**Activity 2.1: Exploring Rivers with Google Earth**

In this activity, we will use Google Earth to observe and investigate some interesting fluvial (river related) features. We will then collect some data to test your hypothesis about the relationship between gradient and sinuosity.

**Learning objectives**

* Practice navigating and gathering data in Google Earth.
* Practice recording data in Excel.
* How to characterize rivers using gradient and sinuosity index.
* Test a hypothesized relationship using a scatterplot and regression analysis.

**Part 1: Understanding gradient and sinuosity index**

Two measurements we use to characterize rivers are gradient and sinuosity index. First, let’s learn about those, and how to measure them in Google Earth.

**Stream Gradient and Sinuosity Index**

All rivers are governed by the same basic principle: water flows downhill under the influence of Earth’s gravity. Despite this simple underlying mechanism, rivers exhibit a tremendous range of sizes and shapes. To understand the factors that give rise to this diversity, it helps to have a systematic way to describe the key parameters that vary across river systems. **Stream gradient** is simply a description of the steepness of streams, i.e. the relationship between elevation and distance along the course of the river. Rather than express this as an angle, we will stick to “rise over run” or change in elevation per unit distance as we travel upstream. **Sinuosity index** describes the ‘curviness’ of a river. It is calculated by dividing a channel length measured along the course of a river by the straight line distance between the start and end of the channel. A river with a high sinuosity index takes lots of twists and turns as it travels downhill, while a low index indicates a straighter channel.

**Task 1: Measure the gradient and sinuosity of the Cumberland River**

1. Download and save the excel workbook River\_Data.xlsx. You’ll record your data, do your calculations, and create your figures here. (If you want to use this later, be sure to save it somewhere you can access it later – on a flash drive, on Google Driver, or save when you’re done and email the file to yourself).
2. Load Google Earth and navigate to Nashville, TN.
3. Make sure that the ‘Borders and Labels” box in the lower left ‘Layers’ panel is selected.
4. Locate the course of the Cumberland River across Davidson County, TN beginning near the Old Hickory Dam and ending near Gower Island just upstream from Ashland City, TN.
5. Use the ruler tool to measure the straight-line distance (in km) between these two points. Record this in your excel sheet.
6. Record the elevation (in m) of the upstream (below Old Hickory Dam) and downstream (near Gower Island) points along the river (measure these on the river, not adjacent bank). Enter this in your Excel sheet.
7. Click on the “Add Path” tool on the top toolbar within Google Earth that looks like this:

*Note: The path tool allows you to create more complicated paths than straight lines you have drawn with the ruler tool. Each mouse click adds a new point to the path allowing you to approximate a curved path by adding lots of short line segments together.*

1. Use your mouse to draw a path along the course of the Cumberland River through Davidson County from the Old Hickory Dam to Gower Island.

*Tip: It might take a few tries to get this right. Use the “delete” or “backspace” key when you make a mistake and use the arrow keys on your keyboard to adjust the view in the Google Earth window while you draw your path. Try your best to follow the central channel of the river but don’t worry about making it absolutely perfect (for now).*

1. Once you are finished, give your path with a useful name like “Cumberland River”
2. Click on the “Measurements” tab in the “Edit Path window” to see the length of your path. Record that distance (channel length) in your Excel sheet (in km).
3. Now you have everything you need to calculate gradient & sinuosity.

**Question 1a: What is the stream gradient of the Cumberland River through Davidson County? (Include the units!)**

*Hint: Gradient is calculated as change in vertical elevation divided by the length of the river channel. In cell D2, enter an equation to calculate the difference in the upstream and downstream elevation. Remember, that you start with an “=” and then click on cells to include them in your equation. Then enter an equation in cell G2 to calculate the gradient.*

**Question 1b: What is the sinuosity index of the Cumberland River in Davidson County? (Note that this one is unitless)**

*Hint: this is calculated as length of the river channel length divided by straight-line distance between upstream start point and downstream end point. Create an equation in cell H2 to calculate this value.*

**Question 1c: Based on your preliminary data, what do you hypothesize might be the relationship between gradient and sinuosity?** (e.g. positive correlation? negative correlation? no correlation?) Remember that a hypothesis is an ‘educated’ guess, so it should always be based on some preliminary data or on some understanding of earth processes.

Now that you know how to calculate gradient and sinuosity, and have a hypothesis about the relationship between these river characteristics, we’ll explore some more rivers and test your hypothesis.

**Task 2: Observe how river behavior complicates political boundaries**

1. In Google Earth and navigate to Natchez, MS.
2. Make sure that the ‘Borders and Labels” box in the lower left ‘Layers’ panel is selected.
3. Examine the course of the Mississippi River northward from Natchez to Vicksburg and observe the surrounding terrain.

**Question 2a: How would you describe the *sinuosity* of the Mississippi River in this area?** (For this answer you do not need to calculate the sinuosity index, just use descriptive words e.g. highly sinuous, somewhat sinuous, fairly straight etc.)

**Question 2b: Has the sinuosity of the river in this region changed over time? What is your evidence?**

1. Note that the border between Mississippi and Louisiana largely follows the course of the river, but in some places it deviates such that a piece of Louisiana is isolated on the east bank of the river, or a piece of Mississippi is stranded on the west bank.

**Question 2c: Explain these geographical oddities in the context of river channel behavior over time.**

**Task 3: Visit a weird river in Virginia.**

1. Navigate to Woodstock, VA.
2. Examine the course of the North Fork of the Shenandoah Riverobserve the surrounding terrain.

**Question 3a: How would you describe the *sinuosity* of the Shenandoah River in this area?** (Again, you do not need to calculate the sinuosity index, just use descriptive words e.g. highly sinuous, somewhat sinuous, fairly straight etc.)

**Question 3b: Has the sinuosity of the river in this region changed much, at least in the recent past? What evidence (or lack thereof) tells you this?**

**Question 3C: Examine the prominent ridge that runs parallel to the river to the east and locate distinctive ‘notches’ along its eastern crest. What are these and how might they have formed? (It’s okay to guess here – this isn’t something we’ve discussed before)**

**Task 4: Visit a weird river in California.**

1. Navigate to **Wallace Creek, Santa Margarita, CA. (35°16'N 119°50'W)**
2. Examine the course of Wallace Creekand observe the surrounding terrain.

**Question 4a: Note the prominent bend in the stream channel how is this different in terms of its geometry compared to normal river meanders?**

**Question 4b: What geological process is influencing the shape of this channel?**

*Hint: If you are stumped, load the plate-boundaries.kmz file that used in the previous module.*

**Question 4c: Note the wide channel that shows a similar shape directly to the northwest, how does this feature relate to Wallace Creek?**

**Task 5: Visit a remote river in Alaska.**

1. Navigate to **Nikolai, AK**
2. Examine the course of South Fork of the Kuskokwim River andobserve the surrounding terrain.

**Question 5a: What type of sinuosity and river morphology does the river exhibit downstream (northwest) of Nikolai?**

**Question 5b: What type of river morphology does the river exhibit upstream (southeast) of Nikolai?**

**Question 5c: Examine other rivers in the region and see if you can find similar transitions. What factors might influence this transition?**

*Hint: Consider the broader landscape and where these rivers are originating.*

**Task 6: Investigate the relationship between sinuosity and stream gradient**

At the end of Task 1 you made a hypothesis about the relationship between sinuosity and gradient. Now you will test that hypothesis using real data.

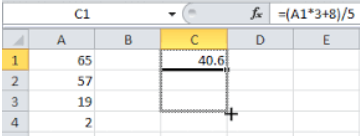
1. Return to your River\_data.xlsx excel spreadsheet.
2. Use Google Earth to determine “**upstream elevation”, “downstream elevation”, “channel length”** and **“straight distance”** for the following four river channel sections (fill in data in the yellow highlighted cells):

**Cumberland River –** you’ve already got this from Task 1

**Mississippi River – Start point:** 30°25' N, 91°12' W; **End point:** 30°17' N, 91°13' W

**Delaware River – Start point:** 40°59'N, 75°08’W; **End point:** 40°41'N, 75°12’W

**San Juan River – Start point:** 36°44'N, 108°15’W; **End point:** 36°46'N, 108°40’W

1. Once you have completed the yellow highlighted cells you can calculate the elevation change for all the rivers by filling the equations down the column. Click on the cell that the original equation is in (D2). Grab the little square at the bottom right corner of the cell and dragging down to fill the column.
2. Now calculate the gradient & sinuosity index for all the rivers in the same way.
3. Once these values are calculated create an X-Y scatterplot of sinuosity vs. gradient.

*Hint: When selecting your dependent and independent variables consider which is more likely to have influence on the other.*

1. Note that while there appears to be a relationship between these variables, it does not seem to be a linear relationship. Instead of using a linear trend line as we have in the past, this time add a logarithmic trend line.

For more detailed instructions on how to add a logarithmic trend line see: <https://goo.gl/3IwBz2>

🡪 **Attach your graph with the added logarithmic trend line to your document.**

**🡪 Copy and paste your full data table into your document.** If your table doesn’t fit on the page, once you paste it, you can click on the little clipboard icon that appears near the figure, and choose ‘paste options 🡪 picture.’ This should format your table to fit on the HW document page.

**Question 6: Do the data support your hypothesized relationship between gradient and sinuosity? Why or why not? Based on the available data how would you now describe the relationship between these variables?**