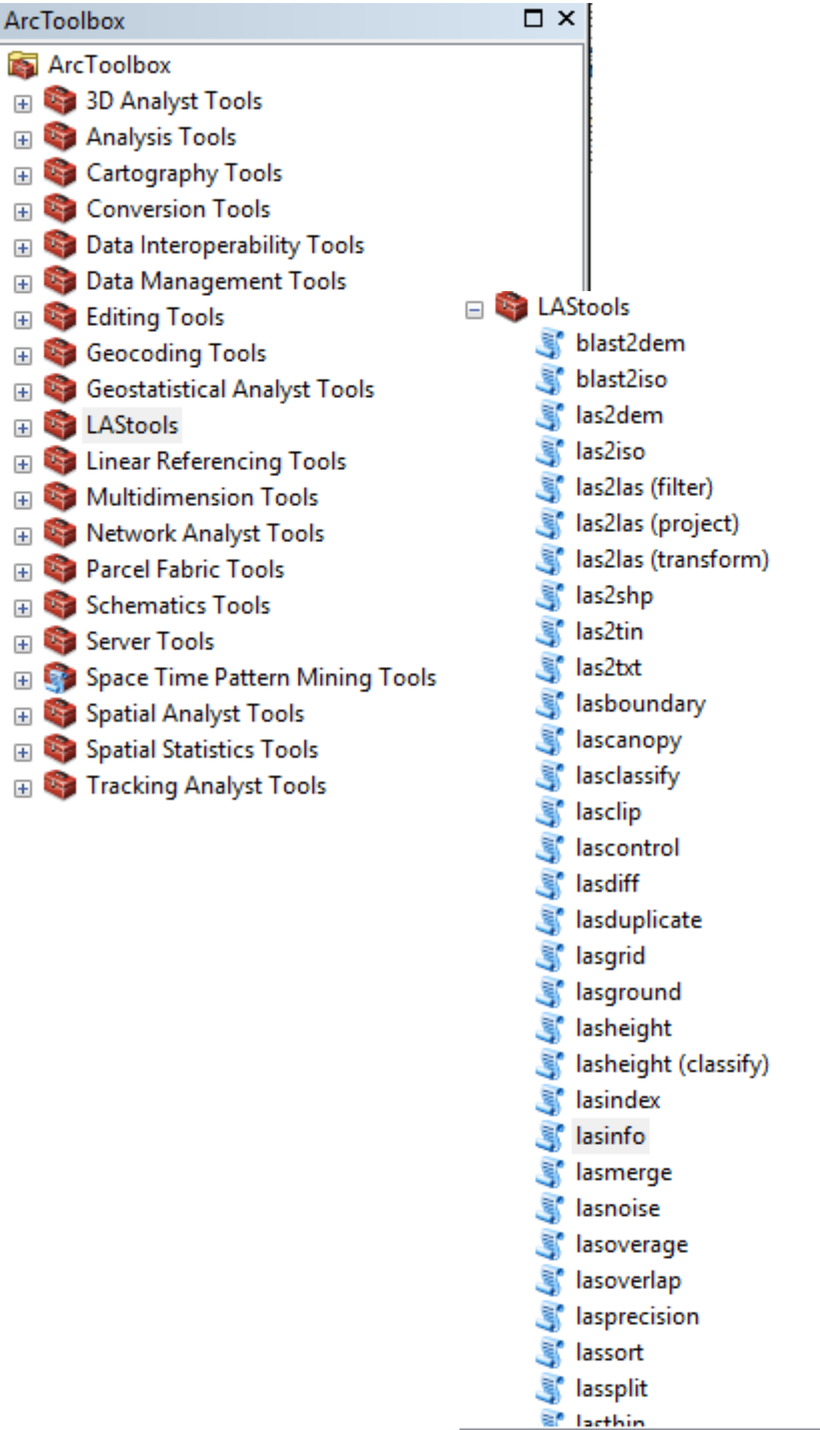
LASview – simple point cloud viewing

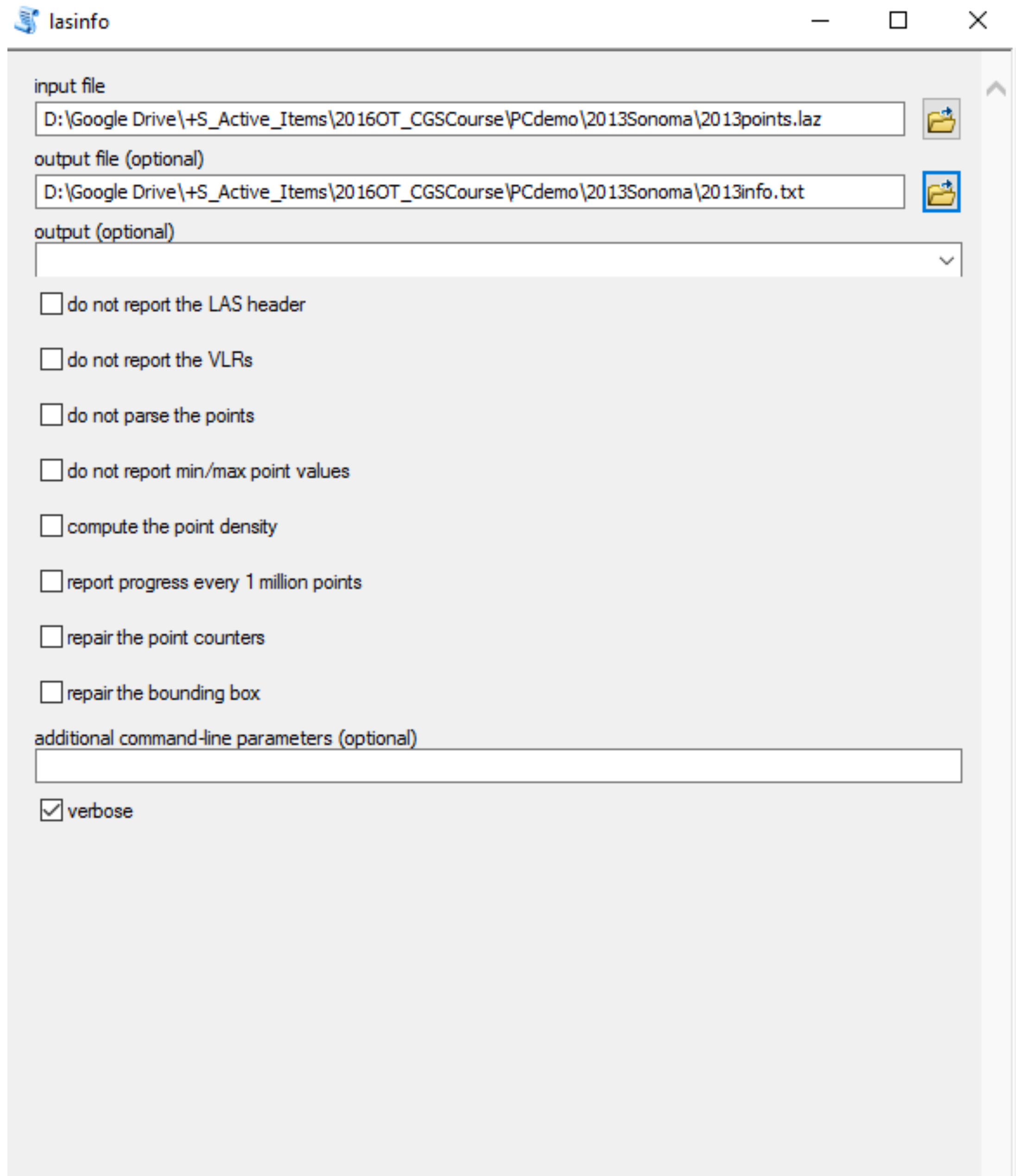





just a little LAS and LAZ viewer
pan

LASinfo – what's in my LAS/LAZ file?





LASinfo – header and content report

```
reporting all LAS header entries:
  file signature:            'LASF'
  file source ID:            0
  global_encoding:           1
  project ID GUID data 1-4:  00000000-0000-0000-4F53-4F4E0000414D
  version major.minor:       1.2
  system identifier:         'LAStools (c) by Martin Isenburg'
  generating software:       'las2las (version 120628)'
  file creation day/year:    120/2016
  header size:               227
  offset to point data:      1300
  number var. length records: 3
  point data format:         3
  point data record length:  34
  number of point records:   4735481
  number of points by return: 4288133 389741 54520 3087 0
  scale factor x y z:        0.01 0.01 0.01
  offset x y z:              0 0 0
  min x y z:                 6211604.43 1946923.89 81.56
  max x y z:                 6213674.87 1949335.93 871.26
variable length header record 1 of 3:
  reserved             43707
  user ID              'LASF_Projection'
  record ID            34735
  length after header  64
  description          'GeoTIFF GeoKeyDirectoryTag'
    GeoKeyDirectoryTag version 1.1.0 number of keys 7
      key 1024 tiff_tag_location 0 count 1 value_offset 1 - GTModelTypeGeoKey: ModelTypeProjected
      key 1025 tiff_tag_location 0 count 1 value_offset 1 - GTRasterTypeGeoKey: RasterPixelIsArea
      key 1026 tiff_tag_location 34737 count 39 value_offset 0 - GTCitationGeoKey: NAD83(HARN) / California
zone 2 (ftUS)
      key 2049 tiff_tag_location 34737 count 12 value_offset 39 - GeogCitationGeoKey: NAD83(HARN)
      key 2054 tiff_tag_location 0 count 1 value_offset 9102 - GeogAngularUnitsGeoKey: Angular_Degree
      key 3072 tiff_tag_location 0 count 1 value_offset 2871 - ProjectedCSTypeGeoKey: NAD83(HARN) / California
zone 2 (ftUS)
      key 3076 tiff_tag_location 0 count 1 value_offset 9003 - ProjLinearUnitsGeoKey: Linear_Foot_US_Survey
variable length header record 2 of 3:
  reserved             43707
  user ID              'LASF_Projection'
  record ID            34737
  length after header  51
  description          'GeoTIFF GeoAsciiParamsTag'
    GeoAsciiParamsTag (number of characters 51)
      NAD83(HARN) / California zone 2 (ftUS)|NAD83(HARN)|
variable length header record 3 of 3:
  reserved             43707
  user ID              'liblas'
  record ID            2112
  length after header  796
  description          'OGR variant of OpenGIS WKT SRS'
LASzip compression (version 2.1r0 c2 50000): POINT10 2 GPS
reporting minimum and maximum for all LAS point record en
  X          621160443  621367487
  Y          194692389  194933593
  Z               8156      87126
  intensity          0        238
  return_number      1          4
  number_of_returns  1          4
  edge_of_flight_line 0         0
  scan_direction_flag 0         1
  classification     1          7
  scan_angle_rank  -17         16
  user_data        117        134
  point_source_ID  5333      5340
  gps_time 67452811.791205 67455847.866464
  Color R 1024 65280
        G 2048 65280
        B 1280 65280
number of first returns:        4288133
number of intermediate returns: 57649
number of last returns:         4287713
number of single returns:       3898014
overview over number of returns of given pulse:
3898014 670700 154429 12338 0 0 0
histogram of classification of points:
         1427491  unclassified (1)
         1722512  ground (2)
         1355413  high vegetation (5)
            2265  building (6)
          227800  noise (7)
```

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*

http://www.asprs.org/a/society/committees/standards/asprs_las_format_v12.pdf

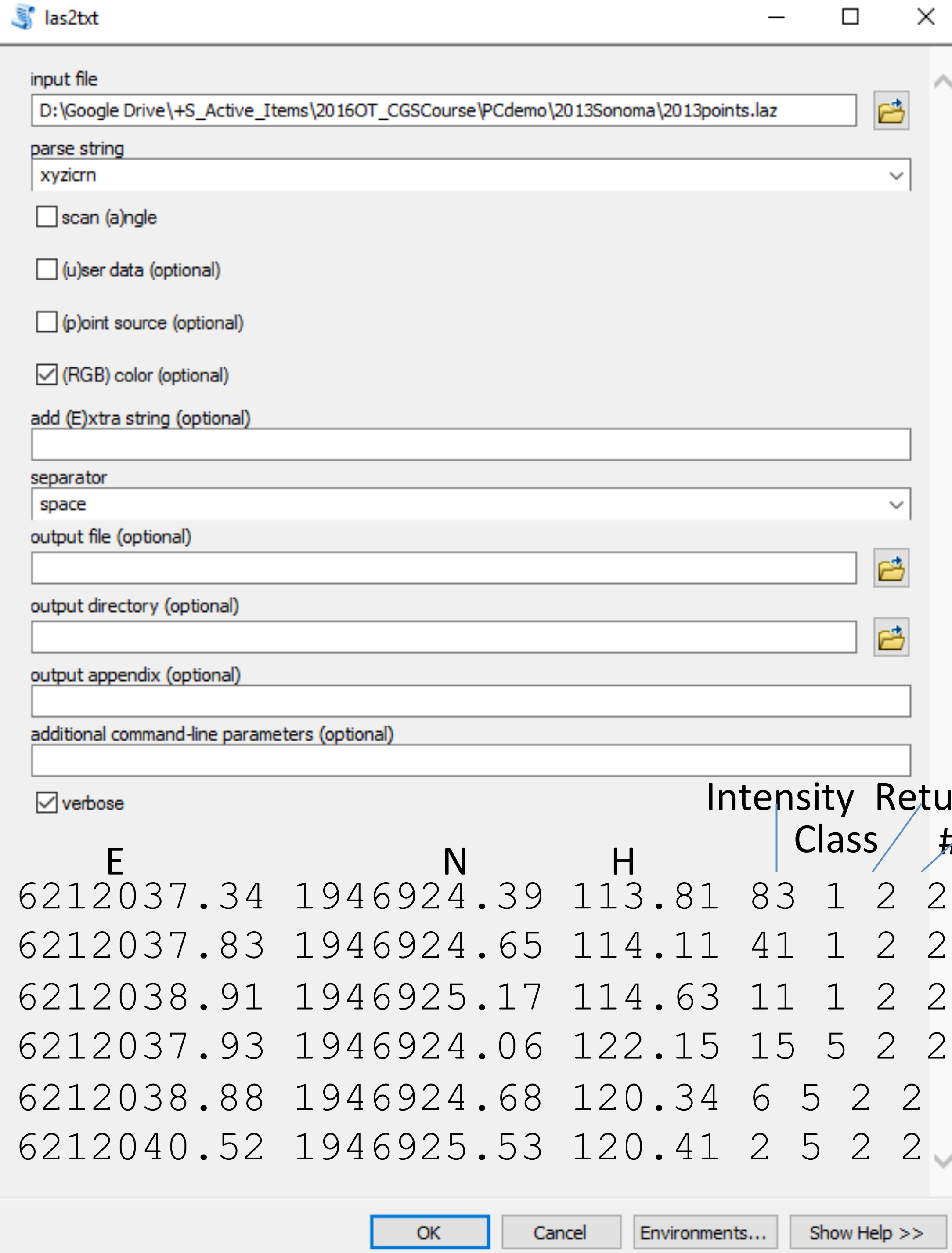
LASvalidate – Do my LAS files conform to the specification?

C:\Users\crosby\Desktop\CGS_HRT_shortcourse\NS
C:\Users\crosby\Desktop\C...


```
<?xml version="1.0" encoding="UTF-8"?>
- <LASvalidator>
  - <report>
    - <file>
        <name>NSAF.laz</name>
        <path>C:\Users\crosby\Desktop\CGS_HRT_shortcourse\NSAF_sampledata\NSAF.laz</path>
        <version>1.2</version>
        <system_identifier>LAStools (c) by Martin Isenburg</system_identifier>
        <generating_software>las2las (version 120628)</generating_software>
        <point_data_format>1</point_data_format>
        <CRS>NAD83(HARN) / California zone 2 (ftUS)</CRS>
      </file>
      <summary> fail </summary>
    - <details>
      - <fail>
          <variable>return number</variable>
          <note>there are 612084 points with a larger return number (5) than their number of returns of given pulse (1)</note>
        </fail>
      - <fail>
          <variable>return number</variable>
          <note>there are 12044 points with a larger return number (6) than their number of returns of given pulse (2)</note>
        </fail>
      - <fail>
          <variable>return number</variable>
          <note>there are 15 points with a larger return number (7) than their number of returns of given pulse (3)</note>
        </fail>
      - <warning>
          <variable>VLR</variable>
          <note>payload size of 104 for geokey VLR with 11 + 1 geokey entries has padding of 8 bytes. while the VLR is valid, software that (incorrectly) uses the
            VLR size to determine the number of geokey may fail.</note>
        </warning>
      - <warning>
          <variable>return number</variable>
          <note>there are 12044 points with a return number of 6</note>
        </warning>
      - <warning>
          <variable>return number</variable>
          <note>there are 15 points with a return number of 7</note>
        </warning>
      - <warning>
          <variable>point source ID</variable>
          <note>file source ID in header and point source ID of all 636201 points is 0</note>
        </warning>
      </details>
    </report>
  - <total>
      fail
    - <details>
        <pass>0</pass>
        <warning>0</warning>
        <fail>1</fail>
      </details>
    </total>
    <version> 160119 built with LASread version 1.0 (160119) </version>
    <command_line> C:\geospatial\LAStools\LAStools\bin\lasvalidate.exe -i C:\Users\crosby\Desktop\CGS_HRT_shortcourse\NSAF_sampledata\NSAF.laz -o
      validate.xml </command_line>
</LASvalidator>
```

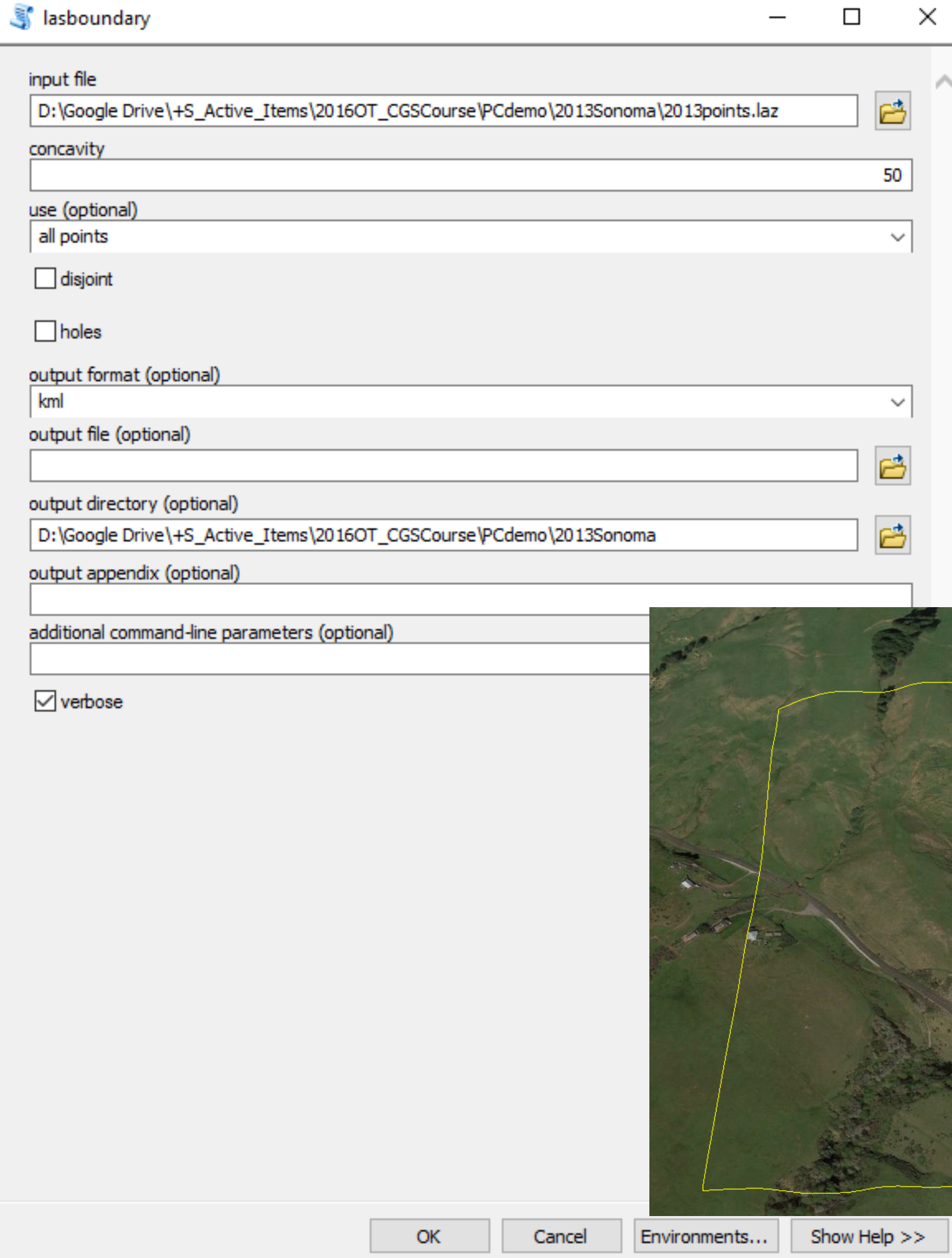

FAIL! = 2003 dataset delivered as ascii, converted to LAS

LAS2txt – points in ascii



E	N	H	Intensity	Class	Return #	# of returns	R	G	B
6212037.34	1946924.39	113.81	83	1	2	2	21760	22016	17152
6212037.83	1946924.65	114.11	41	1	2	2	22016	22528	17408
6212038.91	1946925.17	114.63	11	1	2	2	22528	22528	17408
6212037.93	1946924.06	122.15	15	5	2	2	25344	26368	20736
6212038.88	1946924.68	120.34	6	5	2	2	21504	21504	16640
6212040.52	1946925.53	120.41	2	5	2	2	31744	33024	25600

LAS2txt – generate outline of file (or group of files)



Point clouds and DEMs

Datum and projection

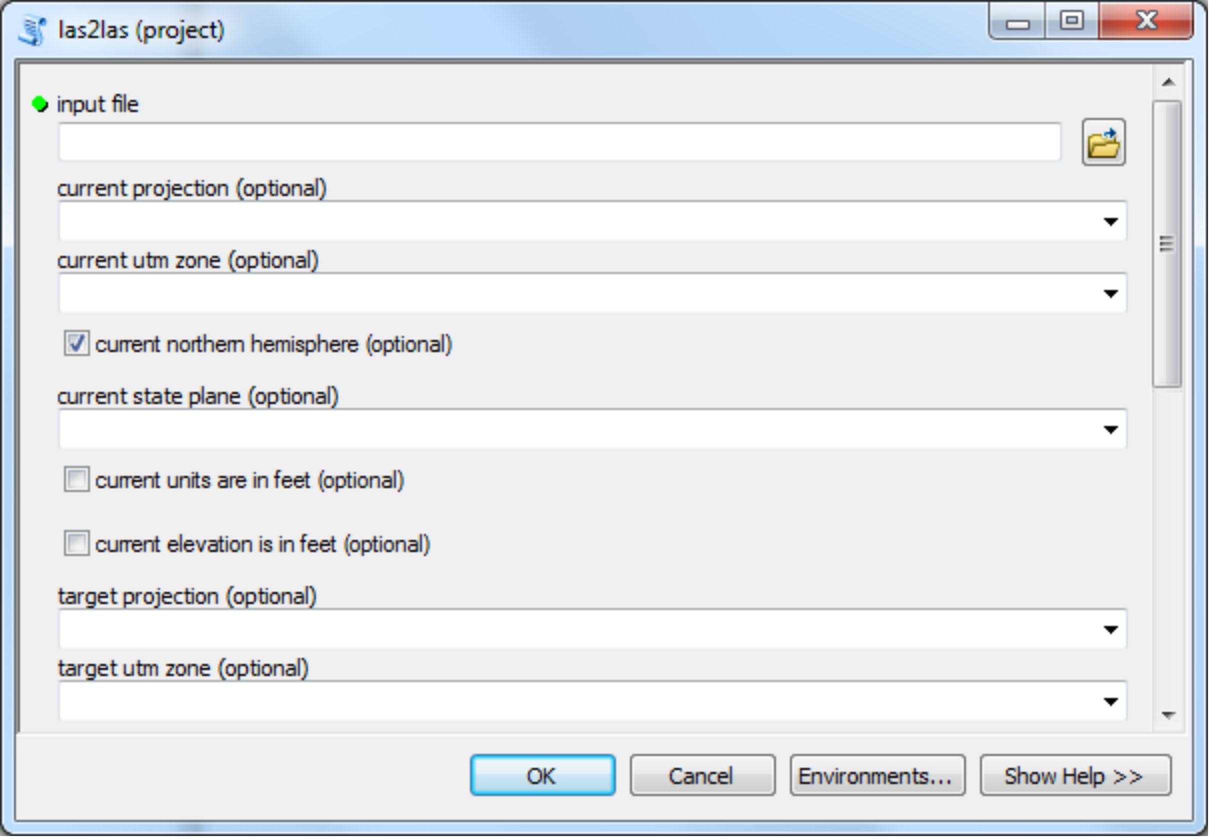
http://geology.isu.edu/wapi/geostac/Field_Exercise/topomaps/ref_datum.htm

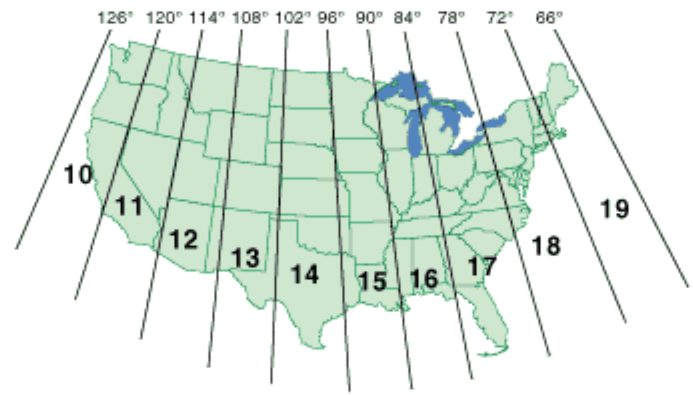
http://geology.isu.edu/wapi/geostac/Field_Exercise/topomaps/utm.htm

http://geology.isu.edu/wapi/geostac/Field_Exercise/topomaps/state_plane.htm


California State Plane
Coordinate System
1
2
3
4
5
6
7

LAS2LAS – projections, filtering, clipping



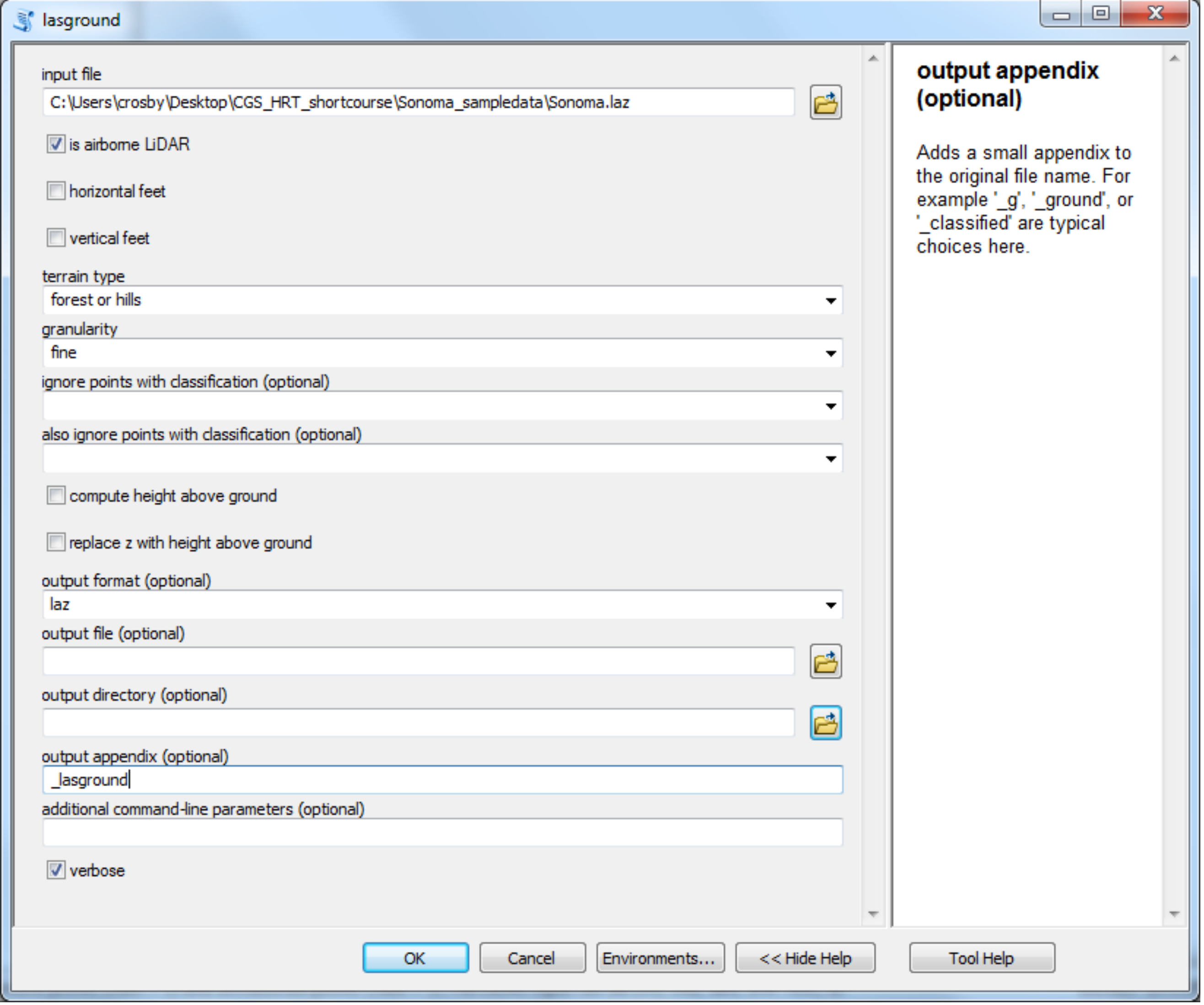


ORIGINAL FILE:

key 1024 tiff_tag_location 0 count 1 value_offset 1 - GTModelTypeGeoKey: ModelTypeProjected
key 1025 tiff_tag_location 0 count 1 value_offset 1 - GTRasterTypeGeoKey: RasterPixelIsArea
key 1026 tiff_tag_location 34737 count 39 value_offset 0 - GTCitationGeoKey: **NAD83(HARN) / California zone 2 (ftUS)**
key 2049 tiff_tag_location 34737 count 12 value_offset 39 - GeogCitationGeoKey: NAD83(HARN)
key 2054 tiff_tag_location 0 count 1 value_offset 9102 - GeogAngularUnitsGeoKey: Angular_Degree
key 3072 tiff_tag_location 0 count 1 value_offset 2871 - ProjectedCSTypeGeoKey: NAD83(HARN) / California zone 2 (ftUS)
key 3076 tiff_tag_location 0 count 1 value_offset 9003 - ProjLinearUnitsGeoKey**: Linear_Foot_US_Survey**

AFTER LAS2LAS:

key 1024 tiff_tag_location 0 count 1 value_offset 1 - GTModelTypeGeoKey: ModelTypeProjected
key 3072 tiff_tag_location 0 count 1 value_offset 26910 - ProjectedCSTypeGeoKey: **NAD83 / UTM 10N**
key 3076 tiff_tag_location 0 count 1 value_offset 9001 - ProjLinearUnitsGeoKey: Linear_Meter
key 4099 tiff_tag_location 0 count 1 value_offset 9001 - VerticalUnitsGeoKey**: Linear_Meter**



LASground – classification of ground returns

Vendor classification:
histogram of classification of points:
1427491 unclassified (1)
1722512 ground (2)
1355413 high vegetation (5)
2265 building (6)
227800 noise (7)

LASground classification:
histogram of classification of points:
2959272 unclassified (1)
1776209 ground (2)

Similar results – a few % more points in ground class w/ LASground. But by default LASground over-writes other classes. Need to use other LAStools (LASheight, LAScanopy) for full classification.

Point clouds and DEMs

8. Lecture burst on generating DEMs from points
9. Lasgrid point density
10. Lasgrid DEM
11. blast2dem

Digital Elevation Models

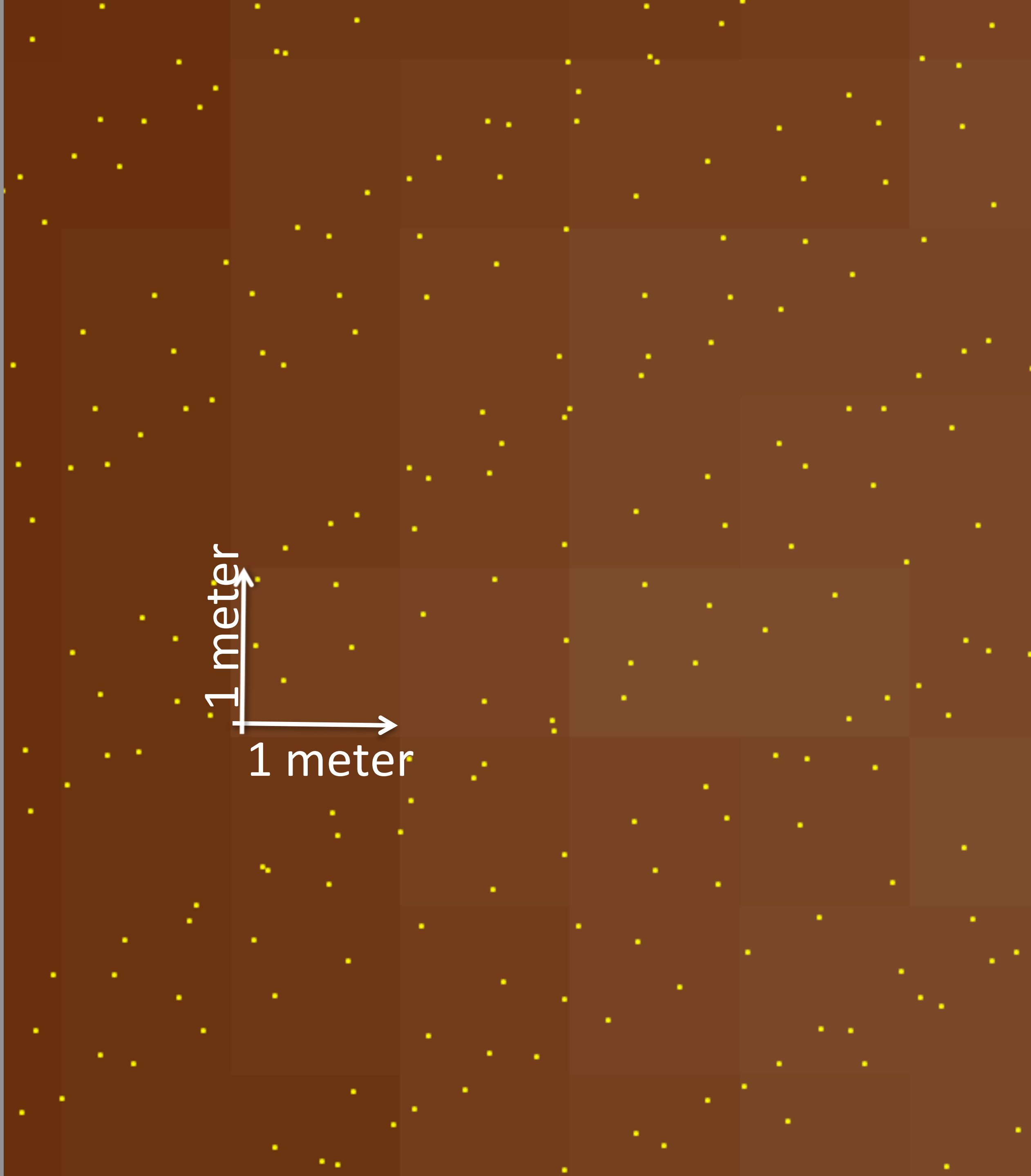
- Digital representation of topography / terrain
  - "Raster" format – a grid of squares or "pixels"
  - Continuous surface where Z (elevation) is estimated on a regular X,Y grid
  - "2.5D"

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	0
0	50	100	100	100	100	100	100	100	100	100	100	100	100	100	50	0
0	50	100	150	150	150	150	150	150	150	150	150	150	150	100	50	0
0	50	100	150	200	200	200	200	200	200	200	200	200	150	100	50	0
0	50	100	150	200	250	250	250	250	250	250	250	200	150	100	50	0
0	50	100	150	200	250	300	300	300	300	300	250	200	150	100	50	0
0	50	100	150	200	250	300	350	350	350	300	250	200	150	100	50	0
0	50	100	150	200	250	300	350	400	350	300	250	200	150	100	50	0
0	50	100	150	200	250	300	350	350	350	300	250	200	150	100	50	0
0	50	100	150	200	250	300	300	300	300	300	250	200	150	100	50	0
0	50	100	150	200	250	250	250	250	250	250	250	200	150	100	50	0
0	50	100	150	200	200	200	200	200	200	200	200	200	150	100	50	0
0	50	100	150	150	150	150	150	150	150	150	150	150	150	100	50	0
0	50	100	100	100	100	100	100	100	100	100	100	100	100	100	50	0
0	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

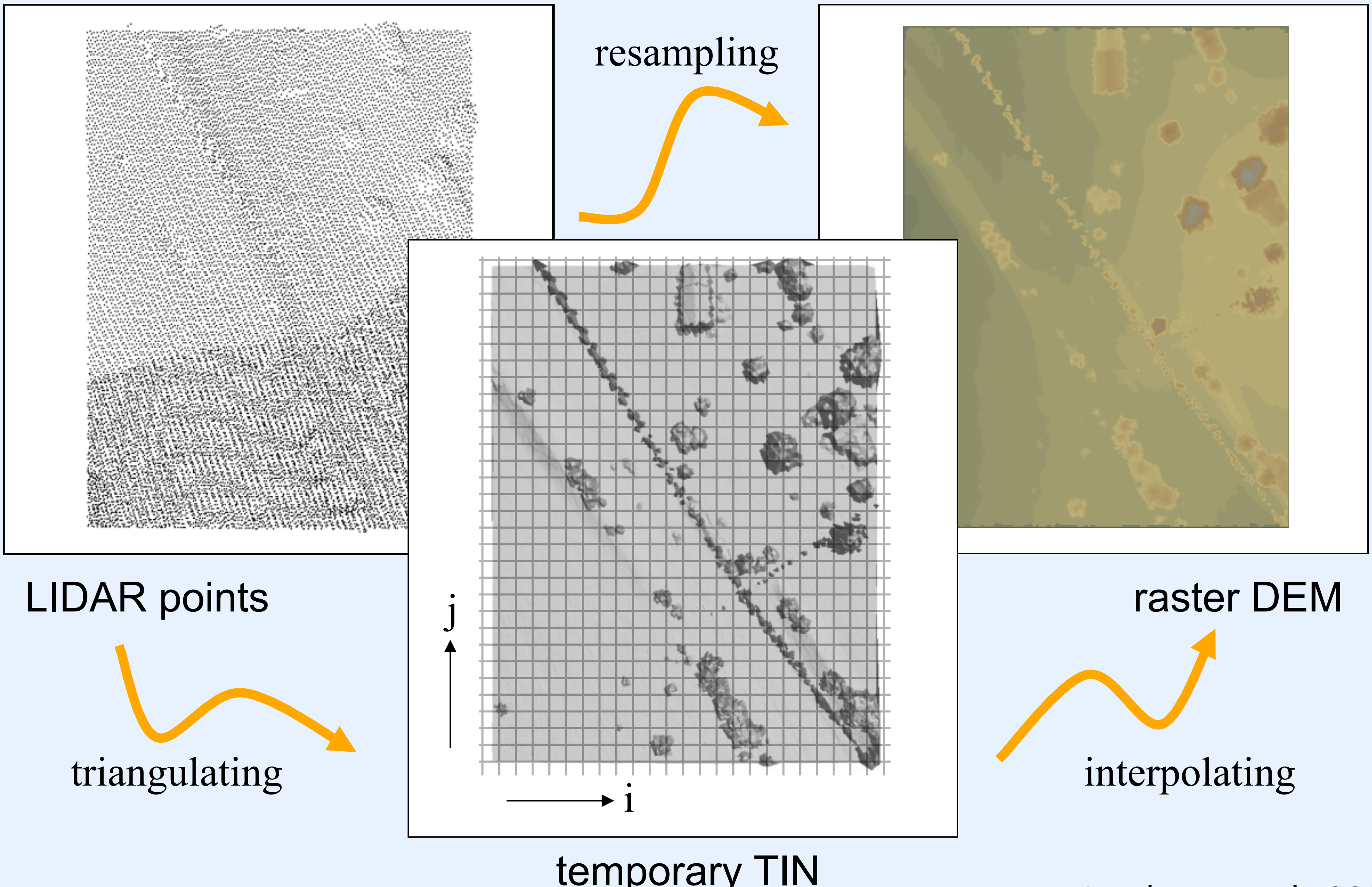
Source: http://www.ncgia.ucsb.edu/giscc/extra/e001/e001.html

- Grid resolution is defined by the size in the horizontal dimension of the pixel
  - 1 meter DEM has pixels 1 m x 1m assigned a single elevation value.

- 1 meter grid
- LiDAR returns from EarthScope data collection
- Example from flat area with little or no vegetation so ground is sampled approx. 5+ times per square meter
- How do we best fit a continuous surface to these points?
- Ultimately wish to represent irregularly sampled data on a regularized grid.



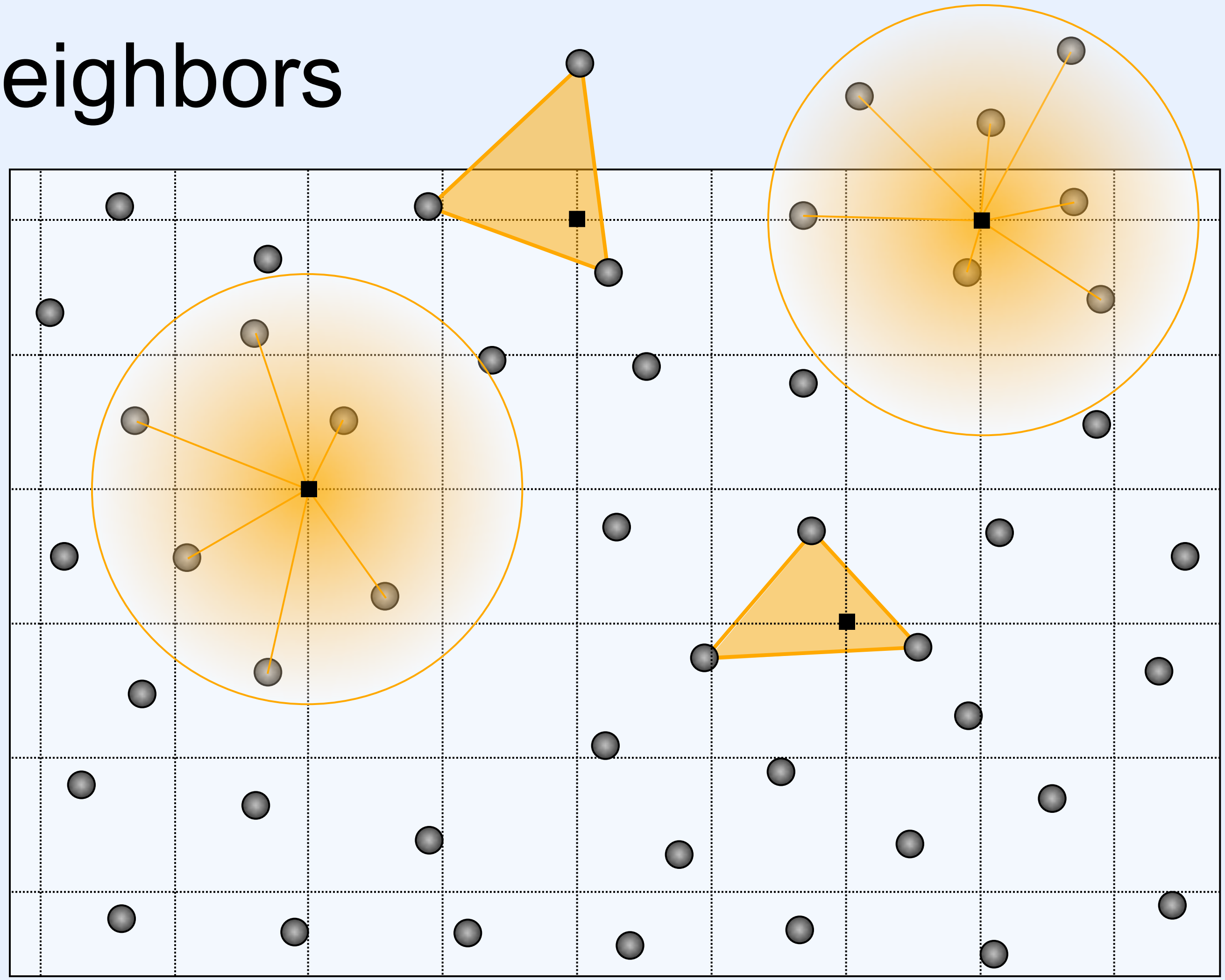
Generating DEMs from LIDAR



Isenburg, et al., 2006

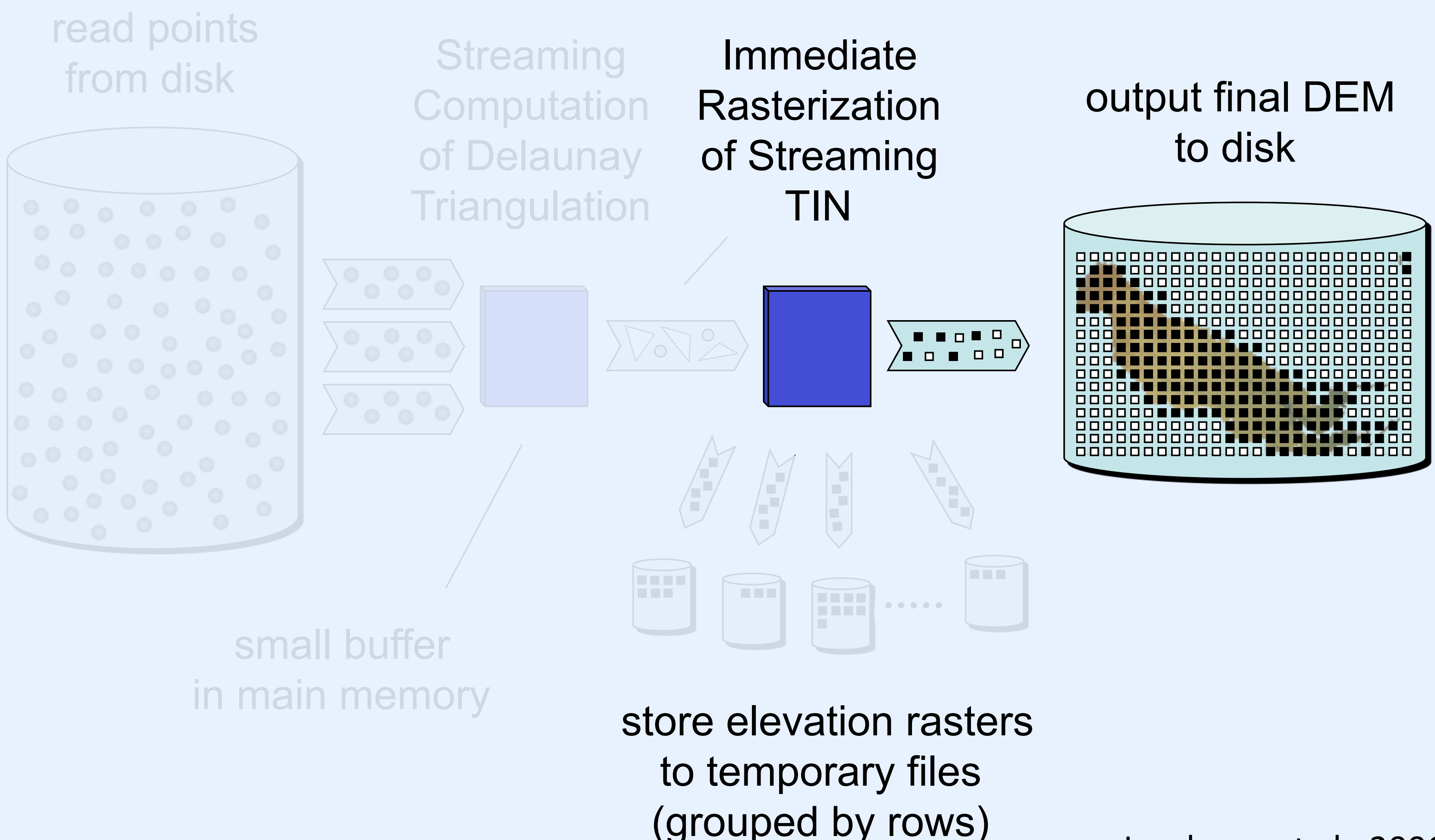
Interpolation Methods

- Inverse Distance Weighting (IDW)
- Natural Neighbors
- Kriging
- Splines
- TIN
  - linear
  - quintic
- …



Isenburg, et al., 2006

DEM Generation via TIN Streaming

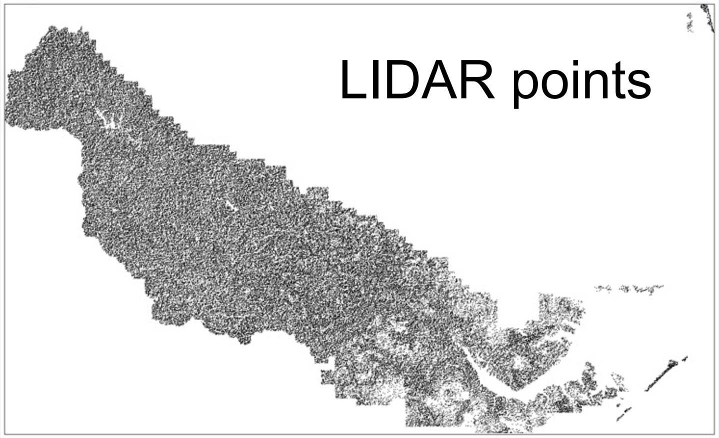


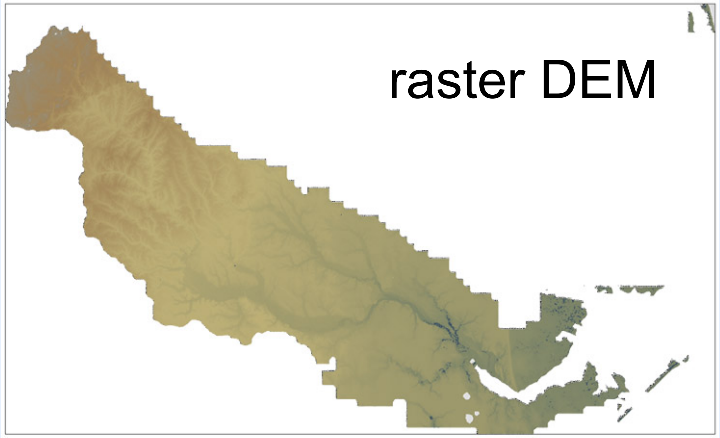
Isenburg, et al., 2006

Example Result

500,141,313 Points
11 GB
(binary, xyz, doubles)

50,394 × 30,500 DEM
3 GB
(binary, BIL, 16 bit, 20 ft)



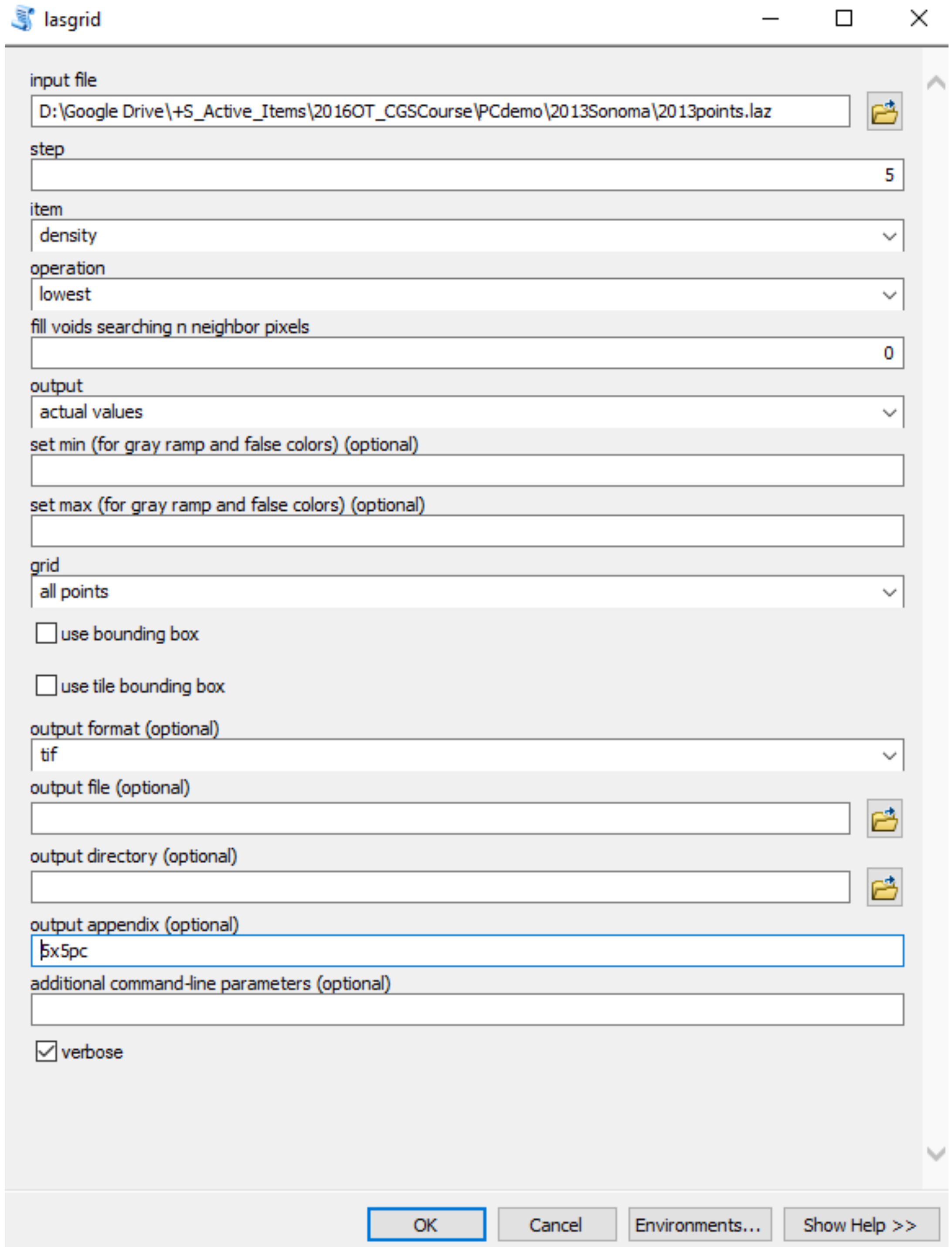


▫ on a household laptop with two harddisks ▫
▫ in 67 minutes ▫
▫ 64 MB of main memory ▫
▫ 270 MB temporary disk space ▫

Isenburg, et al., 2006

LASgrid – generating raster derivatives from points

Calculate point density



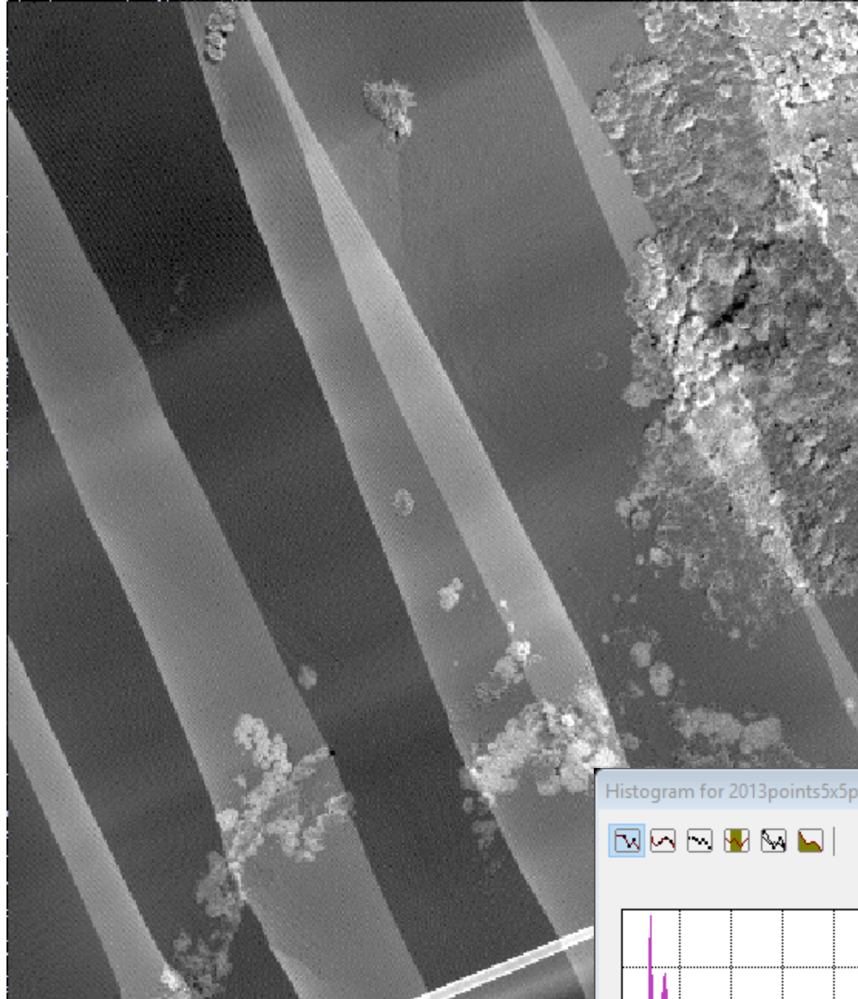
2013points5x5pc.tif

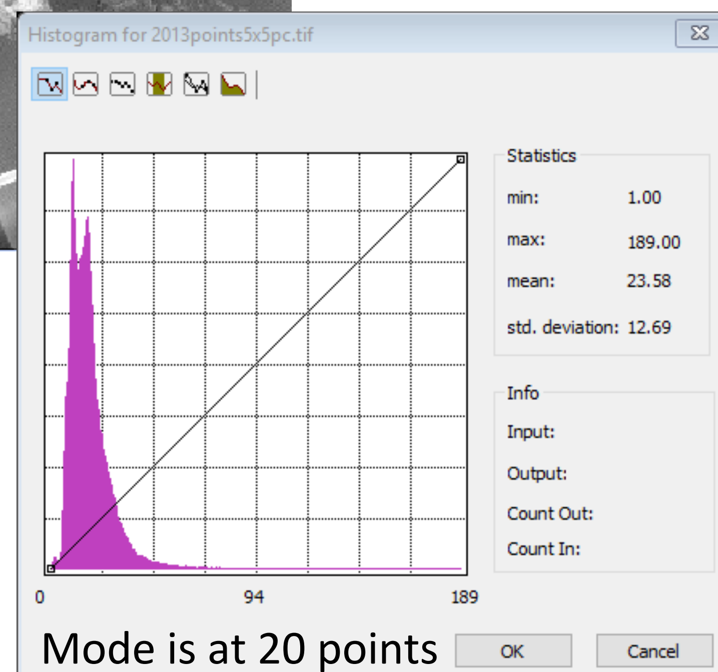
Value

High : 189

Low : 1

Raster Information	
Columns and Rows	415, 484
Number of Bands	1
Cell Size (X, Y)	5, 5





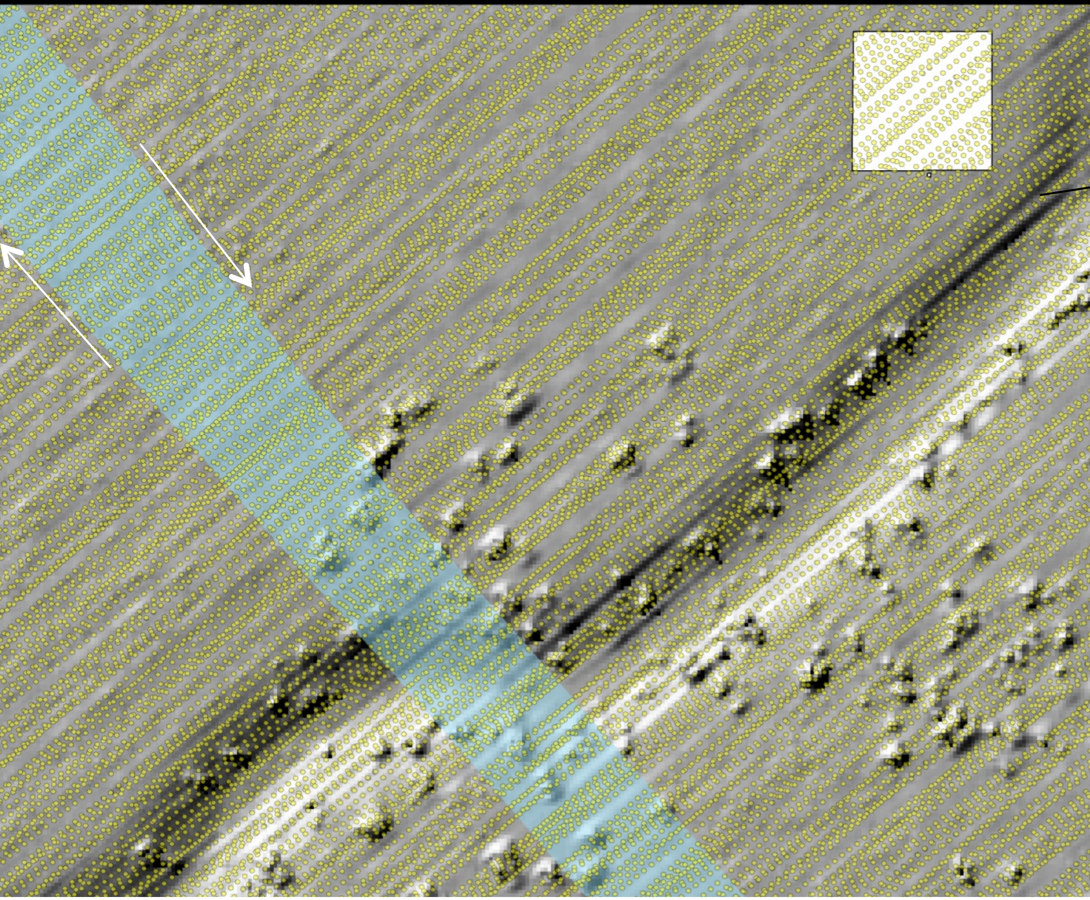
of the DEM. A common method for determining the cell size of a DEM has been defined by Hu (2003). The grid size of a DEM can be estimated by:

$$s = \sqrt{\frac{A}{n}} \quad \text{Sqrt}(25\text{ft}^2/20) = 5.6 \text{ ft/pix} \sim 6 \text{ ft/pix} \qquad (1)$$

where s is the estimated cell size (typically in m), n is the number of sample points and A is the area containing the sample points. The

Measure fault slip at the appropriate scale

B4 LiDAR topography 0.25 m DEM



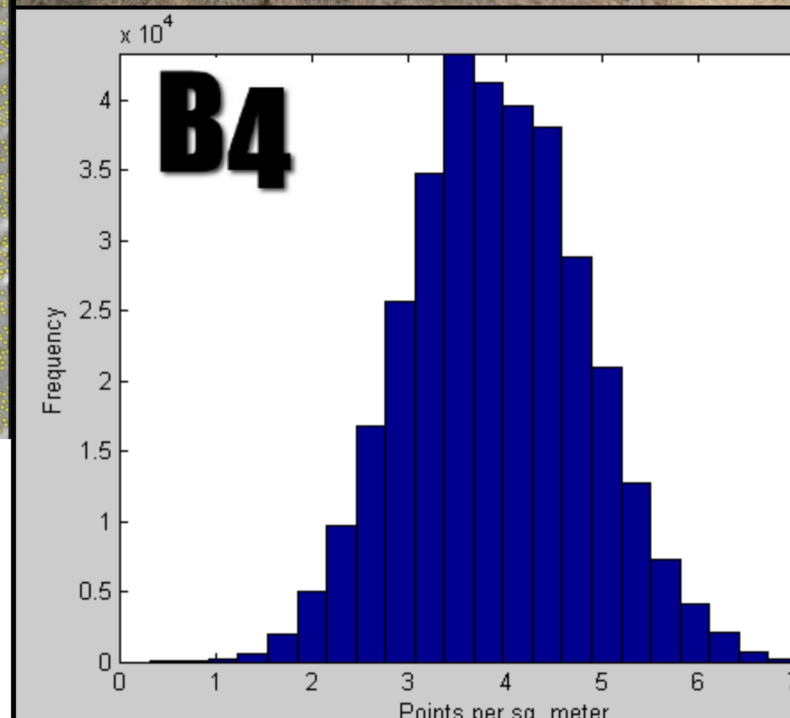
of the DEM. A common method for determining the cell size of a DEM has been defined by Hu (2003). The grid size of a DEM can be estimated by:

Langridge, et al. 2014

$$s = \sqrt{\frac{A}{n}} \qquad (1)$$

$\text{Sqrt}(1\text{m}^2/4) = 0.5$ m/pix

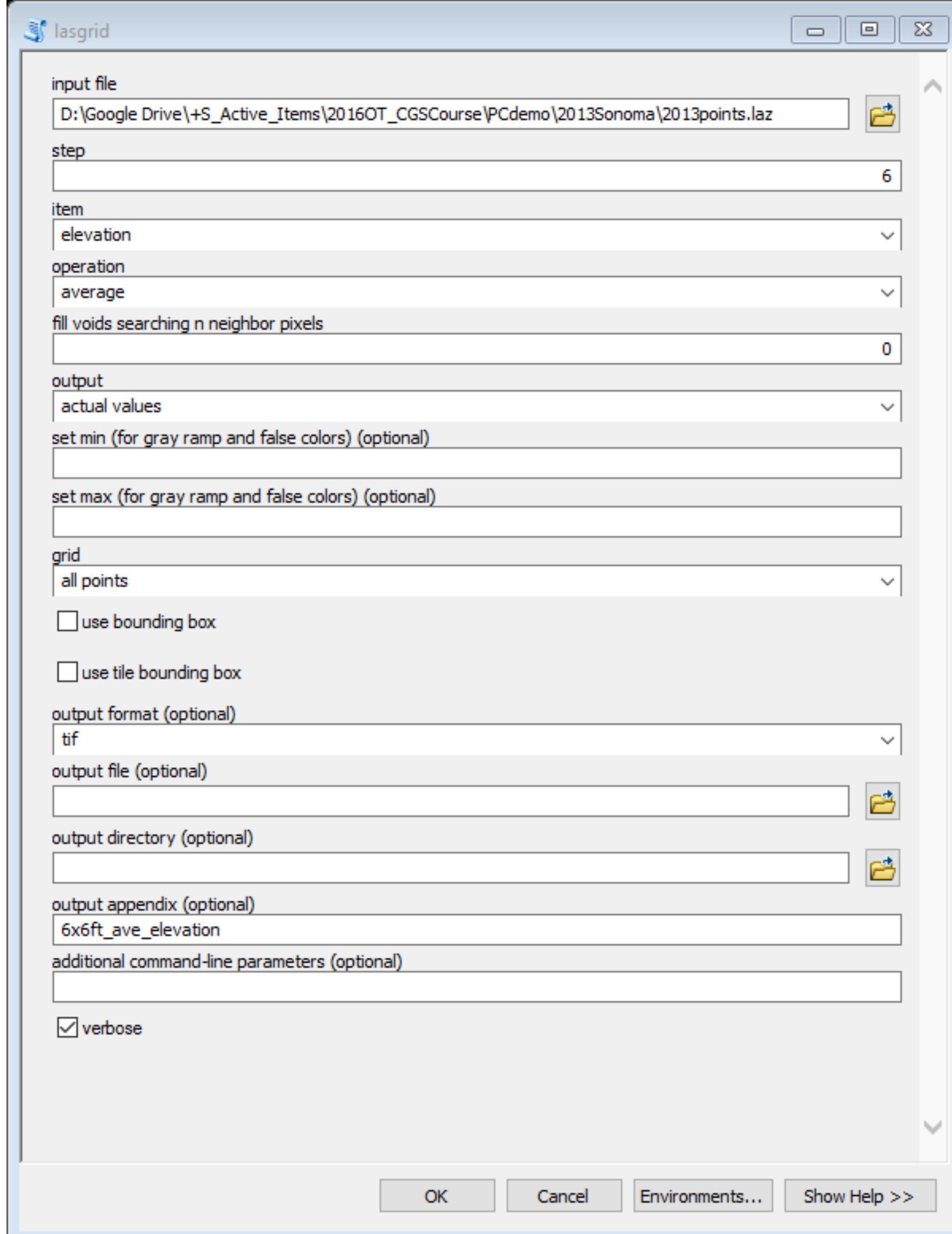
where s is the estimated cell size (typically in m), n is the number of sample points and A is the area containing the sample points. The

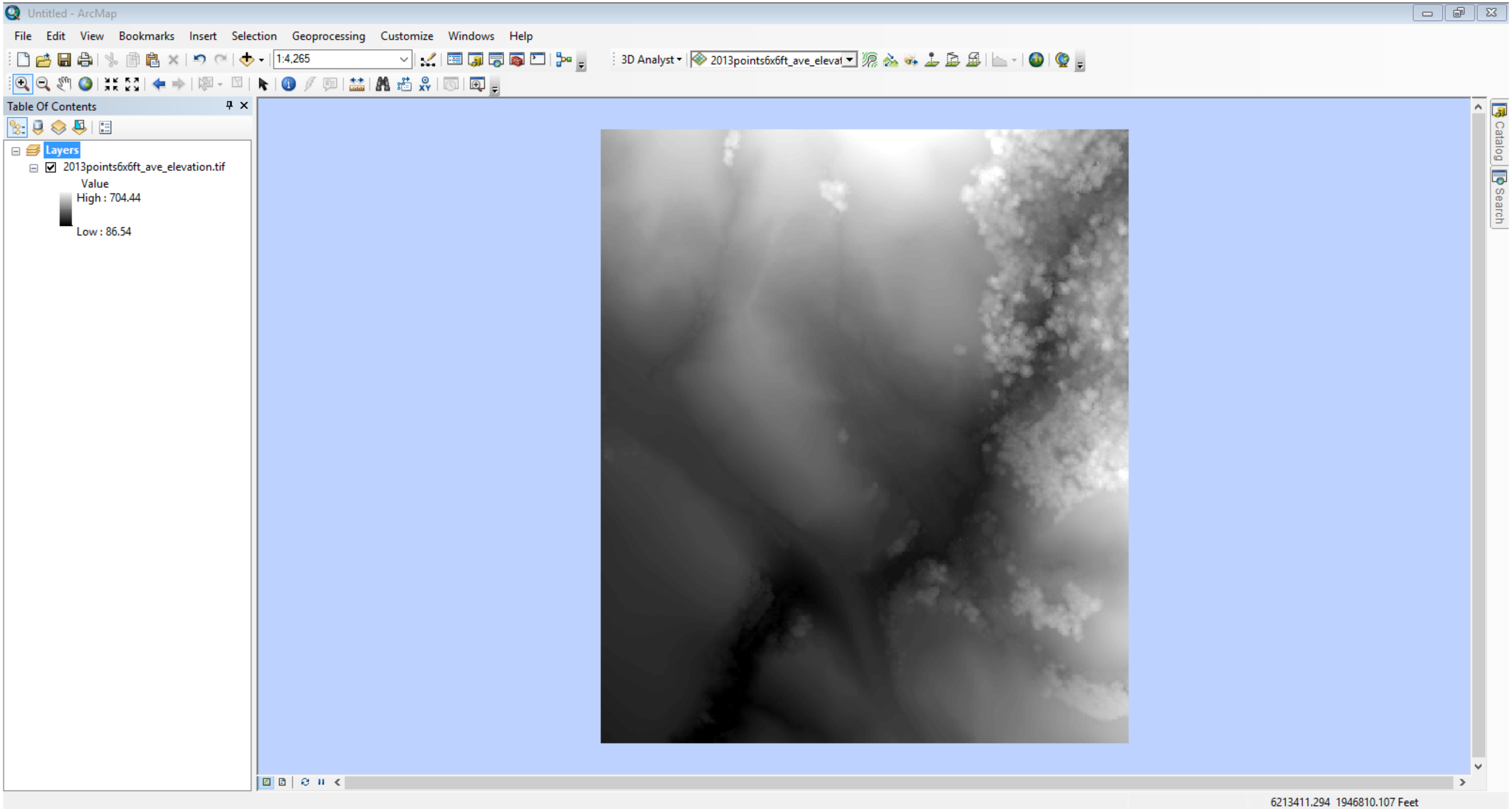


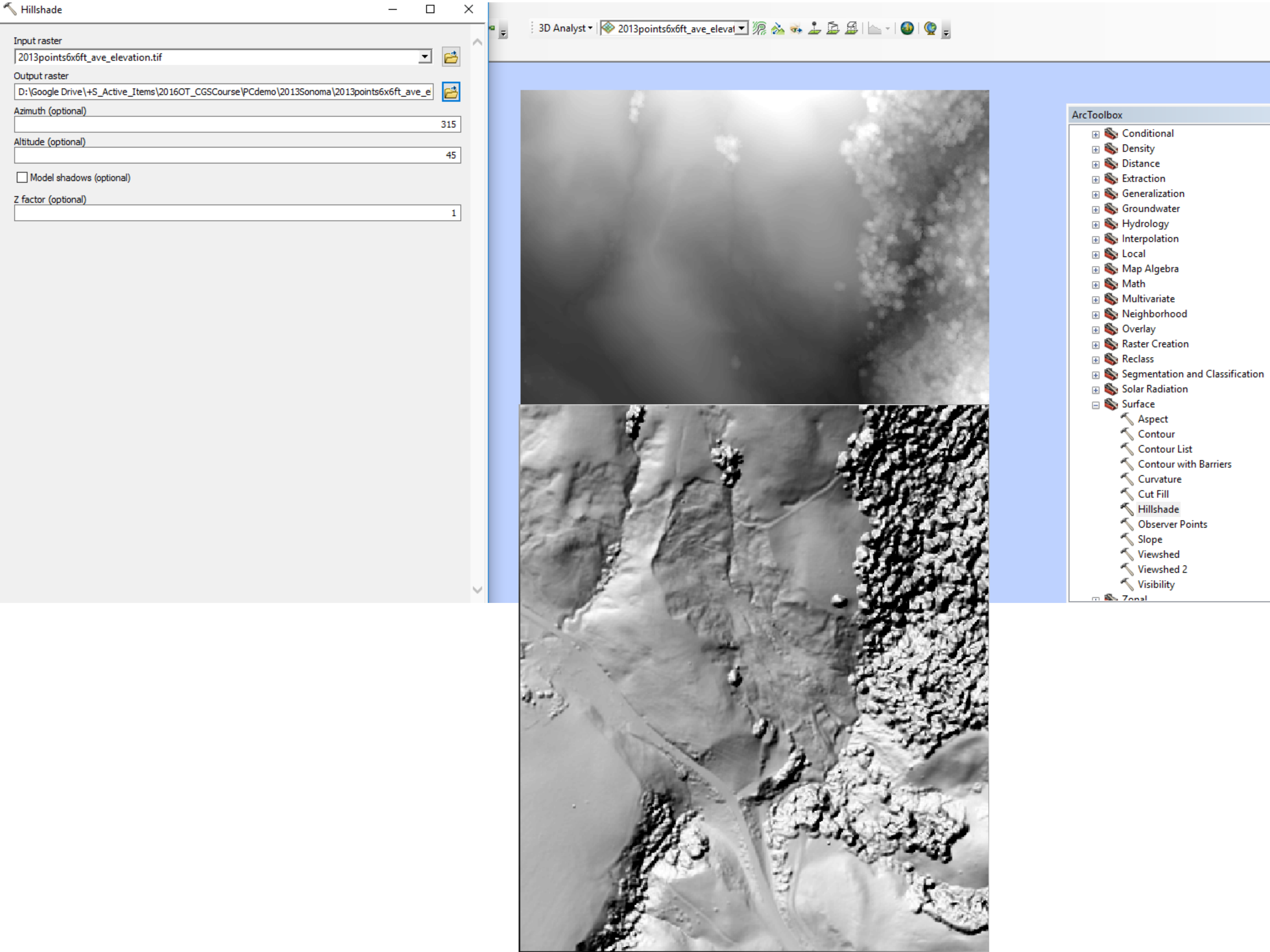
Mean ~4 shots/sq. m

LASgrid – generating raster derivatives from points

Calculate grid elevation for all points = DSM

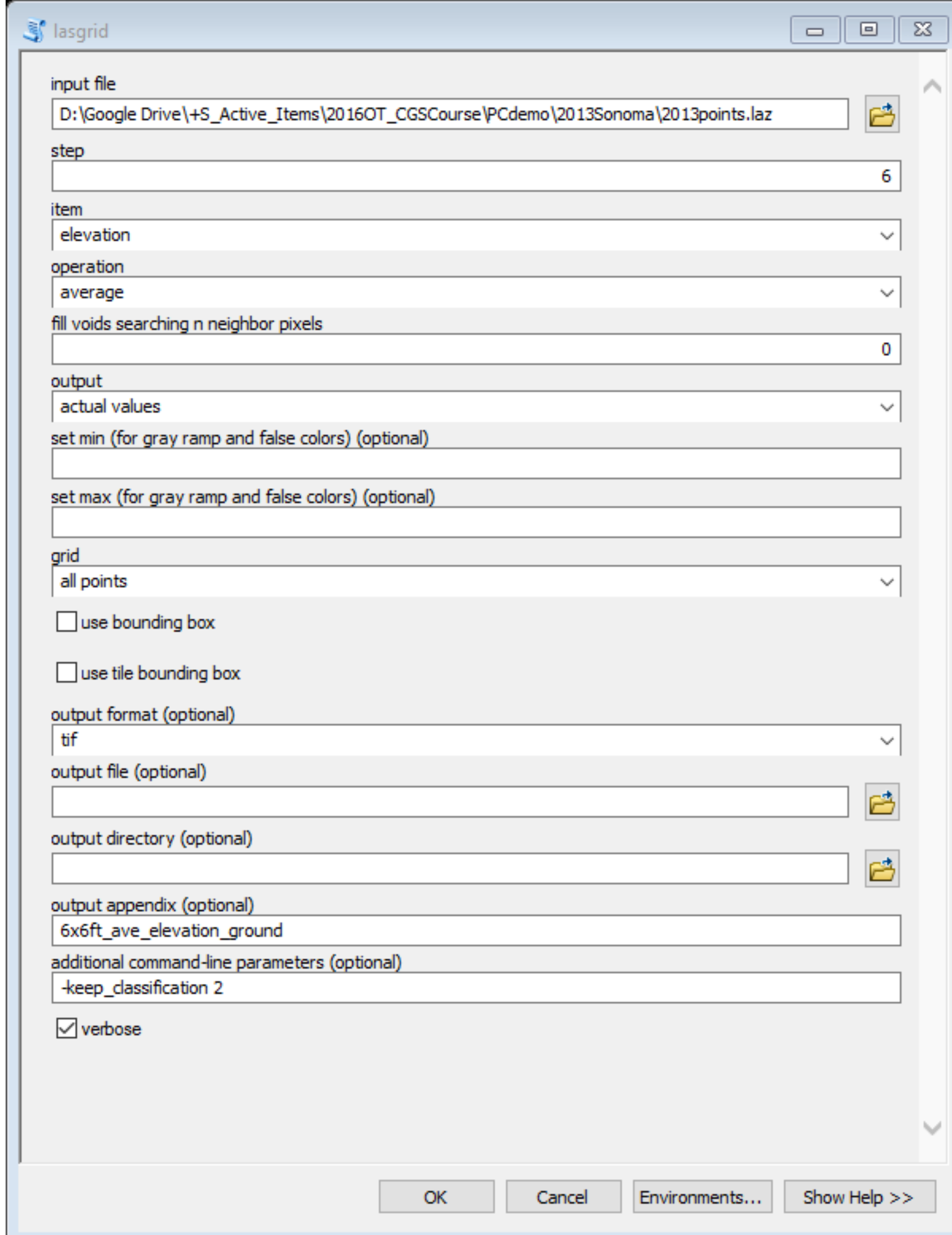


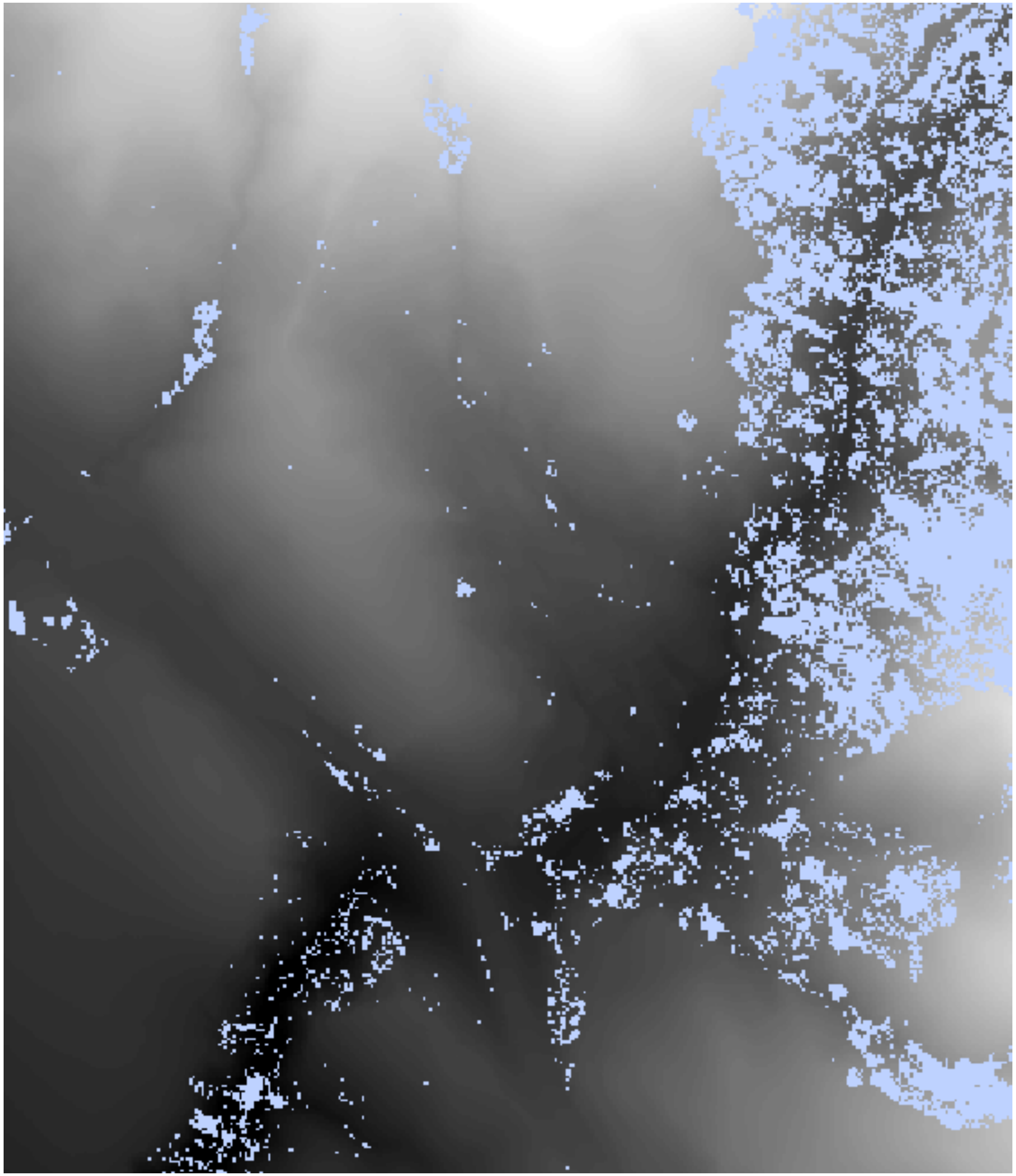

Untitled - ArcMap
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:4,265
3D Analyst
2013points6x6ft_ave_elevat
Table Of Contents
Layers
2013points6x6ft_ave_elevation.tif
Value
High : 704.44
Low : 86.54
Catalog
Search
6213411.294 1946810.107 Feet


Hillshade
Input raster
2013points6x6ft_ave_elevation.tif
Output raster
D:\Google Drive\+S_Active_Items\2016OT_CGSCourse\PCdemo\2013Sonoma\2013points6x6ft_ave_e
Azimuth (optional)
315
Altitude (optional)
45
Model shadows (optional)
Z factor (optional)
1
3D Analyst
2013points6x6ft_ave_elevat
ArcToolbox
Conditional
Density
Distance
Extraction
Generalization
Groundwater
Hydrology
Interpolation
Local
Map Algebra
Math
Multivariate
Neighborhood
Overlay
Raster Creation
Reclass
Segmentation and Classification
Solar Radiation
Surface
Aspect
Contour
Contour List
Contour with Barriers
Curvature
Cut Fill
Hillshade
Observer Points
Slope
Viewshed
Viewshed 2
Visibility

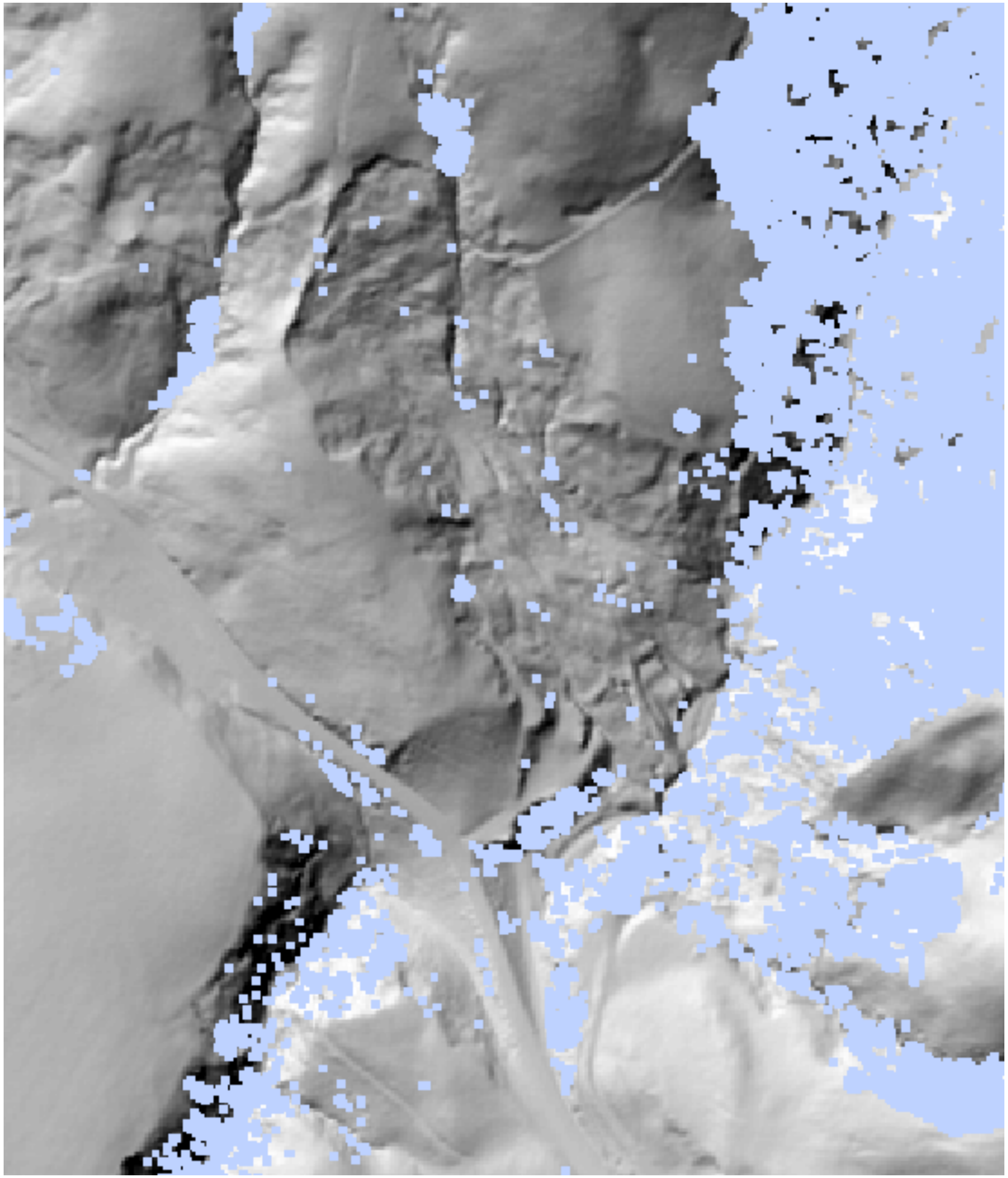
LASgrid – generating raster derivatives from points

Calculate grid elevation for ground points = DTM (bare earth)





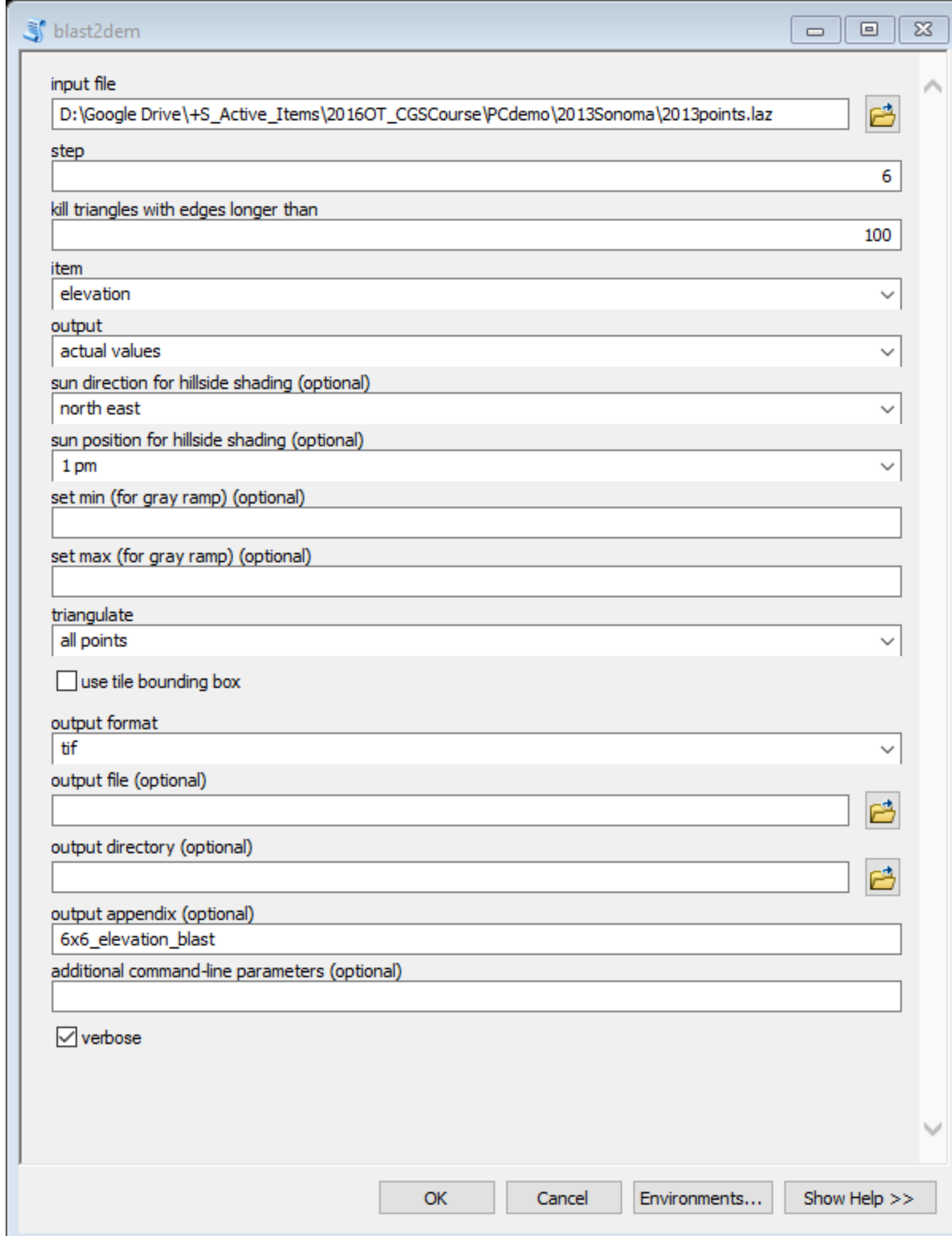
Blue means empty

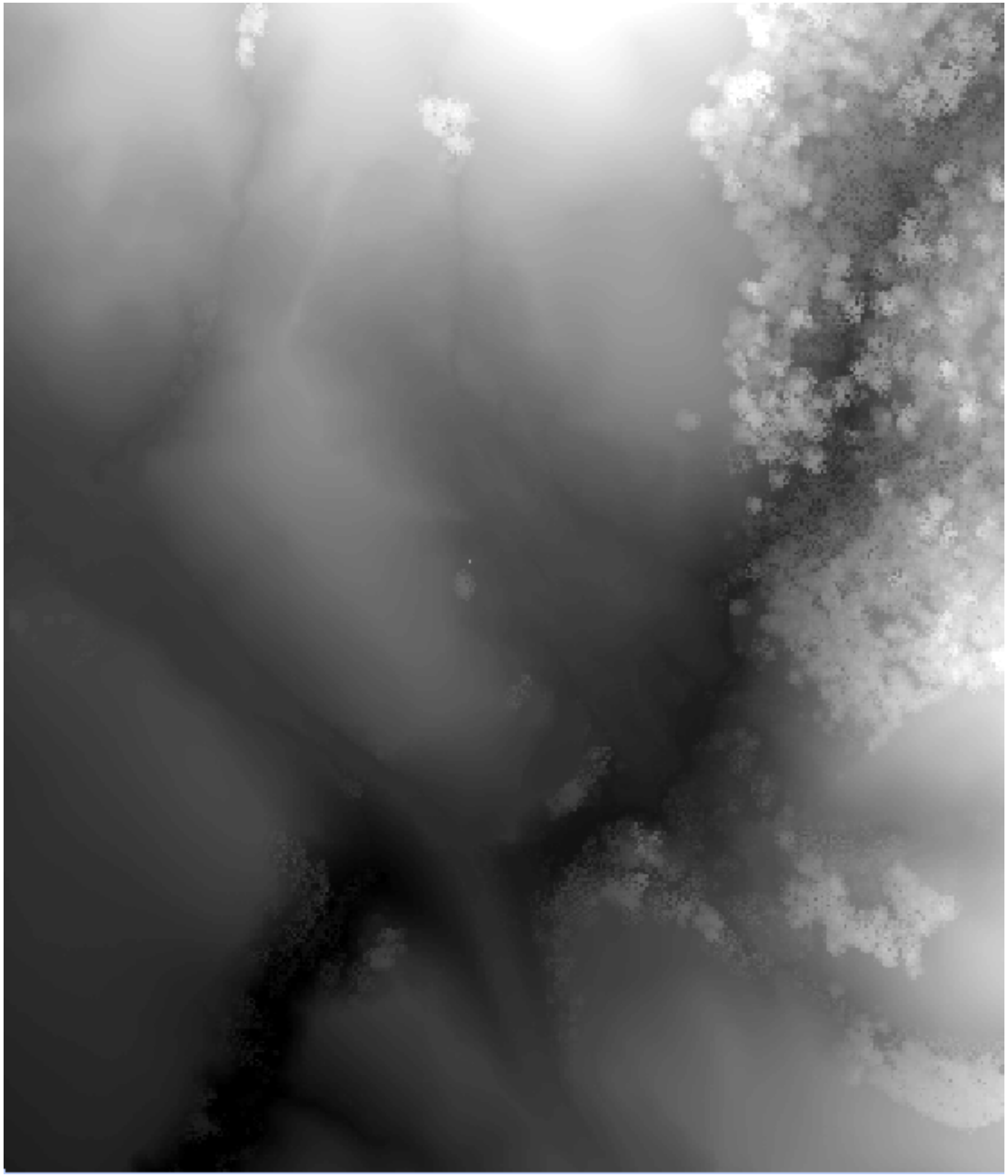


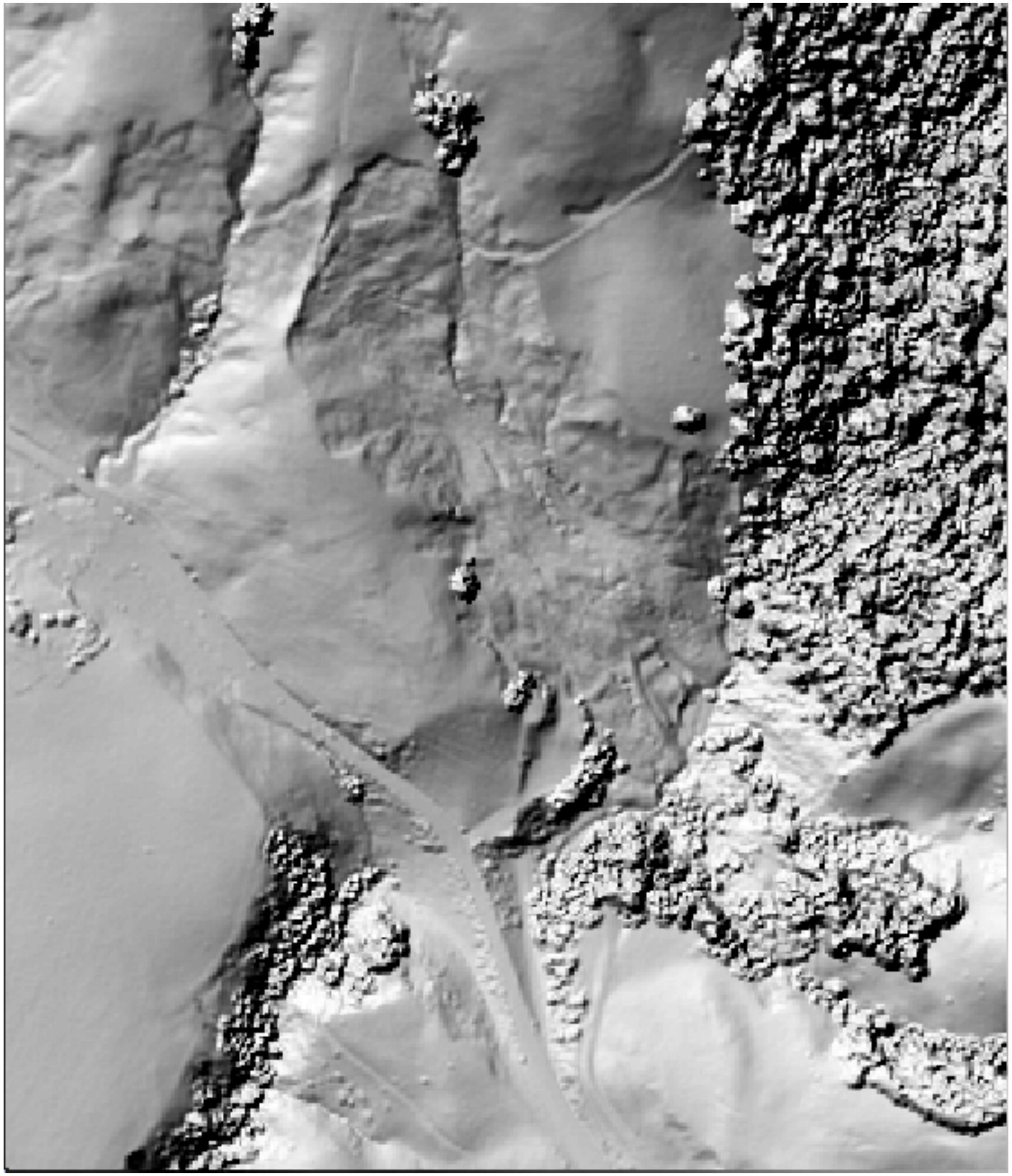
Blue means empty

blast2DEM – generating raster derivatives from points using triangulation

Calculate grid elevation for all points = DSM

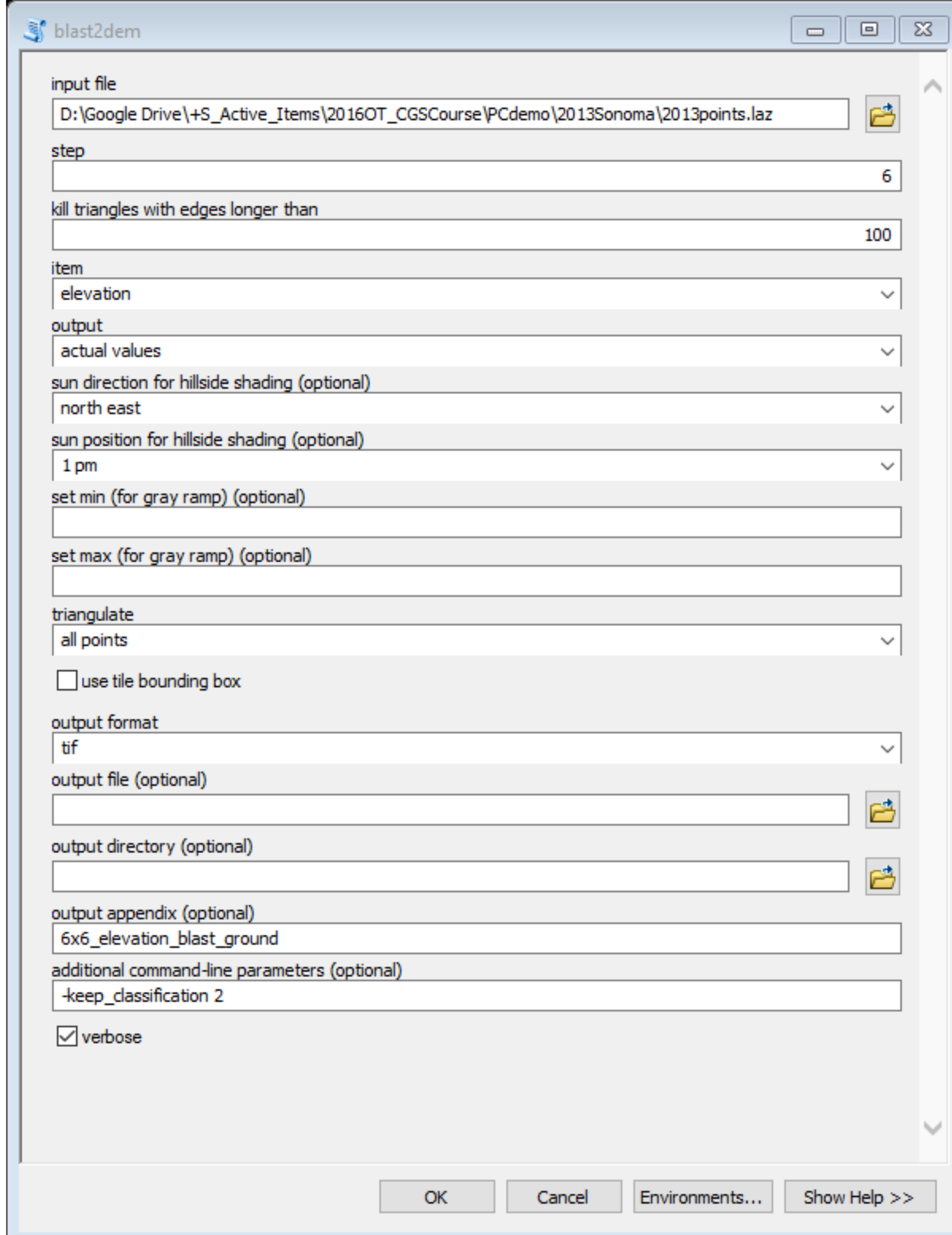


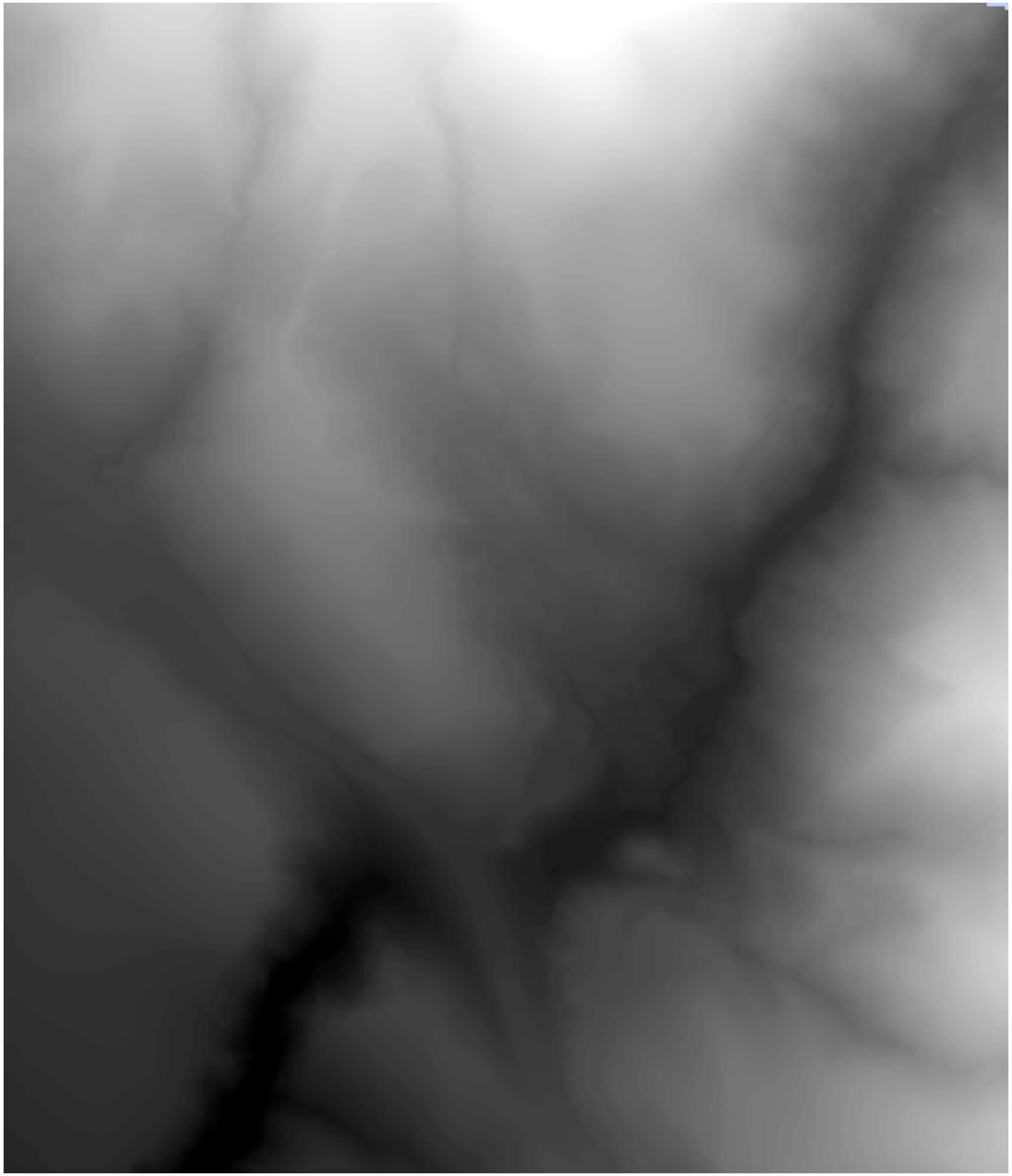


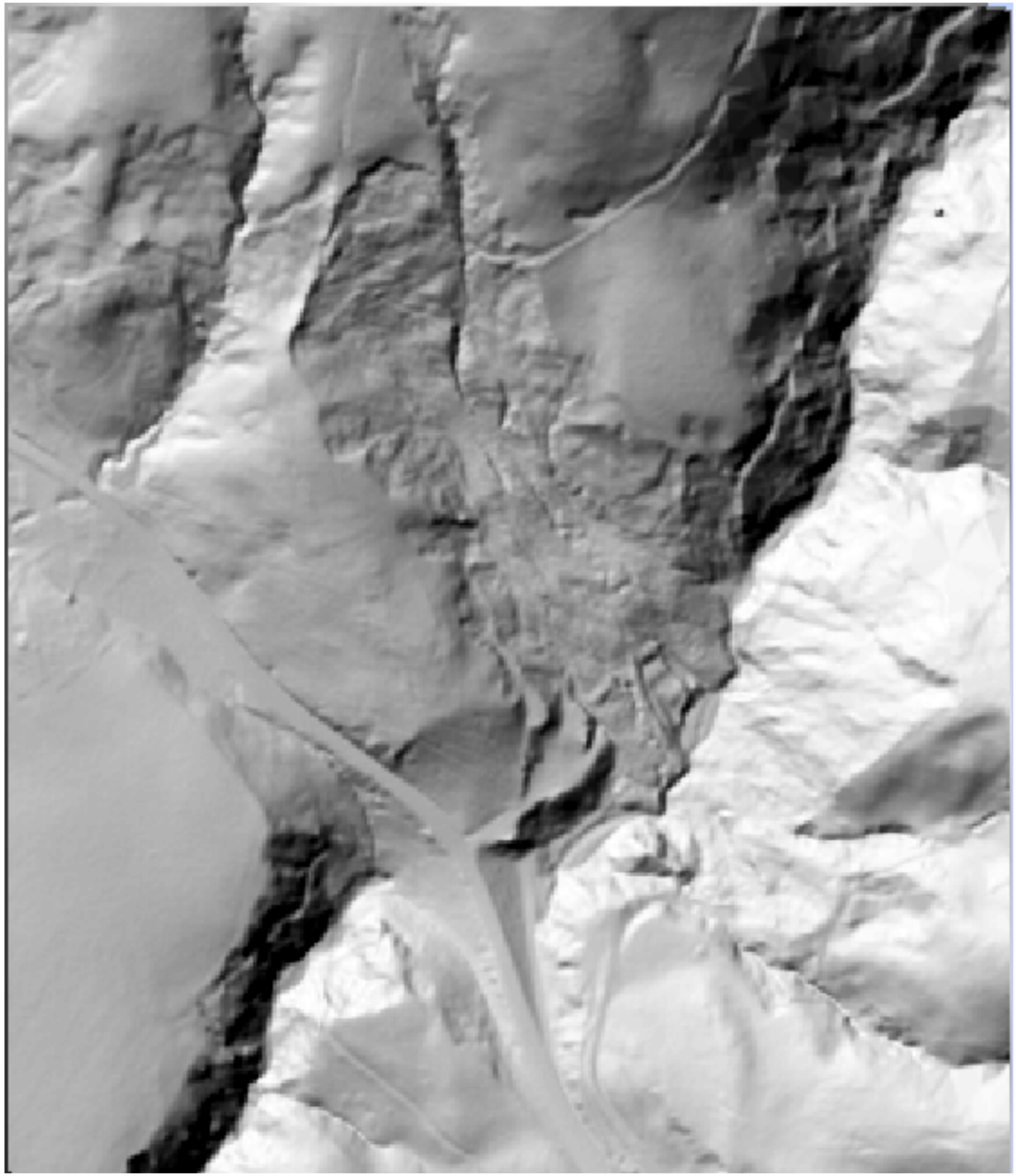


blast2DEM – generating raster derivatives from points using triangulation

Calculate grid elevation for ground points = DTM



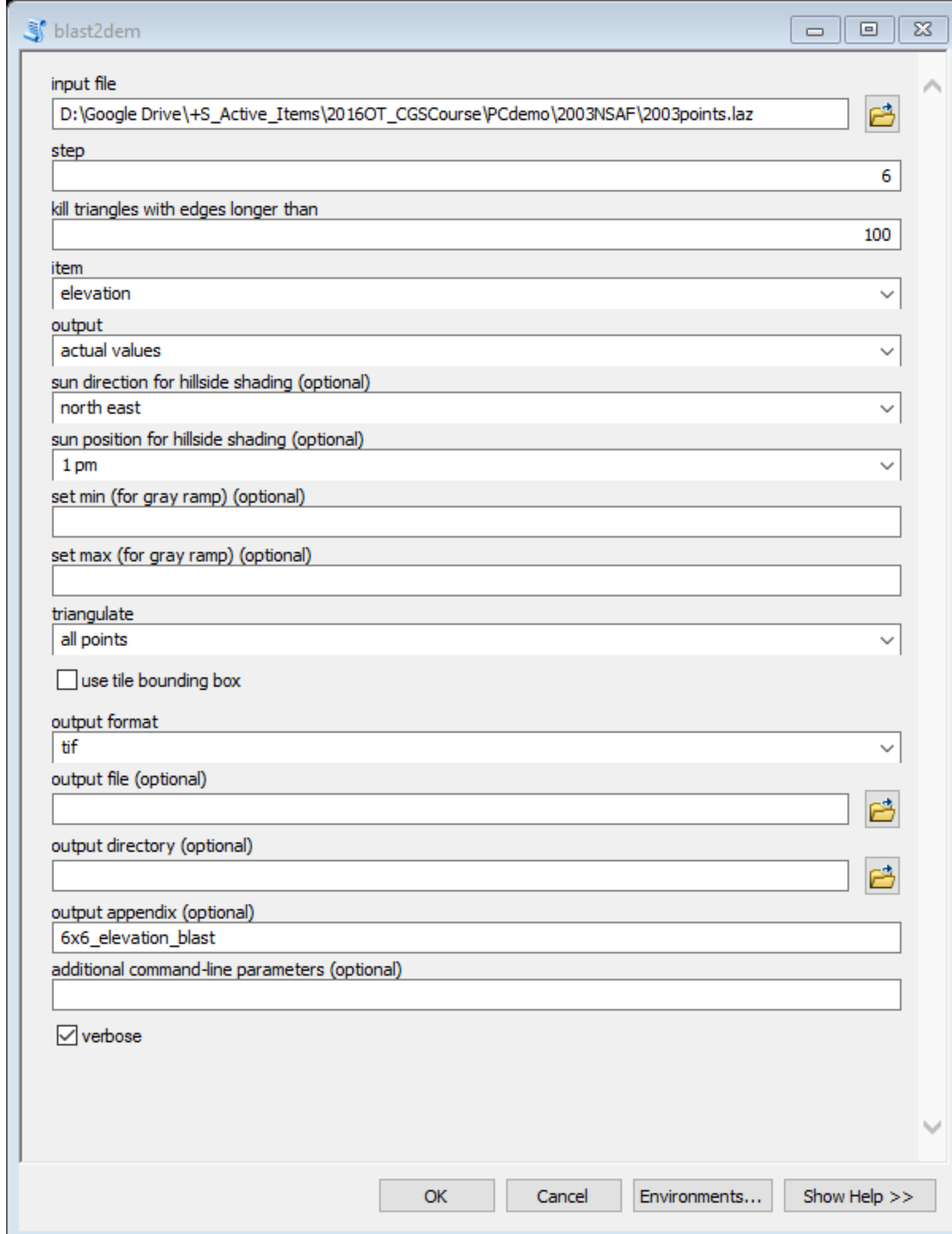


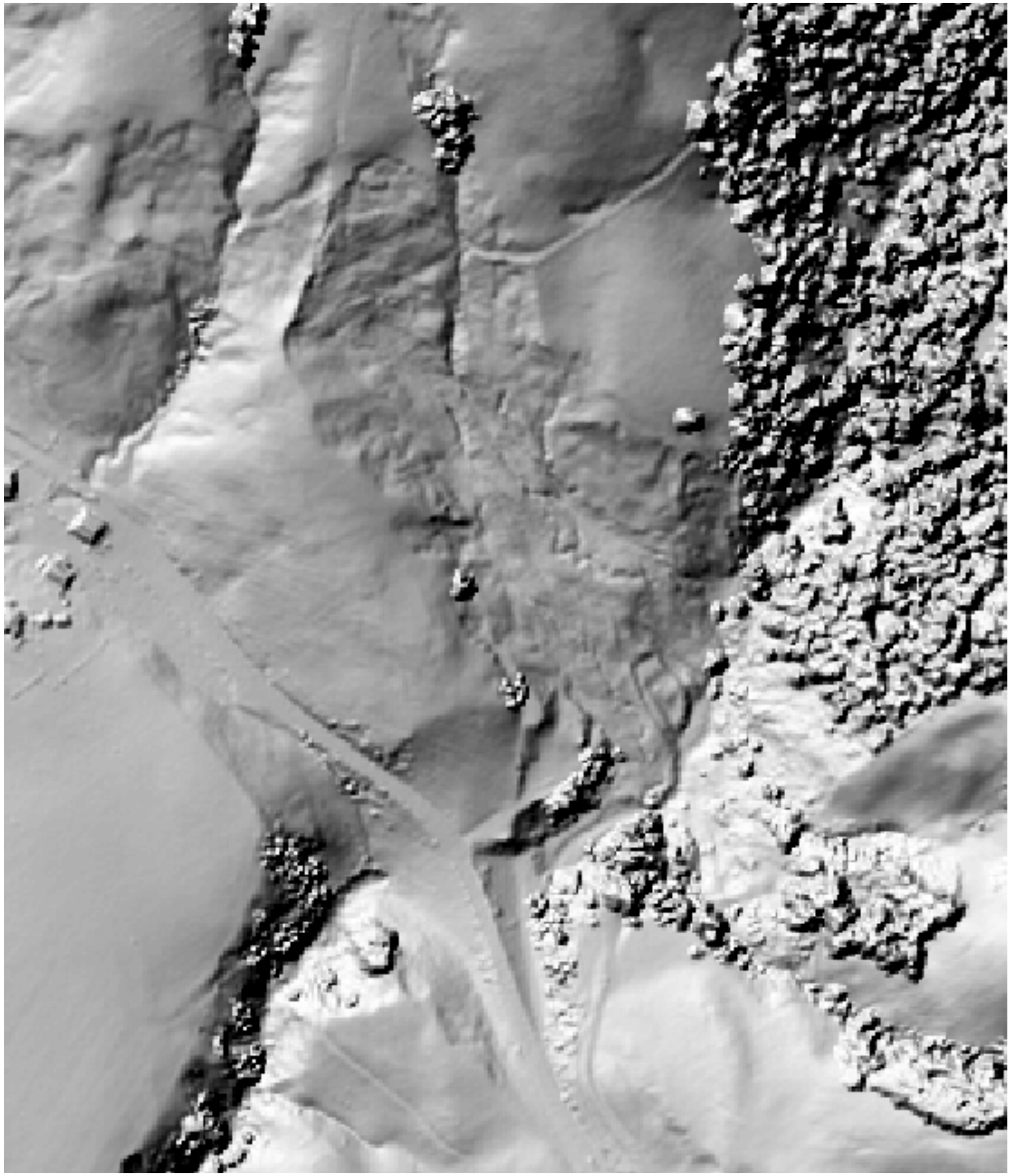


blast2DEM – generating raster derivatives from points using triangulation

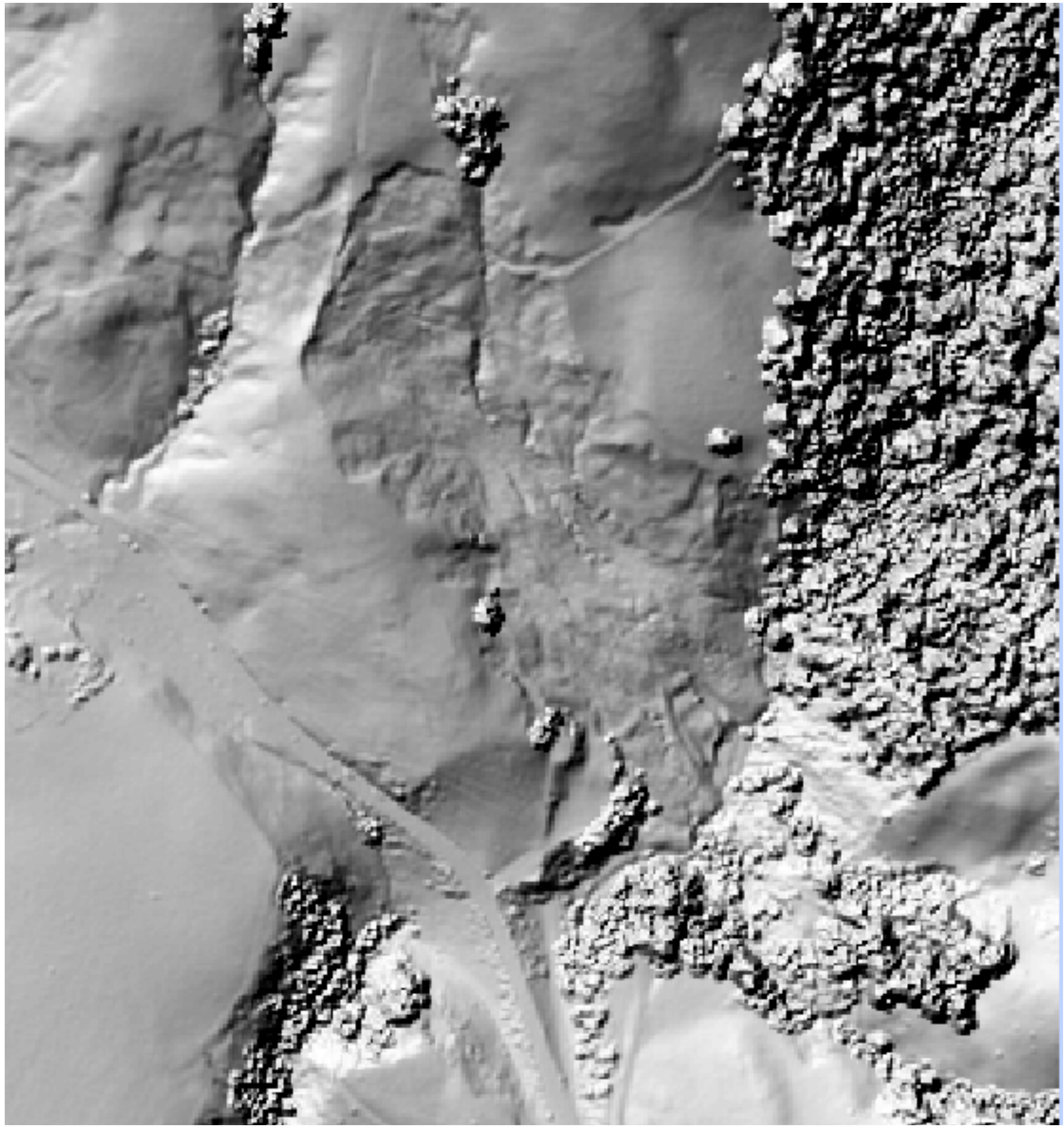
Calculate grid elevation for all points = DSM

2003 NSAF dataset





2003 6’ dsm



2013 6’ dsm

DeLong, S.B., Prentice, C., Hilley, G.E., Ebert, Y.; 2012, Multitemporal ALSM change detection, sediment delivery, and process mapping at an active earthflow. Earth Surface Processes and Landforms DOI: 10.1002/esp.2234

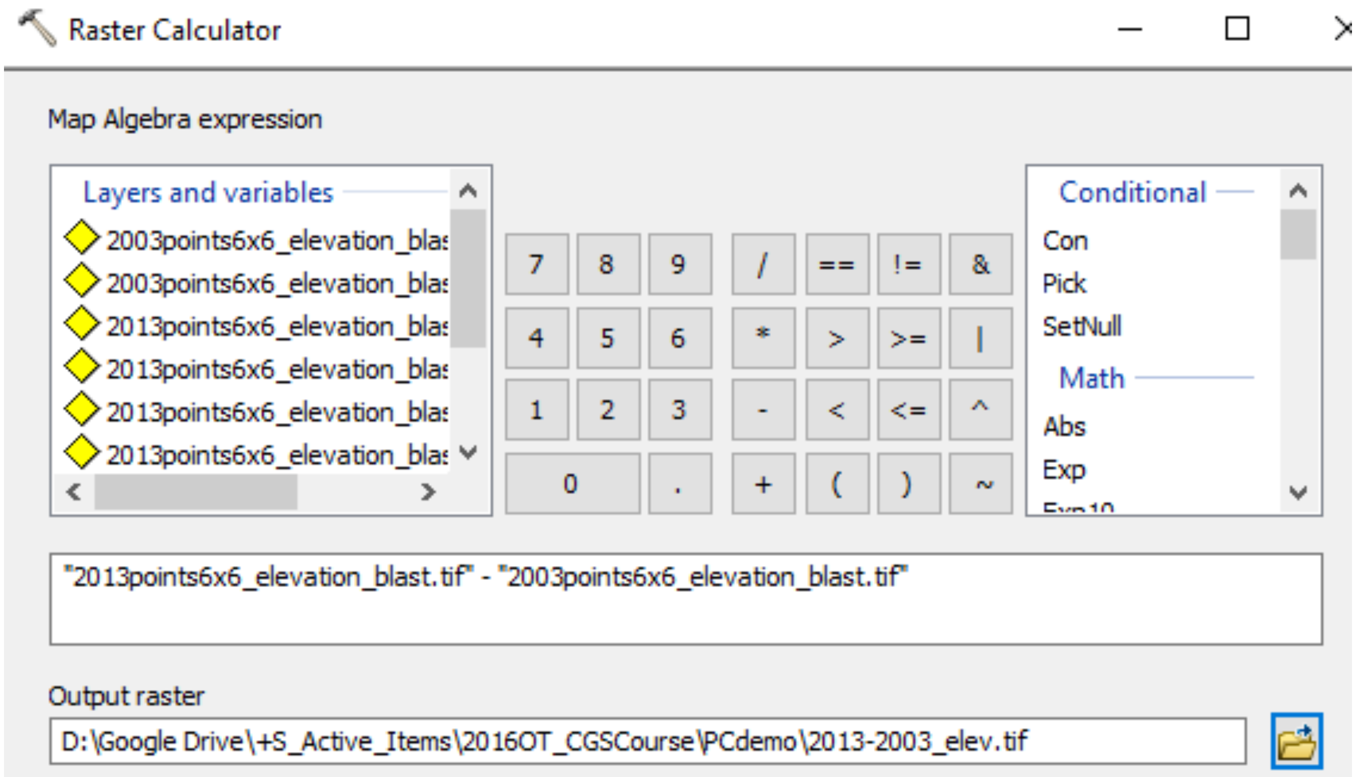
DEMs in ArcMap

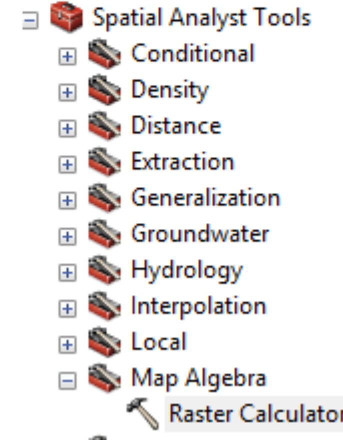
Basic visualization and colorization

Point and profile measurements

Raster Math (difference and conditional)

3D viewing in ArcScene

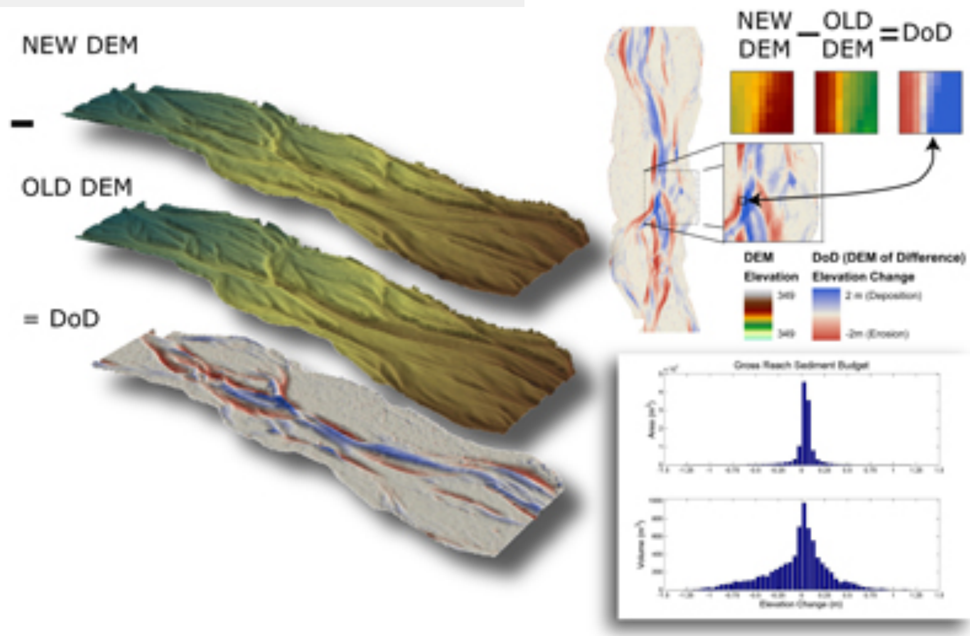


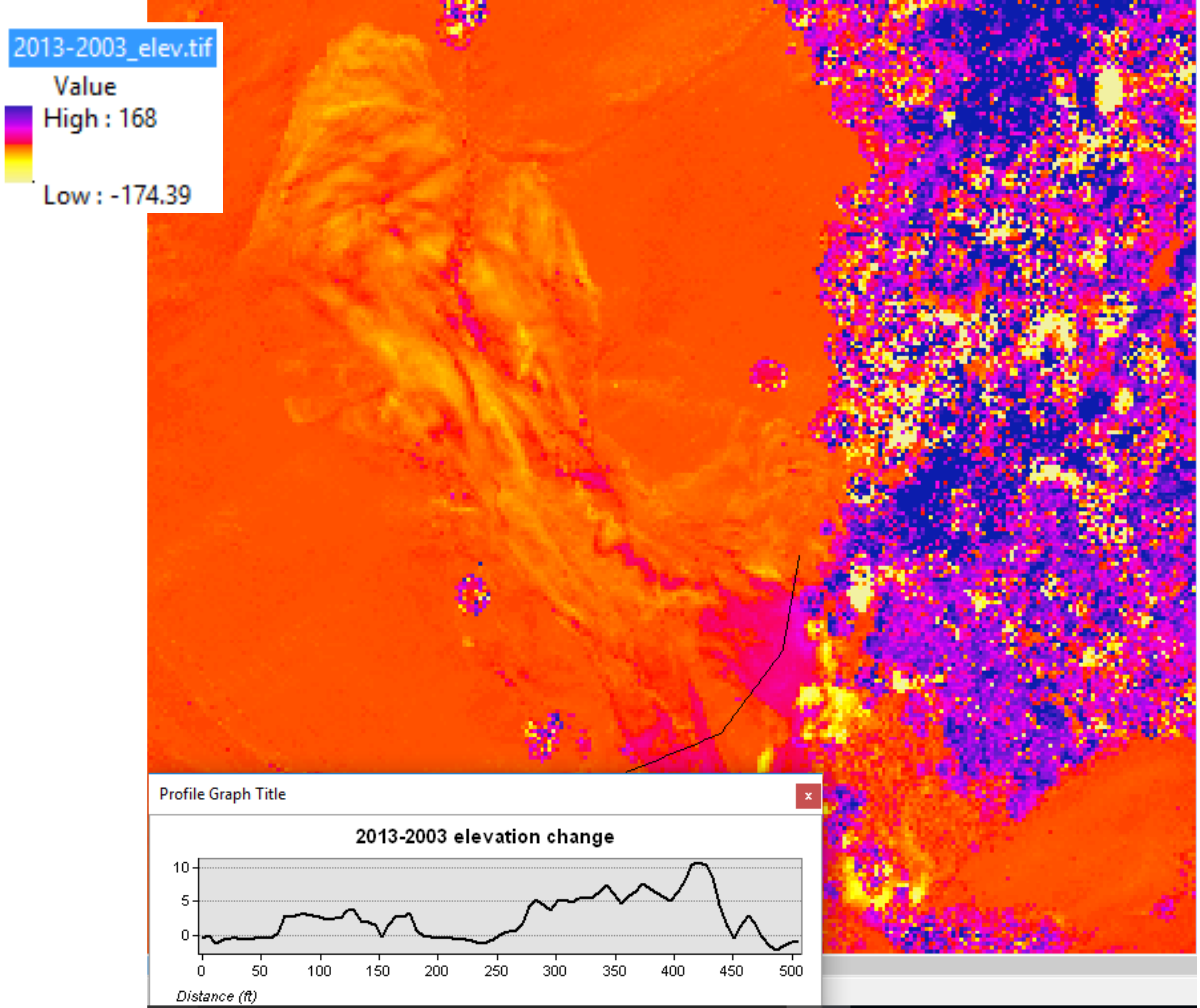


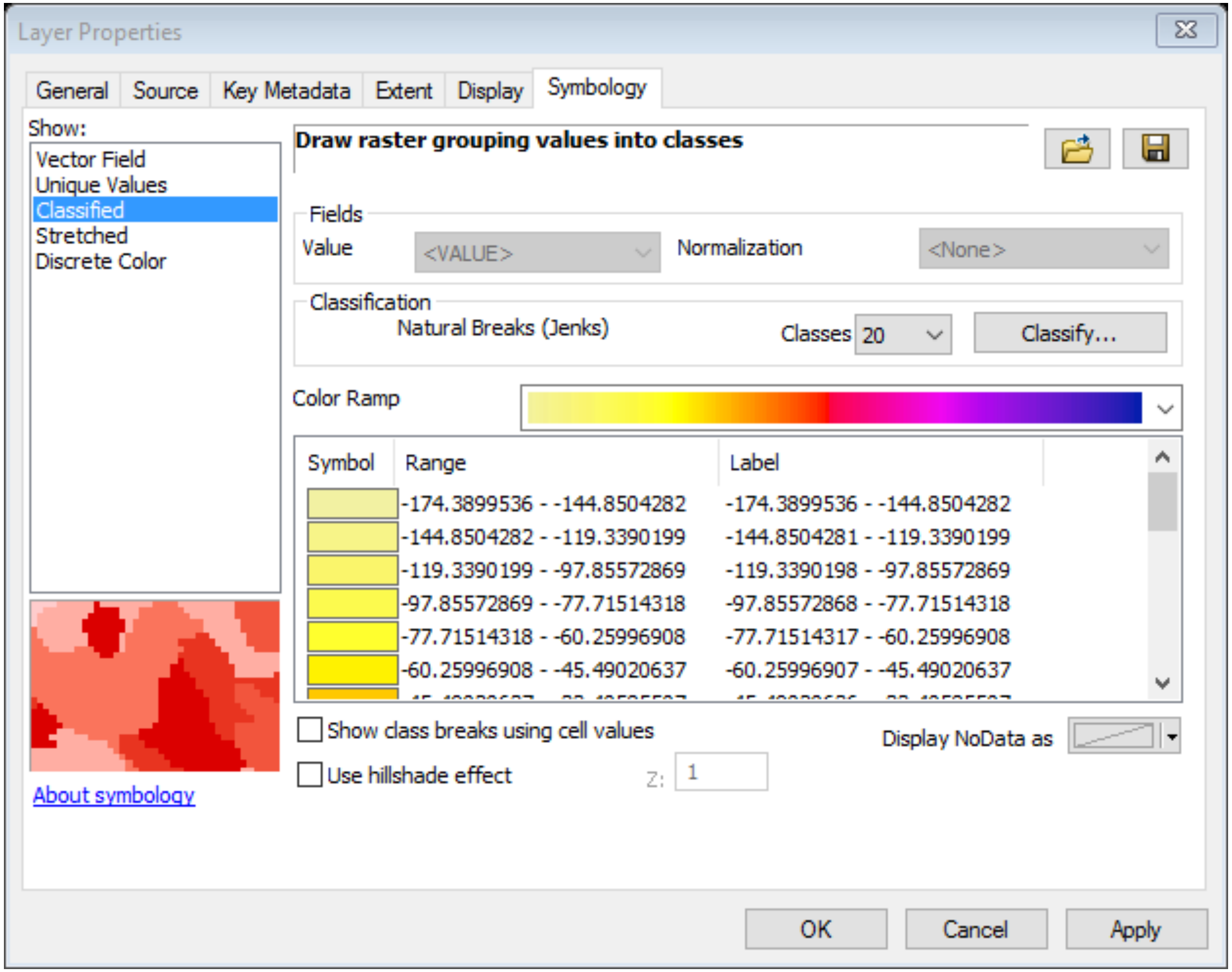
Note that is the beginning of other sorts of topographic differencing
e.g., Morphological sediment budgeting

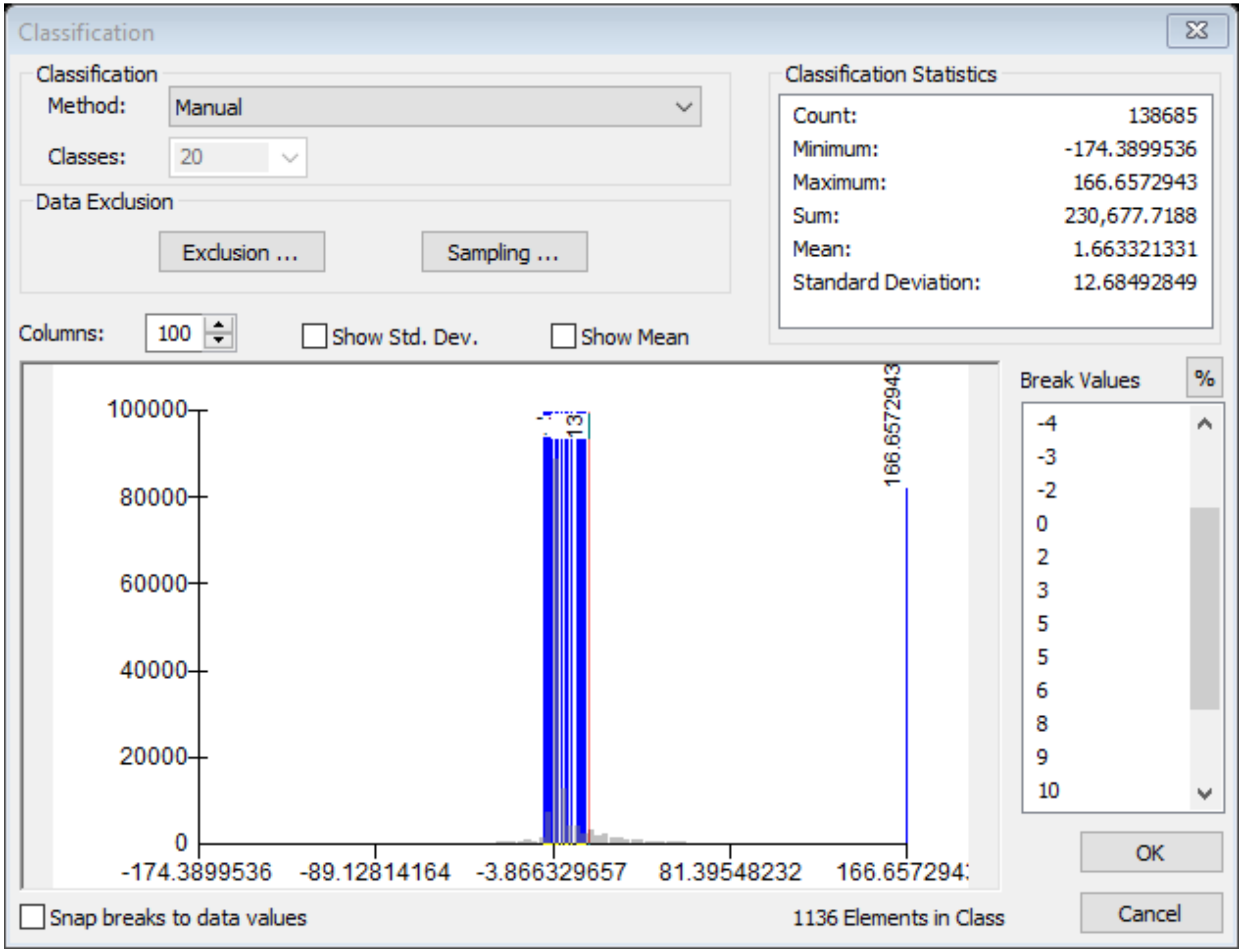
JOSEPH M. WHEATON
Research Linking Fluvial Geomorphology & Ecohydraulics

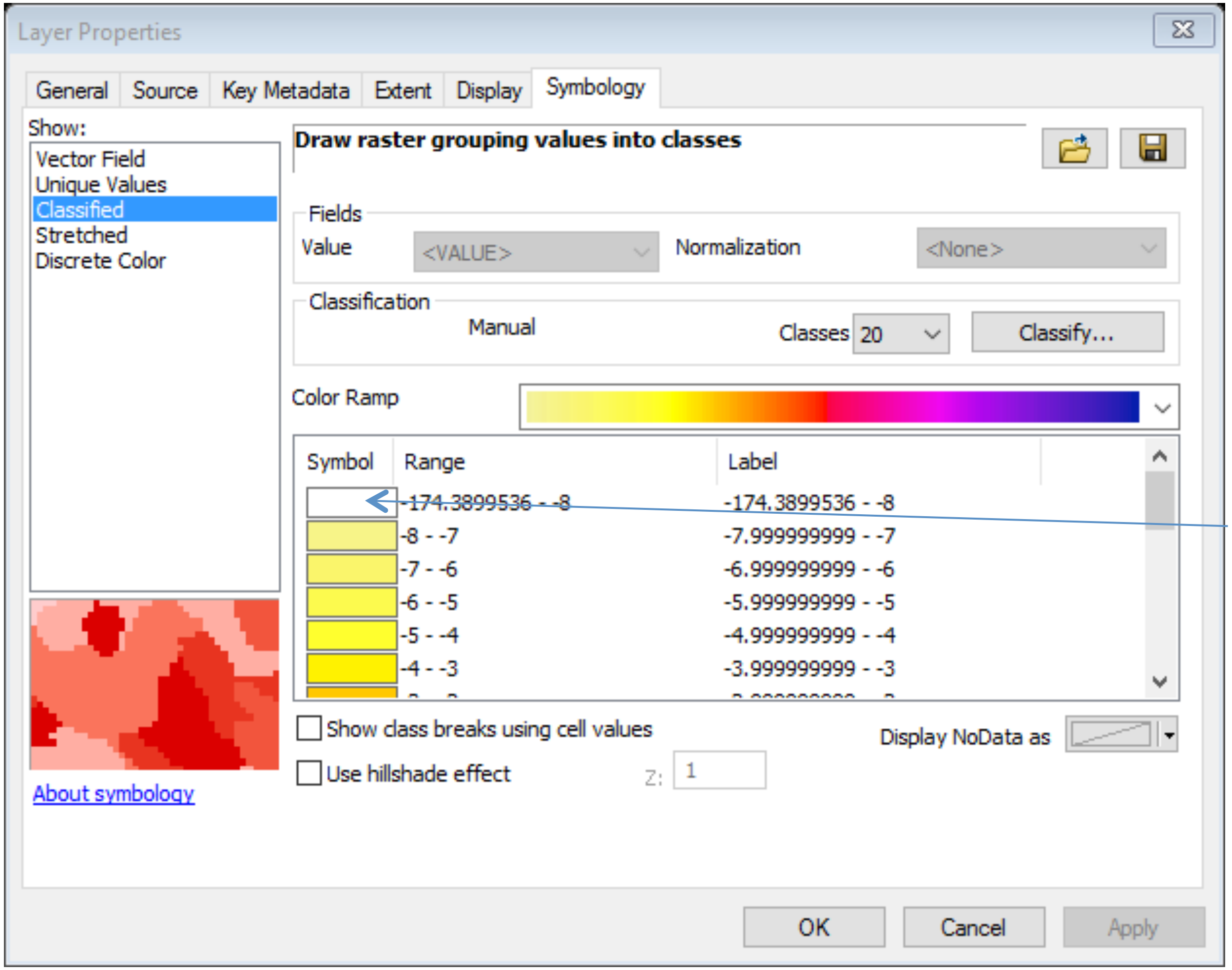
http://www.joewheaton.org/



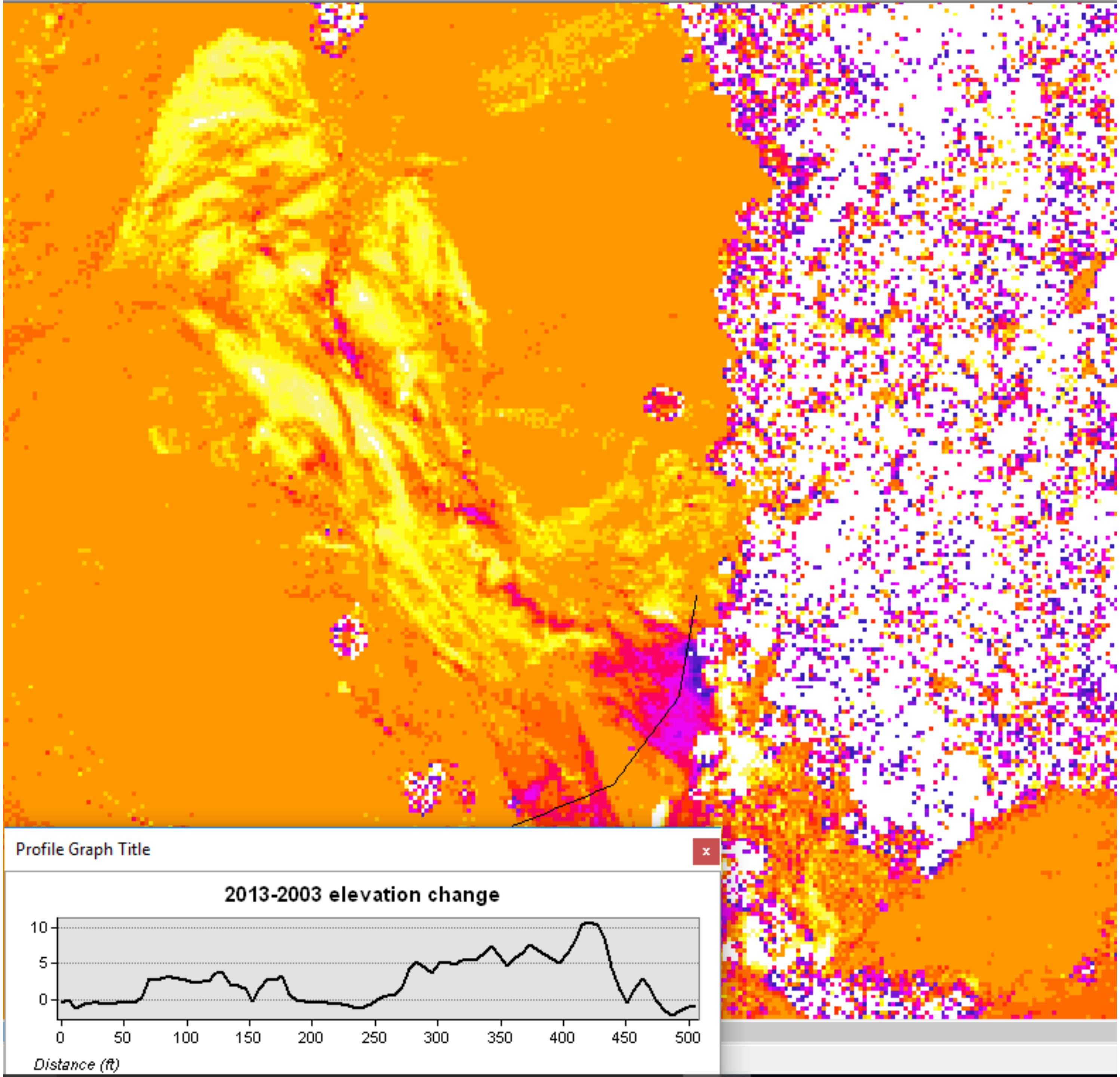

2013-2003_elev.tif
Value
High : 168
Low : -174.39
Profile Graph Title
2013-2003 elevation change
10
5
0
0
50
100
150
200
250
300
350
400
450
500
Distance (ft)


Layer Properties
General
Source
Key Metadata
Extent
Display
Symbology
Show:
Vector Field
Unique Values
Classified
Stretched
Discrete Color
Draw raster grouping values into classes
Fields
Value
<VALUE>
Normalization
<None>
Classification
Natural Breaks (Jenks)
Classes
20
Classify...
Color Ramp
Symbol
Range
Label
-174.3899536 - -144.8504282
-174.3899536 - -144.8504282
-144.8504282 - -119.3390199
-144.8504281 - -119.3390199
-119.3390199 - -97.85572869
-119.3390198 - -97.85572869
-97.85572869 - -77.71514318
-97.85572868 - -77.71514318
-77.71514318 - -60.25996908
-77.71514317 - -60.25996908
-60.25996908 - -45.49020637
-60.25996907 - -45.49020637
Show class breaks using cell values
Display NoData as
Use hillshade effect
Z:
1
About symbology
OK
Cancel
Apply

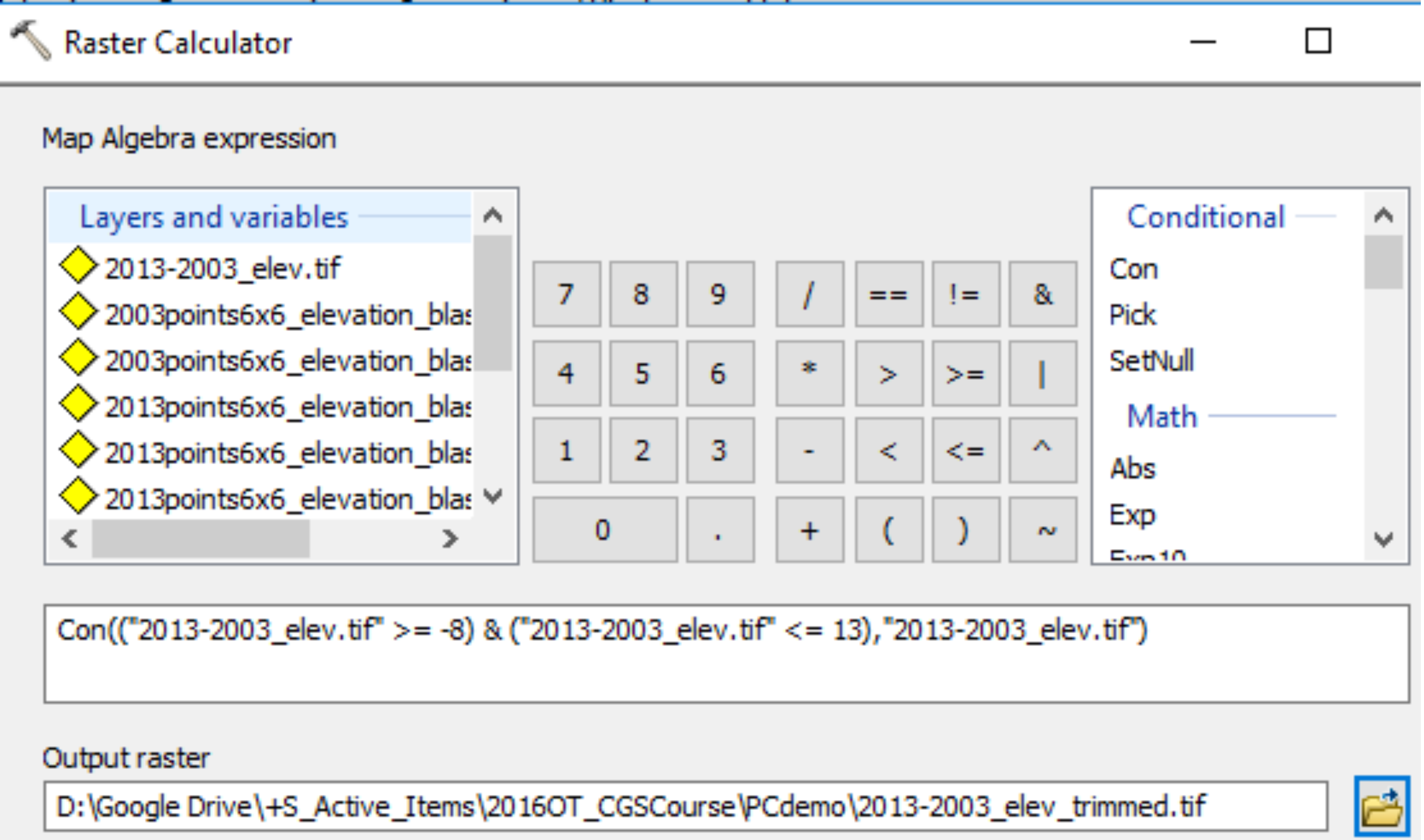

Classification
Classification
Method: Manual
Classes: 20
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
Count: 138685
Minimum: -174.3899536
Maximum: 166.6572943
Sum: 230,677.7188
Mean: 1.663321331
Standard Deviation: 12.68492849
Columns: 100
Show Std. Dev.
Show Mean
100000
80000
60000
40000
20000
0
-174.3899536
-89.12814164
-3.866329657
81.39548232
166.6572943
Break Values
%
-4
-3
-2
0
2
3
5
5
6
8
9
10
OK
Cancel
Snap breaks to data values
1136 Elements in Class



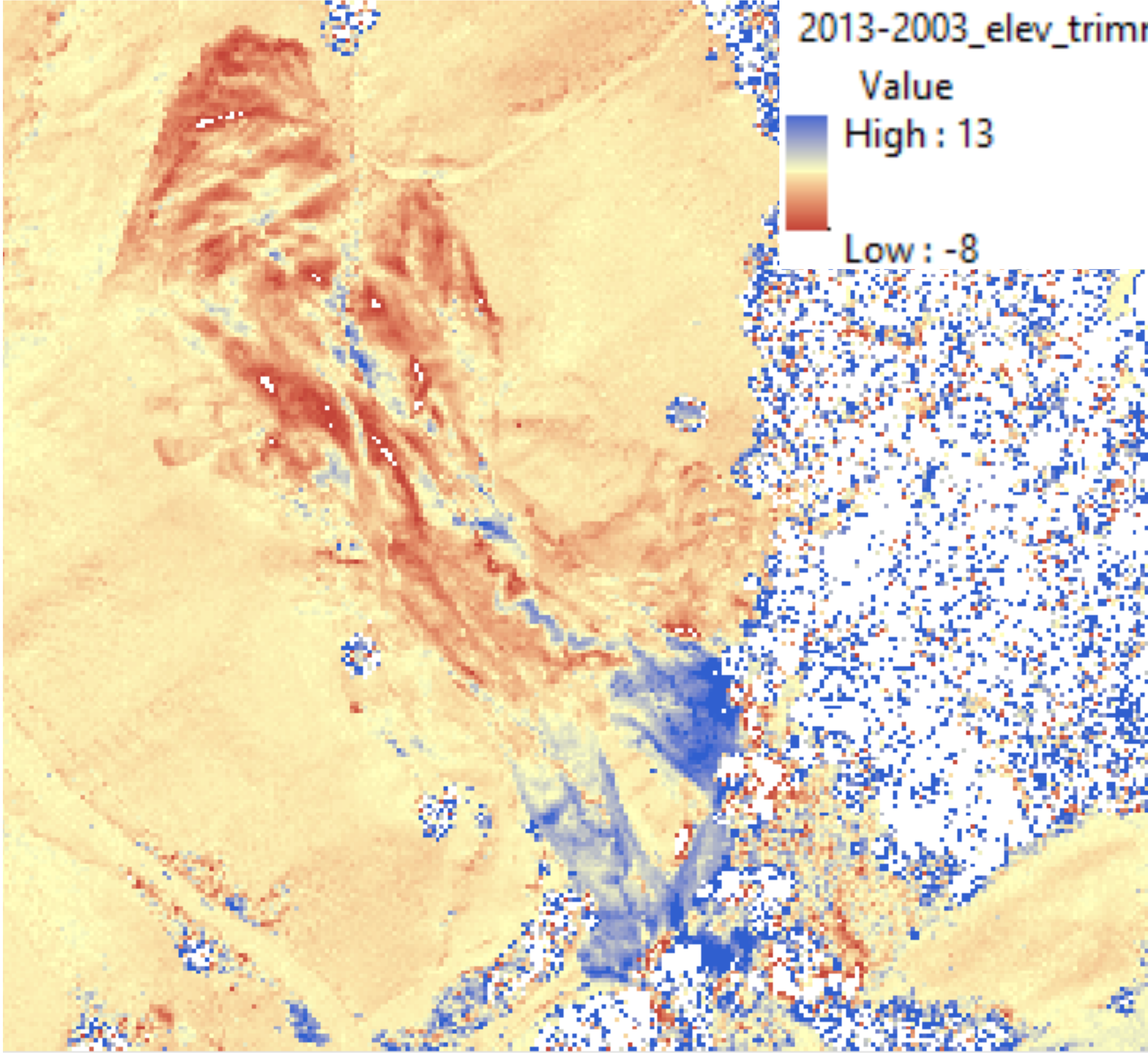
Give no color to the end classes

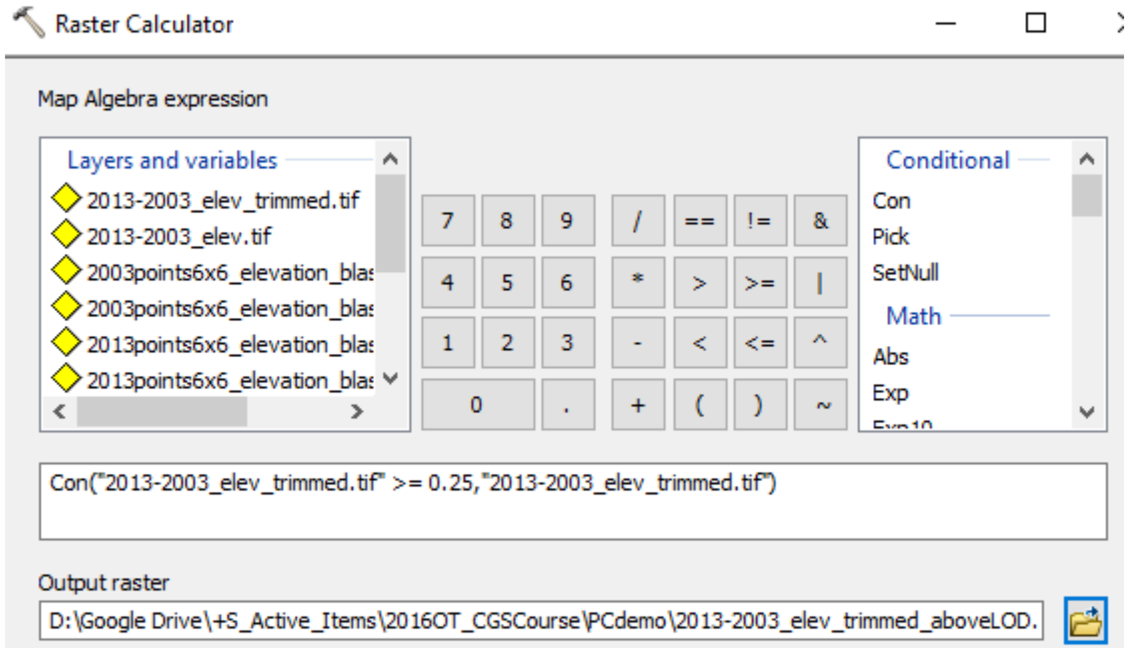


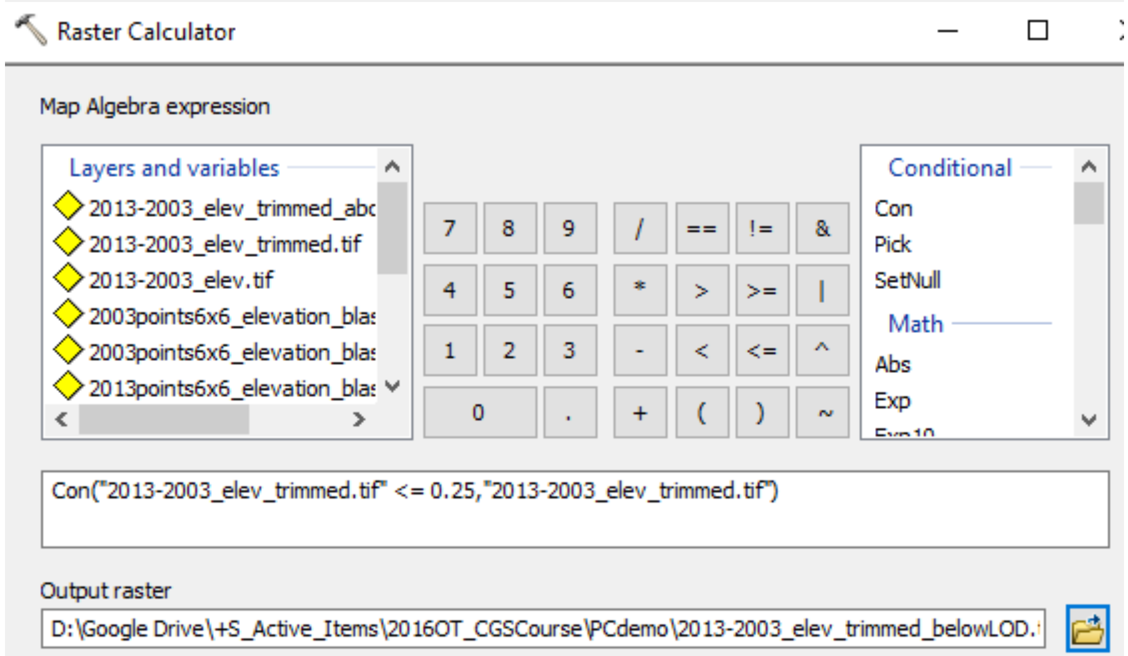
Profile Graph Title
x
2013-2003 elevation change
10
5
0
0
50
100
150
200
250
300
350
400
450
500
Distance (ft)

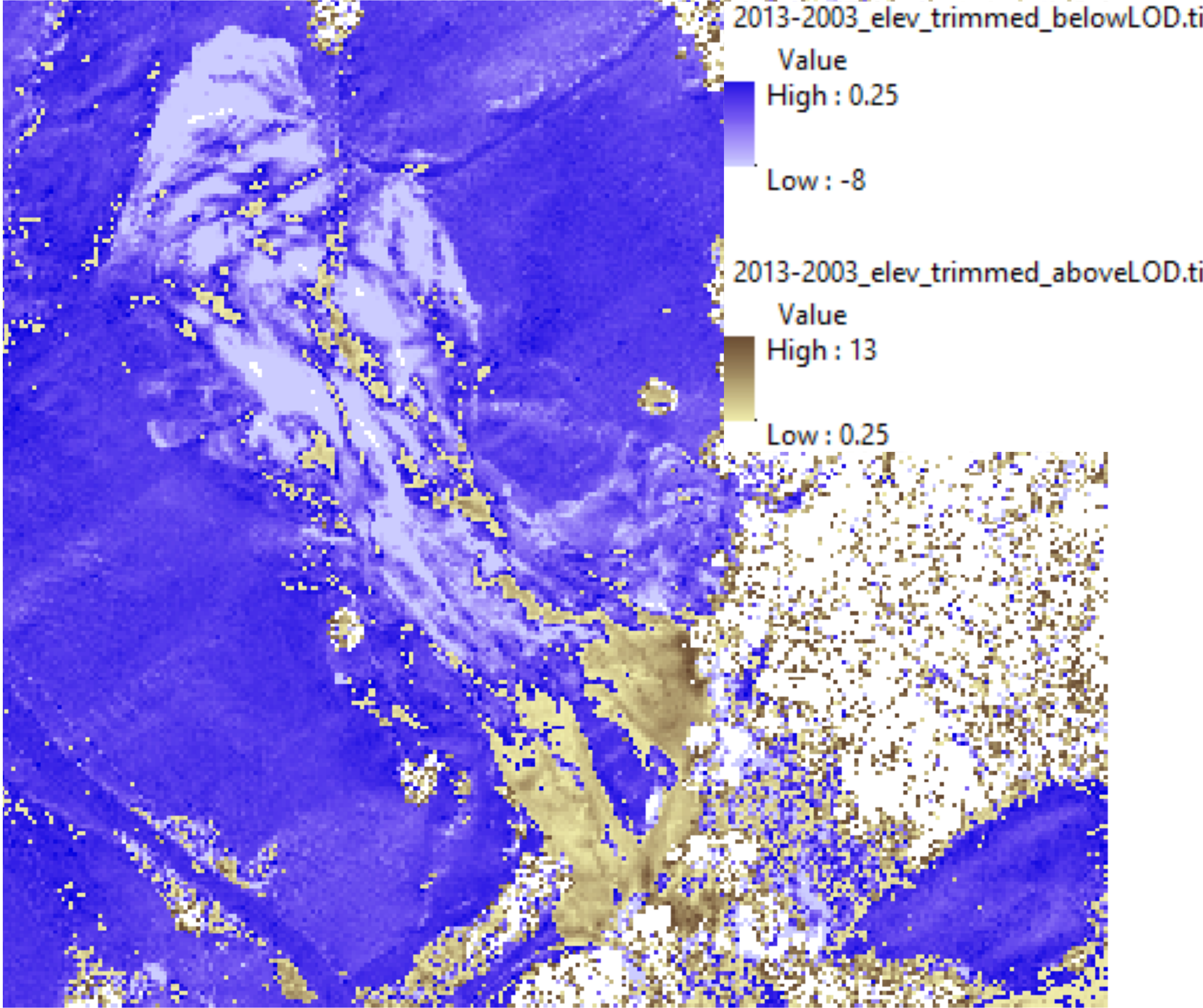


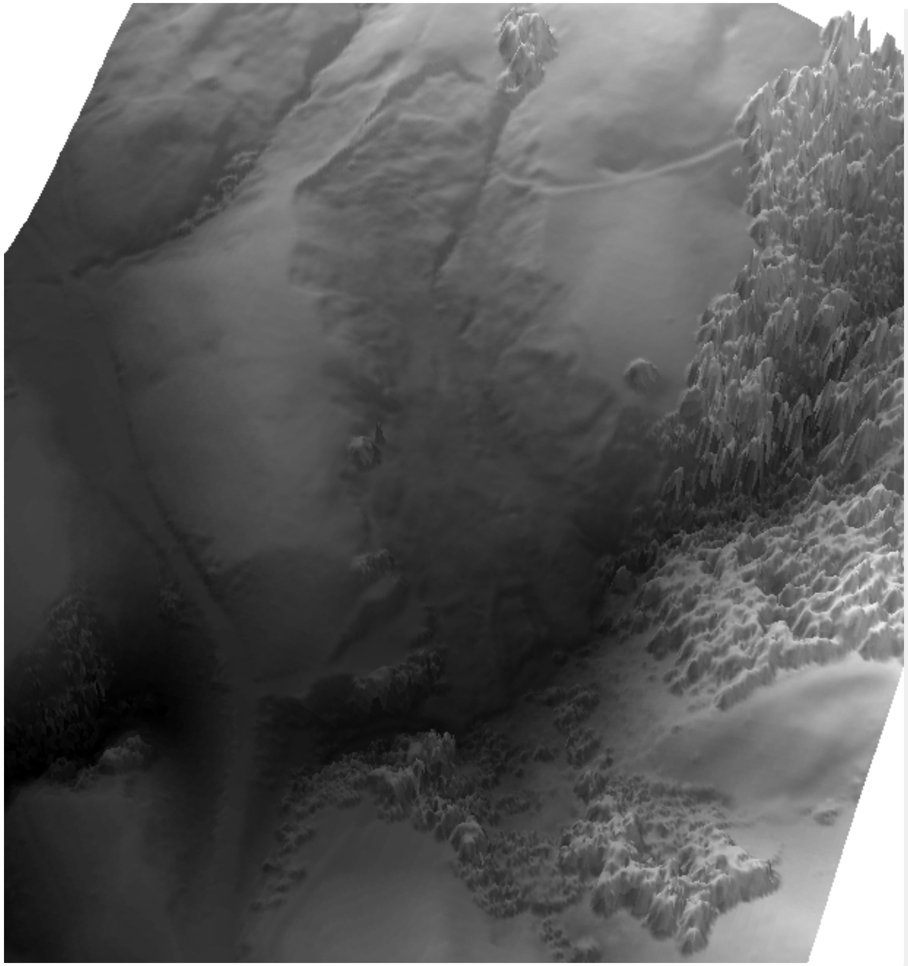
Con: Performs a conditional if/else evaluation
on each of the input cells of an input raster.
Really powerful!!!

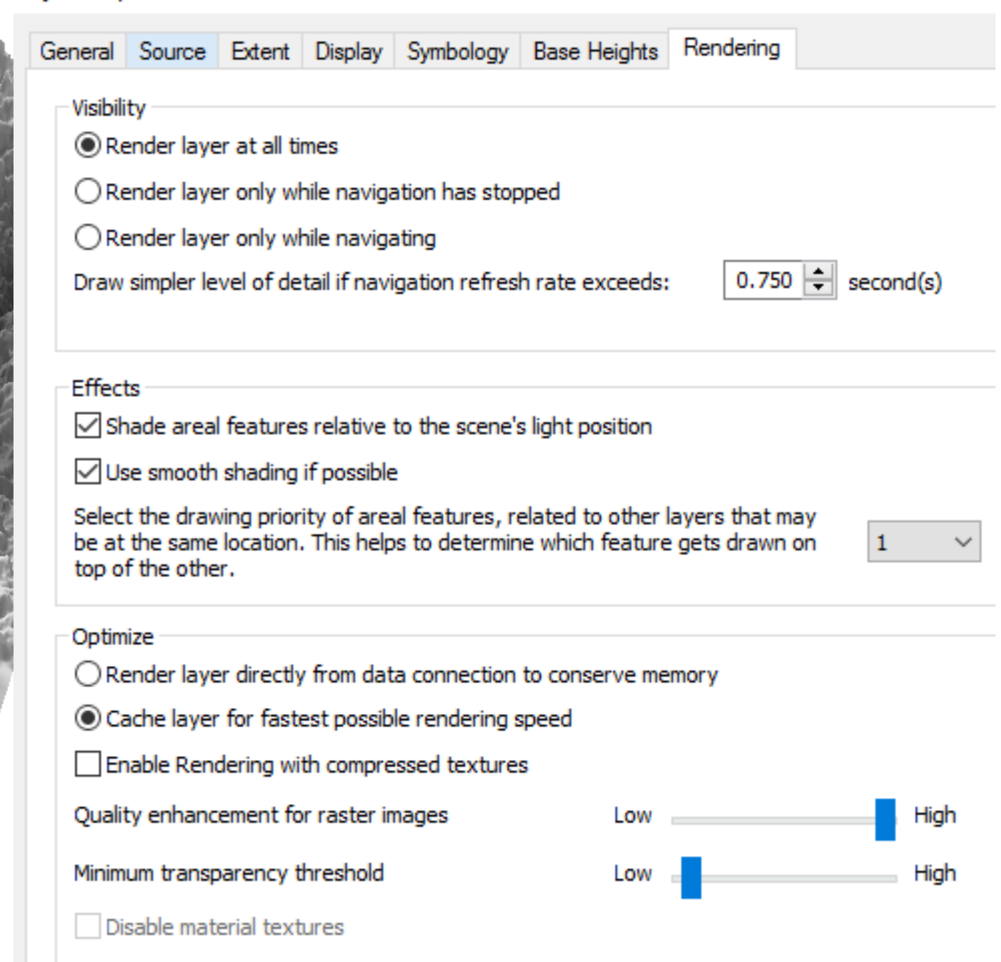

2013-2003_elev_trimmed.tif
Value
High : 13
Low : -8

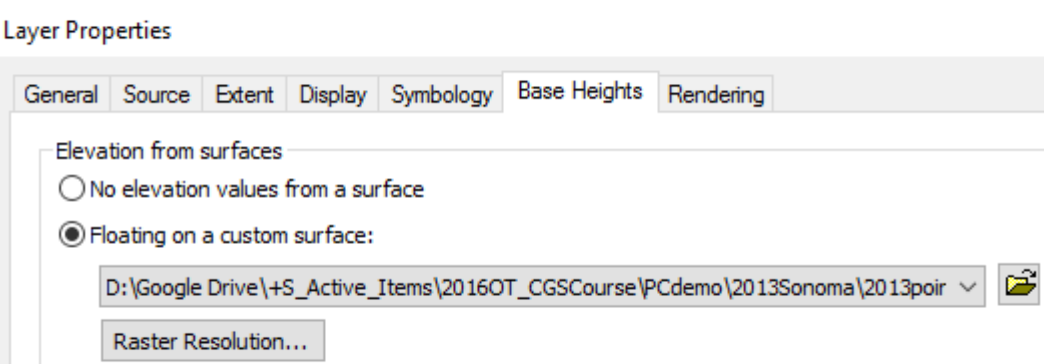

Raster Calculator
Map Algebra expression
Layers and variables
2013-2003_elev_trimmed.tif
2013-2003_elev.tif
2003points6x6_elevation_blas
2003points6x6_elevation_blas
2013points6x6_elevation_blas
2013points6x6_elevation_blas
Conditional
Con
Pick
SetNull
Math
Abs
Exp
Con("2013-2003_elev_trimmed.tif" >= 0.25,"2013-2003_elev_trimmed.tif")
Output raster
D:\Google Drive\+S_Active_Items\2016OT_CGSCourse\PCdemo\2013-2003_elev_trimmed_aboveLOD.

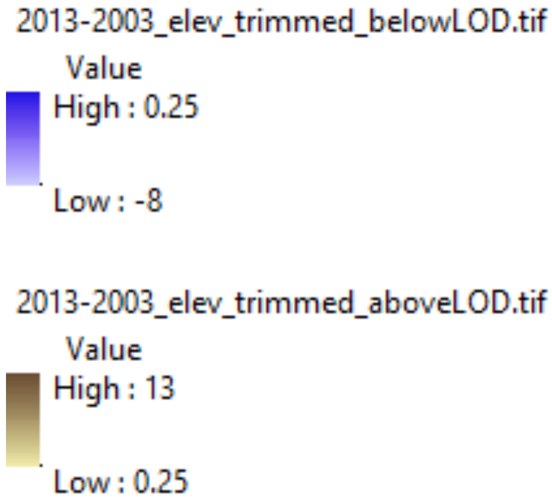

Raster Calculator
Map Algebra expression
Layers and variables
2013-2003_elev_trimmed_abc
2013-2003_elev_trimmed.tif
2013-2003_elev.tif
2003points6x6_elevation_blas
2003points6x6_elevation_blas
2013points6x6_elevation_blas
Conditional
Con
Pick
SetNull
Math
Abs
Exp
Con("2013-2003_elev_trimmed.tif" <= 0.25,"2013-2003_elev_trimmed.tif")
Output raster
D:\Google Drive\+S_Active_Items\2016OT_CGSCourse\PCdemo\2013-2003_elev_trimmed_belowLOD.

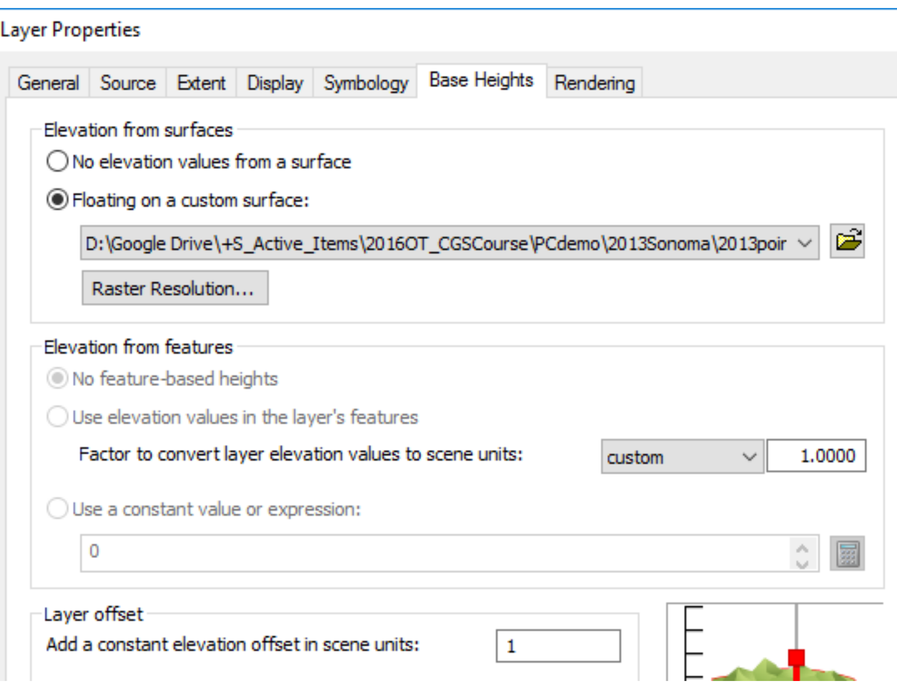

2013-2003_elev_trimmed_belowLOD.tif
Value
High : 0.25
Low : -8
2013-2003_elev_trimmed_aboveLOD.tif
Value
High : 13
Low : 0.25




General
Source
Extent
Display
Symbology
Base Heights
Rendering
Visibility
Render layer at all times
Render layer only while navigation has stopped
Render layer only while navigating
Draw simpler level of detail if navigation refresh rate exceeds:
0.750
second(s)
Effects
Shade areal features relative to the scene's light position
Use smooth shading if possible
Select the drawing priority of areal features, related to other layers that may be at the same location. This helps to determine which feature gets drawn on top of the other.
1
Optimize
Render layer directly from data connection to conserve memory
Cache layer for fastest possible rendering speed
Enable Rendering with compressed textures
Quality enhancement for raster images
Low
High
Minimum transparency threshold
Low
High
Disable material textures


Layer Properties
General
Source
Extent
Display
Symbology
Base Heights
Rendering
Elevation from surfaces
No elevation values from a surface
Floating on a custom surface:
D:\Google Drive\+S_Active_Items\2016OT_CGSCourse\PCdemo\2013Sonoma\2013poir
Raster Resolution...


2013-2003_elev_trimmed_belowLOD.tif
Value
High : 0.25
Low : -8
2013-2003_elev_trimmed_aboveLOD.tif
Value
High : 13
Low : 0.25


Layer Properties
General
Source
Extent
Display
Symbology
Base Heights
Rendering
Elevation from surfaces
No elevation values from a surface
Floating on a custom surface:
D:\Google Drive\+S_Active_Items\2016OT_CGSCourse\PCdemo\2013Sonoma\2013poir
Raster Resolution...
Elevation from features
No feature-based heights
Use elevation values in the layer's features
Factor to convert layer elevation values to scene units:
custom
1.0000
Use a constant value or expression:
0
Layer offset
Add a constant elevation offset in scene units:
1