

Unit 3.5: Geodetic Data for Hillslope Diffusion in MATLAB – Student Exercise

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One additional way to conduct a hillslope diffusion analysis is using MATLAB. Scarps change morphology over time due to erosional processes, so modeling the diffusion of the scarp enlightens us on the deformation history of the fault and the time between the last earthquake and present. Hillslope diffusion analysis only works on transport-limited scarp slopes.

Introduction:

In this exercise, use the fault scarp data you collected in the field to conduct a hillslope diffusion analysis using a provided script for the program MATLAB. To prepare the data you need for analysis, you will apply the skills you learned in data exploration, as well as learn how to use the program ArcGIS for DEM creation and data extraction. Once you have completed the calculations, summarize your results in a brief report.

Project Description:

Below is a description of the workflow to follow when working on this project. This exercise is expected to take a lab period.

If using TLS data: RiScan Pro

Use the *Data Processing and Exploration Manual* as your guide to clean up the data. This may entail using the filters listed, including the terrain filter. Because TLS data can be quite noisy, thinning the data using the filters makes the data much easier to work with in other programs. After the data have been cleaned, select the area of interest and follow the steps in your manual to export the data.

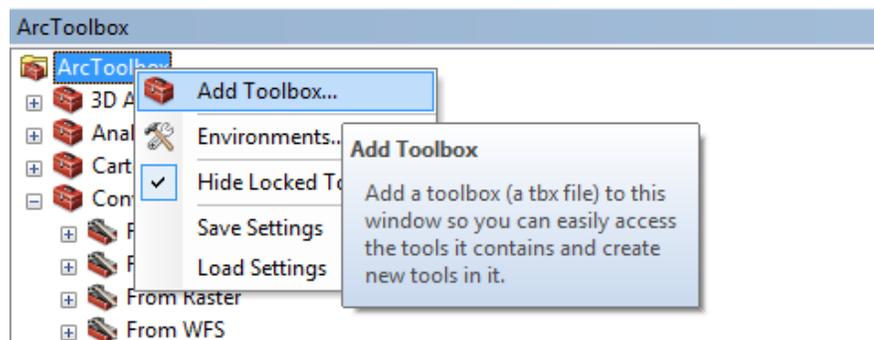
If using SfM data: Agisoft Photoscan Pro

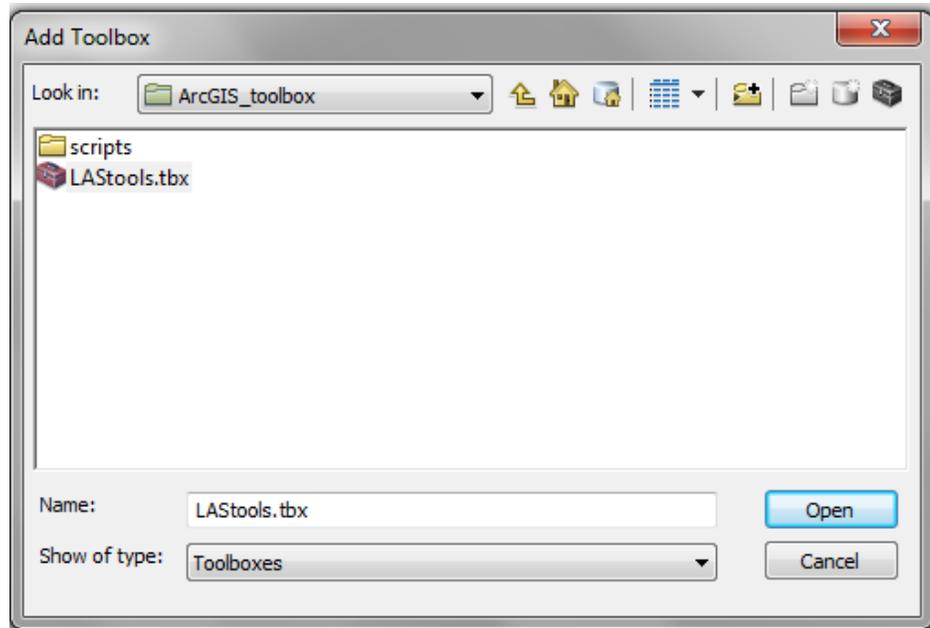
Use the *Data Processing and Exploration Manual* to clean up and crop the data.

Create DEM

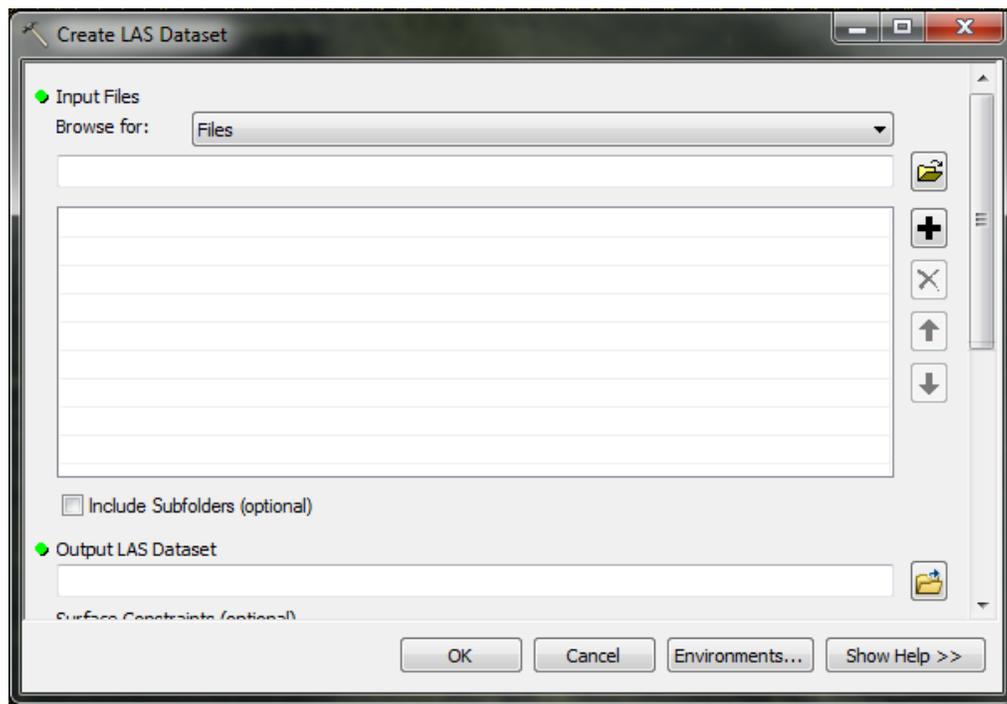
After the data has been exported, open ArcGIS. If LASTools has not been downloaded to your computer, follow this link (<http://rapidlasso.com/lastools/>) and download the folder. Click on the ArcToolbox icon to open the Toolbox tab, and right-click the heading “ArcToolbox” and select “Add Toolbox.”

Click the folder with a plus sign icon and navigate to the LASTools folder to connect to the folder. Then navigate to the LASTools.tbx file like below. Open it.



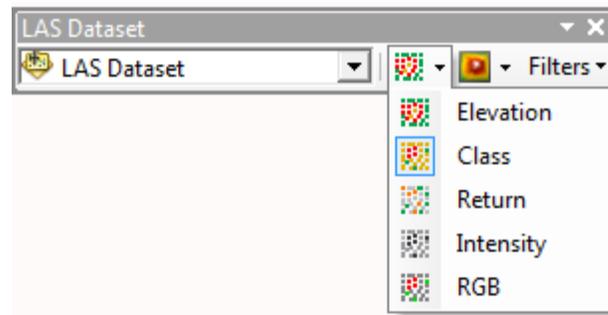


This adds a toolbox to ArcToolbox that has been designed specifically to work with .las data. To visualize your data, go to ArcToolbox—Data Management Tools—LAS Dataset—Create LAS Dataset.

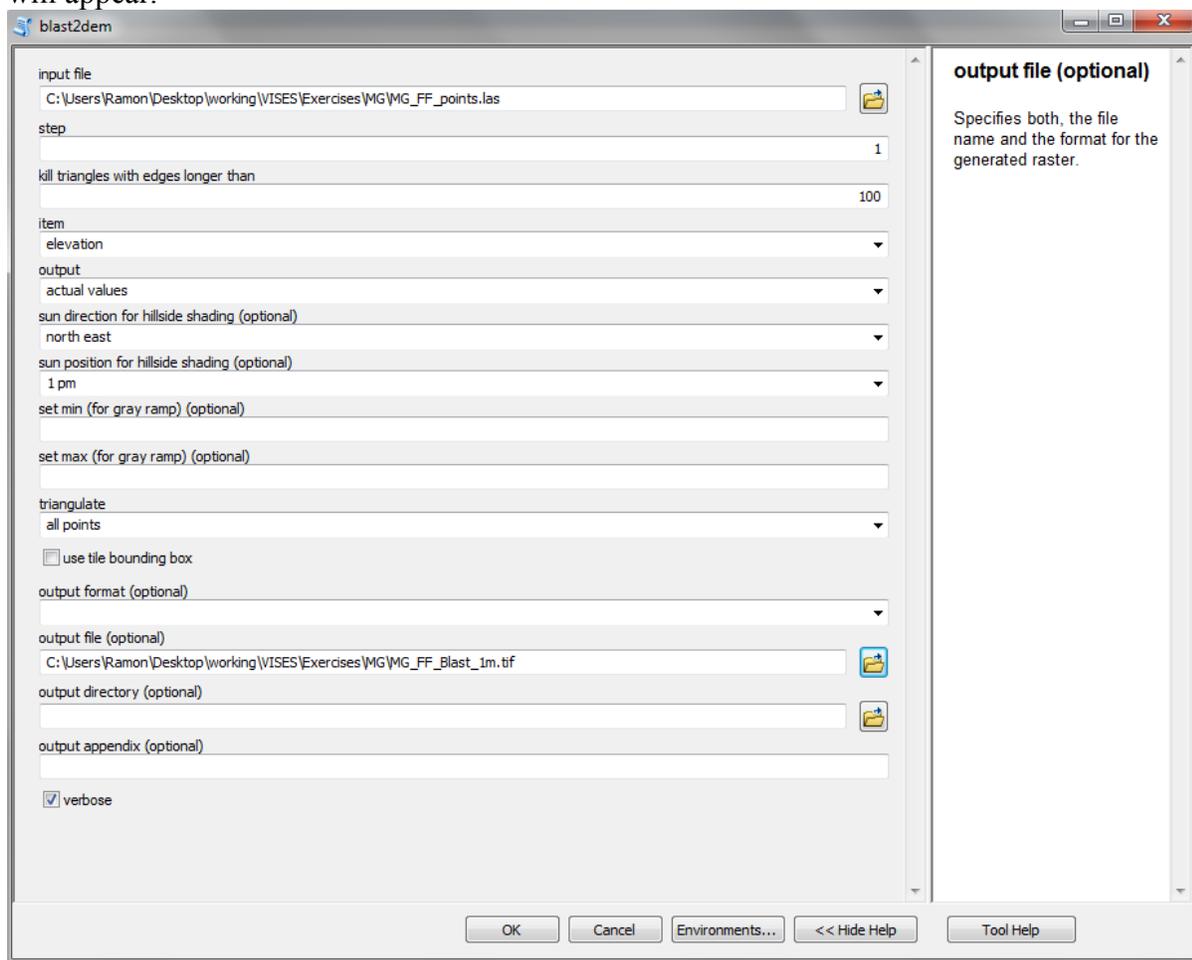


Add the .las file you exported from RiScan Pro or CloudCompare. Make sure you ONLY include the .las file for that time; you need to create a separate LAS Dataset if you would like to visualize

both. You can use ArcScene to view the LAS Dataset. Add the LAS Dataset toolbar (in the Customize—Toolbars menu). The following toolbar will appear and you can view the data. This toolbar only works when you are zoomed in on the data.



To create the DEM, go to the LASTools Toolbox and select blast2dem. The following window will appear.



Set the parameters above based on your project. Make sure to record the parameters you used to calculate the DEM.

Generate profiles

First, you need to use the 3D Analyst Toolbar. Go to Customize—Toolbars—3D Analyst. Use the dropdown menu next to “Layer:” to select the layer that you want to use for analysis.



Use the interpolate line function as shown above to create the profile. Click once to start the line. You can make the profile from a multipart line by clicking once at each point where the profile turns, but that is likely unnecessary for this exercise. Double-click at the endpoint of the profile.



If you do not like the profile, you can click the black selection arrow icon and click the profile and delete it. After you have selected the profile, create a graph of the profile by clicking the icon shown in the figure above. This may take some time. After the profile is created, right-click on the plot. In this menu, you can select properties if you want to change aspects of the graph and select export to export the data points. Go to the Data tab in the export window and deselect all options under the Include sub-tab. Export the data.

Hillslope diffusion analysis

Open MATLAB. MATLAB has several panels: the current folder, which shows you the folder you are in as well as whether this files are “on the path”; the command window, where you enter commands; the workspace, which shows the variables you are currently working with; and the command history, which shows all the commands you have input into the command line.

A few things to know about MATLAB:

1. Files need to be “on the path” for you to reference them in the command line. To do this, right-click a folder and say “Add to Path – selected folders and subfolders.”
2. To run a script, type the name of the script next to the double arrows in the command window and then hit enter.

Before starting this section of the assignment, add the folder of scripts provided to you to the Computer—Documents—MATLAB folder. Then in MATLAB, right-click and add selected folders and subfolders to the path.

Open the GUI for hillslope diffusion by typing “scarpdater_gui” into the command window and hit enter.

Variables to know:

- Theta: scarp initial slope

- a: half offset
- kt: morphologic age
- b: far field slope

The variables a and b will be found in steps 3–4.

Steps for using scarpdater_gui:

1. In the Scarp Dater Window, go to File—Import—Text X-Z file and select your exported profile from GIS.
2. Go to Edit—Offset data. This program only works when the elevation decreases to the right. Hit the flip profile button.
3. Tell the program where the middle of the scarp is by clicking the center button and then selecting the center of the profile.
4. Set the a (half height) of the profile. Then adjust the b value to set the dotted lines at the edges of the screen parallel to the scarp. Continue to adjust the center as well as the a and b values until the profile appears centered and the two dotted lines are flush with the edges of the profile. This will take a few tries. Write down your final a and b values!
5. Close the Offset data window.
6. Go to Calculate—Calculate Finite-Scarp RMS.
7. Set the morphologic age based on your data. Set $n = 50$; this is the number of times that the model will run. Your result will be an average of these.
8. Change a to the value you recorded in step 4.
9. Set the range of b values (b min, b max) around your recorded b value (from step 4).
10. Theta, or the initial slope, is difficult to determine sometimes. A good base value is 45.
11. The horizontal offset is not the fault offset. The horizontal offset is just an adjustment of the location of the profile on the graph. This will be adjusted in this range of values during the calculations; essentially, it refines the center of the profile you picked by hand.
12. After this, a window will pop up with the selected best values for a, b, theta, kt, and offset. Record these values and click OK.
 - a. If you want more detail about why these values were the best, go to Plot—Plot Single-Event Sensitivity Analysis.
 - b. These graphs show the range of values that were calculated for b, kt, and offset; the value calculated the most number of times was selected as the best value.
13. Go to Plot—Plot Single-Event Forward Models.
14. In this window, input the parameters from step 12. These will define a simple initial scarp (blue dotted line), and then the modeled projection of what the scarp should look like at present (black solid line).
 - a. To compare, click the “show data” check box to layer your real data on top (red stars).
 - b. When you do this turn the hold on in the dropdown menu in the right-most column.
 - c. Make sure the xmin and xmax values are the same as your own profile length in the middle column too!
15. Now you can manipulate the different input values to see how the changes modify the modeled scarp.

16. To save the data, go to File—Save. It will automatically save as a MATLAB file (.fig). Save a .fig file so you can easily modify the graph (color, types of lines, etc.) later. Save as a .jpeg if you want an image and .eps if you want to open the file in Adobe Illustrator.

Write-up:

After completing the steps in ArcGIS, create a write-up detailed below about the results of fault scarp analysis.

Project Report:

Make a map showing the locations of the profiles you extracted and indicate which profiles you used in Scarp Dater. There is a chance you will use multiple profiles, as some may not work, given the simplicity of one-dimensional analysis (like hillslope diffusion).

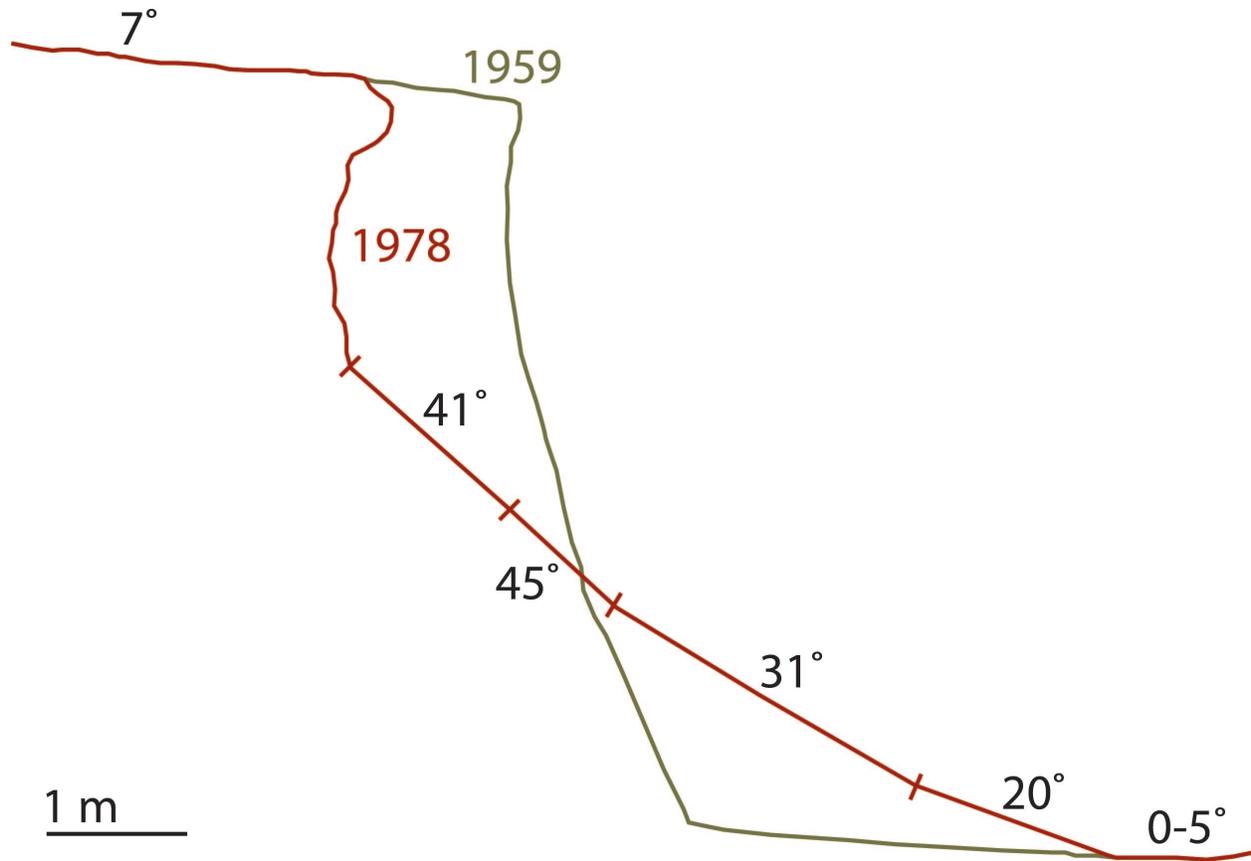
Conduct a hillslope diffusion analysis.

1. Model the diffusion of the profile you made using traditional methods using Scarp Dater. List the parameters output after step 12.
2. If you know the age of the scarp, choose a kt that makes the model represent the scarp in the present. How does this compare to the scarp you measured using traditional methods? Save this figure.
3. Model the diffusion of the profile you made using LiDAR using Scarp Dater. List the parameters output after step 12.
4. If you know the age of the scarp, choose a kt that makes the model represent the scarp in the present. How does this compare to the scarp you measured from LiDAR?
5. Manipulate the kt values. At what age does the step in the topography disappear?

Write a brief description (1–2 paragraphs), based on the above calculations, of the deformation history of the fault.

Write a paragraph to answer the following questions:

1. What is the societal impetus to study fault scarps and why use geodetic survey techniques?
2. What are the most useful components of Unit 1 that you used for Unit 3? What did you need to change from what you did in Unit 1?



Example fault scarp evolution: Hebgen Lake, Cabin Creek location, 1959 and 1978. Modified from Wallace, 1980.

Unit 3.5 Rubric - Geodetic survey of fault scarp

This rubric covers the material handed in for Unit 3.5 student exercise and is the summative assessment for the unit.

Component	Exemplary	Basic	Nonperformance
General Considerations	Exemplary work will not just answer all components of the given question but also answer correctly, completely, and thoughtfully. Attention to detail—as well as answers that are logical and make sense—is an important piece of this.	Basic work may answer all components of the given question, but some answers are incorrect, ill-considered, or difficult to interpret given the context of the question. Basic work may also be missing components of a given question.	Nonperformance occurs when students are missing large portions of the assignment, or when the answers simply do not make sense and are incorrect.
Part C: Fault Scarp Analysis 2 (10 points)	<p>9–10 points:</p> <p>Figure of locations (1 point)</p> <p>Hillslope diffusion for traditional profile (2 points); Hillslope diffusion for LiDAR profile (2 points); paragraph on deformation history of fault (2 points)</p> <p>Detailed and thoughtful answer to reflection question about learning experience and societal impetus (2 points)</p> <p>If all of the above is included and the material is presented in a clear, concise and well-written fashion (1 point)</p>	<p>5–8 points:</p> <p>Missing 1–2 of the characteristics for an exemplary report and may be poorly written or unclear;</p> <p>AND/OR</p> <p>All characteristics are present but lack detail or are incorrect, showing a lack of comprehension.</p> <p>AND/OR</p> <p>Answer to reflection question not considered or thoughtful</p>	<p>0–4 points:</p> <p>Missing 3 of the characteristics, maybe poorly written and unclear;</p> <p>AND/OR</p> <p>Two characteristics are present but are incorrect, showing a lack of comprehension.</p> <p>AND/OR</p> <p>Did not answer reflection question</p>