

## LESSON PLAN: Evaluating Glacier and Landscape Change

Middle school and High School (extension activities)

Web Link: <https://www.usgs.gov/science-support/osqi/yes/resources-teachers/lesson-plan-activities-6-8#glo>

<b>Grades</b>	6-8 9-12 see HS extension activities
<b>Length</b>	2-3 lessons (45 min each)
<b>Topics</b>	Climate Change, Repeat Photography, Qualitative vs Quantitative data, Glacier Recession, Aerial Photography, Evaluating Graphic Data
<b>NGSS Alignment</b>	<a href="#">MS-ESS3 Earth and Human Activity</a> <a href="#">MS-ESS2 Weather and Climate</a> <a href="#">HS-ESS2 Earth and Human Activity</a>
<b>Overview</b>	In this lesson students interpret USGS data in multiple formats and draw conclusions based on the data presented. Oblique repeat photographs, satellite imagery, and tables of glacier area change from Glacier National Park, Montana, are presented and the concept of “qualitative and quantitative data” is explored. Students draw conclusions based on the data provided and extension lessons allow them to draw relationships between CO <sub>2</sub> emissions, climate trends, and glacier recession. Students share their observations and make linkages about climate and impacts.
<b>Activity Summary</b>	Activity 1: Evaluate and discuss differences/similarities in repeat photographs of glaciers. Activity 2: Trace glacier and moraine perimeters using a time series of aerial and satellite imagery to document glacier retreat. Activity 3: Create a line or bar graph to show glacier area change over time. Activity 4 (HS extension): Discuss and evaluate graphic data that relates to glacier loss at regional and global scale and a graphic that displays projected glacier loss. Extension Ideas: suggestions for creating art inspired by repeat photographs, student repeat photography project, career exploration

## Objectives

Students will be able to:

- Interpret information from multiple formats
- Understand the benefits and limitations of certain types of data representation
- Understand how area data is obtained for glacier analysis and appreciate some of the skills and challenges involved in analyzing aerial imagery.

## Vocabulary

anomaly, climate change, glacier, moraine, qualitative, quantitative, recession, trend

## Teacher Background

The retreat of glaciers worldwide is one of the most visible effects of climate change currently impacting our world. Glaciers are excellent indicators of climate as they grow or retreat in response to regional temperature trends. Glaciers store 70% of the planet's fresh water and play ecological, economic, natural hazard, and aesthetic roles in our modern world. Understanding how glaciers respond to climate change will help prepare the global community for glacier reduction and loss resulting from climate change. USGS scientists in Glacier National Park are studying mid-latitude mountain glaciers and share their methods, results, and data representations in this lesson plan.

## Materials

Lesson Plan\_Evaluating Change.pdf

Lesson Materials.pdf

USGS Scientist Profile Video links on YouTube:

Repeat Photography\_usgs\_LM.avi

Aerial Imagery\_usgs\_CM.avi

Pencils, markers or colored pencils, plastic sheet protector

## Related Links

[USGS Retreat of Glaciers in Glacier National Park](#)

[USGS Repeat Photography Project](#)

## INTRODUCTION

There is scientific consensus that humans are influencing the buildup of carbon dioxide and other greenhouse gases, causing the earth to heat up. This climatic trend of heating, or global climate change, is having an impact on the planet in many ways such as drought, extreme weather events, sea level rise, and shifting plant and animal ranges. One of the most obvious signs of climate change is the melting of glaciers and ice caps around the world.

Worldwide, glaciers store 70% of the planet's fresh water and have ecological, economic, natural hazard, and aesthetic roles in our modern world. Glaciers are excellent indicators of climate trends, responding to climate by expansion or retreat. Understanding how glaciers respond to climate change will help prepare the global community for inevitable glacier reduction and loss resulting from a warming climate.

In Glacier National Park (GNP), Montana, USGS scientists are studying the retreat of mid-latitude mountain glaciers to assess their ecological and hydrological effects, and to predict future changes and impacts to the ecosystem. At the end of the Little Ice Age, around 1850, an estimated 146 glaciers existed in GNP. Aerial imagery analysis, included in this lesson, determined that only 26 glaciers remained in 2015.

**The USGS has been documenting glacier retreat with repeat photography and measuring glacier retreat with aerial photography as two means of tracking glacier change. By comparing these techniques of glacier monitoring and analyzing climate-related trends, students can formulate cause and effect relationships impacting our changing planet and evaluate benefits and limitations of certain types of data representation.**

### Resources:

National Snow and Ice Data Center, <https://nsidc.org/cryosphere/glaciers/quickfacts.html>

NASA Global Climate Change: Vital Signs of the Planet, <https://climate.nasa.gov/effects/>

IPCC Summary for Policy Makers: [https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15\\_SPM\\_version\\_stand\\_alone\\_LR.pdf](https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_version_stand_alone_LR.pdf)

## BACKGROUND:

**What is a glacier?** A glacier is a body of snow and ice of sufficient size and mass to move under its own weight. USGS scientists in Glacier National Park define glaciers as ice bodies with an area of at least 0.1 km<sup>2</sup> (100,000 m<sup>2</sup>), or about 25 acres. Glaciers are dynamic, changing in response to temperature and precipitation. A glacier forms when winter snowfall exceeds summer melting. Glaciers retreat when melting outpaces accumulation of new snow.

Glacier definition: [https://www.usgs.gov/centers/norock/science/what-makes-it-glacier?qt-science\\_center\\_objects=0#qt-science\\_center\\_objects](https://www.usgs.gov/centers/norock/science/what-makes-it-glacier?qt-science_center_objects=0#qt-science_center_objects)

Other glacier FAQs <https://nsidc.org/cryosphere/glaciers/quickfacts.html>

**A brief history of recent glacier change in GNP:** During the 16<sup>th</sup> – mid-19th century, much of the northern hemisphere experienced cooler climatic conditions that favored glacier expansion. This period is known as the Little Ice Age and the glaciers in Glacier National Park reached their most recent largest extent during that period, leaving morainal evidence of their size behind. As glaciers move downslope, rocks and debris are deposited at the base of the glacier. When a glacier retreats, these piles of rock debris, known as moraines, are left on the landscape and mark the furthest extent of the glacier before it's retreat. Aerial and satellite imagery have made it possible to identify and digitize the moraines, allowing scientists to estimate the shape and area of most of the glaciers in Glacier National Park dating around 1850.



*Complementary Lesson Plan: Unit 3 -Climate Changes: Glaciers and Glaciation Lesson 3 (pg 16 –glacier features)*

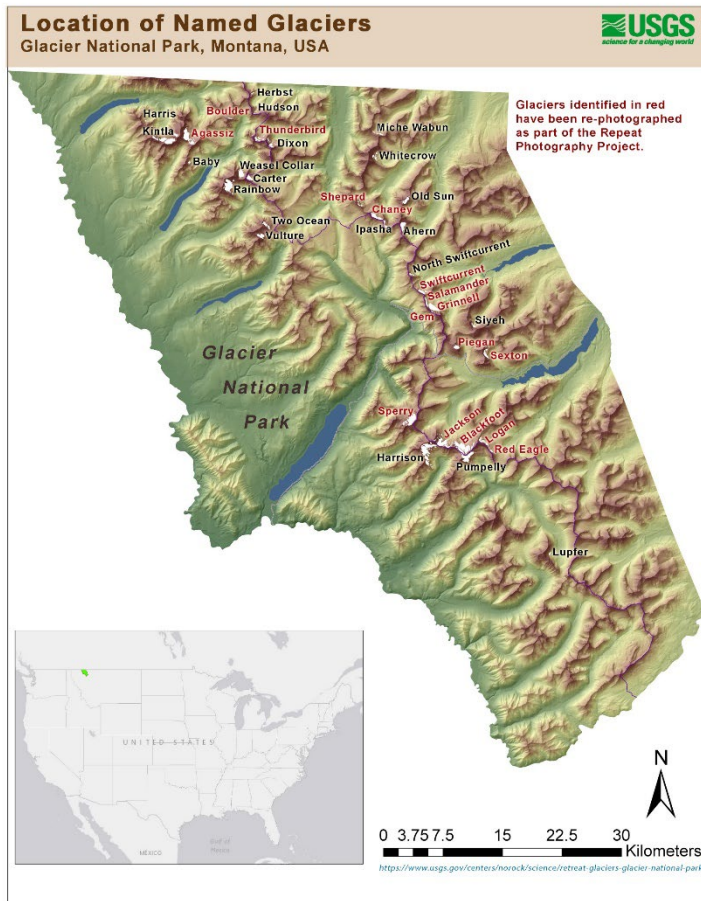
<https://www.nps.gov/glac/learn/education/work-house-program.htm>

Since the Little Ice Age, all the glaciers have retreated in response to the warming climate, and many smaller glaciers have disappeared from the landscape entirely. Increased air temperatures, coupled with longer melting seasons have created conditions that foster glacial melt, as seen in repeat photographs. USGS Scientists are also studying the local impacts of aspect, snow avalanches, wind distribution of snow, and ice flow patterns which contribute uniquely to each glacier's rate of retreat. Though each glacier melts at its own rate, there is a clear trend of retreat for all glaciers in the park, and similarly for glaciers around the world. This lesson includes both qualitative and quantitative data as evidence of glacier change in response to a warming climate.

**Who does this research?** The United States Geological Survey (USGS) is conducting glacier research in Glacier National Park, Montana. The USGS is a government agency that provides science about impacts of climate and land-use change, natural hazards that threaten lives and livelihoods; the water, energy, minerals, and other natural resources we rely on and the health of our ecosystems and environment. USGS scientists develop new methods and tools to supply timely, relevant, and useful information about the Earth and its processes. There are many kinds of interesting careers with the USGS. Motto: *Science for a changing world*

[United States Geological Survey](https://www.usgs.gov) <https://www.usgs.gov>

[Glacier research in Glacier National Park](https://www.usgs.gov/centers/norock/science/glacier-research?qt-science_center_objects=0#qt-science_center_objects) [https://www.usgs.gov/centers/norock/science/glacier-research?qt-science\\_center\\_objects=0#qt-science\\_center\\_objects](https://www.usgs.gov/centers/norock/science/glacier-research?qt-science_center_objects=0#qt-science_center_objects)



**Where is Glacier National Park?** Glacier National Park (GNP) is located in northwest Montana, USA, and is part of the Rocky Mountains. The Continental Divide bisects the park and visitors come from all over the world to experience the mountain scenery and wildlife.

GNP MAP – [Lesson Materials.pdf](#)

[Glacier National Park](https://www.nps.gov/glac/index.htm) <https://www.nps.gov/glac/index.htm>

## Procedure

### Lesson Introduction

- Create groups of students. Opening: Ask each group to name one thing they know about climate change.
- Optional video – overview of climate change effects in Glacier National Park :  
<https://video.nationalgeographic.com/video/news/00000150-870f-d9fe-abf5-af3f23060000>
- Introduce topic of glacier loss and orient students to the location of Glacier National Park with the map. ([Lesson Materials.pdf](#))
- Show Video to introduce the USGS scientist and the topic of Repeat Photography.
  - [YouTube: Repeat Photography\\_usgs\\_LM.avi](#)

## Activity #1: Documenting Glacier Change with Qualitative Data (repeat photography)

### Background: [USGS Repeat Photography Project](#)

[https://www.usgs.gov/centers/norock/science/repeat-photography-project?qt-science\\_center\\_objects=0#qt-science\\_center\\_objects](https://www.usgs.gov/centers/norock/science/repeat-photography-project?qt-science_center_objects=0#qt-science_center_objects)

The United States Geological Survey (USGS) started the Repeat Photography Project in 1997 with a systematic search of Glacier National Park's archives for historic photographs of glaciers in the park. They found many historic images taken by early photographers who were hired to attract visitors with photos of the scenery and glaciers. USGS scientists selected historic glacier photos, then hiked to the exact same vantage point to repeat the photograph many years later to document the change that had occurred over time.

Photographing the glaciers occurs in a narrow window in late August and September after the previous winter's snow has melted from the surface of the glacier and before the first snows of autumn. This is often the time of year that wildfire smoke fills the air, which has made repeat photography impossible in some years. Some photo points are a single day hike, others involve multi-day backpacking trips to reach the glacier and then locate the photo point. Finding the exact spot where the historic photo was taken can be very challenging and involve hours of hiking up and down a mountainside to find the correct elevation. The repeat photographer uses the intersection of background mountains and alignment of other permanent features to locate the photo point. Google Earth technology has aided scientists by allowing them to place themselves in the landscape from their office and move about digitally to help narrow down the location of the photo point before heading into the field.

- 1) **Evaluate** repeat photographs: Project on Smartboard or arrange printed photo pairs from [Lesson Materials.pdf](#) at stations around the room for students to evaluate. Have students complete Repeat Photo Observation Form individually or in groups. **ONLINE alternative:** use slider bar on Glacier National Park's [Melting Glaciers website](#) to compare photos and discuss observed differences and similarities. (<https://www.nps.gov/glac/learn/nature/melting-glaciers.htm>)
- 2) **Discuss** as a class or have individuals/groups presents their observations:

Where is the glacier?

- *Identify the glacier on the GNP map*

Did the glacier change a little or a lot?

What other differences did you notice in the landscape between photos?

- *Are there trees and plants growing where once there was ice?*
- *Is there a glacier moraine visible in the photo? (rocky deposit that marks the glacier edge before it retreated)*
- *Is there a lake where the glacier used to be? Do you think the lake influences the rate at which the ice melts? (yes – ice generally melts faster when exposed to water)*
- *What does the rock look like that is now exposed?*

What similarities did you find between photos?

- *Vegetation? Snow patches?*
- *Background landscape and mountain summits -the intersection of background features helps the repeat*

*photographer locate the same photo point*

How can you tell the photos were taken in the same location?

- *Intersection of mountain tops, similar foreground features*

Why are the historic photos all black and white?

- *color photography wasn't used widely until the mid-1930s*

What conclusions can you draw from comparing the photos?

- *Glaciers are getting smaller (retreating) – climate is getting warmer*



### 3) Introduce Qualitative Vs Quantitative Data:

Can scientists measure anything from the photographs?

- *No, the photo pairs are "QUALITATIVE" data – information that describes the "quality" of the object – the glacier is larger in one photo than the other, description in words, not numbers (eg. How smooth is a maple leaf? What color is the ocean?)*
- *QUANTITATIVE data is information about "quantities", things that can be measured and written down with numbers. (eg. your height, distance to the moon, area of a glacier)*

What is the value of the photos?

- *Visual document of glacier and landscape change, tell a story, easy to understand and interpret, can be viewed as science (documentation) or art (aesthetic)*

Can you think of other examples of photographs used as documentation?

- *Dental x-rays, photographs of museum collections, school pictures, family photos, Instagram posts...*

*\*\*FOLLOW-UP Activities for incorporating art/science, writing, career exploration included at the end of the lesson plan*

## Activity #2: Documenting Glacier Change with Quantitative Data (aerial photography)

### Background: Use of Aerial Imagery to Track Glacier Change

Aerial photography allows USGS scientists to measure the footprint of glaciers from a bird's eye perspective. Scientists carefully evaluate aerial photos to determine where the edge of the ice is and digitally draw (digitize) the perimeter of the glacier using GIS (geographic information system), recording the glacier's size and shape on that day. The best images for this task are those with little seasonal snow or strong shading since those factors can make it difficult to determine the edge of the glacier. Aerial photos often cover large sections of land, and sometimes the entire region of Glacier National Park, so most of the glaciers can be evaluated at a similar point in time and then compared to other points in time to track changes in shape and area. Aerial photos can be taken from planes, but high resolution satellite imagery has proven to be the clearest and most useful for evaluating glacier ice margins. The technological advancement of high resolution imagery has made analyzing aerial image much easier and more accurate. Satellite imagery has also allowed USGS scientists to estimate how large the glaciers were before they began retreating, by digitizing moraines left by glaciers. The use of GIS technology allows the computer program to calculate the area and perimeter with great precision. Students will perform similar image assessment, perimeter delineation and graph area change.

Note: Aerial photo analysis allows scientists to determine changes in the glacier's area (or footprint), but it does not record the change in the volume, or deflation, of the glacier. Glacier volume is currently hard to calculate since ice thickness is usually not known. For example, a very thick glacier could melt all summer, but not change shape/area (eg cut a marshmallow in half to represent melt with same area). Glaciers that are thin at their margins are more likely to show a change in area over time, but thick glaciers may be losing just as much ice, without a significant change in area. Area measurements are not indicative of all the change that may be occurring. This is a limitation of area analysis.

### Lesson Introduction

Show Video to introduce the USGS scientist and the topic

· **YouTube: [search AerialImagery\\_usgs\\_CM.avi](#)**

- 1) Analyze satellite imagery and trace glacier perimeters: Project or distribute printed copies of the time series of aerial and satellite images of Grinnell Glacier: [Lesson Materials.pdf](#)
- 2) **Create a time series of glacier perimeter.** Evaluate each aerial image and trace the perimeter of Grinnell Glacier in a different color for each year on a plastic sheet cover. Trace the scale bar and use it to align each subsequent image for tracing the glacier margin. Make your best guess where shade, seasonal snow, or rocky debris make it difficult to determine the true margin.

(Note – scientists zoom in to the image on the computer and use additional images taken from other angles to help them make their best determination of the perimeter. Some glaciers can be very challenging. This is a skill that takes patience and time.)

**ONLINE Alternative:** In Google Earth, locate and trace the margin of Grinnell Glacier using the following dates, chosen because the imagery contains the least seasonal snow on the glacier, making actual glacier margins easier to interpret: Slider bar dates: 8/1991, 8/1995, 9/2003, 9/2005, 7/2013. The 2013 image should be traced last since it's the most difficult to determine the glacier margin with the icebergs and seasonal snow. Tracing earlier years will help students get a feel for the size of the glacier and the aerial perspective. (Note: the dates listed on the Google Earth images are not always representative of the date the photo was actually taken)

- 3) **Estimate the Little Ice Age (circa 1850) size of the glacier** by evaluating the aerial images and tracing the moraines left by Grinnell Glacier when it began retreating at the end of the Little Ice Age. Review what moraines look like in aerial images (Activity #2 slides) and use practice page to work with other images. Moraines look like mounds of rock at the edge or further from the glacier. They can be hard to see and not always in a continuous line. Sometimes there are intermediate moraines (rock piles closer to the glacier) if the glacier paused in its retreat for a while.
- 4) **Discuss** as a class or have individuals/groups presents their observations as before:

What made it difficult to determine where to trace?

What does the series of aerial images tell us about the glacier?

Do the glacier moraines provide enough information to determine the exact size of the glacier?

- *Not exact size, but an approximate size, which is the best that can be done since there are no photos from that time.*

## B) Revisit Qualitative Vs Quantitative Data:

*Can scientists measure anything from the photographs?*

- *Yes – the perimeter and area of the glacier are recorded when the scientist digitizes (draws in a GIS computer program) the footprint of the glacier. These are numerical measurements, or QUANTITATIVE data.*
- *(NOTE:*

*What advantage does quantitative data have for communicating the change in glacier size?*

- *the information is not subjective or influenced by personal experience*
- *easier to compare than qualitative*
- *may be repeatable, which lends credibility*

*What other types of landscape change can be mapped and compared using satellite imagery?*

- *Forest fires, avalanche paths, snow cover, stream/river channels, deforestation, floods, agricultural use, buildings/development...*



### Activity #3: Graph Area Change

The GLACIER AREA TABLE in [Lesson Materials.pdf](#) displays the area of each of the named glaciers in Glacier National Park, as determined by the perimeters drawn (digitized) from aerial images. The computer software calculates area from the perimeter so this table is the end result of tracing margins from imagery taken in 1966, 1998, 2005, and 2015 and from moraine evidence that records the maximum glacier size at the end of the Little Ice Age (mid-1800s).

- 1) Distribute glacier area table (full version or subset, depending on teacher preference) and area change graph template.
- 2) Have each student graph several glaciers of their choice (using different color or pattern for each glacier) using the area data from LIA – 1966 -1998 – 2005 – 2015. Students can also graph the total ice area for GNP over time.
- 3) Have students describe their graphs and compare with others.

#### 4) Discuss:

Are all glaciers responding the same?

*they are all retreating, but not all at the same rate as demonstrated in the graph and in the % Change data column*

Why do glaciers melt at different rates?

*Features that influence glacier melt which may vary for each glacier depending on site-specific conditions: Aspect, extra snow input from avalanching or wind distribution, ice flow dynamics/steepness of underlying terrain, lake at edge, shading, depth of ice at receding edge, size of the glacier, rock/debris cover.*

- 5) **Extension:** Have students calculate area change between different years and compare the change based on the glacier's size.  $\text{Percentage Decrease} = (\text{original \#} - \text{new \#}) / \text{original \#} \times 100$ 
  - *Does the size of the glacier influence the amount of loss?*

#### D) Revisit Qualitative Vs Quantitative Data:

*Can scientists measure anything from the photographs?*

- *Yes – the perimeter and area of the glacier are recorded when the scientist digitizes (draws in a GIS computer program) the footprint of the glacier. These are numerical measurements, or QUANTITATIVE data.*

*What advantage does quantitative data have for communicating the change in glacier size?*

- *the information is not subjective or influenced by personal experience*
- *easier to compare than qualitative*
- *may be repeatable, which lends credibility*

## Extension Activities (advanced grade levels):

### Activity #4: Evaluate Graphic Data

The repeat photographs describe what is happening to the glaciers in Glacier National Park with qualitative and quantitative data. Now, look at other ways of displaying data and discuss what the graphics convey, and how they might best be used. These graphs depict glacier change at the regional level (Glacier National Park) and then scale up to compare what is occurring at the global scale, including a projection of how glaciers will respond to varying levels of CO<sub>2</sub> in the atmosphere. Discuss the trends apparent at both scales and how they relate. Discuss what each axis represents and have students answer questions included in [Lesson Materials.pdf](#)

Print or project the four graphic pages in [Lesson Materials.pdf](#) and discuss in small groups:

Graphic	Discussion Points
Glacier Area Change Data Table	<ul style="list-style-type: none"> <li>- Qualitative or quantitative data?</li> <li>- Which graphic is easiest to interpret?</li> <li>- What is the benefit of each style of data representation?</li> </ul>
Glacier Area Change Graphic	
Location of Glaciers on Earth	<ul style="list-style-type: none"> <li>- How are glaciers responding to climate around the world?</li> <li>- Is there a trend worldwide? What could be responsible for a worldwide trend in glacial melt?</li> </ul>
Average cumulative mass balance* of "reference" glaciers worldwide 1945- 2015	
Projections of Glacier Retreat in Glacier National Park, MT, and Canada	<ul style="list-style-type: none"> <li>- Assess projections for glaciers around the world based on three different scenarios of CO<sub>2</sub> in the atmosphere.</li> <li>- Notice that the size of the glacier (listed on each graph as km<sup>3</sup>) influences the longevity of the glacier.</li> <li>- Notice that the differing levels of CO<sub>2</sub> impact the longevity of the large glaciers more than the small glaciers.</li> </ul>
Worldwide Projections of Glacier Retreat at World Heritage Sites	

### Activity #5: Evaluate Climate Trends and Impacts

Glaciers are excellent indicators of climate. Climate is the average of decades of weather events. The worldwide decline in glaciers is an ecosystem response to warming climate. Is there evidence of such warming that could impact glaciers in Glacier National Park and around the world? Display and discuss the graphics and how they are related to climate change and glacier retreat.

**Teacher Background:** Review or discuss the role of CO<sub>2</sub> and warming climate. NASA website has a nice description. <https://climate.nasa.gov/causes/>

**Evaluate** atmospheric CO<sub>2</sub> levels and climate trend data in relation to glacier retreat. Discuss what each axis represents and have students answer questions included in [Lesson Materials.pdf](#)

Graphic	Discussion Points
Global Land Temperature Anomalies 1850-2018, Jan-Dec	- Discuss temperature anomalies since 1850 (deviation from average) - Are there linkages and connections that can be made between CO <sub>2</sub> , temp, and glacier melt?
Centuries of CO <sub>2</sub> Levels from Ice Core Records and Recent Direct Measurements	- Qualitative or quantitative data? - Evaluate CO <sub>2</sub> levels over the past 400,000 years (deduced from air bubbles in ice cores and recent Mauna Loa measurements)

Could glaciers get bigger? If so, how?

Climate trends that favor less melting – cooler temps and increased snowfall.

Is this likely to happen in your lifetime? Why or why not?

No – based on the amount of CO<sub>2</sub> in the atmosphere and its effect on climate trends

Related video: [NASA: A Year in the Life of Earth's CO<sub>2</sub>](#)

Do the glacier changes in the photos represent weather or climate?

CLIMATE - discuss the difference – weather is daily/short term, climate is the long-term trend – relate to anomaly graphic again

## FOLLOW\_UP ACTIVITIES for MS and HS:

### ART & WRITING

Artists have used USGS repeat photographs as inspiration for their own work in documenting and exhibiting impacts of climate change. This is an example of how science and art sometimes intersect and allow for a broader audience and expanded communication.

**Discuss:** [Art – Science.PDF](#) (venn diagram and examples of artists’ renderings of USGS repeat photographs, and exhibit examples). Can you think of other ways science and art intersect? (*eg images from mars, satellite images of the world, illustrated bird books, Leonardo DiVinci drawings of the body, photos from electron microscopes...*)

- 1) Document change as art. Choose a repeat photo pair from [USGS Repeat Photographs](#) and draw or paint your own version of the repeat photographs. Write a description to accompany the art work.
  - Scan and print on postcard size cardstock to send to a friend or relative
  - Create a display with images and captions at your school
- 2) Create an exhibit of repeat photos, artistic renderings, or both:
  - Print the repeat photo pairs and write descriptions to accompany the pairs. Display for your school (hallway, bulletin board, lunchroom wall) or host an open house for parents to see the photos and artistic renderings of the photos.
  - HIGH SCHOOL: In conjunction with repeat photo/art exhibit, host a panel discussion that includes members of the community discussing local impacts and strategies to cope with climate change and how students can be empowered to cope with climate change.

### RESEARCH & ACTION

- 1) Find a photo that you can repeat and share (seasonal change, construction, younger version of yourself, historic)- what story does the pair tell?
- 2) Expand the Scope: Have students find other examples of climate change, in their own community or worldwide, and share supporting data.
- 3) HIGH SCHOOL EXTENSION - GIS application:  
Using GIS technology, compare glacier margin perimeters based on aerial and satellite photography from 1966, 1998, 2005, 2015 and moraine perimeters estimating glacier area around 1850. Area comparisons can be made and percentage change between years calculated between years.

#### **USGS datasets available for download:**

- [Glacier margin time series \(1966, 1998, 2005, 2015\) of the named glaciers of Glacier National Park, MT, USA](#)
- [A comprehensive inventory of maximum glacial extent in Glacier National Park during the peak of the Little Ice Age](#)

## CAREER EXPLORATION

- 1) Browse [USGS Science Explorer website](#) to get an overview of the topics and career opportunities with this government agency. Each topic area includes data, news, images, video, social media, and much more. Have students research an area and present to the class.
- 2) Explore this USGS publication that has 1-page highlights covering the breadth of careers in the USGS including: Media Outreach Coordinators, Field Technicians, Public Affairs Specialists, Chemists, Cartographers, and PhD Research Scientists, to name a few. Print a different page for each student to read and present to the class for discussion.

[A Snapshot of Women of the U.S. Geological Survey in STEM and Related Careers](#)

### Suggested Complementary Lesson Plans:

[NASA Introduction to Earth's Dynamically Changing Climate](#)

[People & Climate Change: The data is in](#)

[Your Family's Carbon Footprint](#)

[EPA Carbon Footprint Calculator](#)

[NASA: What Can We Do To Help?](#)

### Related Resources & Publications:

Glacier National Park [Melting Glaciers website](#)

NASA [Climate Time Machine](#)

[USGS A Snapshot of Women of the U.S. Geological Survey in STEM and Related Careers](#)

[USGS Repeat Photography Collection](#)

[NOAA Climate at a Glance](#)

[USGS Glaciers Dynamic Cryosphere](#)

[USGS Mtn Glaciers Dynamic Cryosphere](#)

**Vocabulary:**

**Anomaly:** something that deviates from what is standard, normal, or expected.

**Climate change:** a change in global or regional climate patterns, in particular a change apparent from the mid to late 20th century onwards and attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels.

**Glacier:** a slowly moving mass or river of ice formed by the accumulation and compaction of snow on mountains or near the poles, generally larger than .1km<sup>2</sup> (about 25 acres)

**Moraine:** a mass of rocks and sediment carried down and deposited by a glacier, typically as ridges at its edges or extremity.

**Qualitative:** relating to, measuring, or measured by the quality of something rather than its quantity.

**Quantitative:** relating to, measuring, or measured by the quantity of something rather than its quality.

**Recession:** the action of receding; go or move back or further away from a previous position.

**Trend:** a general direction in which something is developing or changing.

**Assessment:**

Students complete the following:

I learned that: \_\_\_\_\_

I was surprised about: \_\_\_\_\_

I felt: \_\_\_\_\_