In our previous assignment, "Observing the Change", we started with this quote from Chapter 9 of *Climate Change: The Science of Global Warming and Our Energy Future (2nd Edition)*, p.265:

> Global warming is not a theoretical construct. Rather, the fact that the Earth is warming is based on *observations*. The warming has been measured on land, in the atmosphere, in the ocean, and even in the ground. If that's not enough, the ice caps are melting, and sea level is rising, the latter due to both the melting of ice on land and the thermal expansion of the warming ocean.

Then, we shared our findings about these three subtopics:

- A Century of Warming
- Precipitation, Drought and Storms
- The Sensitive Arctic

This week, we're going to look more closely at the changes happening to the world's glaciers using 360 videos, repeat photos or "rephotos", and imagery in Google Earth. Unlike last week, you'll complete this activity on your own, but you're always welcome to collaborate and help each other!

**Part 1 – 360 videos of glaciers**

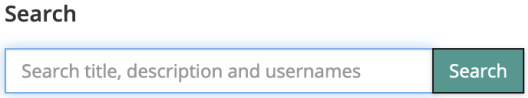
Since we can't easily take a field trip to a glacier, we'll use 360° video instead, which allows users to pan around the environment in the video as if they're actually there, kind of like virtual reality (VR). Please follow these steps:

1. Go to YouTube and search for "360 video glacier" – if possible, use the free YouTube app on your phone with headphones for a more immersive experience!
2. Select a glacier video labeled "360°" (you may want to use the Filter to only select 360 videos)
3. Watch the video and look around the glacier's environment:
    - if you're using a computer, use the mouse/trackpad controls
    - if you're using your phone, move your phone around you like a pair of binoculars
4. Take note of which video you watched, and try watching one or two more 360° videos of glaciers using the steps above

**Part 2 – Rephotos of glaciers**

One powerful tool that researchers can use to compare changes in glaciers over time is repeat photography, or "rephotos". These photos are taken of the same subject in the exact same location at different times, often many years or decades apart. Please follow these steps:

1. Using a computer, go to the Re.photos website.
2. In the "Search" field, enter "glacier" and click the green "Search" button:

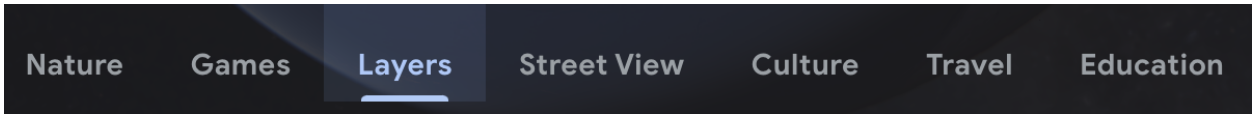


3. Select a glacier from the list that has photos more than 80 years apart and click one of the thumbnails to display it.
4. Click and drag the white slider in the middle of the rephoto to compare how the glacier looked in the past to how it looks now. Make a note of the glacier's name, its location, and the years between photographs.
5. If time allows, repeat these steps for another glacier, or peruse the USGS Repeat Photography Collection.

**Part 3 – Historical satellite images of glaciers**

Glaciers have retreated even faster over the past several decades. We can measure this change using historical satellite imagery in an app such as Google Earth. To find historical satellite imagery of a glacier, please follow these steps:

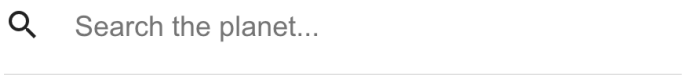
1. Using a computer, go to the Google Earth website.
2. On the left, click the Voyager icon:
3. Click on "Layers", and then scroll down to click on "Timelapse in Google Earth":







4. Select one of the glaciers you looked at in the Re.photos collection in Part 2, or choose one from the USGS Repeat Photography Collection.
5. Enter the name of the glacier you selected in the “Search the planet...” field in Google Earth and click on its full name and location when it appears below the search field:




6. Observe the changes in the glacier from 1985 to 2020. You may need to zoom in to observe it more closely, and you can use the blue play/pause button in the upper right of the Google Earth window to control playback of the images.
7. Use the scale in the bottom center of the screen to estimate how much the face, or terminus, of the glacier has moved over the past 35 years.
8. If time allows, repeat these steps for another glacier.

Here are some guiding questions you should answer in your presentation:

- **Part 1 – 360° video**
    - Which 360° video did you watch, and why? What did you think of it?
    - What did you think of the 360° video experience? Have you ever watched a 360° video before?

    - Do you think the 360° video contributed to your understanding of glaciers more than a standard "flat" video would have? Why or why not?
- **Part 2 – Rephotos**
    - Which glacier "rephoto" did you choose, and why? What did you think of it?
    - What did you think of the rephoto experience? Have you ever done it before?
    - Do you think the rephoto contributed to your understanding of glaciers more than standard photos would have? Why or why not?
- **Part 3 – Historical satellite photos**
    - Which glacier did you choose, and why?
    - Where is your glacier located?
    - What has been happening to this glacier over the last three decades? How do you know?
    - What do you think might happen to this glacier in the future? Why do you think so?

Remember, these are guiding questions to help you assemble information about your topic. You aren't expected to answer every single question, but if you do, you'll have a deeper understanding of your topic, and you'll be better able to explain it to the rest of us. Make sure you keep track of your sources so you can share them with us!

Next week, we'll look at the widespread changes happening in Greenland and Antarctica, and how they're both connected to sea-level rise!