DSM, DTM, and watershed characteristics in OpenTopography

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UNAVCO

Tutorial notes

Applications of High Resolution Topography to Geologic Hazards in Utah
September, 2017, Salt Lake City, Utah

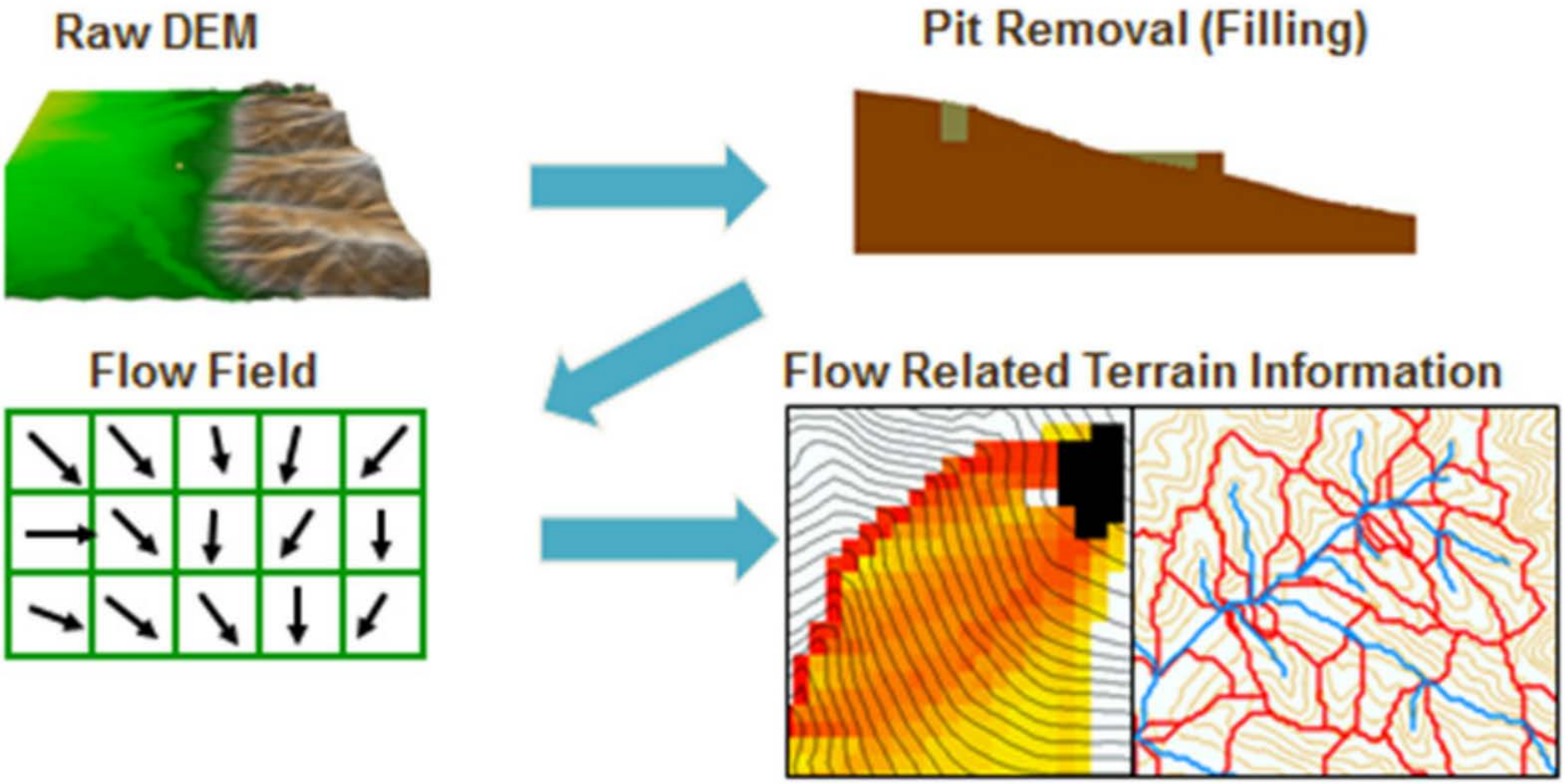
OpenTopography
High-Resolution Topography Data and Tools

Overview

Demonstrate the OpenToporaphy point cloud to raster workflow. Using predominantly the digital terrain model ("bare earth") compute topographic metrics emphasizing the drainage network contributing area and topographic roughness using ArcGIS.

Outline

1. Short lecture on watersheds and flow related terrain information
2. Compute DSM and DTM on selected data in OpenTopography.
3. Select data and run DTM computations including using TAUDEM for watershed calculations in OpenTopography.
4. Compute topographic roughness in ArcMap
5. Manipulate and visualize drainage network in ArcMap and ArcScene



TauDEM 5.0

http://hydrology.usu.edu/taudem/taudem5/

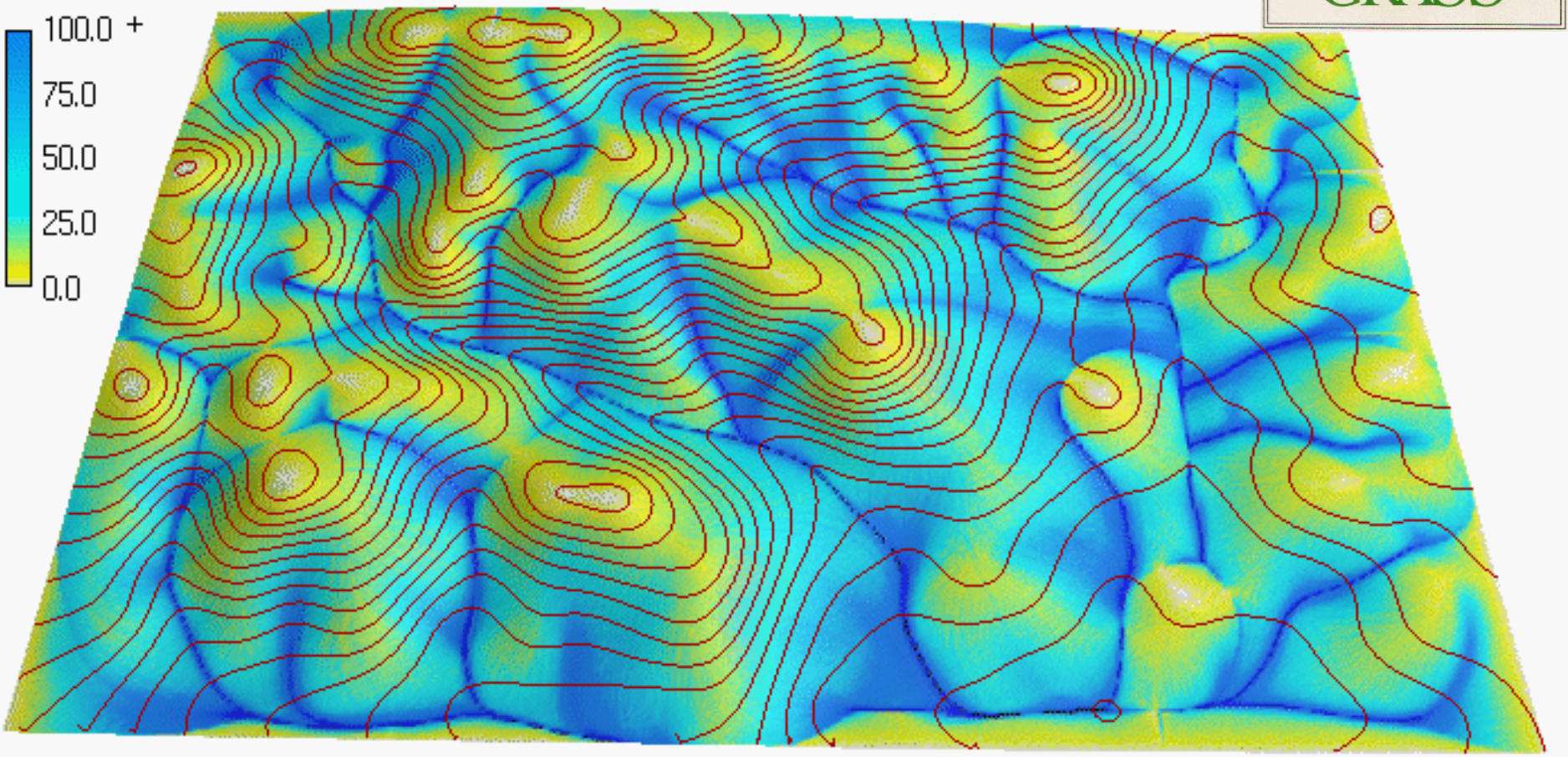
WATERSHED DELINEATION USING TAUDEM

A tutorial for using TauDEM to delineate a single watershed

Geographic Modeling Systems Laboratory
University of Illinois at Urbana-Champaign

GRASS

UPSLOPE AREA



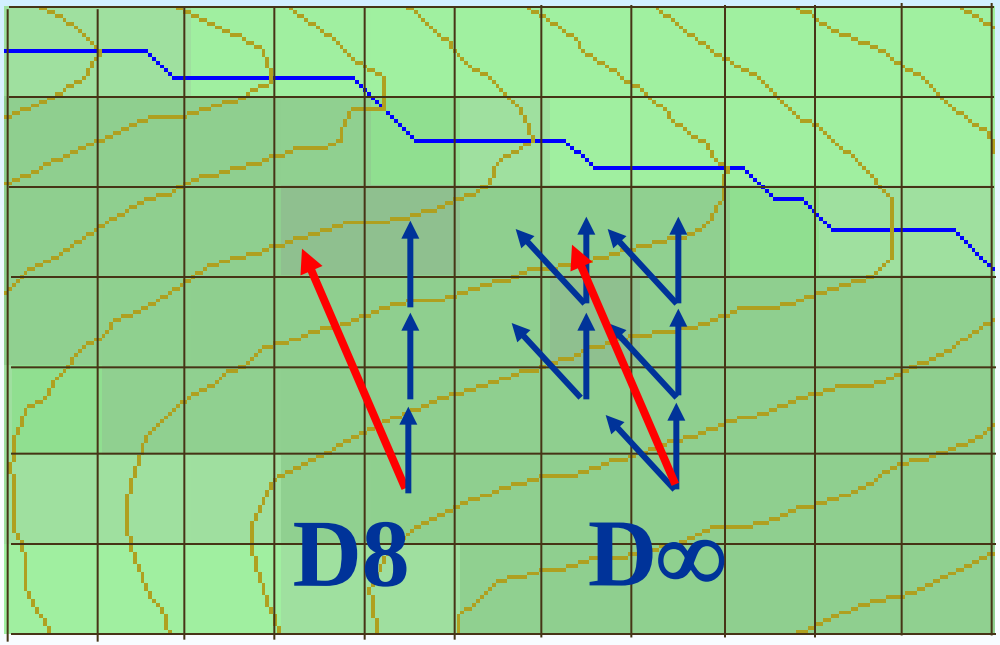
http://www4.ncsu.edu/~hmitaso/gmslab/pfarm/farm1.html

Representation of Flow Field

Steepest single direction

48	52
56	67

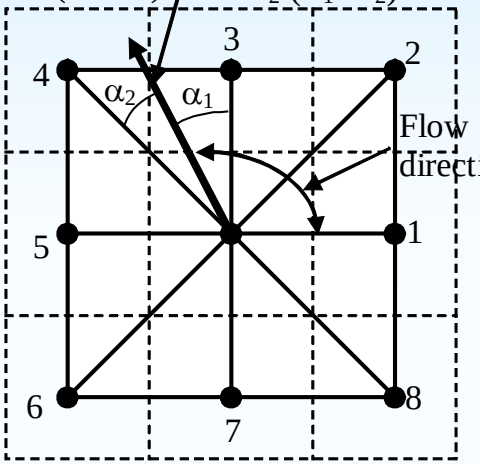
$$\frac{67-52}{30}=0.50$$

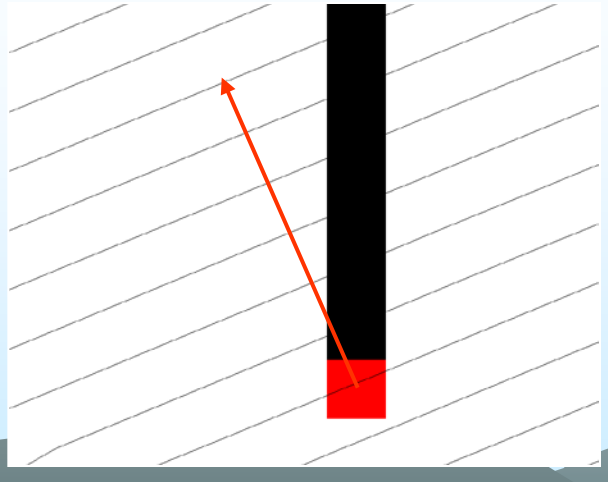


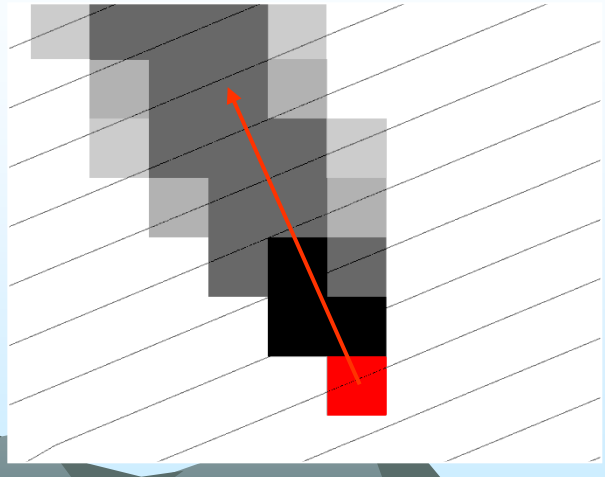
Proportion flowing to neighboring grid cell 4 is $\alpha_1/(\alpha_1+\alpha_2)$

Steepest direction downslope

Proportion flowing to neighboring grid cell 3 is $\alpha_2/(\alpha_1+\alpha_2)$

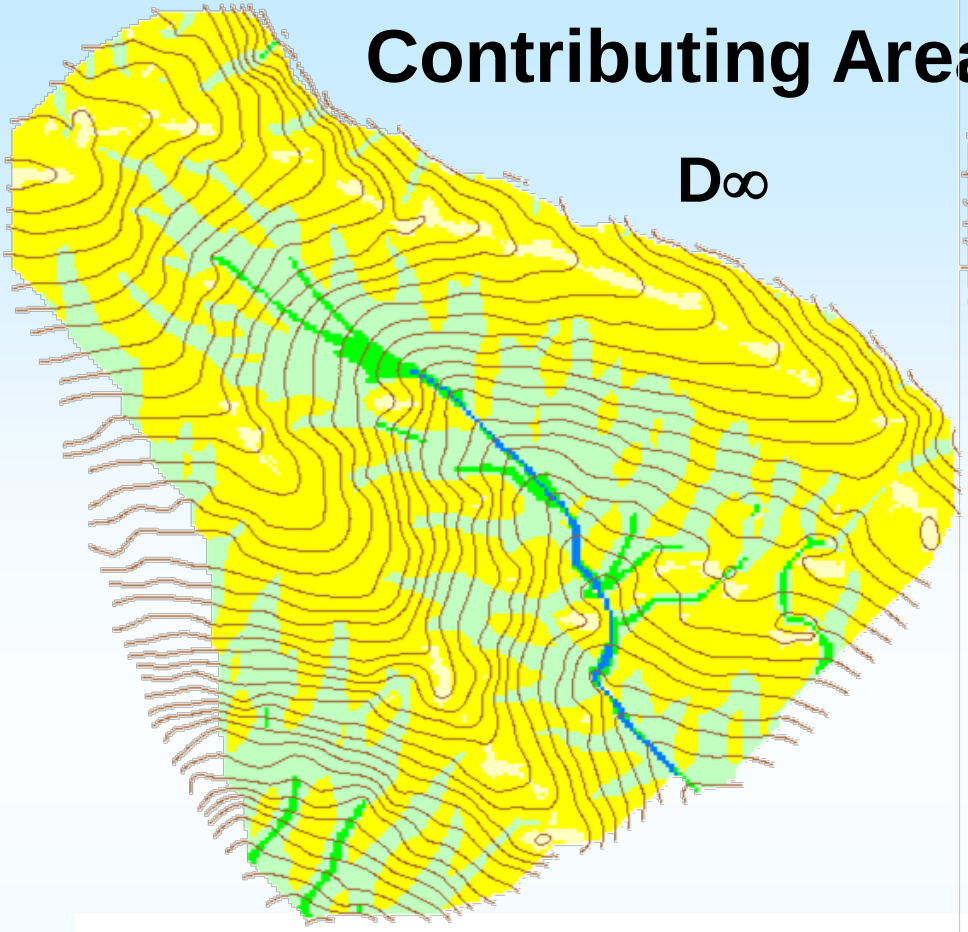






Tarboton, D. G., (1997), "A New Method for the Determination of Flow Directions and Contributing Areas in Grid Digital Elevation Models," Water Resources Research, 33(2): 309-319.)

Contributing Area



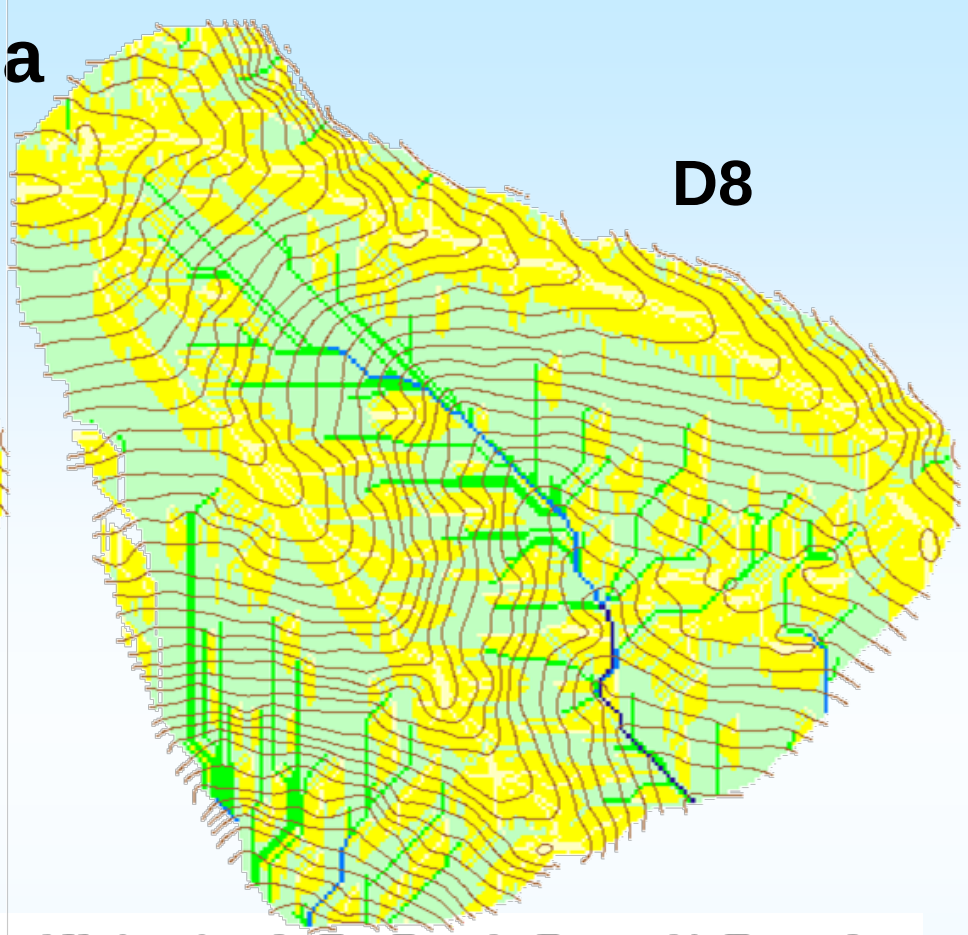


Table 2. Differences Between Theoretical and DEM-Computed Upslope Area for Test Examples Expressed in Terms of the Mean Error and Mean Square Error

	Outward Cone		Inward Cone		Plane	
	Bias Mean $(A - \hat{A})$	MSE Mean $((A - \hat{A})^2)$	Bias Mean $(A - \hat{A})$	MSE Mean $((A - \hat{A})^2)$	Bias Mean $(A - \hat{A})$	MSE Mean $((A - \hat{A})^2)$
D8	−0.13	2.13	1.76	118.88	−0.17	0.065
MS	−0.81	0.69	−1.07	5.70	−1.37	2.065
Lea's [1992] method	−1.29	2.41	−4.05	44.00	−2.57	7.912
DEMON	−0.37	0.17	−0.37	19.23	−0.40	0.161
D∞	−0.13	0.20	1.87	30.58	−0.17	0.065

WATER RESOURCES RESEARCH, VOL. 33, NO. 2, PAGES 309–319, FEBRUARY 1997

OpenTopography

High-Resolution Topography Data and Tools

Log In

Log in to OpenTopography with your email and password.

Username (Email) *

ramon.arrowsmith@asu.edu

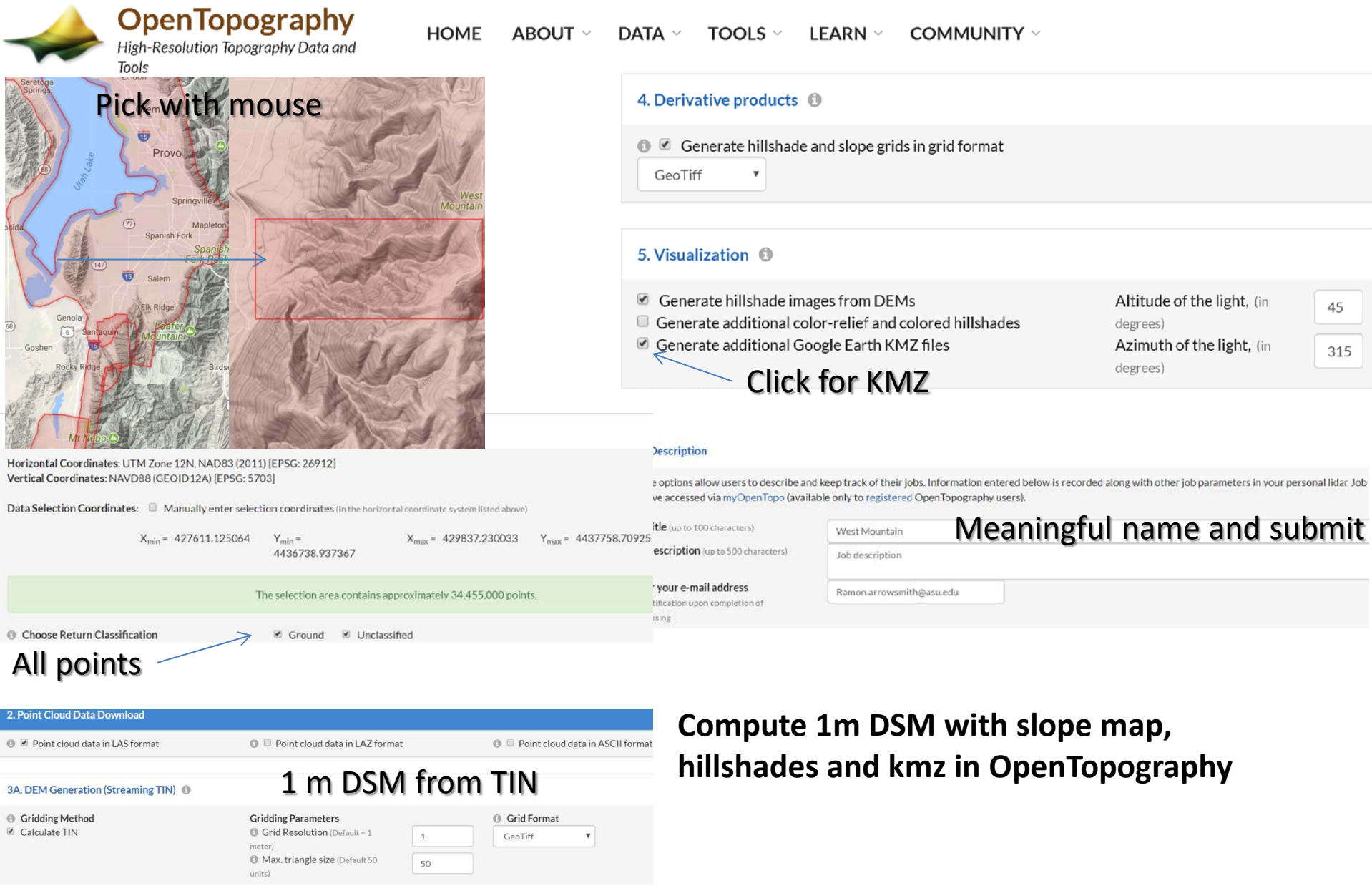
Password *

••••••••

☑ **Remember my login**

LOG IN

State of Utah Acquired Lidar Data - Wasatch Front



Compute 1m DSM with slope map, hillshades and kmz in OpenTopography

Point Cloud Job Report

Modify and resubmit this job
Full job metadata report

Modify and resubmit: just a couple of changes for the DTM and tauDEM; can also find it in MyOpenTopo

Job Id	Dataset	Title	Submission	Completion	Duration		
pc1505706169406	UGS_Wasatch	West Mountain	2017-09-17 20:42:49	N/A	N/A	34,978,372	Streaming TIN

1. Coordinates & Classification

Horizontal Coordinates: UTM Zone 12N, NAD83 (2011) [EPSG: 26912]
Vertical Coordinates: NAVD88 (GEOID12A) [EPSG: 5703]

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

X_{min} = 427601.376371 Y_{min} = 4436717.985397 X_{max} = 429846.630333 Y_{max} = 4437779.667239

The selection area contains approximately 15,071,000 points.

Choose Return Classification ☑ Ground ☐ Unclassified

Select Ground Only

6. Hydrologic Terrain Analysis Products (tauDEM)

All tauDEM products

☑ Hydrologically correct DEM with pits filled
☑ D-Infinity Flow Direction
☑ D8 Flow Direction:
☑ D-Infinity Specific Catchment Area
☑ D8 Contributing Area
☑ Topographic Wetness Index

Job Description

These options allow users to describe and keep track of their jobs. Information entered below is recorded along with other job parameters in your personal lidar Job archive accessed via myOpenTopo (available only to registered OpenTopography users).

Job title (up to 100 characters): West Mountain TauDEM

Change job title

Job description (up to 500 characters): Job description

Enter your e-mail address for notification upon completion of processing: ramon.arrowsmith@asu.edu

Getting Started | MyOpenTopo

Access jobs and results in MyOpenTopo

OpenTopography
High-Resolution Topography Data and Tools

HOME ABOUT DATA

myOpenTopo Workbench

Welcome Ramon Arrowsmith

Jobs currently running: 2 (Point Cloud jobs: 2)

User Admin

Data

1. Point Cloud Jobs: View currently submitted and previous point cloud jobs.
2. Raster Jobs: View currently submitted and previous raster jobs.
3. User Jobs Statistics: Overview of your processing jobs statistics.

User Point Cloud Jobs

	Job Id	Dataset	Title	Submission ↓	Status
1	pc1505706544249	UGS_Wasatch	[E] West Mountain TauDEM	2017-09-17 20:49:04	Querying
2	pc1505615743550	UGS_Wasatch	[E] UGS Pearsons Canyon demo	2017-09-16 19:35:44	Done
3	pc1504304147938	UGS_Wasatch	[E] weber test ground	2017-09-01 15:15:48	Done (Expired)
4	pc1504304037763	UGS_Wasatch	[E] weber test	2017-09-01 15:13:57	Done (Expired)

Point Cloud Job Report

Modify and resubmit this job
Full job metadata report

Download Job Metadata
View Job Configuration

Job Id	Dataset	Title	Submission	Completion	Duration	Num points	Final Status
pc1505706169406	UGS_Wasatch	West Mountain	2017-09-17 20:42:49	2017-09-17 20:45:34	165 secs	34,978,372	Done ✔

Download products and quick visualization in Google Earth

Download Job Results

Point Cloud Results	• Download point cloud data in LAS format points.las (1.1 GB)
DEM Results	• Download DEM (TIN) dems.tar.gz (5.9 MB)
Derivative Products	• Download Hillshade & Slope Products (TIN) viz.tar.gz (9.4 MB)

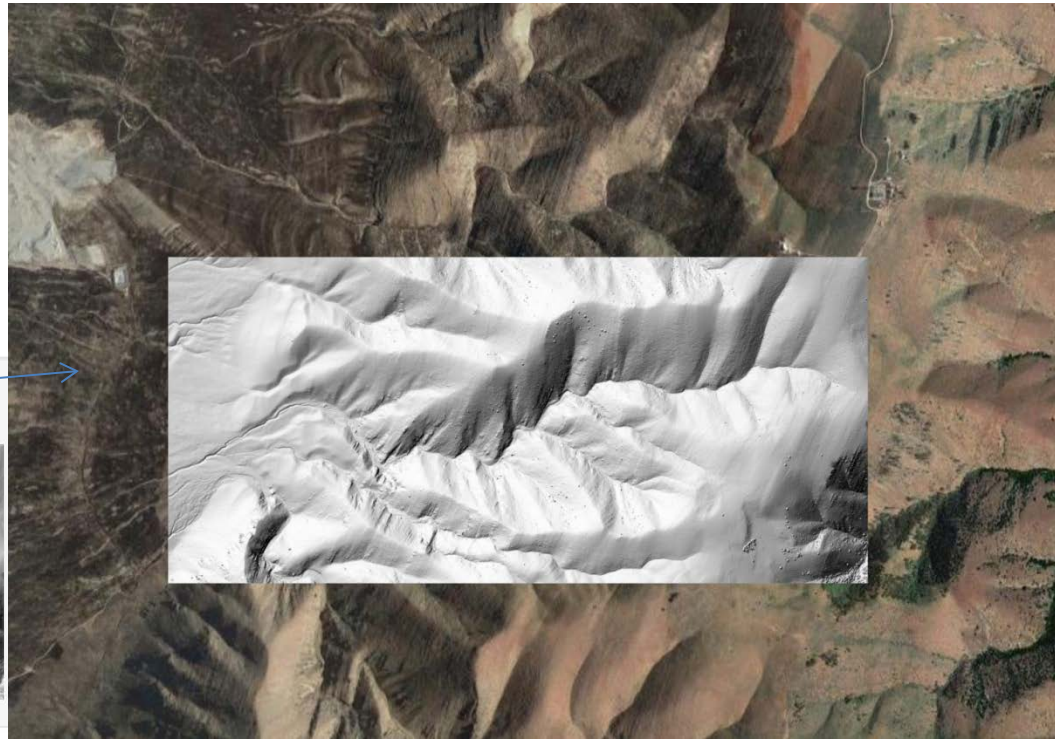
Download dems as DSM

View KMZ in Google Earth

Visualization Products

Ztin DEM

- View with Google Map



Point Cloud Job Report

Modify and resubmit this job
Full job metadata report

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Job Id	Dataset	Title	Submission	Completion	Duration	Num points	Final Status
pc1505706544249	UGS_Wasatch	West Mountain TauDEM	2017-09-17 20:49:04	2017-09-17 20:52:16	192 secs	17,715,525	Done ✔

Download products and quick visualization in Google Earth

Download Job Results

Point Cloud Results
- Download point cloud data in LAS format points.las (574.4 MB)

DEM Results
- Download DEM (TIN) dems.tar.gz (6.1 MB)

Download dems as DTM

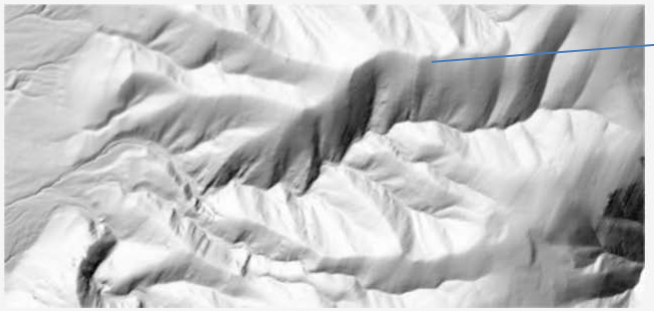
Derivative Products
- Download Hillshade & Slope Products (TIN) viz.tar.gz (9.8 MB)

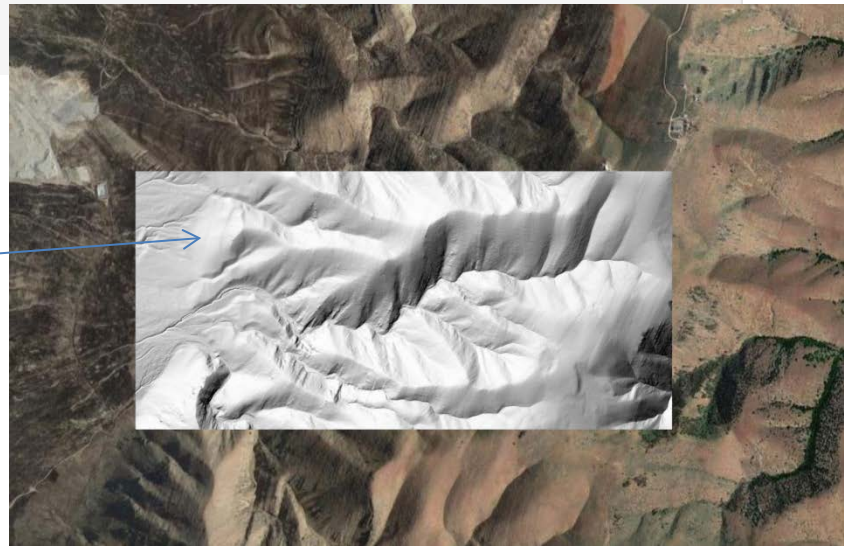
Hillshades too

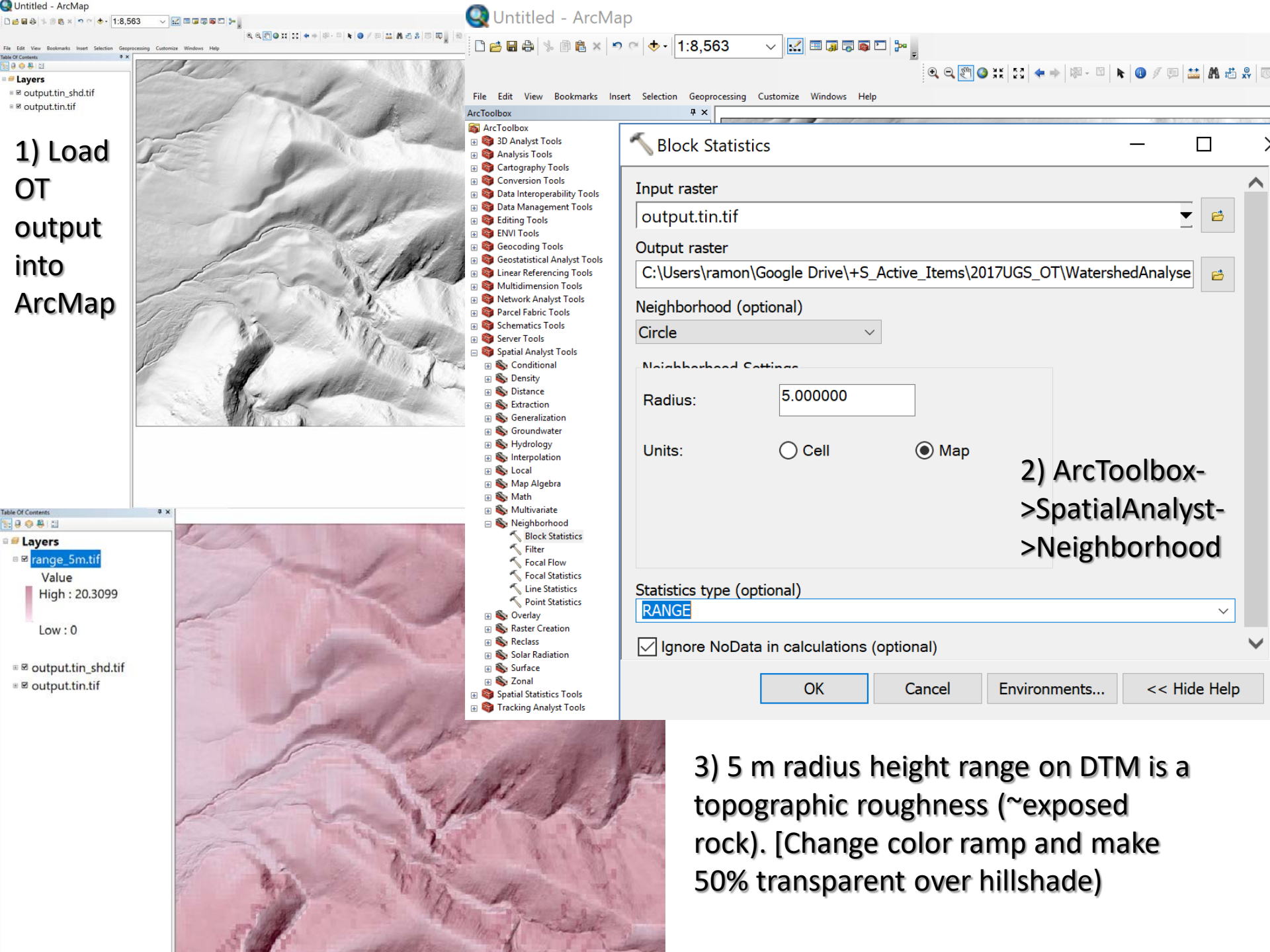
TauDEM Products
- Download PitRemove file pitRemove.tar.gz (5.9 MB)
- Download D-Infinity: Flow Direction file dinfFlowDirection.tar.gz (6.4 MB)
- Download D-Infinity: Slope file dinfSlope.tar.gz (5.9 MB)
- Download D-Infinity Specific Catchment Area file Dinfarea.tar.gz (7 MB)
- Download Topographic Wetness Index file TWI.tar.gz (6.7 MB)
- Download D8 - Flow Direction file d8FlowDirection.tar.gz (497.3 KB)
- Download D8: Slope file d8Slope.tar.gz (3.8 MB)
- Download D8 Contributing Area file D8area.tar.gz (2.5 MB)

Visualization Products

Ztin DEM
- View with Google Map






Untitled - ArcMap
1:8,563
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
Layers
output.tin_shd.tif
output.tin.tif
1) Load OT output into ArcMap
ArcToolbox
ArcToolbox
3D Analyst Tools
Analysis Tools
Cartography Tools
Conversion Tools
Data Interoperability Tools
Data Management Tools
Editing Tools
ENVI Tools
Geocoding Tools
Geostatistical Analyst Tools
Linear Referencing Tools
Multidimension Tools
Network Analyst Tools
Parcel Fabric Tools
Schematics Tools
Server Tools
Spatial Analyst Tools
Conditional
Density
Distance
Extraction
Generalization
Groundwater
Hydrology
Interpolation
Local
Map Algebra
Math
Multivariate
Neighborhood
Block Statistics
Filter
Focal Flow
Focal Statistics
Line Statistics
Point Statistics
Overlay
Raster Creation
Reclass
Solar Radiation
Surface
Zonal
Spatial Statistics Tools
Tracking Analyst Tools
Block Statistics
Input raster
output.tin.tif
Output raster
C:\Users\ramon\Google Drive\+S_Active_Items\2017UGS_OT\WatershedAnalyse
Neighborhood (optional)
Circle
Radius:
5.000000
Units:
Cell
Map
2) ArcToolbox->SpatialAnalyst->Neighborhood
Statistics type (optional)
RANGE
Ignore NoData in calculations (optional)
OK
Cancel
Environments...
<< Hide Help
Table Of Contents
Layers
range_5m.tif
Value
High : 20.3099
Low : 0
output.tin_shd.tif
output.tin.tif
3) 5 m radius height range on DTM is a topographic roughness (~exposed rock). [Change color ramp and make 50% transparent over hillshade)

Point Cloud Job Report

Analyze D∞ catchment area in ArcMap

Modify and resubmit this job
Full job metadata report

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Download products to a watershed folder and uncompress.

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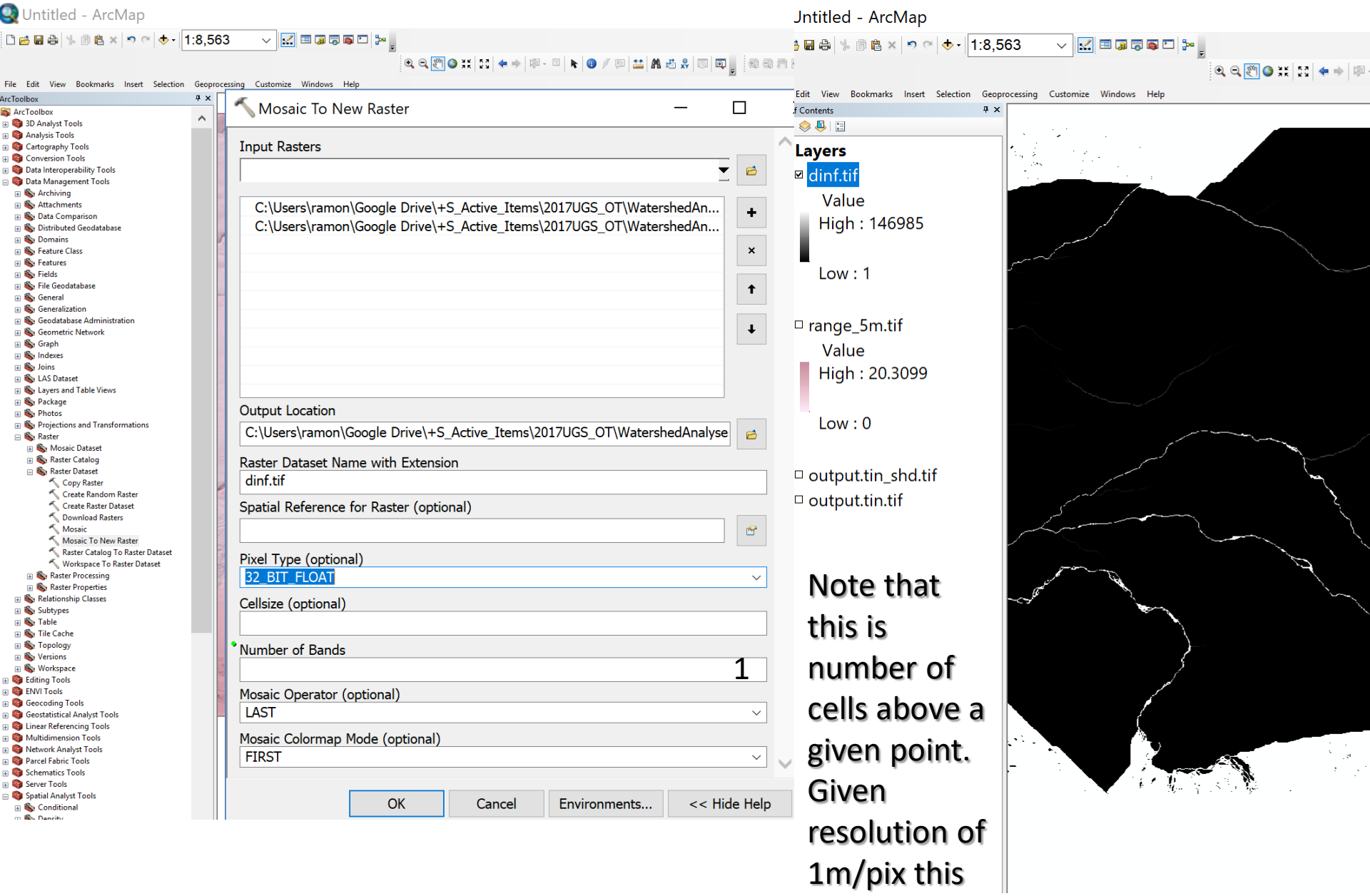
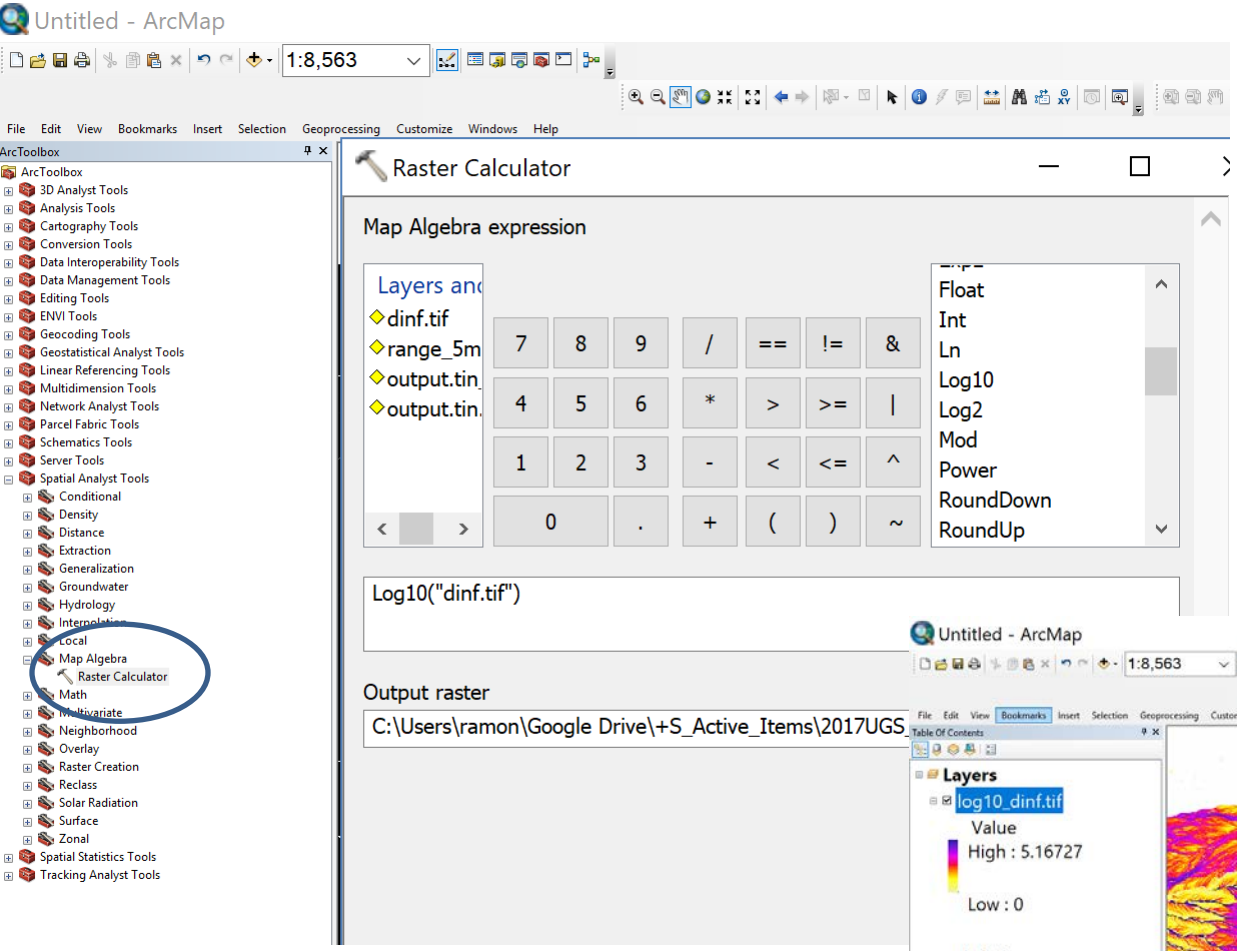
DinfArea

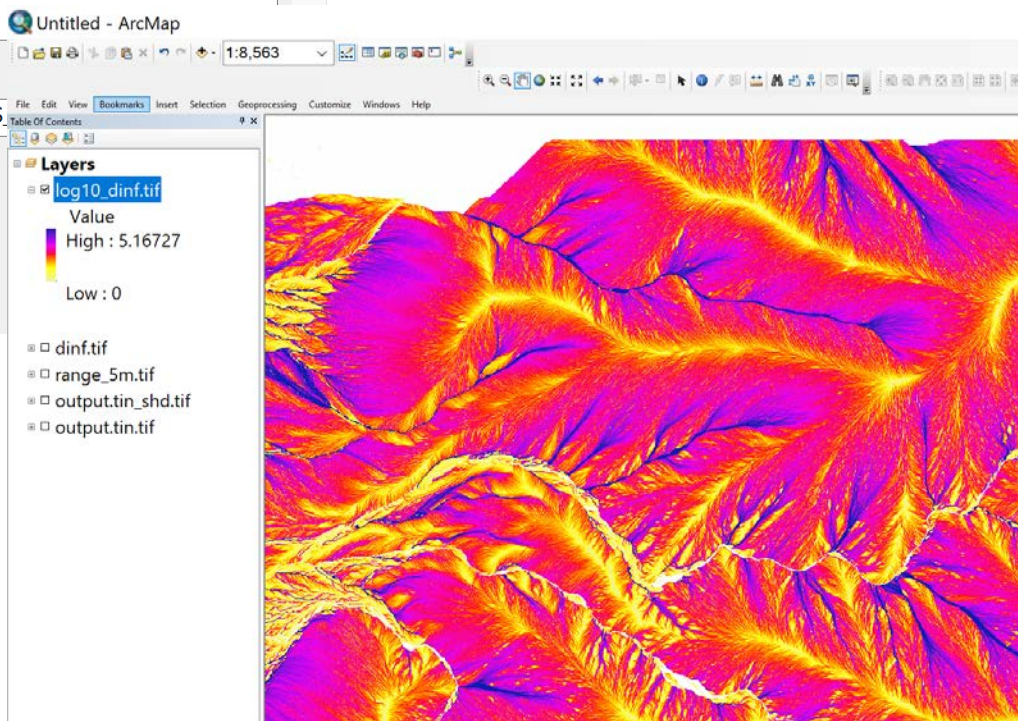
Mosaic to new raster the output files



Note that this is number of cells above a given point. Given resolution of 1m/pix this is in sq. m.

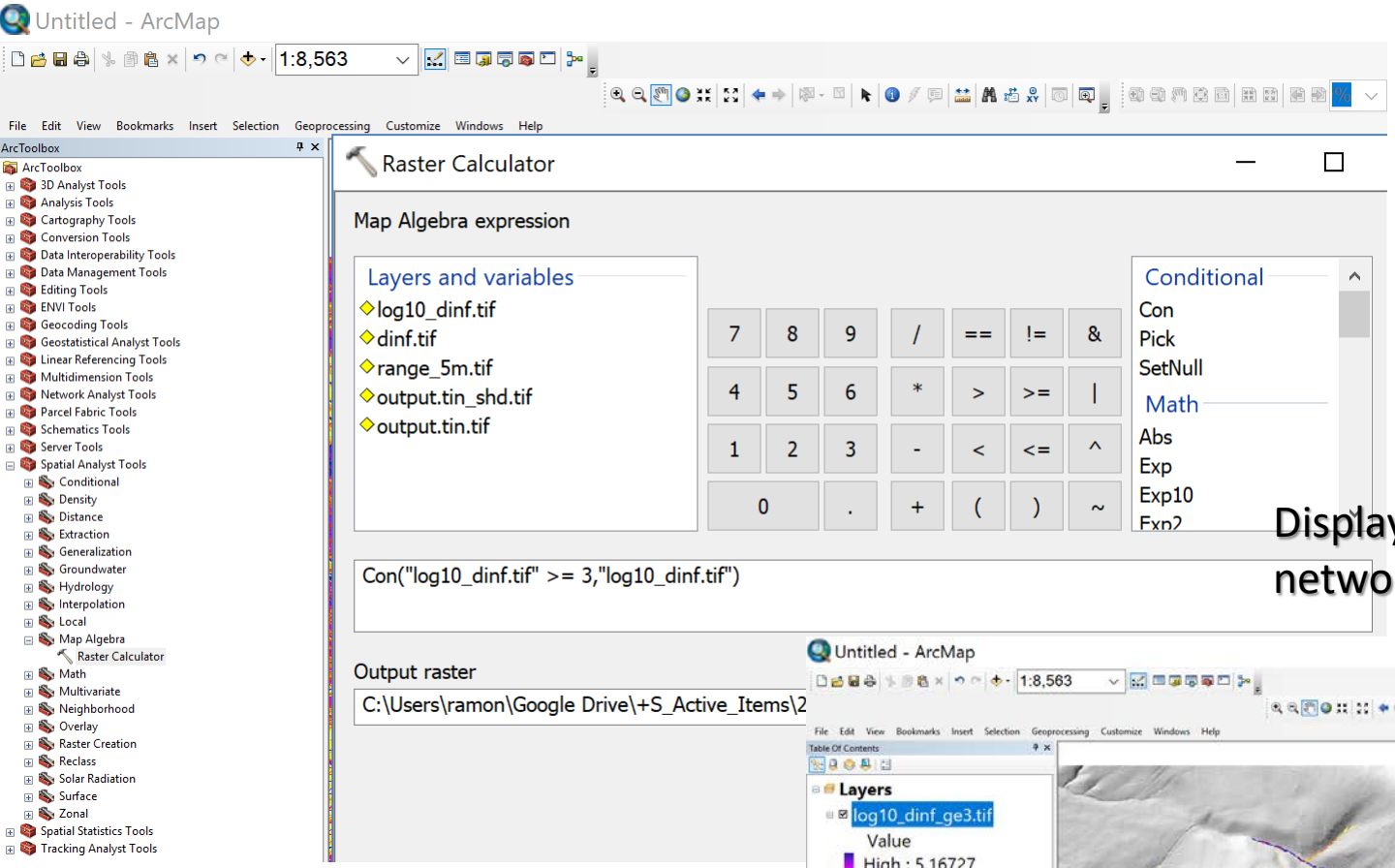
Compute log10 of the area using Raster Calculator



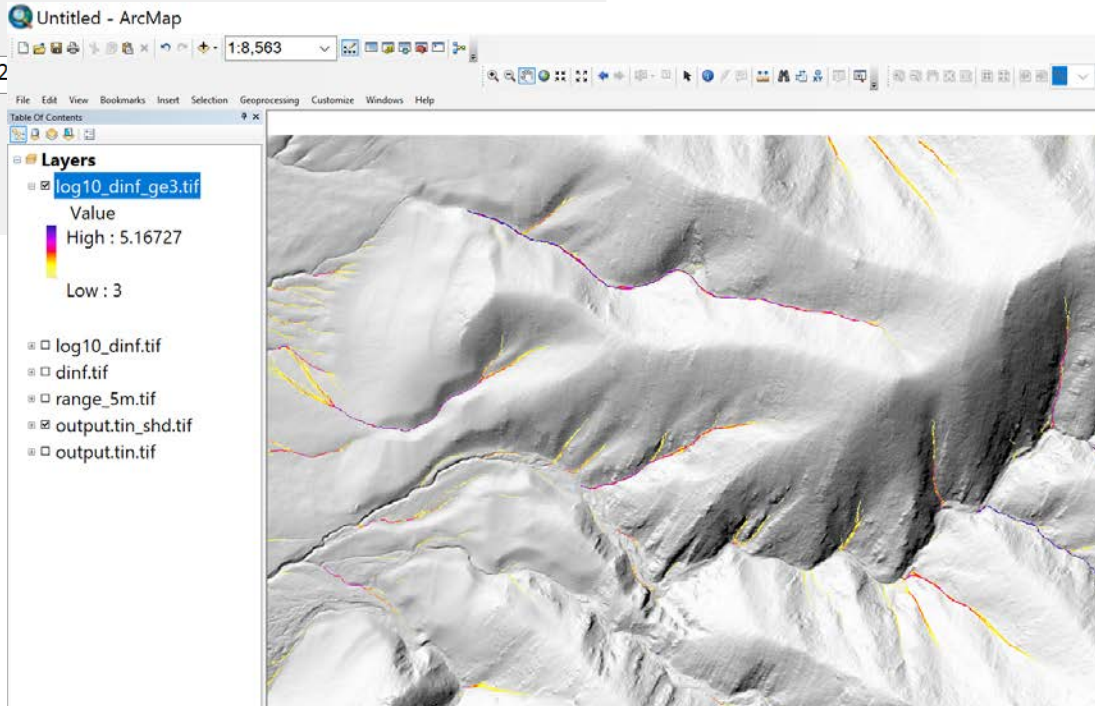


Now we are getting a sense of the drainage network.

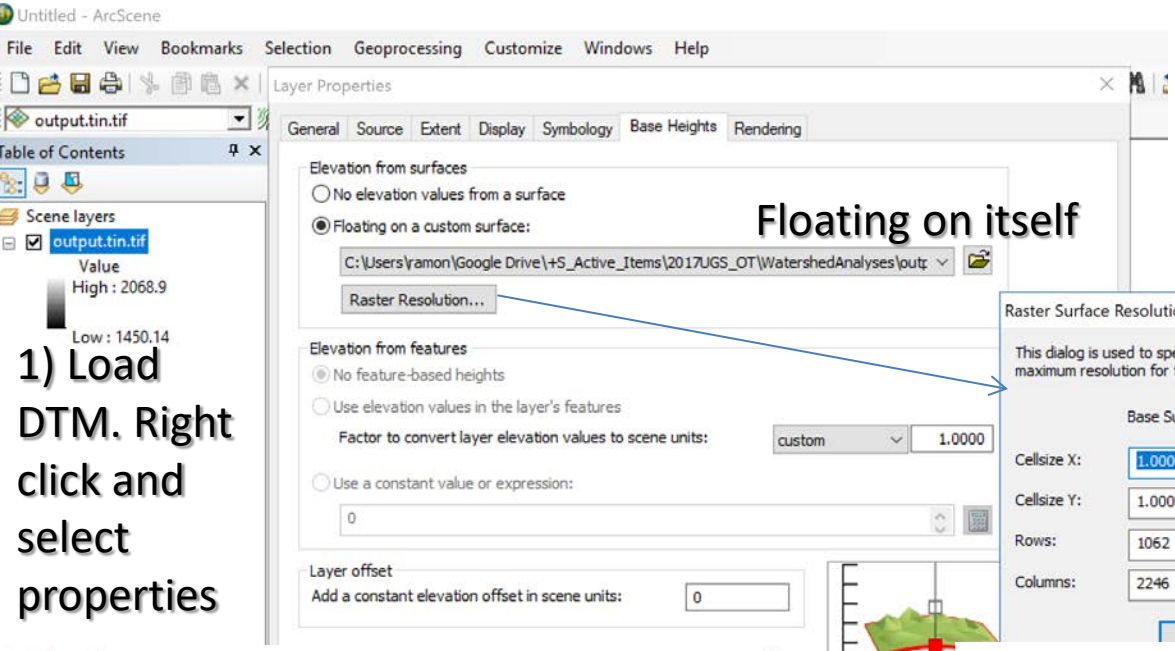
Extract contributing areas greater than 10^3 m^2 using Raster Calculator



Display stable drainage network over hillshade



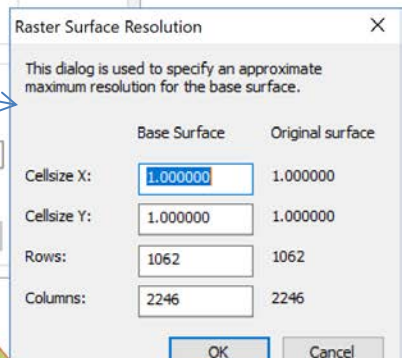
Visualize DTM in ArcScene

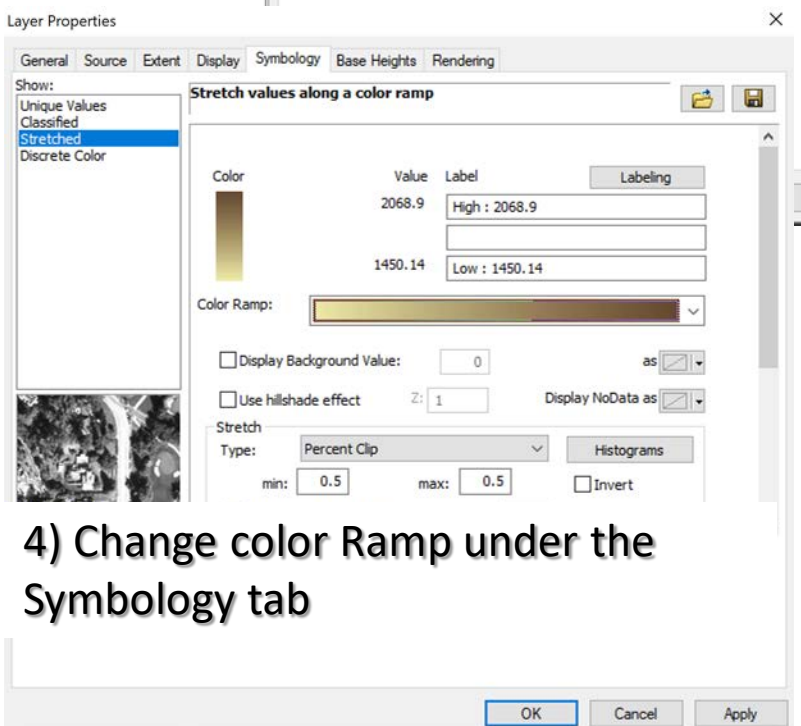


1) Load DTM. Right click and select properties

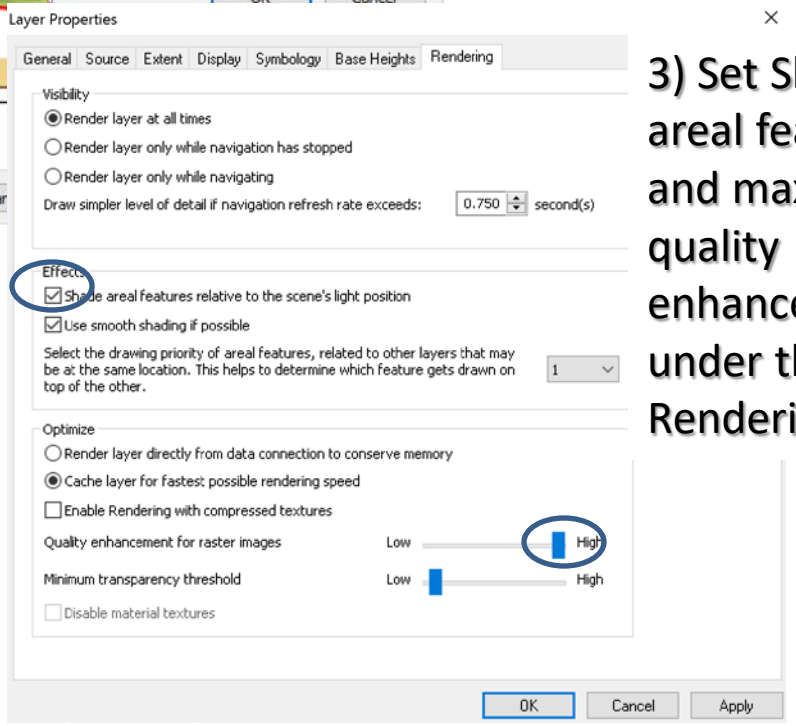
Floating on itself

2) Set it to float on itself and increase the base surface resolution to 1 m under the Base Heights tab



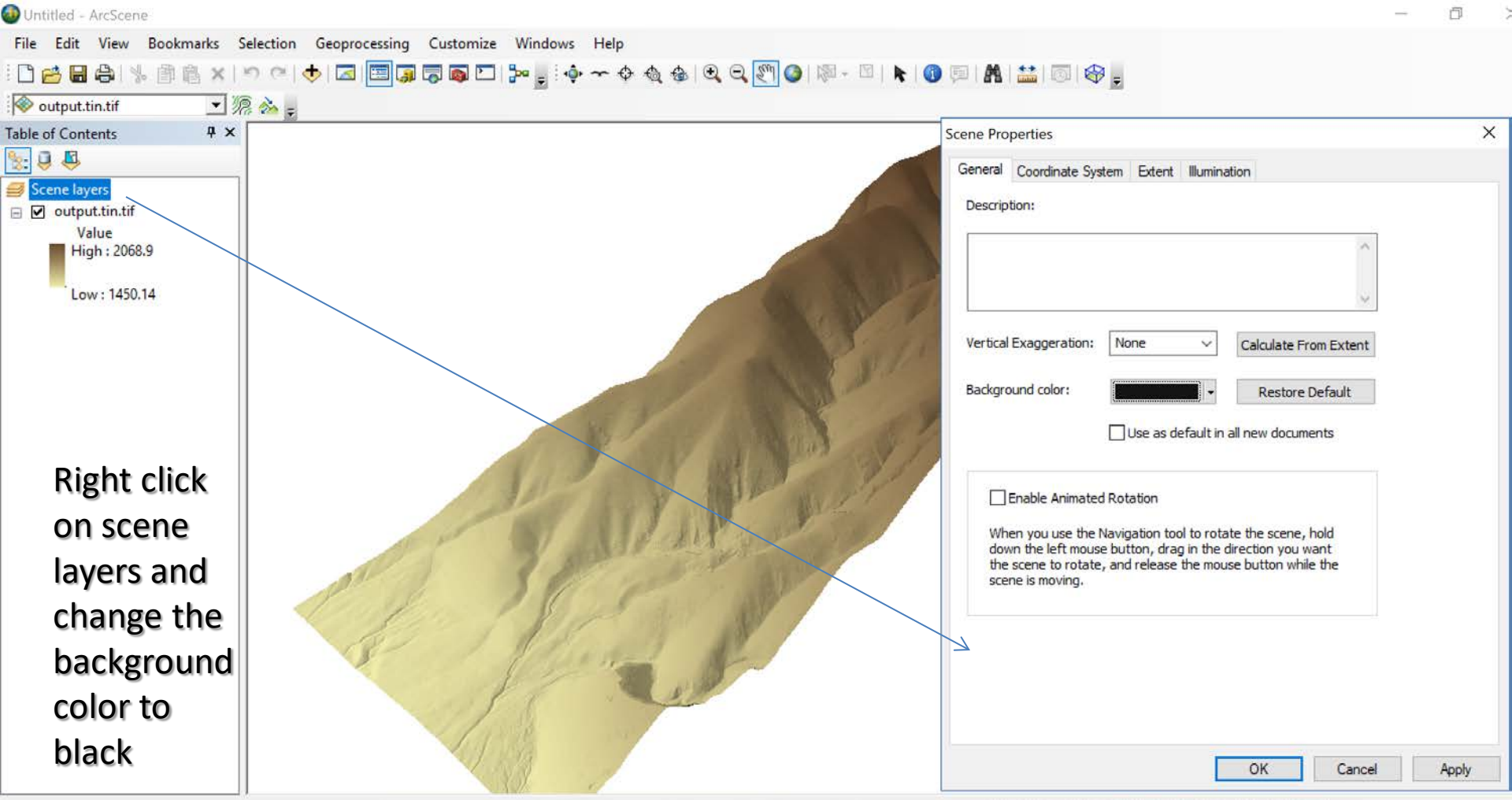


4) Change color Ramp under the Symbology tab



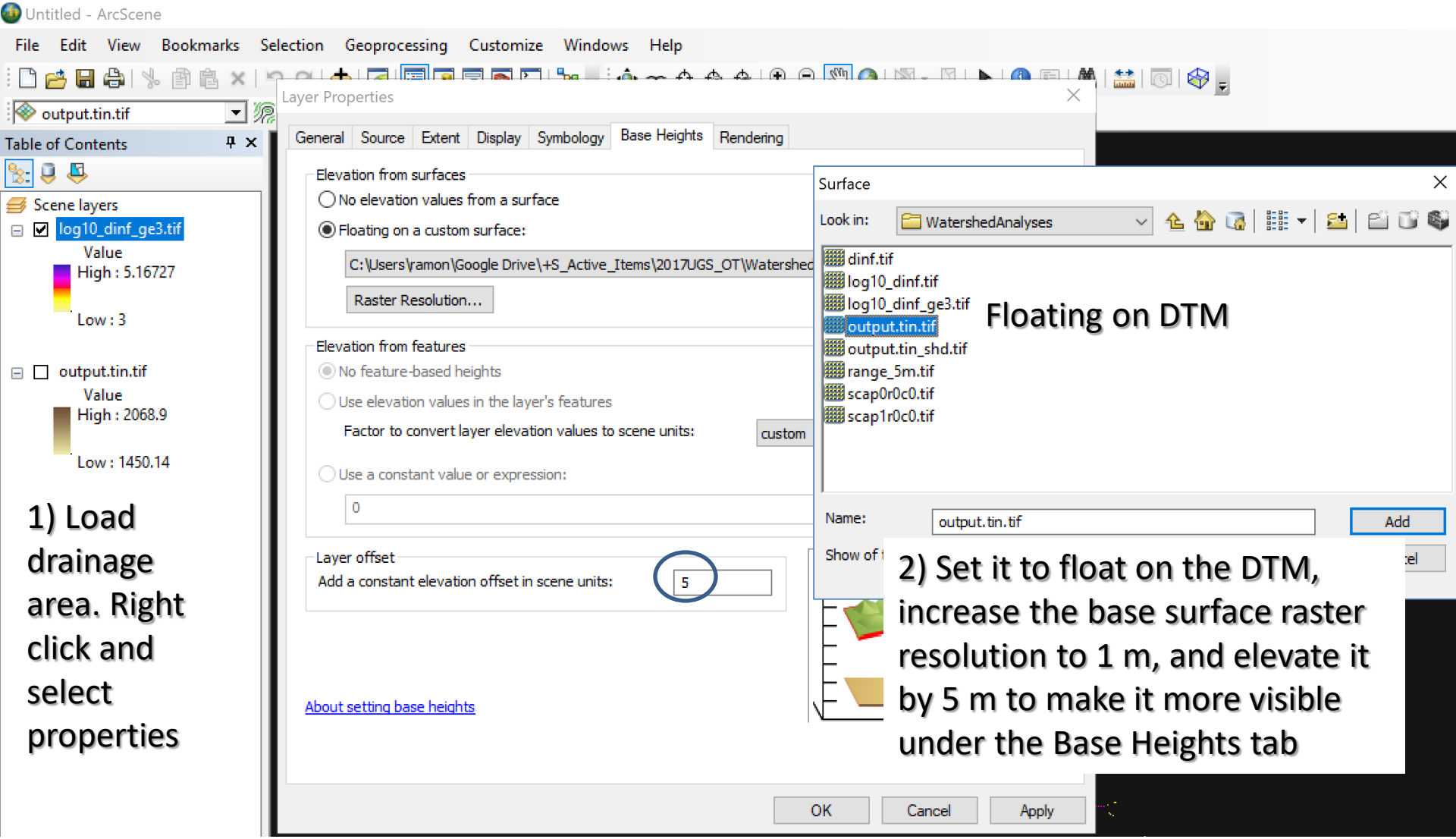
3) Set Shade areal features and maximize quality enhancement under the Rendering tab

Change the background to black in ArcScene



Right click on scene layers and change the background color to black

Visualize drainage network in ArcScene



1) Load drainage area. Right click and select properties

2) Set it to float on the DTM, increase the base surface raster resolution to 1 m, and elevate it by 5 m to make it more visible under the Base Heights tab

3) Set maximize quality enhancement under the Rendering tab (no need to shade it)

4) Change color Ramp under the Symbology tab

Visualize drainage network in ArcScene (“skeleton of the landscape”)