Overview

This activity builds on the Factor-of-Safety Activity. It runs a computer model to solve the factor-of-safety equation over a spatial grid of a real world landscape. The location is Thunder Creek watershed in North Cascades National Park Complex in Washington. The park is a steep terrain with glaciers at the mountain tops and relatively frequent landslides. Students will acquire data and access the “Landlab” landslide component through the internet. Landlab is a landscape modeling platform based in the Python computer programing language, although knowledge of Python coding is not required. The landslide component is one of many components available for Landlab users to access and link together to build their own landscape model. For more information about Landlab, see http://landlab.github.io/#/. Data and use of Landlab is provided online through HydroShare (https://www.HydroShare.org) – an internet resource designed for sharing, acquiring, and collaborating with hydrological data. The Landlab landslide component assessable through HydroShare will run the modeling on a super computer.

Performance Expectations

In this data and model driven activity, students should execute the tutorial code in order and try to understand what the code is doing by reading the descriptions above and below code boxes. They should recognize the spatial variability of input parameters over real landscape and how that influences the variability of the results. The activity provides practice accessing data online and in code execution, even trying to write some code themselves.

Background Information

This activity accesses a tutorial created to demonstrate the landslide component of Landlab. Landlab functions on a gridded landscape, like a map with latitude and longitude lines. Teachers would benefit from
reading a little about Landlab to familiarize themselves about this earth sciences modeling toolbox by starting with:  [http://landlab.github.io/#/](http://landlab.github.io/#/).

The tutorial uses a square grid where each grid box is 30 m by 30 m on the actual park landscape. The center of each of these grids is called the node and data is assigned to the node as fields, such as an elevation field. The tutorial accesses data previously generated from ESRI ArcGIS and assigns it to these nodes. Then, the factor-of-safety (FS) equation is calculated at each node by accessing the data in the fields assigned to each node as input variables. The model performs many of these FS calculations at each node using a Monte Carlo simulation approach by sampling from distributions (think datasets) of each variable (like cohesion) used in the FS equation. Thus, the Monte Carlo simulation produces a distribution of FS values at each node. A probability of failure is then calculated from this distribution as the number of simulations where FS<=1 divided by the number of simulations. Maps of the data used in the model and the resulting probability of failure are produced for the national park toward the end of the tutorial.

**Prior Knowledge and Learning Assets**

For the Landlab landslide model, students should have already completed the previous 2 activities. It is helpful if students have skills at accessing a web browser and email. Some prior knowledge of computer coding is helpful, but not required. Some terms are likely to be new to students, so encourage them to look up the meaning of terms they don’t understand.

**Anticipated Challenges**

Students will need to carefully read and follow instructions during this exercise using Landlab in Hydroshare via the internet because it will exposed them to computer programming. Some students may find the coding exposure exciting, but other will be intimidated by executing code. Students won’t break anything by trying different commands and should be encouraged to explore. Some of the program code boxes can take a few seconds or even minutes to respond after students execute the code box, so students need to be patient. If the computer server hosting the data and model crashes, students should be patient and try restarting. By in the end, they will be surprised as to what they accomplish.

**Safety Issues**

None
Conducting the Lesson

Landlab Landslide Modeling Exercise

Following the detailed knowledge students obtained from the previous activities, this exercise exposes students to more advanced computer modeling used in assessing hillslope stability. This activity requires internet access, but does not require students to know Python coding language. Students need access to their email to join HydroShare (which can be done in advance) because www.Hydroshare.org will provide a verifying message to give students secure access to HydroShare resources using their personal username and password (detailed below). Once students are logged in, they will be accessing data and a Python tutorial to complete the landslide modeling exercise. It may be easier to have students carry out this activity in pairs, particularly if some do not have email.

1. Access the data of Thunder Creek watershed and the Jupyter Python Notebook tutorial via HydroShare requires students to have a Hydroshare account. A jupyter notebook is like a computer code in a notebook where you can execute code and see the results, plus add notes about what is being run or results.
2. Go to www.Hydroshare.org and click on ‘Sign up now’ blue button.
3. Create an account if you don’t have one. After filling out ‘Sign Up’ profile information (can edit at a later date), verify and activate account from your email (sent by HydroShare).
4. Go back to www.Hydroshare.org and ‘Sign In’ (upper right corner) with your user name (email) and password.
5. Click on ‘Discover’ tab at top.
6. In Search window, type: “Thunder Creek Landlab Landslide Example” and select this resource by clicking on it.
7. Read the Abstract about this data and exercise.
8. Scroll down to see the ‘Content’ and the data used in the ‘landslide’ component and the Jupyter Notebook that accesses the tutorial code called “landslide_driver.ipynb” that will ‘drive’ (give it direction) the component.
9. To run this tutorial within HydroShare, once you’ve navigated to the “Thunder Creek Landlab Landslide Example”, click on the ‘Open With...’ blue button and select ‘JupyterHub-USU’ or ‘JupyterHub-NCSA’.
EXTRA - For instructions on how to run an interactive iPython notebook, click here:
https://github.com/landlab/tutorials/blob/master/README.md
and links within.
For more Landlab tutorials, click here:
https://github.com/landlab/landlab/wiki/Tutorials

10. Read the “Welcome to the HydroShare Python Notebook Server landing page.

11. To access the tutorial notebook, you will need to execute the “1. Establish a Secure Connection” and import the required libraries. Scroll down and clicking once in the shaded code box with In [ ]: in front and then press “shift-enter” (both keys at the same time). A * will appear inside the [ ] while this code box is running.

12. You may need to enter your HydroShare Password again in box provided. This should end with a green text saying “Successfully established a connection with HydroShare” and a 1 in the [ ].

13. Also execute (shift-enter) the “2. Query HydroShare Resource Content” next code box down. This accesses the Thunder Creek data and “landslide_driver.ipynb” tutorial notebook. If you’ve run this tutorial before, it will ask if you want to overwrite your previous work, type ”y” for yes or “n” for no if you want to resume from when you previously accessed this notebook.

14. A list of the content of this resource is provided and it also lists the notebook we want at the top. Click on the “landslide_driver.ipynb” notebook in blue text at the bottom.

15. Now you are inside the landslide tutorial. Congratulations!
Try executing your first code by typing “Hello world” in the gray code box at the top just below “Example of Landlab ‘landslide’ component”. Pretty cool!

16. Read the introduction below this box and begin executing the code boxes one-by-one using “shift-enter” as you move down through the tutorial. Also, read the text before and after the boxes to understand what you’re executing. Some might take a few seconds or even minute to run given the large size of the datasets, so BE PATIENT.

17. If an error occurs or you suspect a code crash, click once on
'Kernel' in the menu, and select ‘Restart & Clear Output’. Then, begin re-executing the code boxes one-by-one.

18. You can also try some of your own code by selecting the + in the menu bar at top, which adds a new code cell.

19. Learn more about the programs output. Try running:
   “LandslideProbability.output_var_names” (without ”). Get help about a specific input data or field variable by running:
   “LandslideProbability.var_help(‘topographic__slope’)”

Assessment/Discussion Points

The landslide modeling exercise gives the teacher the ability to evaluate student’s capacity to follow directions, access big data, and run a computer model on a super computer. Students will obtain exposure to Python coding—a contemporary computer language applicable in many industries. They will also gain experience in understanding model parameters (inputs) and interpreting results (outputs).

Discussion Questions:

1. Using the code box at the end of the tutorial, what are the units of the slope ‘topographic__slope’ variable? (Hint: look at step 19 or near code box 9 for code syntax). What do these units indicate about the how slope is represented? Show an example of how you would convert this type of “unit” to a unit more familiar to you.

2. Where in the landscape does mean relative wetness appear to be highest? (Hint: compare to the elevation map). What contributes to spatial variability of relative wetness? Does this make sense, why or why not?

3. What is transmissivity? Try to figure it out by accessing var_help like in step 19. Would transmissivity be more or less in deeper soil, why? What is ‘mode’ and how is it different from mean and median?

4. The probability of failure map shows the highest instability in the upper slopes just below receding glaciers. What do you think is going on there; why would these areas be less stable than farther down slope? Will this get better or worse in the future, why?

5. Why is having a probability of failure in a landslide hazard map important for risk assessment? What is the general equation for risk and where would this model result fit in? (Hint: Look up risk on internet). Provide an example of how you use probability in your decision making?
Acknowledgements

Review and comments provided by Miriam Bertram, University of Washington, Program on Climate Change, Program Specialist.

This module was developed in part through support from the National Science Foundation – Award No. 1336725, Predicting climate change impacts on shallow landslide risk at regional scales to E. Istanbulluoglu and J. Lundquist. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.