

Lab 7 DEMs and Lidar

Utilizes Textbook's Remote Sensing Digital Database: Chapter 7 data.

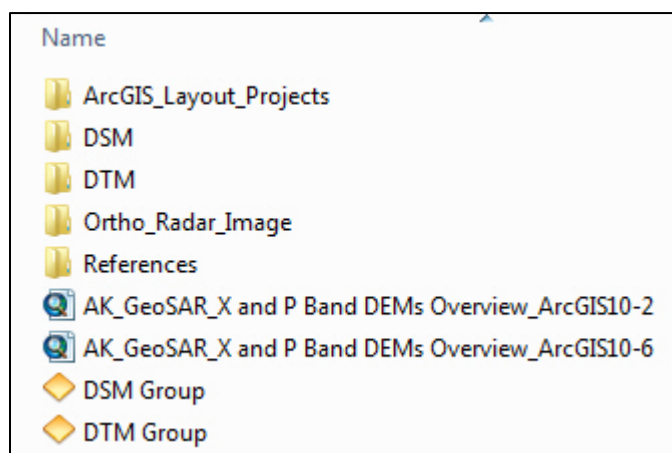
The objectives of this lab include enhancement of DEMs generated with radar and lidar using image-processing tools and visualization to improve understanding of the models. **ENVI Toolbox** contains the tasks that we will use for this lab. A short video for the lidar section that reviews the tools in the new ENVI LiDAR display is in the **Lab_7_Data** folder

Two digital files are to be uploaded to the instructor and ten questions are to be answered on the final pages of this handout.

Radar DEMs

1) Airborne L-band and P-band radar were flown over the Fairbanks, Alaska area to generate a Digital Surface Model (DSM) and a Digital Terrain Model (DTM). See discussion in the textbook Chapter 7. The data are located in the Remote Sensing Digital Database \ Ch_7_DEMs in the Chapter 7 folder. The path is:

Plate 23 P-and X-band GeoSAR_AK \
GeoSAR_DSM-DTM_ \ DSM, DTM, and Ortho_Radar_Image folders



Subfolders in "GeoSAR_DSM-DTM_" folder

2) Review the "READ ME..." pdf in the "Plate 23 P-and X-band..." folder. The READ ME file provides an overview of the technology applied and examples from the textbook of final products that can be generated with remote sensing and GIS software.

3) Open the newer ENVI "GIS-look" program > *File* > *Open* >

drive to the "Ortho_Radar_Image folder and select "ORI_N6445W14800.tif"
> *Open*

> *Zoom to Full Extent* Fairbanks is on the East side of the image, North of the Chena River.

Question 1: A. In which direction is the radar beam pointing (N, S, E, or W)?

B. Why does the river south of Fairbanks have a very dark?

4) **DSM:** Open the DSM folder and load “DSM_N6445W14800.tif” into the View.

Right-click on this DSM layer in the Layer Manager > Quick Stats

The “Statistics View:...” window pops-up.

In the upper left, *Select Plot > Histogram Plot 1*

Question 2: What is the minimum elevation of this DSM?

4a) *ENVI Toolbox > Classification > Raster Color Slices*

Select the DSM in the “Data Selection” window >

Accept Defaults: 16-slices, rainbow color scheme > OK

4b) *ENVI Toolbox > Terrain > Create Hill Shade Image*

Select the DSM in the

“Select Hill shade Input DEM File” window > OK

The “Hill shade Image Parameters” window pops-up

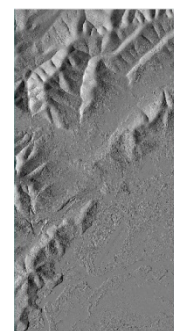
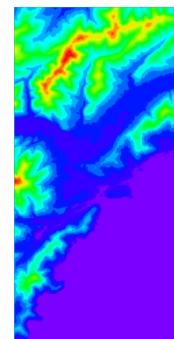
Enter “25” for Sun Elevation Angle

Enter “270” for Sun Azimuth Angle

Select “B-W LINEAR” for Color Table to Apply

Change “Stretch” to “0.0” (no stretch applied)

FileName: “YourName_DSM_hs_ENVI” > OK



The hill shade DSM displays in the View. *Zoom to Full Extent*

Zoom-in and *pan* around

Question 3: What natural and man-made features are generating the surface on the DSM? (Hint: Turn off all layers in the Layer Manager except the hillshade DSM and the ORI radar image. Turn the top layer on & off to identify features.)

Turn on the Raster Color Slice layer in the Layer Manager. If your hillshade DSM is above this layer in the Layer Manager, use the Transparency Tool to fade the hillshade DSM so the color on the DSM can be seen.

Zoom-in to an area of interest.

Type in the scale 1:25,000 (near the top-center of the ENVI display window)

Let's save a jpg of the enlarged area (this display) for the instructor

File > Chip View To > Image

The "Chip to File Parameters" window pops-up.

Choose Output Format "JPEG"

Name the file "YourName_color-coded_25K_DSM"

Don't "display result" We will look at the jpg outside of ENVI.

Open up your jpg. Is the quality acceptable? What's missing? Where's the scale bar, legend, coordinate grid – essential cartography elements for GIS and map-making? This is just a picture – it has very little value in the real world.

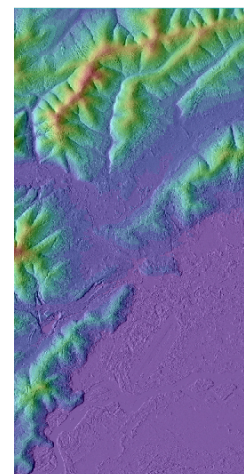
The new ENVI GIS-look front end seemingly cannot attach cartographic elements to exported images – unless you start ENVI in 32-bit mode and have an ArcGIS license...? That is not good – if this is true and there is no work-around. You can create and export images with scale, coordinate grid, N-arrow, logos, text boxes, and other cartographic elements using the older ENVI Classic and the "QuickMap" tool.

Going forward, if you use this new ENVI front end, Export your enhanced imagery and DEMs in the geoTIFF format so you can use GIS software to add symbology and critical cartographic elements.

4d) Let's create a 3D Surface View with our color-coded hill shade DSM (displayed here).

BUT first, the two files are separate in the color-coded, hillshade DSM – 1) the faded grayscale hillshade and 2) the 16-slice color DSM.

We need to combine these two images into one so we can use the 3D Surface View (and other visualization software). The combined color-coded hill shade image will be draped over the DEM to enable perspective 3D viewing.



To combine the full scenes of the two files that we see on the screen into one raster image file we should "Zoom to Full Extent" to see what is going to be saved.

File > Export View To > Image File

The "Export View to Image File" window pops-up.

We want the Full scene, so click the button next to "Full"

Note the pixel size is the original data size, the Zoom Factor is 1.0000

We can output in ENVI format for this exercise.

Name the Output file: "hs_with_color-coded_DSM_ENVI" > OK

The "hs_with_color-coded_DSM_ENVI" image is displayed in our View.

4e) Now we can use the ENVI visualization tool!

ENVI Toolbox > Terrain > 3D Surface View

The "Select 3D SurfaceView Image Bands..." window pops up

Sequentially select Band 1, Band 2, Band 3 that make up the "hs_with_color-coded_DSM_ENVI" color image so that the R, G, B buttons are filled in the correct sequence in the "Available Bands List" menu. > OK

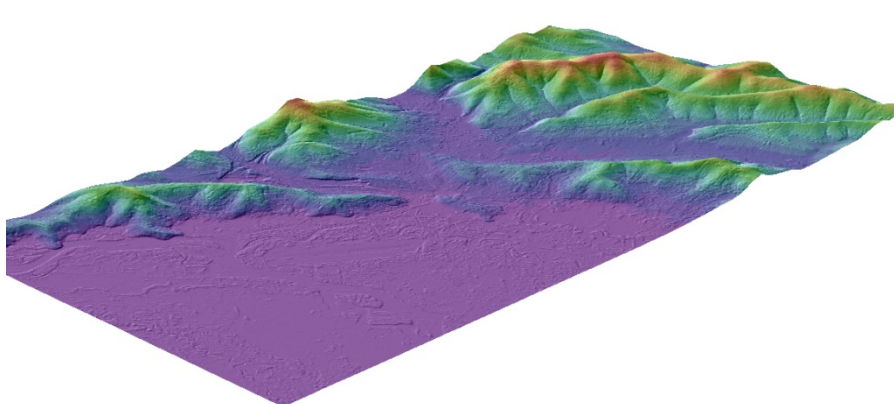
Next we select the "Associated DEM Input File".

Select > "DSM_N6445W14800.tif" > OK

The "3D SurfaceView Input Parameters" window pops-up.

Click on "512" and accept the other defaults > OK

The 3D SurfaceView display pops-up with your color-coded, hill-shade DSM with 5X vertical exaggeration draped on the DSM. Many options are available in this display, including saving the surface view as a VRML file.

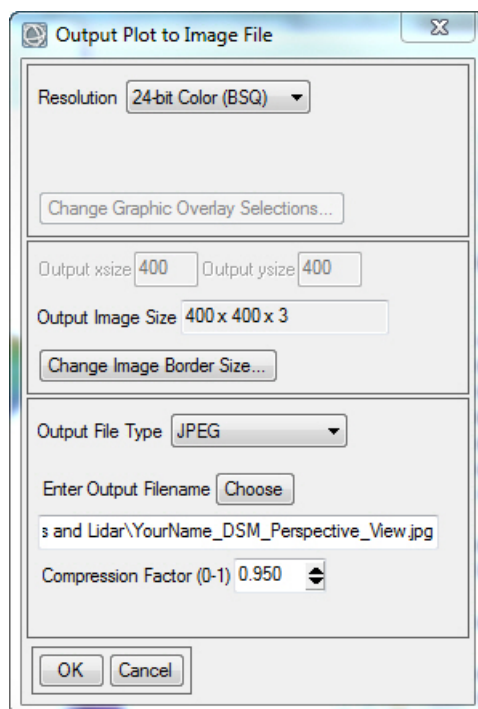


Let's show this to the instructor. In the "3D SurfaceView" display,

File > Save Surface As > Image File

The "Output Plot to Image File" window pops up (see next page).

We want a color jpg of this perspective view so we set Resolution as "24-bit Color (BSQ)", Output File Type as "JPEG", and Compression Factor as "0.95"



Name the jpg "YourName_DSM_Perspective_View" > OK

Upload to the instructor.

Close the "3D_SurfaceView" window.

5) **DTM** Let's compare the DTM to the DSM. *Views > Two Vertical Views*

Activate View 2 by clicking on the empty View 2.

File > Open drive to the "DTM" folder. Select "DTM_N6445W14800.tif" > *Open*
Zoom to Full Extent.

5a) *ENVI Toolbox > Terrain > Create Hill Shade Image*

Select the DTM in the "Select Hill shade Input DEM File" window > OK

The "Hill shade Image Parameters" window pops-up

Enter "25" for Sun Elevation Angle

Enter "270" for Sun Azimuth Angle

Select "B-W LINEAR" for Color Table to Apply

Change "Stretch" to "0.0" (no stretch applied)

FileName: "YourName_DTM_hs_ENVI" > OK

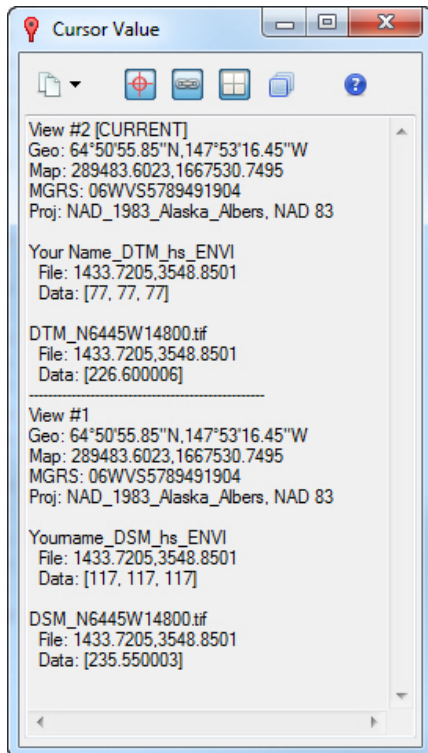
5b) *Views > Link Views* "Link Views" window pops-up > *Link All* > OK

We want to use the "Cursor Value" tool to see the elevation at the same pixel on the DSM and DTM.

The DTM and hillshade DTM and the DSM and hillshade DSM should be turned on in the Layer Manager. Un-check all other files.

- 5c) In the Cursor Value menu,
 press “Link Views” button and
 press “Display Information for all Views” button.

Now you should see the elevation in the DTM and DSM appear in the Cursor Value window.



DTM elevation is here (226.6 m)

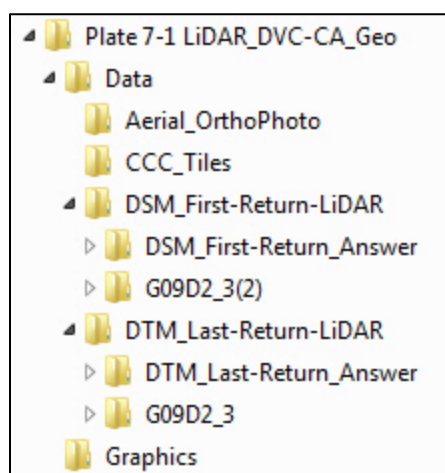
DSM elevation is here (235.6 m)

- Question 4: A. what is the DTM and DSM elevation at the airport runway?
- B. What is the elevation of the DTM and DSM about 3.5 km NW of the airport runway, along the crest of the ridge?
- C. What causes the DSM and DTM to have different elevations along the crest of the ridge about 4 km NW of the airport runway?
- D. Why was one radar wavelength used primarily for the DSM and the other radar wavelength used to generate the DTM?

Lidar

- 6) Let's start over with a new ENVI Display. *File > Exit* to close the Radar DEMs

Using your computer's file management system,
 Open the Remote Sensing Digital Database and then open the subfolder
 "Ch_7_DEMs". There are five DEM examples in this folder. We are going to use
 the lidar data in the subfolder "Plates_21-22_LiDAR_DVC-CA".
 (See file structure below)



The lidar data is in standard .las format and is located in the "DSM_First-Return-LiDAR" and "DTM_Last-return-LiDAR" folders. This .las data was processed and converted to geoTIFFs to simplify use in a GIS, CAD, or other geospatial software. These geoTIFFs are located in the "DSM_First-Return_Answer" and "DTM_Last-Return_Answer"

A color orthoimage is in the "Aerial_Orthophoto" folder. Open these folders to familiarize yourself with the many files that you will be working with in this lab. Many of the files are intermediate forms that were generated by ENVI, ERDAS, and ArcGIS software as the original lidar data was processed.

6a) We will be working with lidar data of a suburban area west of Pleasant Hill, California.

The source of the lidar data is the Contra Costa County 2008 Orthophotographs & Lidar project. Available at: <https://gis.cccounty.us/Downloads/Lidar/2008/> the zip is 70 GB!

The lidar and orthorectified image are in the State Plane CA III FIPS 0403 **Feet (US)** NAD-83 Coordinate System.

6b) Start up a new ENVI Display. *File > Open* the orthorectified aerial color image
 "g09d2_3_color_mar-apr2008_1meter" > *Open*
 > *Zoom to Full Extent*

Review what and where the land cover/land use features are in this area, including single family dwellings, golf course, non-irrigated grass-covered terrain, a road network with many curves, etc.

6c) Now we will review the metadata associated with the .las lidar files

ENVI Toolbox > LiDAR > View LAS Header

Drive to the "Data" folder and open the "DSM_First-Return-LiDAR"

Select "G09D2_3(2).las" > Open

Examine the metadata in the header.

Question 5: A. What is the minimum and maximum elevation (Z) in the DSM?

ASPRS helped establish standards for lidar data. The points are classified into 9 categories as shown below. However, the metadata for our dataset lacks this classification as it notes with "0" that the lidar points were "Created, never classified"

ASPRS Standard LIDAR Point Classes

Classification Value	Description
0	Created, never classified
1	Unclassified
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

Portion of the metadata for our lidar data

```
Points by Return [ 1 ] 0
Points by Return [ 2 ] 0
Points by Return [ 3 ] 0
Points by Return [ 4 ] 0
Points by Return [ 5 ] 0
```

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Now we will look at the metadata for the DTM.

ENVI Toolbox > LiDAR > View LAS Header

Drive to the "Data" folder and open the "DTM_First-Return-LiDAR"

Select "G09D2_3.las" > Open

Examine the metadata in the header.

Question 6: A. What is the minimum and maximum elevation (Z) in the DTM?

B. How many lidar points are in this DTM data set?
(NUM_POINT_RECORDS)

6d) Now we will switch to a new display ENVI has created to view and interact with lidar data. A 9-minute video is included in the **Lab_7_Data_Video** folder that provides an overview of the ENVI LiDAR tools and display options to help you be more efficient working your way through the lidar portion of this lab.

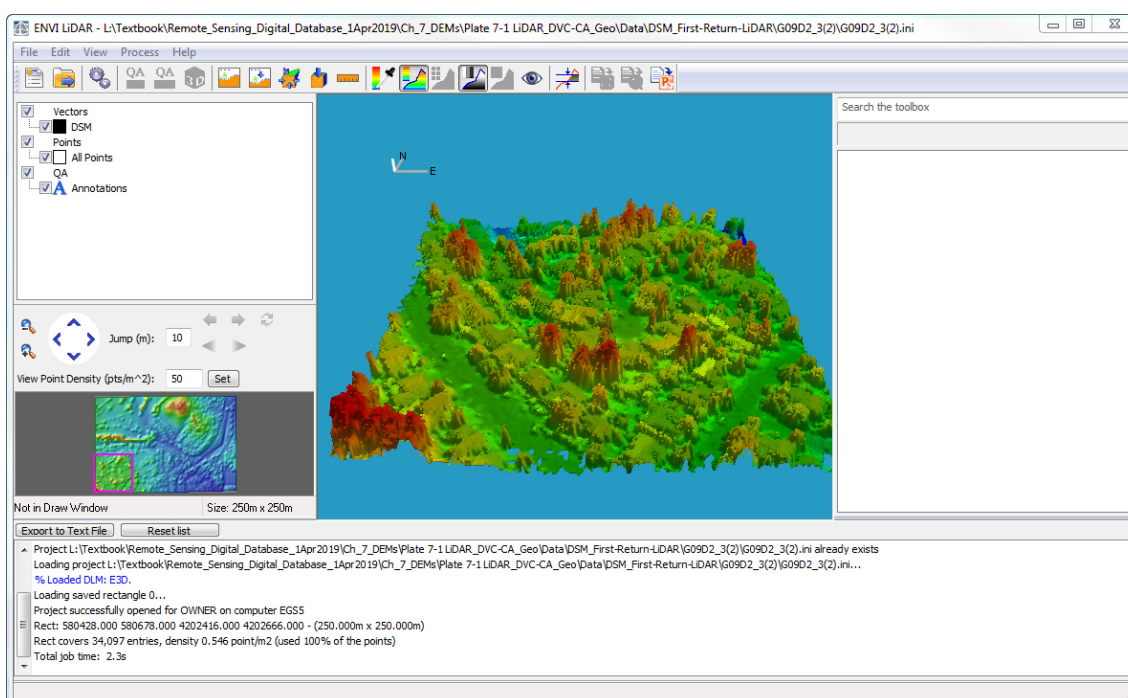
ENVI Toolbox > LiDAR > Launch ENVI LiDAR

We will first load the DSM into this view. *File > Open* Select “G09D2_3(2).las” > *Open* You should see this display. The DSM is displayed as a “Solid” surface.

In the layer manager, right-click on “DSM” > *change* to “Wireframe”

Zoom-in until you see clearly see the the 1 meter grid.

In the layer manager, right-click on “DSM” > *change* to “Solid” *Zoom-out*



The window at the lower left shows the extent of the entire DSM. It has a rectangular outline that shows what portion of the DSM is shown in the main display. Use your cursor to *draw* an outline around the entire thumbnail image (approximately 918 x 616). The entire DSM is shown in the main display.

6e) Interrogate the drop-down menus and the ribbon of icons across the top of the ENVI LiDAR window. We'll activate a few of them.

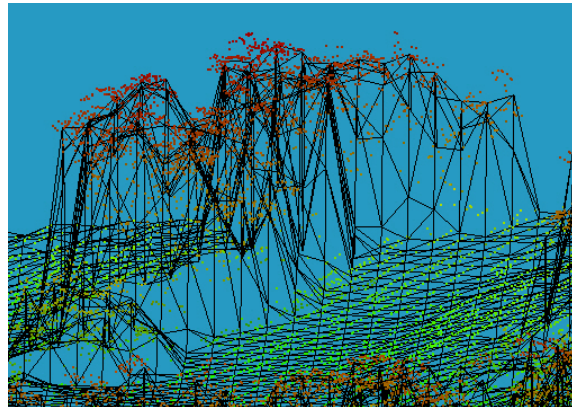
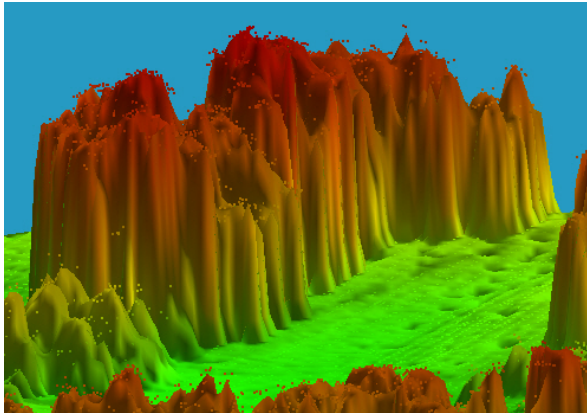


View > Height Legend (note the units are in meters!)

Help > Help Contents (very useful to read before proceeding too far)

Reset Perspective View icon > Move your mouse around to rotate and tilt the model

Zoom-in on the grove of trees along the top margin of the DSM. *Change* the rendition of the model between Wire Frame to Solid (see below)



Question 7: A. Why do the trees have elongated, near-vertical sides around the extent of the tree canopy?

B. What do the red dots at the top of the canopy represent?

Reset Isometric View icon > Click on the model in the display and roll your mouse wheel to zoom in and out.

> Click on the left and right buttons on your mouse and pan around the model.

Reset Isometric View icon > Click-on the Select Cross Section icon.

Move your cursor to the bottom margin of the model, click once and move your cursor to the top of the model and click once to generate a N-S cross section.

7) A “Cross Section” window pops-up at the bottom of the ENVI LiDAR window.

We’ll interact with a few of the tools at the top of the display.



Often the width of the window automatically becomes too large. At the upper right of the “Cross Section” display is “Thickness (cm):” Change to “500”.

The “Movement” tool has up-down arrows. The default value seems to be “100”. *Clicking* on the arrows moves the cross section in a direction perpendicular to the cross section. Increase number to “500” and the cross section moves in larger increments.

The “Angle” rotates the cross-section. Increasing the number from the default of “1.000” moves the cross section in larger increments.

“Reset Position” places the cross section back to its original position (maybe? To the bottom margin of the DSM...). Click the “Movement” Arrow to move the cross section across the model at intervals of “500”.

You can *zoom* into a feature of interest in the cross section with your mouse wheel.

Question 8: What features do you see on the DSM cross section as you traverse the model? (refer to the orthophotograph in the ENVI window that we opened first)

8) Click on the “Measurement Tool” icon (a ruler) in the ENVI LiDAR window. *Measure* the height of some of the trees in the “Cross Section”.

Question 9: What is the height (in feet) of the tallest tree that you measure?

To remove the white banners with the XY and Z elevation at the measurement sites > *Right-click* on the white banner > *Delete Annotation*

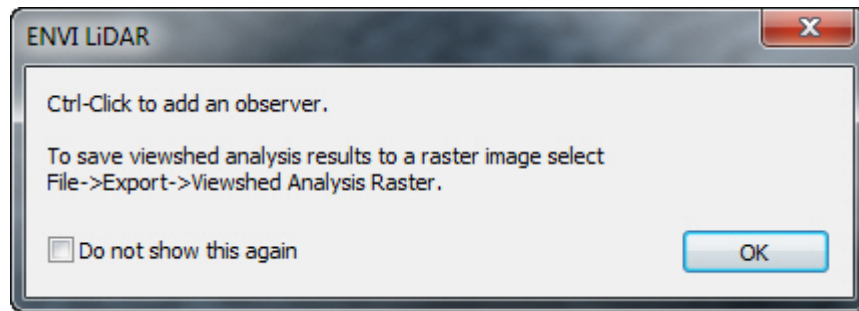
To remove the Cross Section vector lines on your ENVI LiDAR display, close (X) the Cross section display.

9) The last DSM exercise will use the “Color by Viewshed Analysis” icon in the upper ribbon of the ENVI LiDAR menu.

Viewshed analysis is widely used to evaluate the visual impact to a person standing at a specific location of existing land cover/land use features, new construction, proposed logging, new hedgerows or barriers to “hide” infrastructure, etc.

Ensure you are zoomed-out so the entire DSM is displayed (use thumbnail tool in lower left corner)

Click-on the “Color by Viewshed Analysis” icon. Instructions pop-up.



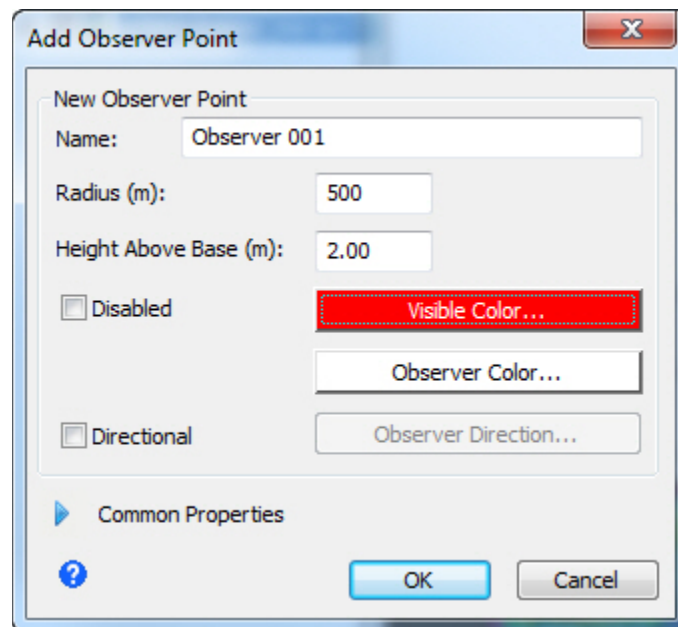
> OK

The DSM turns into a grayscale image.

Move your cursor to the southern slope near the top of the hill in the north margin of DSM. (imagine you are hiking up the slope toward the crest and turn around – what do you see?)

Ctrl-Click at the site for the Viewshed Analysis

Those features that you can see from this site are displayed in green (maybe). The Add Observer Point menu pops-up. Change Radius to “500” and Visible Color to “Red” > OK



The pop-up instructions above tell us how to export this analysis.

File > Export > Viewshed Analysis Raster

This Export option did not allow me to name the file, or to direct it to a specified folder...maybe you can figure out how to make the export work for you...

I'm just going to do a simple screen capture of my Viewshed perspective view using the ENVI LiDAR *File > Screenshot to Powerpoint > Save As*

"LastName_DSM Viewshed"

(If you don't have Microsoft Powerpoint software on your computer, just take a screen capture of your viewshed DSM and save it as a jpg)

Upload this graphic to the instructor.

10) We'll next look at the DTM. *File > Open > "G09D2_3.las" > Open*

The DSM disappears. The DTM is loaded into the display.

In the Thumbnail display of the DTM (lower left corner), *draw* a large rectangle over the East half of the DTM so you capture the red hill and dark blue terrain.

The ENVI LiDAR can only display a 2000 x 2000 area on the main display. *Accept* the program's redrawn area.

The ENVI LiDAR program displays the DTM, but in the Layer Manager it is labelled as "DSM". The software cannot identify the type of DEM being loaded.

Right-click on "DSM" in the Layer Manager and alternate between Solid and Wire Frame. *Zoom in* to see the level of detail in the DTM.

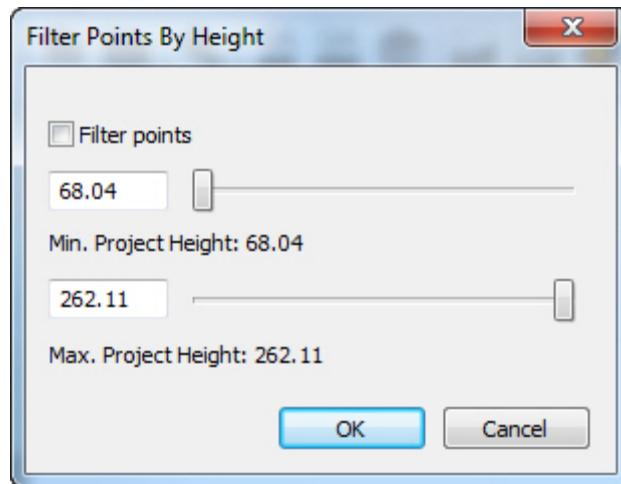
If you see a grayscale DTM in the display, *click on* the Height Palette Editor" icon and load the "Rainbow" palette (lower left corner of the menu)

Note the flat pads that have been constructed for the suburban homes with cut and fill on the sloping terrain.

Notice how the trees in the DSM have been removed from the hill in the north portion of the DTM model.

Display the "Solid" model. Click-on the "Reset Perspective View" icon.

Click on the "Filter Points By Height" icon. (see below)



Move the "Minimum (Min.) Project Height" slider to the right.
Set your minimum height at "100.00" > OK

Question 10. What are you simulating by raising the minimum height on the DTM?

Lab 7 DEMs and Lidar**Name:**

Upload the following files to the instructor:

(4) "YourName_color-coded_25K_DSM" .jpg

(4) "YourName_DSM_Perspective_View"

(9) "LastName_Viewshed" Powerpoint, jpg, or other format.

Question 1: A. In which direction is the radar beam pointing (N, S, E, or W)?

B. Why does the river south of Fairbanks have a very dark?

Question 2: What is the minimum elevation of this DSM?

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Question 6: A. What is the minimum and maximum elevation (Z) in the DTM?

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Question 9: What is the height (in feet) of the tallest tree that you measure?

Question 10. What are you simulating by raising the minimum height on the DTM?