Glacier Melt

This activity explores Arctic and Antarctic sea ice melt as well as global glacier retreat as a result of temperature anomalies and the associated impacts on wildlife

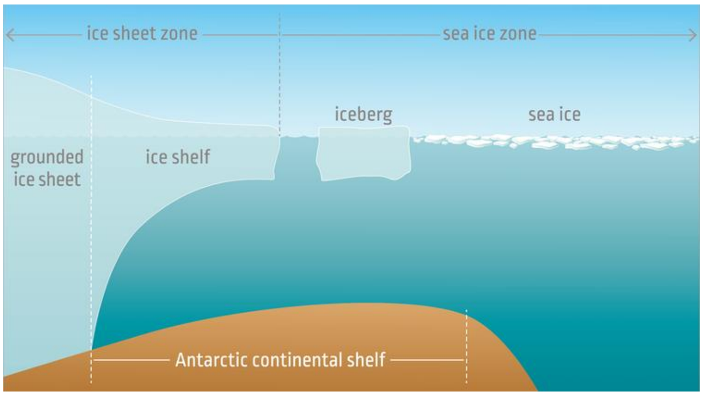
30 – 45 mins

Introduction

This activity will take you through visualisations of how the Earth's ice is melting, where it is melting and potential reasons why the retreat of ice is occurring and how this effects wildlife.

The WWF estimate that Arctic sea ice is being lost at a rate of almost 13% per decade. Ice acts like a protective cover over the Earth and our oceans. These bright white spots reflect excess heat back into space and keep the planet cooler. Loss of these reflective surfaces through melting has raised sea levels by almost 20 cm since 1900, putting coastal regions at risk.

There are two main types of ice: sea ice and land ice.



- Sea ice forms from salty ocean water and is generally no more than a few metres thick, however it can grow to more than 10 metres thick if allowed to grow over many winters. Sea ice forms in the winter months and melts in the summer months, though in certain regions it remains year-round. Roughly 15% of the world's oceans are covered by sea ice during a portion of the year (NSIDC, 2020). In the oceans around Antarctica, almost all the sea ice melts in the southern hemisphere spring. This means that every year an area of ocean twice the size of Australia freezes over and then melts – arguably the largest seasonal change on our planet.

- Land ice, such as glaciers and ice sheets, forms by the gradual accumulation of snow on land over long periods of time. These 'grounded' ice flows then travel to the ocean, or lakes when far from coasts, under the influence of gravity, and when it arrives it eventually melts. If the amount of ice flowing into the oceans is balanced by a similar amount of snowfall on land, the net change in global sea level due to this ice melt is zero. However, if the ice begins to flow and melt more rapidly or snowfall declines, the amount of ice on Earth becomes out of balance, resulting in a net rise in sea level. Today, about 10% of land area on Earth is covered with glacial ice. Almost 90% is in Antarctica, while the remaining 10% is in the Greenland ice cap (WWF, 2021).

So, while ice sheets change over decades and centuries, the time scale of sea ice variability is measured in months.

The loss of ice around the world can be largely attributed to global warming. The global average temperature is expected to rise by 1.5 °C by the end of the 21st century. This is affecting stores of ice all over the world (IPCC, 2018).

Learning Outcomes

In this practical, students will learn how to:

- Use free online maps to visualise ice melt
- Assess ice extent at a temporal and spatial scale
- Measure and compare glacial retreat to historic extents
- Assess global and local temperature anomalies
- Review the impact of glacial melt on wildlife

This activity is aimed at KS4 – KS5 students, however students of all ages are welcome to complete the activity.

Contents

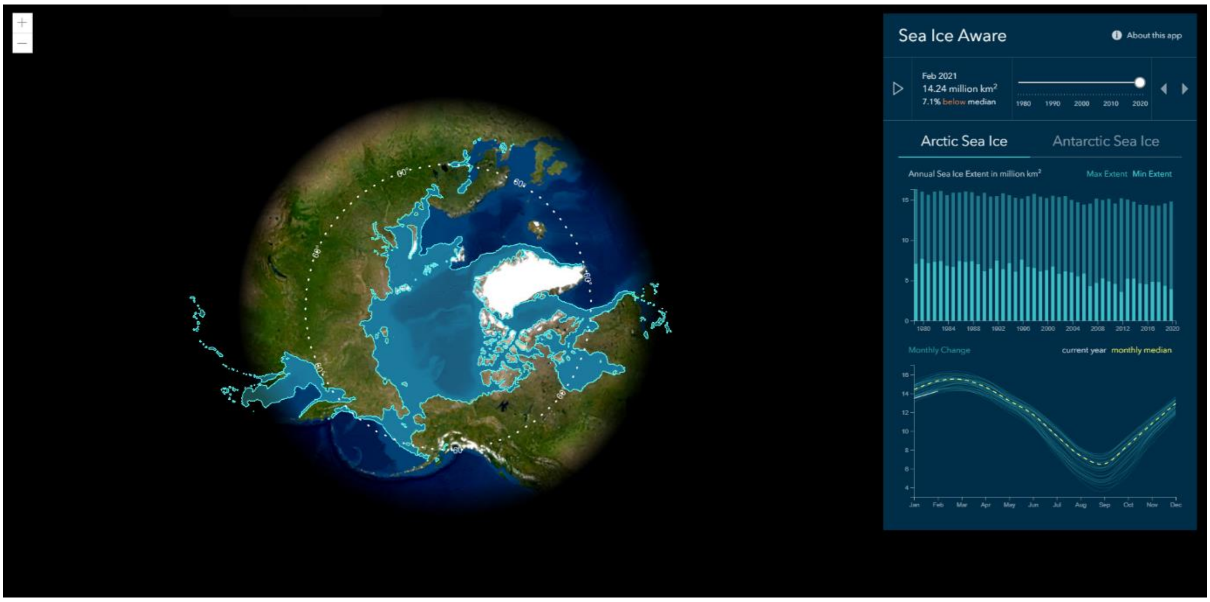
Section 1: Sea Ice

This section will introduce sea ice change through an interactive map showing both Arctic and Antarctic sea ice. [ArcGIS Living Atlas of the World](https://livingatlas.arcgis.com) is a collection of geographic information from around the globe, including maps, apps, and data layers to support your work.

1.1. Accessing ArcGIS Living Atlas of the World

a. Go to https://livingatlas.arcgis.com/sea-ice/

This should open a map of Arctic sea ice which looks something like this:

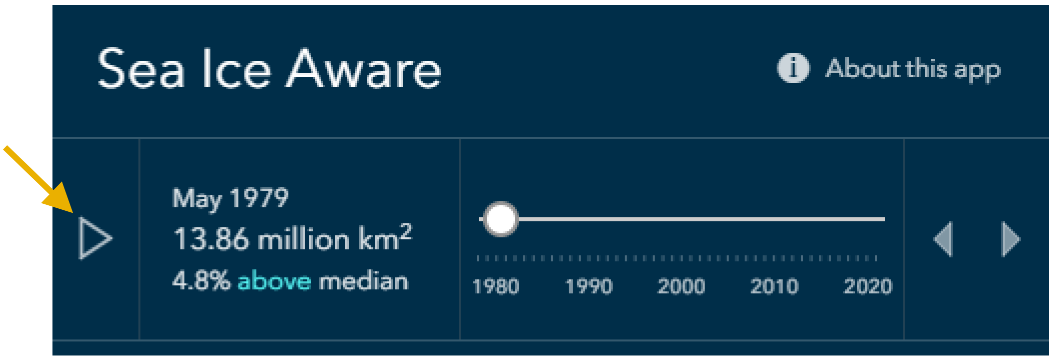


b. This map shows the world from a top-down view, with the North Pole in the centre of the map.

You can drag on the map to move around and use the plus and minus in the top left corner to zoom in and out.

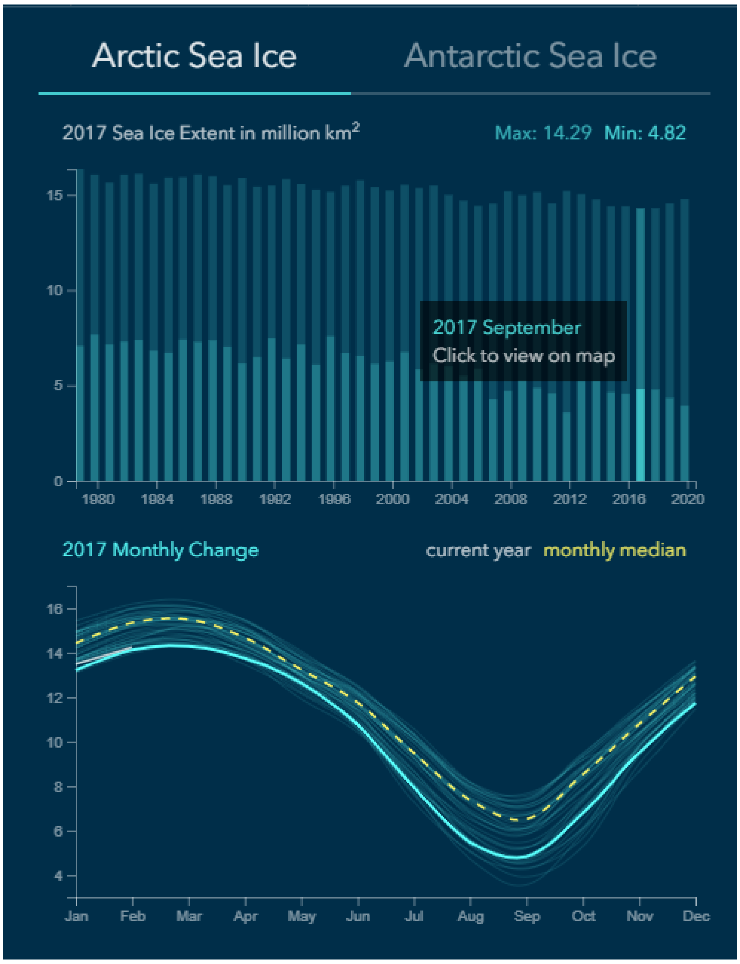
1.2. Visualising Ice Extent Over Time

a. To see how the extent of Arctic sea ice has changed over time, click the 'Play' button.



What trend can you see? Does the amount of sea ice increase or decrease over time?

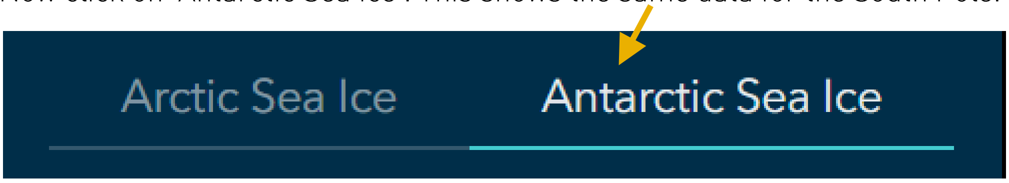
b. You can also look at how the sea ice extent changes through the bar chart and graph.



What trend do you see using the graph? Has sea ice extent dropped below the median (middle value)?

1.3. Visualising Ice Extent Over Space

a. Now click on 'Antarctic Sea Ice'. This shows the same data for the South Pole.



b. By using both the map and the graphs, can you identify any differences and similarities between the two polar regions?

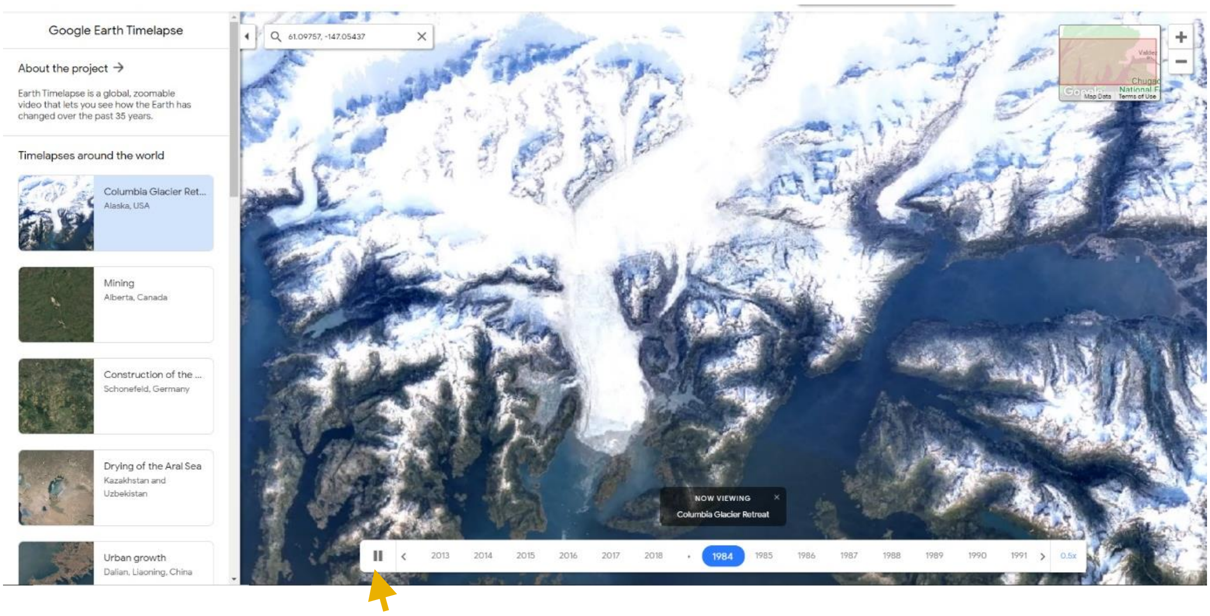
Section 2: Glacial Ice

Sea ice is not the only type of ice which is disappearing from our Earth. Glaciers are a huge store of fresh water which are reducing in size due to global temperatures increasing. This section will introduce how we can look at glacial retreat, and how it can be measured.

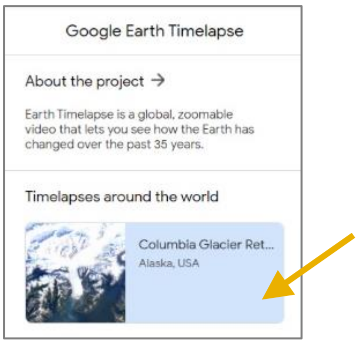
2.1. Envisioning Glacial Ice Retreat

a. Go to https://earthengine.google.com/timelapse/

This will open Google Earth Timeline, which shows a time-lapse of photos taken by satellites in space.



b. Ensure that 'Columbia Glacier Retreat' is selected on the left-hand panel. This will focus the map view on the Columbia glacier, located in Alaska, USA. Then watch the time-lapse from 1984 – 2016.



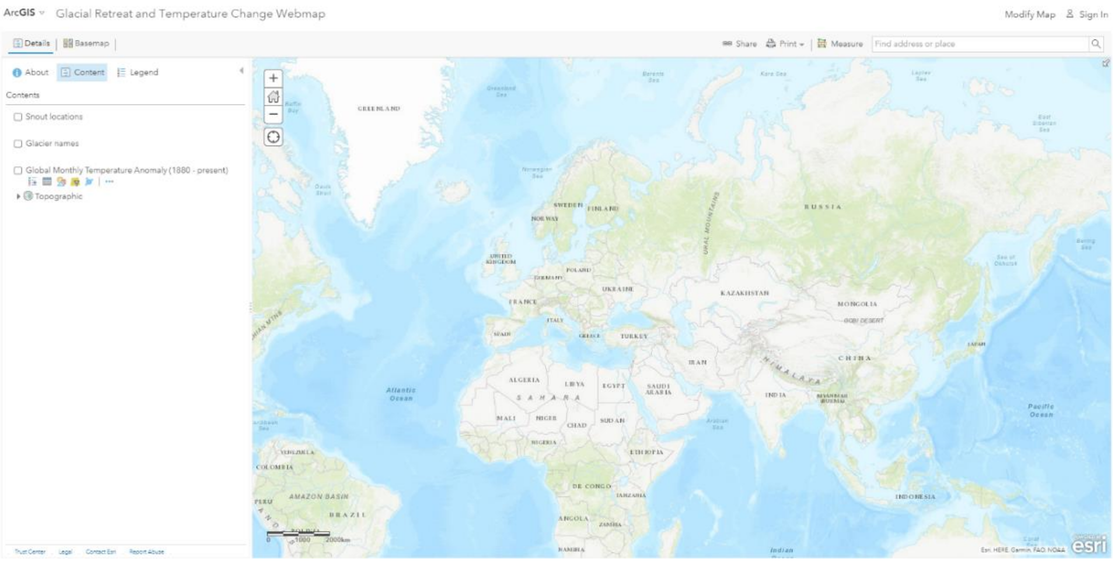
How has the glacier changed over the past 32 years? (Hint: Watch the snout!)

But what do you think caused the change? To understand this, we will use another map.

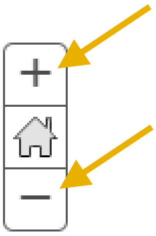
2.2. Accessing ArcGIS Online

a. Go to https://arcg.is/qGb1G

This will take you to a map on ArcGIS Online which looks like this:

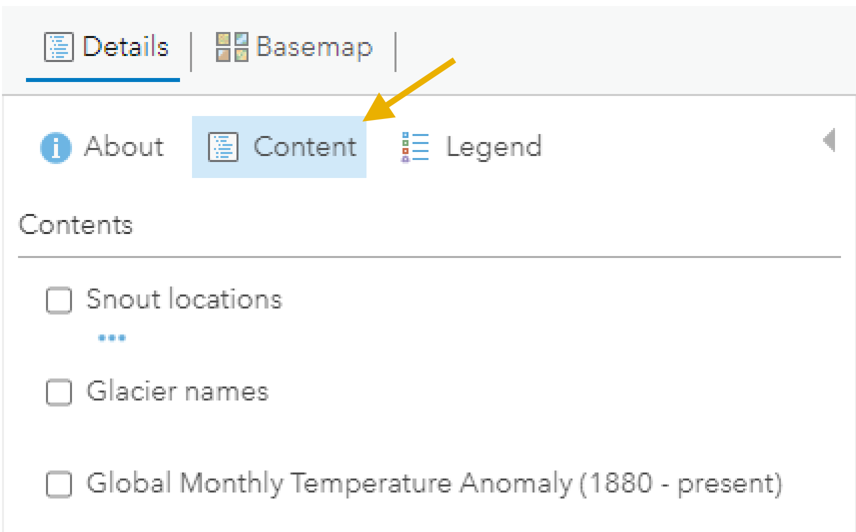


b. You can move around the map by dragging your mouse. Use the plus and minus symbols to zoom in and out.



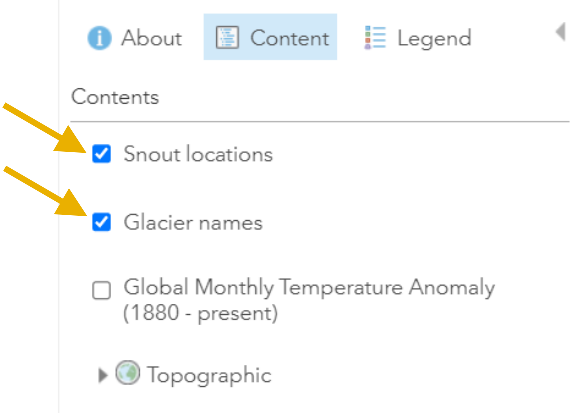
c. Click on the 'Content' tab to show what is displayed on the map.

In this instance we see there are three layers listed.

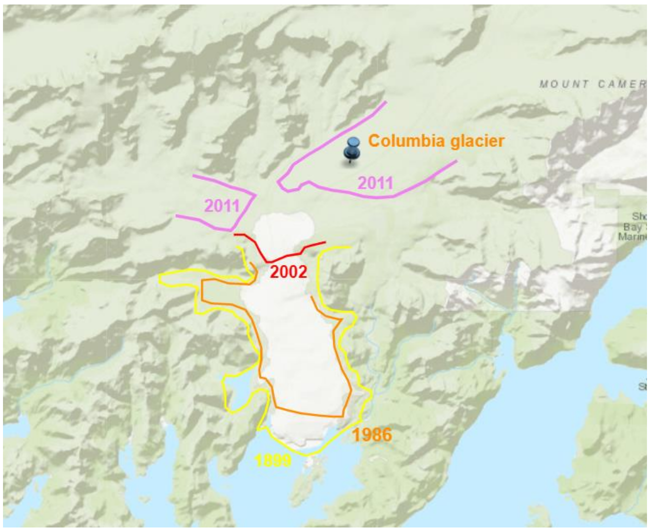


d. To view a layer, select the box next to the layer. You can disable a layer using the same box.

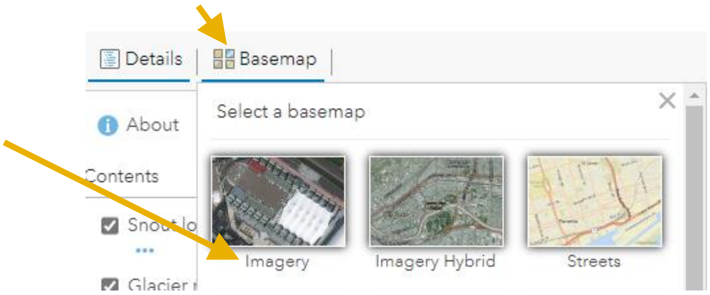
e. Enable the layers called 'Snout locations' and 'Glacier names'.



f. Zoom to the Columbia glacier in Alaska, USA, as previously seen on the Google Earth time-lapse.

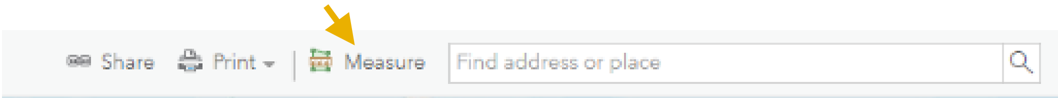


g. We can change the basemap to imagery to get a better understanding of what the glacier looks like. Select the 'Basemap' tab, then click on 'Imagery'. This view will help to visualise the change that has occurred.

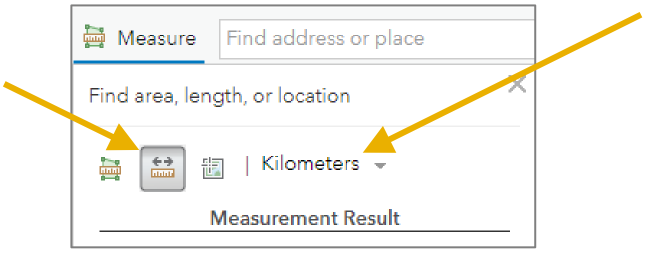


2.3. Measuring Glacial Retreat

a. We can measure the change in terms of how far the glacier has retreated. Click on the 'Measure' tool in the top right-hand corner.



b. Click on the second icon across to measure distance. Set the units to 'Kilometres' using the dropdown options.



Now, if you click two points anywhere on the map, you can measure the distance between the points. Double click to stop measuring.

c. Measure the distance between the historical glacial snouts to see how the glacial extent changed over time. Begin by measuring the distance from the 1899 extent (yellow line) to the 2011 extent (purple line). Record the distance in the table provided.

d. As the glacier extents are not straight edges, we can calculate the common average (also known as the mean) distance by taking 5 measurements, adding them together and then dividing them by the number of measurements taken. Calculate the mean distance for each of the years – 1988, 1986 and 2002.

Measurement Number	1899 Distance to 2011 extent (km)	1986 Distance to 2011 extent (km)	2002 Distance to 2011 extent (km)
1			
2			
3			
4			
5			
Total Distance (km)			
Mean Distance (km)			
Rate of Change (km/yr)			

e. You can also calculate the rate of change by dividing the mean distance by the number of years since 2011. To do this, use the following calculation:

Rate of change = mean distance value ÷ number of years before or since 2011

For example, if the mean distance from the snout in 1899 to the snout in 2011 is 18.6 km, we can calculate the rate of change as:

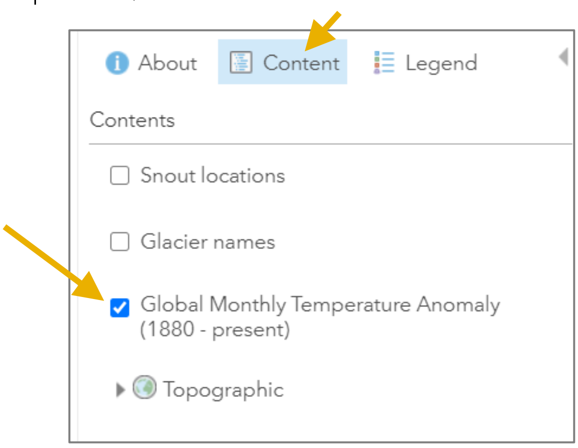
Rate of change = 18.6 ÷ 112 = 0.166 km/year

f. Does the rate of retreat surprise you for any particular time span? Why do you think this may be? Think about the factors that cause a glacier to melt.

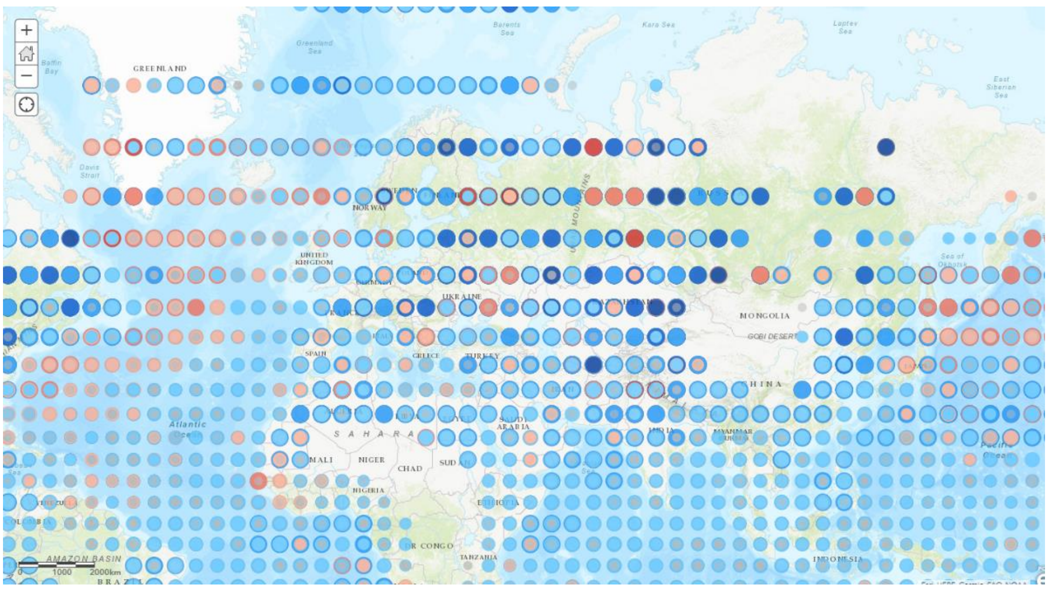
2.4. Global Temperature Anomalies

a. We can investigate what the temperature was like during the same time periods.

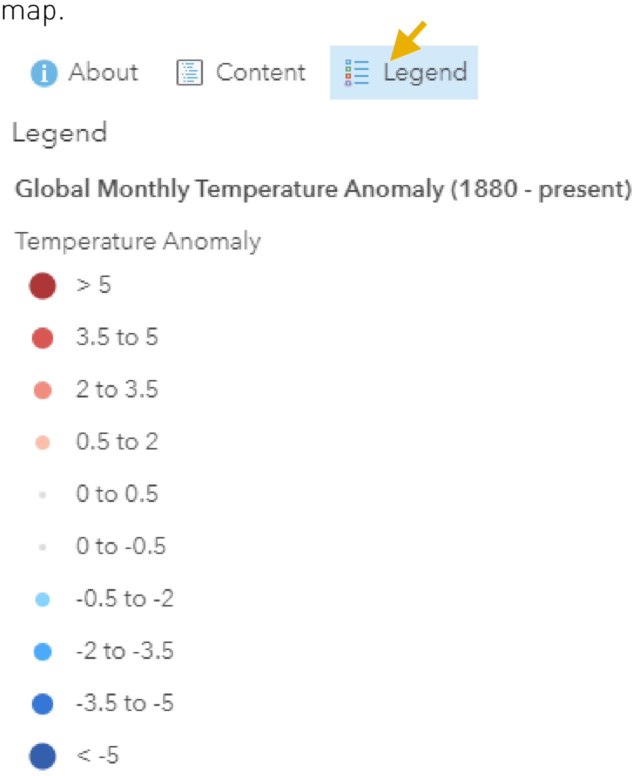
Click on the 'Content' tab. Ensure that the box next to 'Global Yearly Temperature Anomaly (1880 - present)' is ticked.



By clicking on this box, a layer is enabled. The map will now look like this:



b. Now click on the 'Legend' tab. The legend is where we find information about what is shown on the map.



c. This tells us that the map is showing anomalies in temperature, with areas of red showing high anomalies, and blue showing low anomalies. The values are measured in °C.

Because this is a map of anomalies, it does not tell us what temperature an area is. Instead, it tells us how far from the average temperature a location is at any point in time.

d. Zoom out so you can see at least one of the temperature dots near the Columbia glacier.

e. Next, click 'Play' on the timescale at the bottom of the map again. Let it move until it reaches a range which the date you are interested in (for example, 1899, 1986, 2002 or 2011).

What colour was the dot at this time? Does it indicate high or low temperatures?

What about the time periods either side? Do they show high or low temperatures too?

f. Now repeat for the other glacier locations - Athabasca (Canada), Upsala (Argentina), Sólheimajökull (Iceland) and Storbreen (Norway).

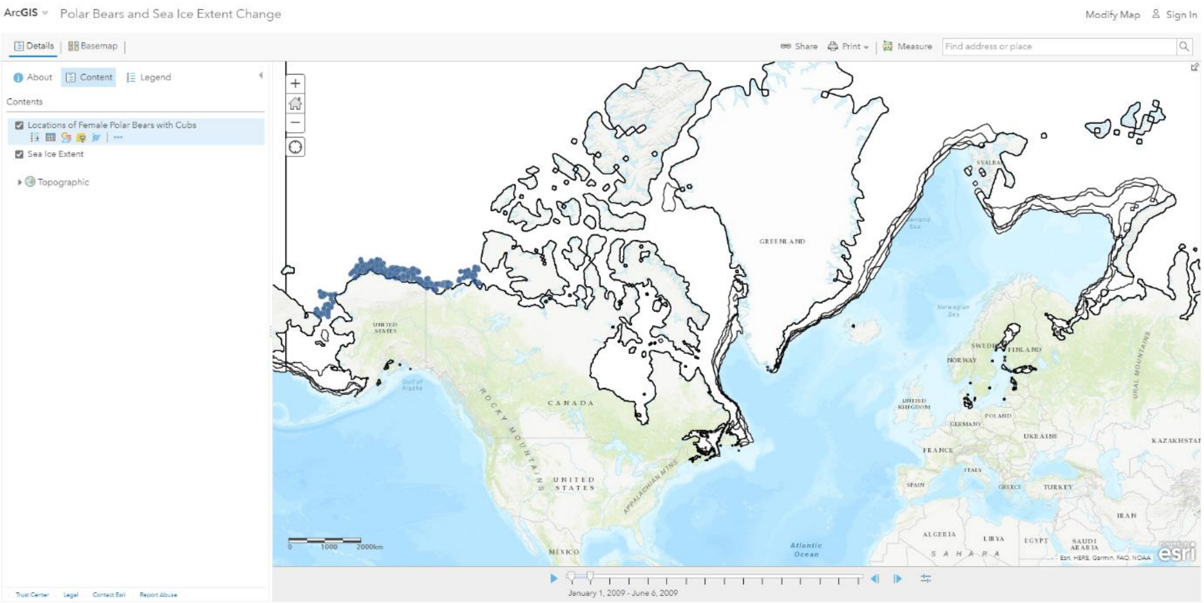
Section 3: Effect on Wildlife

This section looks at the effects of changing amounts of sea ice on wildlife. Polar bears live in the Arctic, where the extent of sea ice changes often. This section will show how polar bear's habitat has changed around Northern Alaska over time.

3.1. Visualising Temporal Wildlife Change

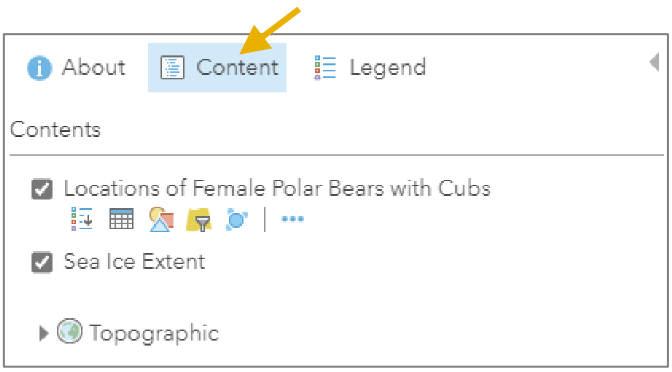
a. Go to https://arcg.is/1nyHe80

This will bring up a map on ArcGIS Online which will look like this:



b. Click on the Content tab to show what is displayed on the map.

In this instance we see the location of female polar bears with cubs shown as blue dots, and the extent of sea ice shown as white polygons.



c. Zoom into the area where polar bears are located.

d. Now selected the 'Play' button at the bottom of the map.

This will show how the extent of sea ice has changed over time, along with the location of polar bears. You may want to pause regularly to allow for all the items to load.

e. What trend do you see between sea ice and polar bears? Does the month have an effect?

Section 4: Summary

This activity demonstrates how visualising change over space or time can help us to identify areas of change, or in this instance, particularly high levels of sea ice or glacial retreat. This activity also shows how to calculate the rate of glacial retreat by measuring the distance between two glacial extents at different times. By linking this to global temperature anomalies, we can see why ice melt occurs (or doesn't). This activity also highlighted the effects of ice melt on wildlife populations.

If you want to investigate further, repeat Section 2.2 – 2.4 with other glacier locations - Athabasca (Canada), Upsala (Argentina), Sólheimajökull (Iceland) and Storbreen (Norway).

Alternatively, for more information about global warming and sea ice, have a look at these links:

Global Temperature Change

- https://www.ncdc.noaa.gov/cag/global/time-series
- https://climatedataguide.ucar.edu/climate-data/global-temperature-data-sets-overview-comparison-table

Antarctic Sea Ice Change

- https://www.bas.ac.uk/
- https://nsidc.org/data/google_earth/
- https://nsidc.org/data/masie/
- https://www.nationalgeographic.org/interactive/introduction-sea-ice/

Glacial Retreat

- http://www.glims.org/maps/glims
- https://www.gislounge.com/creating-time-series-visualization-two-decades-changes-glacier/
- https://learngis.maps.arcgis.com/apps/Cascade/index.html?appid=6b07883769dd48eea629750cfa1ea924
- https://www.eea.europa.eu/data-and-maps/indicators/glaciers-2/assessment

Arctic Seabird Migration Habits

- http://seabirdtracking.org/mapper/?node=sphenisciformes
- https://www.gbif.org/dataset/f7c30fac-cf80-471f-8343-4ec5d8594661

This concludes the exercise.

Geospatial UK

This activity was created by Newcastle University on behalf of Geospatial UK.

For more resources or activities, visit

www.geospatialuk.org

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