Understanding Water Level in a Changing Arctic

Teacher Guide

Background Information

Follow the Water Understanding River Discharge Dynamics in Rapidly Changing High Northern Latitudes

The Follow the Water Project is led by Dr. Eric Klein, a Geology professor from the University of Alaska, Anchorage. The research team is trying to understand how shifts in air temperature, caused by an increase in atmospheric carbon dioxide, are causing changes in the cryosphere and subsequently the Arctic water cycle. They are studying watershed systems that are fed by glaciers connected and disconnected from the ice sheet in Qaanaaq and Pituffik, Greenland.

The Arctic is changing four times faster than any other part of the planet and these changes cause various impacts on different Earth systems. In the past, the Arctic was much cooler and most of the water was frozen for at least part of the year. In a changing Arctic, some of the water that was previously locked in the sea ice or ice sheet is evaporating and entering the atmosphere creating changes in the water cycle and weather patterns, or it is melting and entering streams changing river flow.

To better understand these changes, Dr. Klein's team is looking at three main characteristics of these Arctic watersheds. They're studying the volume of water flowing through river systems, the timing for spikes in water flow, and the characteristics of the water.

This lesson will focus on the timing in spikes in water flow by introducing students to the pressure transducer data logger that measure water depth. It does this my taking hydrostatic pressure measurements which is the weight of the water column above the sensor. Students will learn how to use the hydrostatic pressure formula:

$$Z = \frac{P_1 - P_0}{g * \rho_1}$$

Z = *water depth in meters*

P_1 = *absolute pressure (kPa)*

P_0 = *barometric pressure(kPa)*

g = *Earth's gravitational acceleration constant at the poles* m/s^2 *is 9.83208*

ρ_1 = *density* kg/m^3

Lesson Overview

To get students interested, the lesson will start with a hands-on activity to help them understand how the characteristics of the water can tell scientists a lot about where it is coming from. Students will make red, blue and yellow ice cubes. They will melt the ice on watercolor paper and observe what happens. They will be asked to think about thawing permafrost, melting ice sheets and glaciers when they record their observations. This fun experiment will help them see how melting ice introduces carbon into the watershed.

Next, they will visit the ArcGis StoryMap ***Understanding Water Level in a Changing Arctic*** www.arcg.is/1DmLuS2 to learn more about Greenland and about the Follow the Water Project. The StoryMap will guide them on a journey with the research team to learn how water level is measured using a pressure transducer data logger that collects hydrostatic pressure measurements. They will be introduced to the hydrostatic pressure formula:

$$Z = \frac{P_1 - P_0}{g * \rho_1}$$

Z = water depth in meters
P_1 = absolute pressure (kPa)
P_0 = barometric pressure(kPa)
g = Earth's gravitational acceleration constant at the poles m/s^2 is 9.83208
ρ_1 = density kg/m^3

Once they have solved all 20 water level measurements they will graph their data. They will create a line graph that shows water level and water temperature (on the same graph) for a 24-hour period. Next they will answer questions about the relationship between water temperature and water depth. Finally, they will compare their graph to another graph that shows an unprecedented rain event and rapid increase in water depth. They will answer questions about the graph.

Teaching the Lesson

Introduction

Introduce students to the lesson by explaining that polar researchers work in the Arctic and Antarctic to better understand those environments. The Follow the Water project is a team of researchers led by Dr. Eric Klein from the University of Alaska Fairbanks. The team is trying to understand river discharge dynamics in rapidly changing high northern latitudes. Explain that the students are going to learn more about Dr. Klein's work and help him solve for water depth so that the team can understand how high northern latitudes are changing in a warming polar region. Hand out the student guide to each student.

Melting Ice Activity

Materials:

- student guide
- pencil
- Ice cube trays
- water
- food coloring
- water color paper
- tray
- rock

Help the students make colorful ice cubes and tell them that each color represents carbon locked in the ice. Tell them that the blue cube is carbon locked in glaciers, the red cube is carbon locked in the ice sheet, and the yellow cube is carbon locked in the permafrost.

Students will place the watercolor paper in trays and put their ice on the paper. They will make observations of the ice every 15 minutes.

Questions to ask:

- *What is happening to the carbon that was stored in the glaciers, ice sheet, and permafrost?*
- *Do they see green, orange, or purple on their paper? Can they trace those colors back to the source?*
- *How does this represent what might be happening in the Arctic?*
- *What do you think are the implications of these changes?*

Historically the Arctic was a carbon sink where carbon was captured and stored. With warmer temperatures and additional precipitation, ice that held carbon is melting and releasing the carbon into the watersheds and atmosphere. Locally this impacts aquatic ecosystems, but it also has implications for the global ocean carbon cycle. Additional carbon leads to Ocean Acidification and additional carbon entering the atmosphere leads to warmer temperatures, and more precipitation speeding up the rate at which glaciers, ice sheet, and permafrost is melting.

StoryMap

Materials:

- student guide
- pencil
- computer

Ask the students to use their computers to access the StoryMap at www.arcg.is/1DmLuS2 or scan the QR code if using iPads.

The students will scroll through the StoryMap. Encourage them to click on the video to learn the pronunciation for Kalaallit Nunaat and to click on the links on the map for Pituffik and Qaanaaq to learn more about those places. As they scroll down, they will see on a map where Pituffik and Qaanaaq are located and they will see pictures from those places. They can click on the pictures to zoom in, and they can click on the + and - in the corner of the map to zoom in and out.

Encourage the students to watch the the *Following the Water in Greenland* YouTube video to better understand Dr.Klein's research project.

In the next section the students will be invited to join the research team into the field to collect water depth data. Any of the vocabulary that is underlined is linked to a website with a definition. Encourage students to take their time and to click on the words to get the definitions.

Students will be presented with the equation for determining water depth. You may want to solve the first one or two problems together and then encourage them to work with a partner to solve for the rest.

Answer key for Water Level

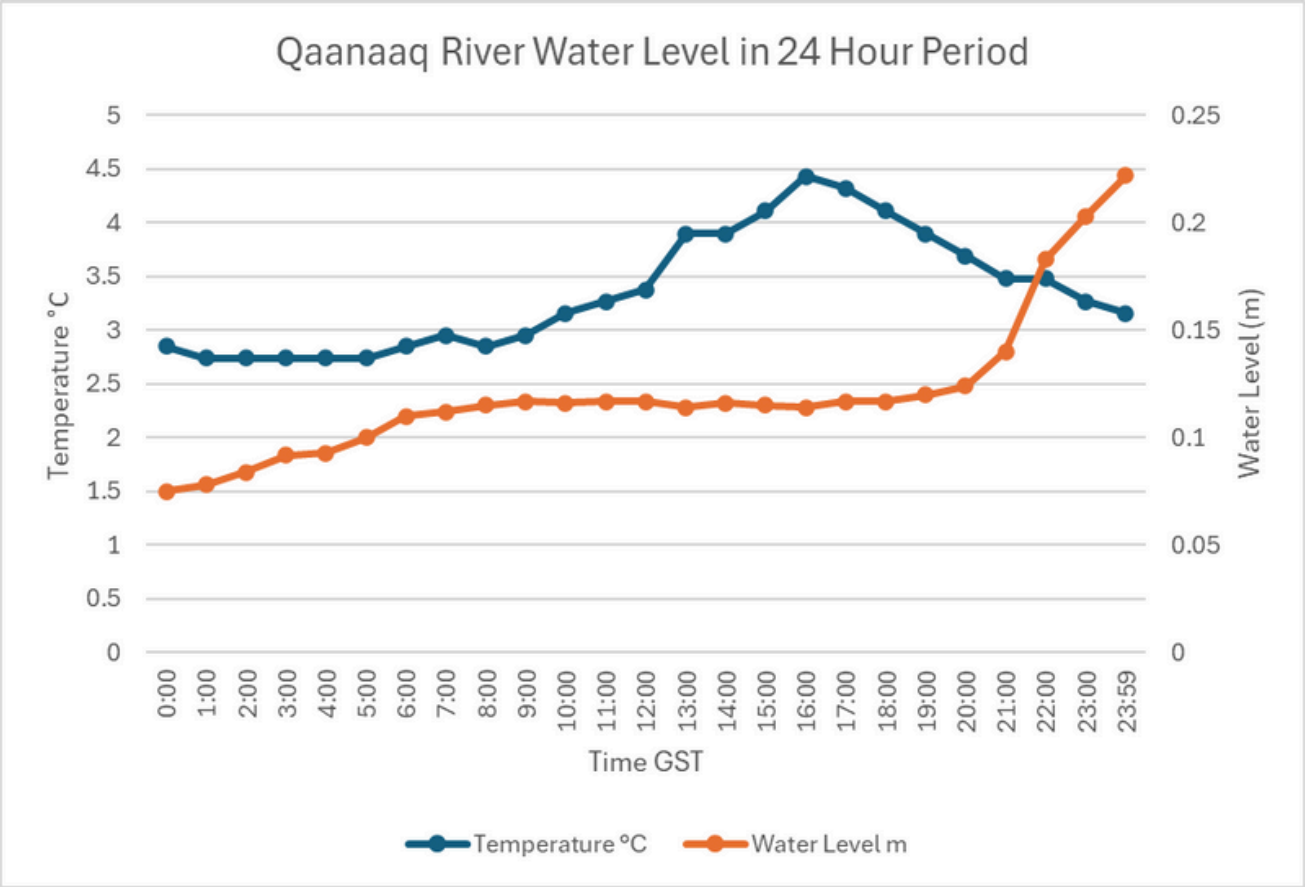
Date-Time (Greenland Daylight Time)	Absolute Pressure (kPa)	Temperature (°C)	Barometric Pressure (kPa)	Density (kg/m³)	Water Level (m)
7/11/2025 0:00	99.333	2.85	98.6	999.98	0.075
7/11/2025 1:00	99.297	2.74	98.527	999.991	0.078
7/11/2025 2:00	99.201	2.74	98.371	999.991	0.084
7/11/2025 3:00	99.105	2.74	98.199	999.991	0.092
7/11/2025 4:00	98.999	2.74	98.082	999.991	0.093
7/11/2025 5:00	98.989	2.74	98.007	999.991	0.1
7/11/2025 6:00	99.044	2.85	97.958	999.98	0.11
7/11/2025 7:00	99.056	2.95	97.951	999.97	0.112
7/11/2025 8:00	99.097	2.85	97.968	999.98	0.115
7/11/2025 9:00	99.07	2.95	97.916	999.97	0.117
7/11/2025 10:00	98.983	3.16	97.839	999.949	0.116
7/11/2025 11:00	98.942	3.27	97.796	999.938	0.117
7/11/2025 12:00	98.905	3.38	97.75	999.927	0.117
7/11/2025 13:00	98.761	3.9	97.645	999.875	0.114
7/11/2025 14:00	98.655	3.9	97.515	999.875	0.116
7/11/2025 15:00	98.52	4.11	97.392	999.854	0.115
7/11/2025 16:00	98.483	4.43	97.365	999.822	0.114
7/11/2025 17:00	98.437	4.32	97.291	999.833	0.117
7/11/2025 18:00	98.342	4.11	97.189	999.854	0.117
7/11/2025 19:00	98.309	3.9	97.125	999.875	0.12
7/11/2025 20:00	98.305	3.69	97.088	999.896	0.124
7/11/2025 21:00	98.431	3.48	97.064	999.917	0.14
7/11/2025 22:00	98.835	3.48	97.036	999.917	0.183
7/11/2025 23:00	99.076	3.27	97.077	999.938	0.203
7/11/2025 23:59	99.286	3.16	97.105	999.949	0.222

Graphing the Data

Materials:

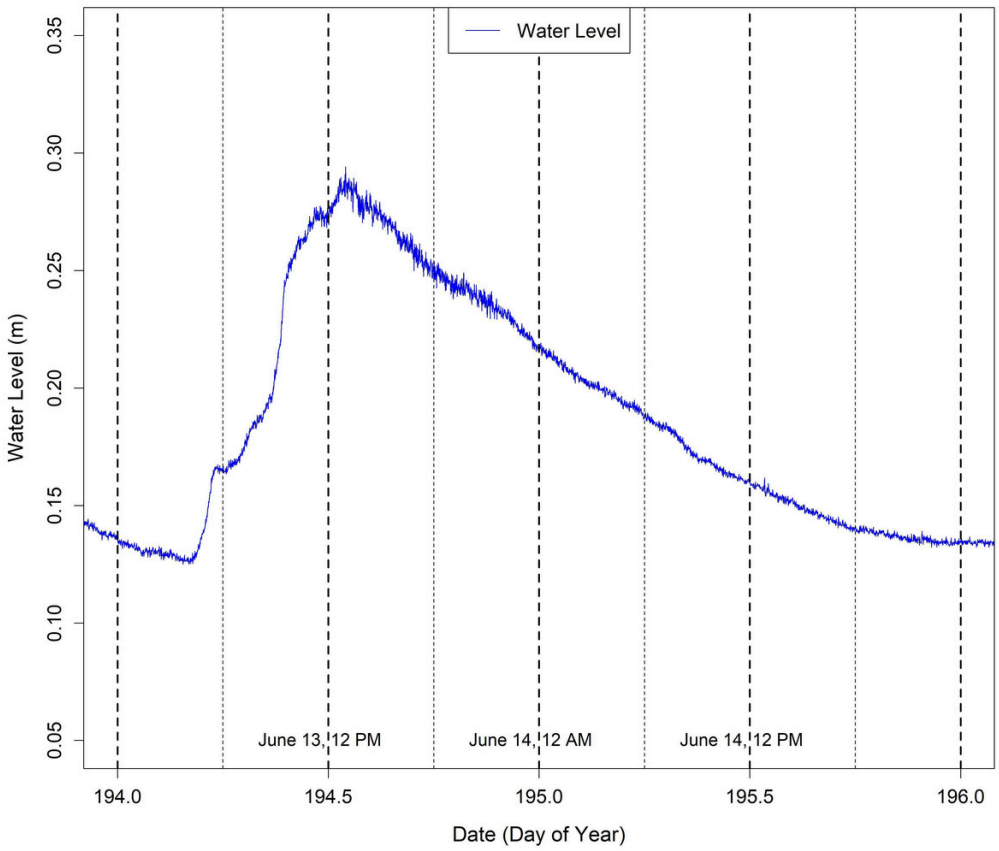
- student guide
- pencil
- water depth measurements
- water temperature measurements
- graph paper
- colored pencils
- ruler

The students will use the data to create a line graph with water temperature and water depth measurements.



Comparing Data

Students will use the graph below to compare data. The graph below shows what happens to Qaanaaq River during a heavy rain event- the water level rises rapidly. Students will answer questions c



Questions to ask:

- How could a rain event cause water to rise? The rain itself contributes more water to the river, but it also increases the rate at which the ice sheet melts or the permafrost thaws.

- Remember the ice experiment? What might happen when the ice sheet melts or the permafrost thaws? What might enter into the river?

- What are the short-term impacts of abnormal rain events? What are the long-term impacts**?**

Conclusion

In this changing Arctic, some of the water that was previously locked in permafrost or the ice sheet is evaporating and entering the atmosphere. This creates changes in the water cycle and changes in weather patterns. Historically, heavy rain fall was incredibly uncommon in the high Arctic, however it is becoming more common and more frequent causing changes in water level.

What are the impacts? This is what polar researchers are trying to figure out. After completing the graphing activities have a discussion with your students about what they predict the impacts of a warmer, wetter Arctic will be and if there are solutions for slowing the rate at which the Arctic warms.

For additional reading share this site with your students:
https://www.earthobservatory.nasa.gov/images/152575/the-arctic-is-getting-rainier