ESCI 121 Physical Geology Name:

Observing Streams & Rivers in Google Earth

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This activity provides students with satellite views of stream and rivers on both Earth and Mars through the Google Earth application. Students can be provided with a series of placemarks to guide them to the appropriate locations or can use the instructions included in the assignment to search out those locations on their own. For two of the terrestrial features (Oxbow Bend, WY and Horseshoe Bend, AZ), students are asked to view and interpret features in panoramic images (viewable on separate web pages and within Google Earth).

The activity is intended as a take home assignment for an introductory physical geology class, but could also be completed as a lab (2 or 3 hour session, depending on the familiarity of the students with Google Earth).

Learning objectives:

- Identify different drainage patterns
  - Draw/sketch the observed drainage pattern
  - Explain the relationship of drainage pattern to underlying geology/tectonics
- Identify locations of erosion and deposition
  - Explain the relationship of these locations to the morphology of the river
- Identify river/stream terraces
  - Explain how these features form
- Compare/contrast two different river systems
  - Propose a reason that explains why the two rivers are different
- Apply the concepts discussed for terrestrial fluvial systems to similar-looking systems on Mars
  - Explain how these systems may have formed
  - Make inferences about the underlying geology based on the stream/river drainage patterns

Students will need access to a computer with v.5 (or later) of Google Earth installed and access to the internet, as well as copies of files with saved placemarks (separate files needed for Earth and Mars).

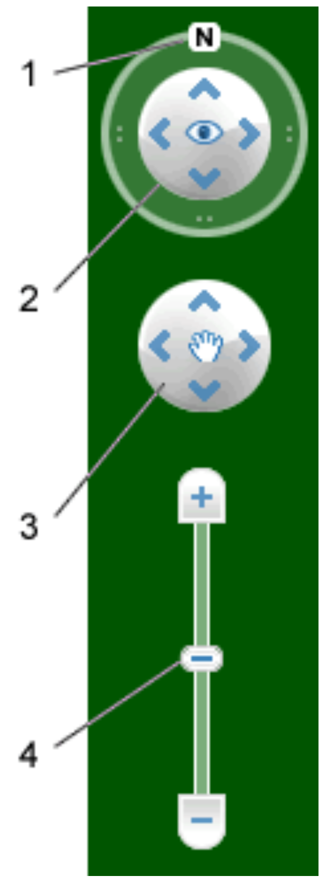
Observing Streams & Rivers in Google Earth

Introduction

We will take advantage of the Google Earth application to examine satellite images of fluvial (flowing water) features on both Earth and Mars (*note*: you must use the separate Google Earth app: the web-based version is not the same!) The following is a quick introduction:

1. First, start the application. It will default to the Earth layer, but we will switch to Mars later.

2. You can navigate using the mouse pointer to drag the surface layer and the scroll wheel/ball to zoom in (the arrow keys and modifier keys like shift and control perform similar functions. There are also controls within the window itself: 1 (the "north-up" button) will reset the display so north is at the top; 2 (the "look joystick") rotates the surface, 3 moves around the surface, and 4 controls the level of zoom. *Remember that you can always hit the "north-up" button to reset the view if you get lost while moving around.*



3. You can also use the "search" area to find specific features or latitude/longitude locations. The "fly to" option will cause the application to fly you directly to the search result you choose.

4. The "Layers" pane can be used to turn on/off various view options: for the Earth, this includes geographic place names, business names, etc. For Mars, we will use this layer to change which dataset to view. To turn on/off a layer, simply click/unclick the checkbox next to the layer name.

5. The "Places" pane will allow to navigate placemarks that help us navigate. Clicking the name of a placemark will cause the viewer window to "fly" to that location. We will add placemarks to this list by opening ".kmz" files.

6. We will be using the "measure" tool to make some distance measurements: if you click the button that looks like a ruler in the toolbar, the "ruler" window will appear. Set the radio button to the "path" option, which will create a path of connected points when you click the mouse with the length of the total path given in the window. *Remember to change your units to **kilometers** in the units menu.*

<u>**All of the placemarks utilized in this exercise are available in .kmz files available on Vista: there is one for Earth and one for Mars locations. Be sure to download these files!**</u>

We will also be utilizing some high resolution panoramas of terrestrial rivers: you may view these panoramas on the website given (gigapan.org), or open them in Google Earth.

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Terrestrial Rivers

1. Locate Oxbow Bend (part of the Snake River in Grand Teton National Park, Wyoming). Observe the feature in Google Earth:
   a. What type of river is this, and how can you tell?

      Meandering river (or mature river):
      the smooth wide flood plain
      (vegetated) and bends in the river.

   b. Discuss briefly the processes of erosion and deposition that are occurring in this area *and why they are happening*. What is the eventual fate of Oxbow Bend?

      Oxbow Bend is a cutoff meander that will eventually become an oxbow lake. (Erosion happens on the outside of the curve due to the relatively higher velocity, which forms a cutbank; deposition occurs as water slows along the inside of the bend, forming a sand bar.)

   c. Is there any evidence of this particular process operating in the past along this portion of the Snake River? *If so, describe the evidence. If not, describe the evidence you would have expected to see but did not.*

      There should be oxbow scars/lakes visible in the overhead satellite view.

2. Open the Oxbow Bend panorama (either in Google Earth or via the webpage http://www.gigapan.org/31360/). You can zoom in and out of the pan as needed. (Click 'Exit Photo' to return to the regular Google Earth view).
   a. Consider the processes of erosion and deposition you observed in Question 1: what evidence of these processes can you find in the panorama?

      The sand bar is pretty well exposed in the pan. Evidence of erosion may, however, be harder to find.

   b. Describe the Snake River plain as seen in the pan: the river plain extends from the foreground out to the base of the Tetons in the distance.

      (any description that resembles the location)

   c. Examine the river plain to determine if any river terraces are present. *Describe the terraces you observe (size, how they likely formed), or suggest an explanation for why there are no terraces present.*

      There are two river terraces visible - but as long as one is mentioned, this is fine. The answer should also note how the terrace likely formed.

3. Locate Horseshoe Bend (near Page, AZ), which is part of the Colorado River east of the Grand Canyon. (Panorama at http://www.gigapan.org/33145/).
   a. First, explore this part of the Colorado River in Google Earth and describe the type of river present. *How is this river similar or different to the portion of the Snake River you observed in Questions 1 and 2?*

      The Colorado is also meandering, but lacks the oxbow lakes/scars. The area is also more arid.

   b. Second, examine the location of Horseshoe Bend. *What type of feature is this? How is it similar and different to Oxbow Bend?*

      Answers should reference the deep incision of the meander, but also note that the processes of erosion and deposition at the current river level are very similar

   c. Examine the panorama. Describe the Colorado River as observed in the pan: in addition *describe any terraces you observe (size, how they likely formed), or suggest an explanation for why there are no terraces present.* What does this suggest about the geologic history of this part of Arizona compared to the portion of Wyoming observed earlier?

      Answers should note the portion of Arizona observed was uplifted quickly, and no terraces are present - the tectonic uplift is the difference between the two areas.

4. Locate the drainage using the placemark “Drainage (CA)” or by searching for the latitude/ longitude 35° 8' 9.74"N, 119° 40' 29.25"W.
    a. What type of drainage pattern does this stream exhibit? How is this different from the Snake and Colorado Rivers? *Include a simple sketch of the drainage below.*

       This is a structurally controlled drainage, not a meandering river.

    b. Suggest a reason for the drainage pattern observed here (*zoom out and consider your location, especially the long linear valley associated with the stream*).

       The long linear valley is part of the San Andreas fault system. Answers should reference tectonic structures (e.g. faults).

5. Find the location where the Volga River enters the Caspian Sea.
    a. What type of structure is this and how does it form? *Include a simple sketch of the feature below.*

       This is a river delta.

Now, on to Mars! The location toolbar contains an icon that looks like Saturn: click the button to bring up a menu of locations - choose Mars. Once Mars appears, you'll have a different set of layers to explore. The Global Maps layer can be used to change the surface layer (you may have to expand this folder to see these options): use the radio button to choose the layer, and click the blue layer name to bring up a brief description of that dataset. *The "Visible Imagery" contains the highest quality images, but the Viking Color Imagery layer is more uniform and may be easier to use in some places. The Daytime Infrared, Nighttime Infrared, and Colorized Terrain are interesting to explore but will not be used here.*

6. Locate the volcano Apollinaris Mons (also called Apollinaris Patera). The placemark is located on one side of the caldera: zoom out so you can see the flanks of the volcano as well.
   a. Describe the linear features that surround Apollinaris: if these were stream channels, what type of drainage would this be? *Include a simple sketch of the drainage below.*

      This is a radial drainage pattern (if it was carved by water).

   b. Consider the material that makes up Apollinaris: what does the presence of these linear channels suggest about the strength (ability to resist erosion) of the underlying material? Suggest an appropriate composition for this material as part of your answer (*note the brief description given of Apollinaris in the instructions above.*)

      The linear channels suggest the material making up the flanks of this volcano is somewhat easily eroded: the most common explanation for this is that the flanks of Apollinaris are covered with pyroclastic material rather than rocky lava flows.

7. Locate the feature Warrego Valles. *This question is best answered using a "eye alt" of about 200 km/120 miles* - set your zoom level so the eye alt value in the lower right corner of the window is about 200 km or 120 miles.
   a. In the space below, sketch the general shape of Warrego Valles. *What type of drainage does this appear to be - and what implications does this have for the formation of Warrego Valles.*

Warrego Valles is often used as an example of a Martian valley network (or runoff channel) - it exhibits dendritic drainage and is thought to form by runoff of either precipitation or ground water.

8. Locate the crater Orson Welles, and examine the valley that starts at the crater's NE rim (Shalbatana Valles). Briefly describe the valley below, along with a sketch of the feature. *Identify any evidence of erosion/deposition in the valley floor, and suggest a process by which this valley may have formed.*

Shalbatana Valles is a long wide valley that lacks tributaries . Features in the valley floor have undergone intense erosion - likely as a result of the catastrophic floods that are thought to have formed this type of feature (outflow channel).

9. Locate Noctis Labyrinthus (this feature is on the western edge of Vallis Marineris, the "Grand Canyon of Mars").
   a. Assume that water has flowed through this area: what type of drainage pattern is present here? *Include a simple sketch of the drainage below.*

      This is an area of interconnected linear valleys that make almost a gridded pattern: structurally controlled drainage

   b. What does this type of drainage pattern suggest about the underlying bedrock?

      The underlying bedrock is probably jointed, and the water further eroded along the fractures.

   c. Last, scan to the east: if water did flow through Noctis Labyrinthus, where did that water end up? *Suggest some possible place/feature names - you might also wish to explore the Colorized Terrain layers for elevation information.*

      The water likely flowed through Valles Marineris and out Eos Chasma, then north to Chryse Planitia. (Other named features that could figure in student answers include Ganges Chasma, Xanthe Terra, and Margaritifer Terra)

10. Locate the "Feature in Eberswalde", and zoom to an "eye alt" of 11 miles / 18 km with the placemark in the center of the window (*this location is a candidate landing site for the Mars Science Laboratory Mission*).
    a. Sketch the feature below *and suggest how it may have formed.* Why do you think this area has been suggested as a landing site for the next Mars rover mission?

       Any sketch that resembles the feature is fine: it appears fan shaped and seems to have a distributary pattern. The most popular interpretation among Mars scientists for this odd deposit is a river delta: but any reasonable student answer is valid (there is no absolute answer here!).