



THE GLOBE PROGRAM

A worldwide science and education program



Hydrosphere ● **Water Temperature
Protocol Using a Probe**





Overview

This module:

- Reviews the selection of a GLOBE hydrology site
- Reviews the water sampling technique used in GLOBE hydrology protocols
- Guides the calibration of the necessary instruments for this protocol
- Provides a step by step introduction of the protocol method

Learning Objectives

After completing this module, you will be able to:

- Describe why water temperature is considered a master variable
- Explain why this measurement accompanies all other hydrology measurement taken using GLOBE protocols
- Describe how the protocol procedures ensure the collection of accurate data
- Apply the calibration and measurement steps of this protocol
- Upload data to the GLOBE portal
- Visualize data using GLOBE's Visualization System

Estimated time to complete this module: 1.5 hours



A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

E. Entering data on GLOBE Website.

F. Understand the data.

G. Quiz yourself



A. What is water temperature?

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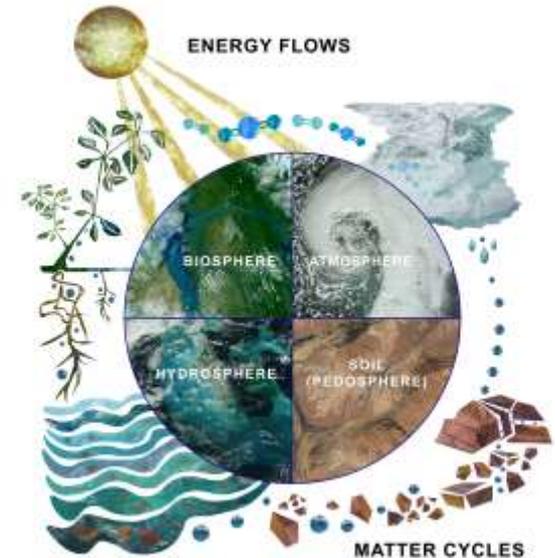
G. Quiz yourself

H. Additional resources

The Hydrosphere

The hydrosphere is the part of the Earth system that includes water, ice and water vapor. Water participates in many important natural chemical reactions and is a good solvent. Changing any part of the Earth system, such as the amount or type of vegetation in a region or from natural land cover to an impervious one, can affect the rest of the system. Rain and snow capture aerosols from the air. Acidic water slowly dissolves rocks, placing dissolved solids in water. Dissolved or suspended impurities determine water's chemical composition.

Current measurement programs in many areas of the world cover only a few water bodies a few times during the year. GLOBE Hydrosphere protocols will allow you to collect valuable data to help fill these gaps and improve our understanding of Earth's natural waters.



The Earth System: Energy flows and matter cycles.



What is Water Temperature?

The measurement of water temperature determines how hot or cold the water is.

Water temperature is sometimes called a **master variable** because almost all properties of water, as well as chemical reactions taking place in it, are affected by it. Most of the GLOBE Hydrosphere Protocols require water temperature measurements.

Sudden increases or decreases of water temperature are unusual. Water has a **higher heat capacity** (specific heat) than air, thus it heats and cools more slowly.

<u>GLOBE Hydrosphere Measurements</u>
Hydrosphere Study Site
Water Temperature
Water Transparency
Conductivity
pH
Mosquito Larvae
Alkalinity
Dissolved Oxygen
Salinity
Nitrates
Freshwater Macroinvertebrates

- A. What is water temperature?
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The Water Cycle

Water temperature is important for understanding local and global weather patterns. Water temperatures change differently than air temperatures because water has a higher heat capacity than air. Water also helps to change air temperature through the processes of evaporation and condensation. The flow of energy, the hydrologic cycle and weather are closely connected.

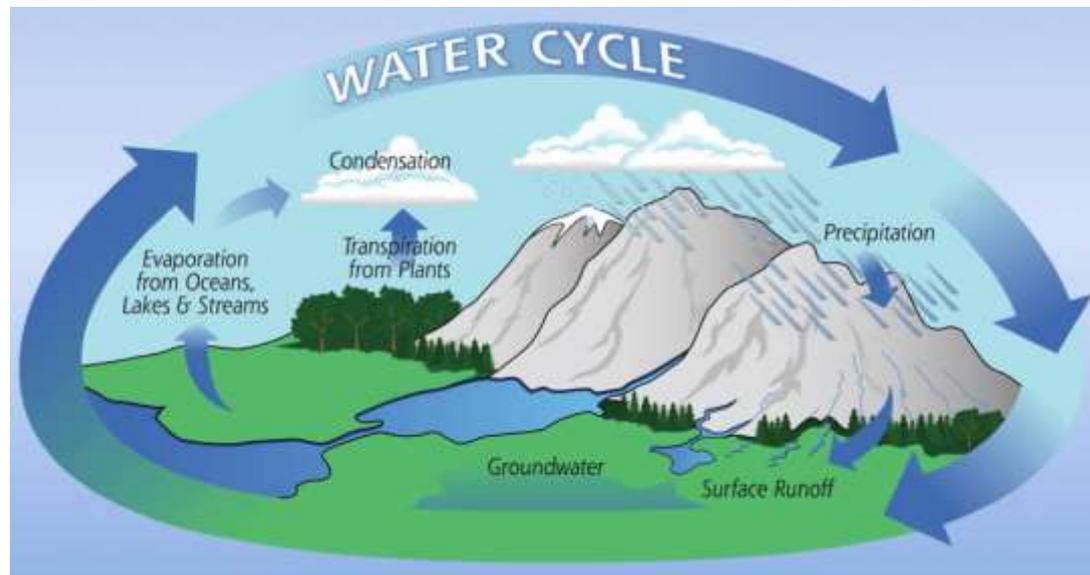


Image Credit: NASA

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Why Collect Water Temperature Data?

Temperature influences the amount and diversity of aquatic life. Lakes that are cold and have little plant life in winter, bloom in spring and summer when water temperatures rise and the nutrient-rich bottom waters mix with the upper waters. Because of this mixing and the warmer water temperatures, the spring overturn is followed by a period of rapid growth of microscopic aquatic plants and animals.



Many fish and other aquatic animals also spawn at this time of year when the temperatures rise and food is abundant. Shallow lakes are an exception to this cycle, as they mix throughout the year.

Water temperature is also important because warm water can be fatal for sensitive species, such as trout or salmon, which require cold, oxygen-rich conditions. Warmer water tends to have lower levels of dissolved oxygen.

A. What is water temperature?

B. Why collect water temperature data?

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Why Collect Water Temperature Data-2

Temperature influences the amount and diversity of aquatic life. Lakes that are cold and have little plant life in winter, bloom in spring and summer when water temperatures rise and the nutrient-rich bottom waters mix with the upper waters. Water temperature determines the density of water. Water is at its most dense at **4 °C**. Because of this mixing and the warmer water temperatures, the spring **overturn** is followed by a period of rapid growth of microscopic aquatic plants and animals. Many fish and other aquatic animals also spawn at this time of year when the temperatures rise and food is abundant. Shallow lakes are an exception to this cycle, as they mix throughout the year.

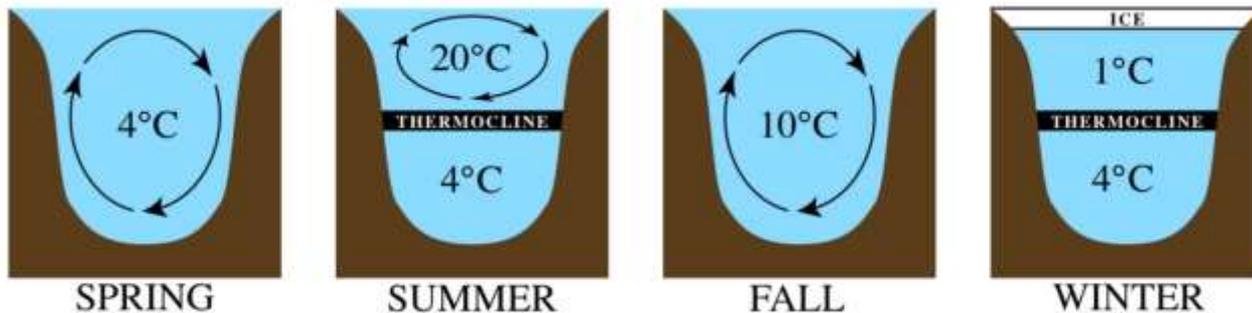


Image: Wikipedia Commons

A. What is water temperature?

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How Your Measurements Can Help

Your water temperature measurements can help in different ways. At the local scale, you are monitoring your local water body and over time keeping track on how it is changing throughout the seasons and over the years.

On a regional and global scale, yours and other GLOBE measurements of water temperature data are helping to better understand hydrologic and energy cycles.



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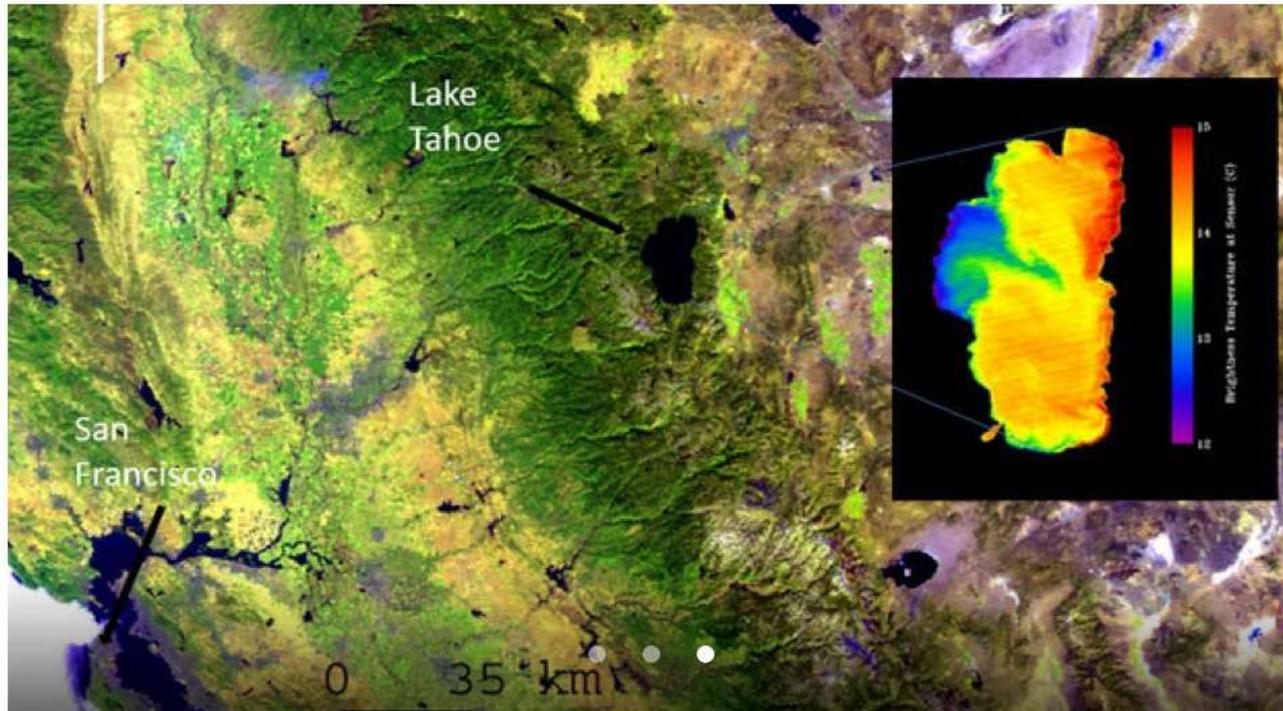
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Climate change is warming Earth's lakes

Climate change is rapidly warming lakes around the world, threatening freshwater supplies and ecosystems. Several large lakes are seen in this image of the California/Nevada border region acquired by the MODIS instrument on NASA's Terra spacecraft. The inset image of Lake Tahoe, from the ASTER instrument on Terra, shows the lake's temperature variations- from about 15 degrees C (red) to about 12.5 degrees C (blue) Credit: NASA.



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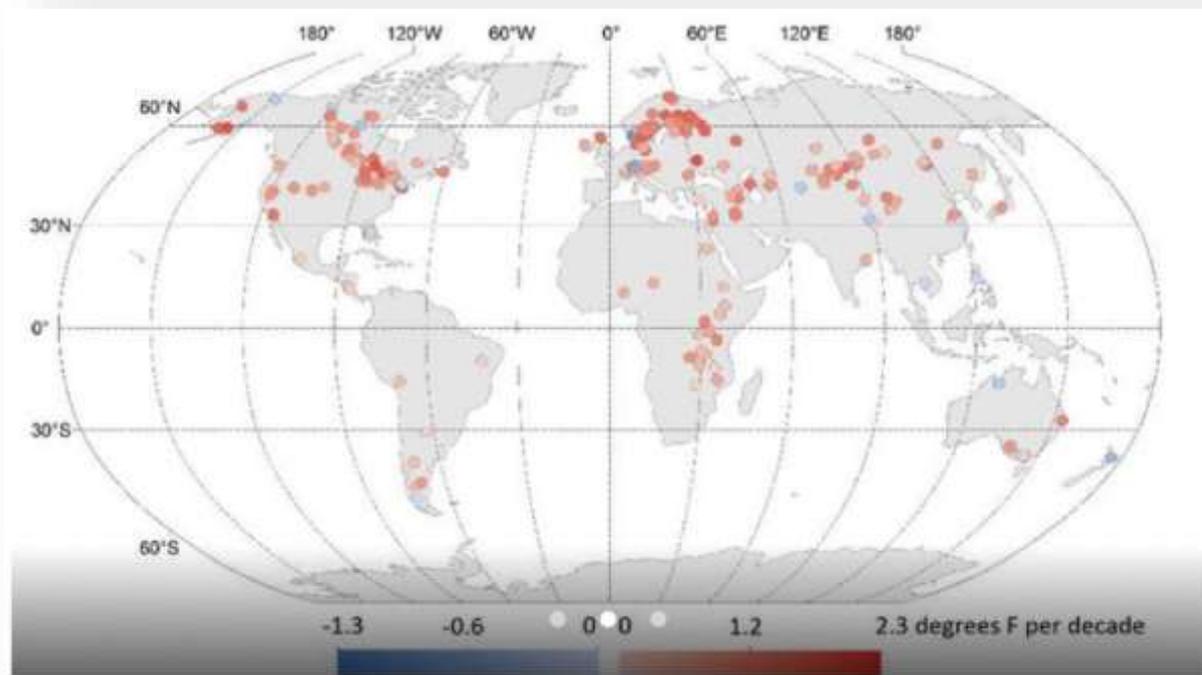
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Ground-based Observations Validate Satellite Data



Global changes in lake temperatures over the past 25 years. Red shades indicate warming; blue shades indicate cooling. The study found Earth's lakes are warming about 0.34 degrees Celsius per decade on average, faster than overall warming rates for the ocean or atmosphere. Credit: Illinois State University/USGS/California University of Pennsylvania. Story: [NASA JPL](#)

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Let's do a quick review before moving onto data collection! Question 1

Why does the water warm and cool more slowly than the same volume of air?

- A. It has a higher heat capacity than air
- B. Air has a higher specific heat
- C. It is a master variable
- D. A and B only

What is the answer?

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

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Let's do a quick review before moving onto data collection! Answer to Question 1

Why does the water warm and cool more slowly than the same volume of air?

- A. It has a higher heat capacity than air 😊 correct!**
- B. Air has a higher specific heat
- C. It is a master variable
- D. A and B only

Were you correct?

A. What is water temperature?

B. Why collect water temperature data?

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G. Quiz yourself

H. Additional resources



Let's do a quick review before moving onto data collection! Question 2

Warmer water tends to have _____ levels of oxygen.

- A. Higher
- B. Lower

What is the answer?

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

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Let's do a quick review before moving onto data collection! Answer to Question 2

Warmer water tends to have _____ levels of oxygen.

- A. Higher
- B. Lower 😊 **Correct!**

Were you correct?

A. What is water temperature?

B. Why collect water temperature data?

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D. How to collect your data.

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Let's do a quick review before moving onto data collection! Question 3

Recent scientific studies of lakes and other water bodies around the Earth are displaying a overall ___ trend.

- A. Warming
- B. Cooling
- C. Stable and unchanging

What is the answer?

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

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Let's do a quick review before moving onto data collection! Answer to Question 3

Recent scientific studies of lakes and other water bodies around the Earth are displaying a overall ___ trend.

- A. Warming 😊 **Correct!**
- B. Cooling
- C. Stable and unchanging

Were you correct?

Let's now look at the GLOBE protocol steps for the water temperature protocol using a temperature probe.

A. What is water temperature?

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Site Selection: Hydrosphere Study Site

A. What is water temperature?

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H. Additional resources

Select a specific site where the hydrosphere measurements (water temperature, dissolved oxygen, nitrate, pH, alkalinity, turbidity, and either conductivity or salinity) will be taken. If the selected study site is a moving body of water (i.e. stream or river), locate your sampling site at a riffle area as opposed to still water or rapids. This will provide a more representative measurement of the water in the stream or river.



If the selected study site is a still body of water i.e. a lake or reservoir), find a sampling site near the outlet area or along the middle of the water body. Avoid inlet areas. A bridge or a pier are good choices. If your water body is brackish or salty, you will need to know the times of high and low tide at a location as close as possible to your study site.



How to Collect Water Temperature Data

A. What is water temperature?

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There are two ways to ways to collect water temperature for GLOBE: using alcohol-filled thermometers or a probe. This slide stack will discuss the calibration and use of the thermometer probe.

When using temperature probes, you will hear references to either temperature probes or meters. For clarification, **probes are the instruments that measure voltage or resistance in a water sample. Meters are instruments that convert voltage or resistance measurements to concentrations.** In order to measure temperature (or other types of measurements), both a probe and meter are required. Sometimes the probe and meter are within one instrument and cannot be taken apart. Other instruments have probes that are separate from the meters and need to be connected to the meters in order to take the water measurements.





How to Collect Water Temperature Data: Measurement Procedures

A. What is water temperature?

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Except for transparency, take water temperature before the other water measurements.

Take the water temperature measurement as soon as possible after the water sample is taken because temperature tends to change very rapidly after a sample is collected.

Read the temperature value on the meter while the probe is in the water. The temperature reading can change quickly once the thermometer is out of the water, especially if the air temperature is very different from the water temperature or if it is windy. Wind can cause evaporation to occur rapidly, lowering the temperature.

It is important that the water temperature be taken at the same place every week. There may be several degrees of difference in water temperature over a small area in your water body: sunny areas vs. shady areas, or shallow and deeper areas.





How to Collect Water Temperature Data: Instrument Care

1. The probe should be stored with the cap on.
2. The probe should be well rinsed with distilled water after use to avoid mineral deposit accumulation.
3. The probe should periodically be cleaned with alcohol.



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Start your Fieldwork and Lab Work with Safety Steps

Safety is important when conducting the Hydrosphere protocols. While you will need to use your judgment in selecting only hydrosphere study sites that are safe to access and sample, additional precautions are needed:

- Students should wear protective gloves and goggles when handling water samples and chemicals to avoid splashing on exposed areas.
- When doing GLOBE Hydrosphere Protocols, it is important to protect students from exposure to biting insects, including mosquitoes. Ask your students to wear clothes that cover the body so there is little bite area exposed. It is also advisable to apply insect repellent if you are sampling during the mosquito breeding season.



SAFETY be sure students wear gloves and goggles during your investigations



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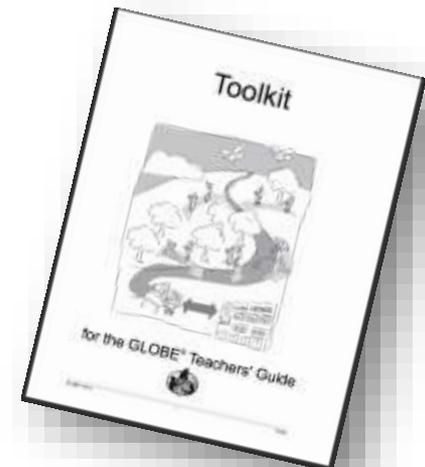
H. Additional resources



Sources for Equipment You Need for the Water Temperature Protocol

The following resources summarize the measurements associated with each protocol, associated skill level, scientific specifications for the instruments, and how to access the equipment you need (purchase, build, or download).

- [Where to find specifications for instruments used in GLOBE investigations](#)
- [Where to find scientific instruments used in GLOBE investigations](#)



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What do you need to start?

When	weekly (if possible)
Where	Hydrosphere Study Site
Time Needed	10 minutes
Prerequisites	Hydrosphere Study Site
Key Instrument	Temperature probe

References:

- [Hydrosphere Investigation Data Sheet](#)
- [Water Temperature Protocol for Thermometer Probes Field Guide](#)
- [Calibrating an Alcohol-filled Thermometer Lab Guide](#)

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Water Temperature Protocol

Assemble Equipment

- Calibrated meter and probe
- Latex gloves/goggles
- Pen or pencil
- Clock or watch

For Calibration:

- - Thermometer
- - 400 mL ice
- - Distilled water
- - 500 mL beaker



A. What is water temperature?

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How To Collect Your Water Temperature Data: Instrument Calibration

Temperature meters must be calibrated before use. Check with your meter manufacturer to be sure it stores the most recent calibration. If it does, the temperature meter should be calibrated in the classroom or lab before going to the Hydrosphere Study Site. If your meter does not keep the most recent calibration, you will need to calibrate it just before you take your measurements taking care not to turn the meter or any associated software off.



Pay close attention to your calibration procedure. Without the calibration step your temperature data will not be meaningful or comparable to data collected by others!

A. What is water temperature?

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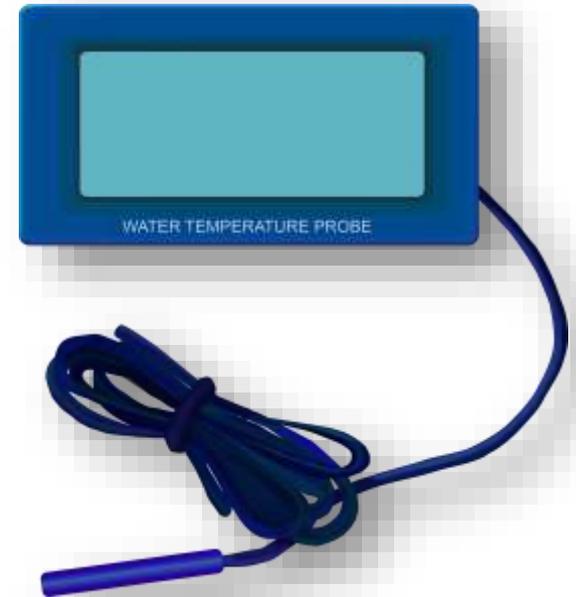
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Calibration Steps: 1-7

1. Make sure that your temperature probe and meter have been calibrated within the last 24 hours (see *Manufacturer's Instructions*)
2. Fill out the top portion of your *Hydrosphere Investigation Data Sheet*.
3. Put the probe or the into the sample water to a depth of 10 cm.
4. Leave the probe in the water for three minutes.
5. Read the temperature on the meter without removing the probe from the water.
6. Let the thermometer probe stay in the water sample for one more minute.
7. Read the temperature again. If the temperature has not changed, go to Step 8. If the temperature has changed since the last reading, repeat Step 6 until the temperature stays the same.



Pay close attention to your calibration procedure. Without the calibration step your temperature data will not be meaningful or comparable to data collected by others!

A. What is water temperature?

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Calibration Steps: 8-11

8. Record the temperature on the *Hydrosphere Investigation Data Sheet*.
9. Have two other students repeat the measurement with new water samples.
10. Calculate the average of the three measurements.
11. All temperatures should be within **1.0° C** of the average. If they are not, repeat the measurement.

Hydrosphere Investigation Data Sheet – Page 4

Water Temperature: Measured with (check one) alcohol-filled thermometer probe

Temperature Test 1: _____ °C

Temperature Test 2: _____ °C

Temperature Test 3: _____ °C

Comments: _____

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

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H. Additional resources



Let's do a quick review before moving onto GLOBE data reporting and visualization. Question 4

True or False: Temperature probes must be calibrated before use.

What is the Answer?

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

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G. Quiz yourself

H. Additional resources



Let's do a quick review before moving onto GLOBE data reporting and visualization. Answer to Question 4

True or False: Temperature probes must be calibrated before use.

The answer is True.

Were you correct?

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

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G. Quiz yourself

H. Additional resources



Let's do a quick review before moving onto GLOBE data reporting and visualization. Question 5

All temperatures should be within _____ of the average.

- A. 1.0° C of the average of 3 replicate readings of the sample
- B. .5° C of the average of 3 replicate readings of the sample
- C. they need to all be the identical, otherwise repeat the measurements

What is the answer?

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

E. Entering data on GLOBE Website.

F. Understand the data.

G. Quiz yourself

H. Additional resources



Let's do a quick review before moving onto GLOBE data reporting and visualization. Answer to Question 5

All temperatures should be within _____ of the average.

- A. 1.0° C of the average of 3 replicate readings of the sample 😊
Correct!
- B. .5° C of the average of 3 replicate readings of the sample
- C. they need to all be the identical, otherwise repeat the measurements

Were you correct?

Now let's review how to report your data to GLOBE.

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

E. Entering data on GLOBE Website.

F. Understand the data.

G. Quiz yourself

H. Additional resources



Report Data to the GLOBE Database

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

E. Entering data on GLOBE Website.

F. Understand the data.

G. Quiz yourself

H. Additional resources

- **Live Data Entry**: Upload your data to the official GLOBE science database
- GLOBE science database
- Email Data Entry: Send data in the body of your email (not as an attachment) to **DATA@GLOBE.GOV**
- Mobile Data App: Download the GLOBE Science Data Entry app to your mobile device and select the right option.
- For Android via **Google Play**
- For IOS via the **App Store**

The GLOBE Program
Science Data Entry

The GLOBE mobile app allows GLOBE users to perform data entry on a large number of GLOBE science protocols. To use this app, you will need a GLOBE account.

I have a GLOBE account:

Sign In

JOIN GLOBE | CONTACT GLOBE



Entering your data via Live Data Entry or Data Entry Mobile App- Step 1

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

E. Entering data on GLOBE Website.

F. Understand the data.

G. Quiz yourself

H. Additional resources

Welcome to the GLOBE data entry site. x

My Bookmarks

You have not bookmarked any investigations yet. Expand the organizations and click the stars next to the investigations to create a bookmark.

My Organizations and Sites

- [University of Nebraska-Lincoln GLOBE v-School](#) Add site

+ [Lefthand Creek](#)
Latitude 40, Longitude -105, Elevation 1600m
Edit site | Delete site

Hydrology

Freshwater Macroinvertebrates ★
New observation Past observations

Integrated Hydrology ★
New observation Past observations

Mosquitoes ★
New observation Past observations

select →



Entering your data via Live Data Entry or Data Entry Mobile App- Step 2

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

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H. Additional resources

1. Select water body state

2. Select protocol

4. Click to send data

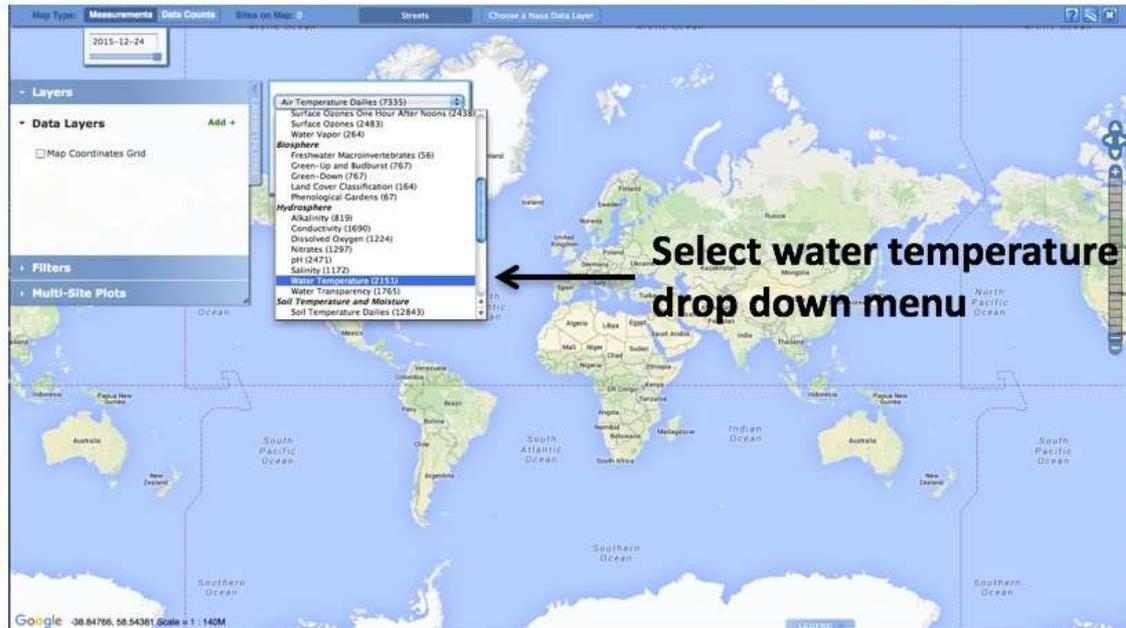
3. Enter each measurement and click "add"

You are done! Want to check who else has submitted temperature data using the GLOBE Visualization System?



Visualize and Retrieve Water Temperature Data- Step 1

GLOBE provides the ability to view and interact with data measured across the world. Select our [visualization tool](#) to map, graph, filter and export water temperature data that have been measured across GLOBE protocols since 1995. Here are screenshots steps you will use when you use the visualization tool:



[Link](#) to step-by-step tutorial on using the GLOBE Data Visualization Tool

A. What is water temperature?

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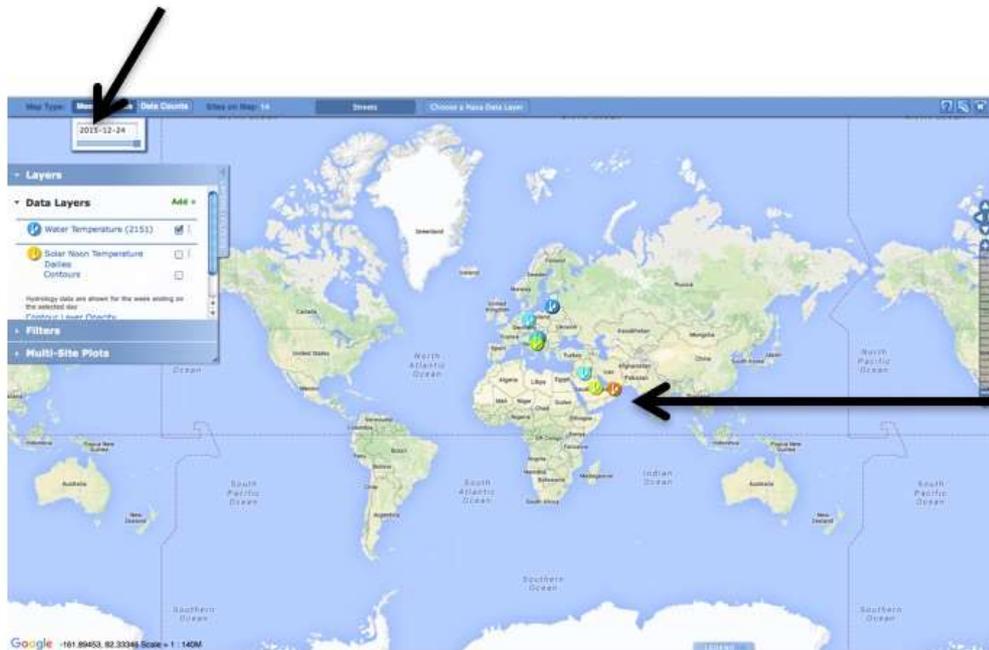
G. Quiz yourself

H. Additional resources



Visualize and Retrieve Water Temperature Data- Step 2

Select the date for which you need water temperature data, add layer and you can see where data are available:



Locations where water temperature data are available for the dates you selected

[Link](#) to step-by-step tutorial on using the GLOBE Data Visualization Tool

A. What is water temperature?

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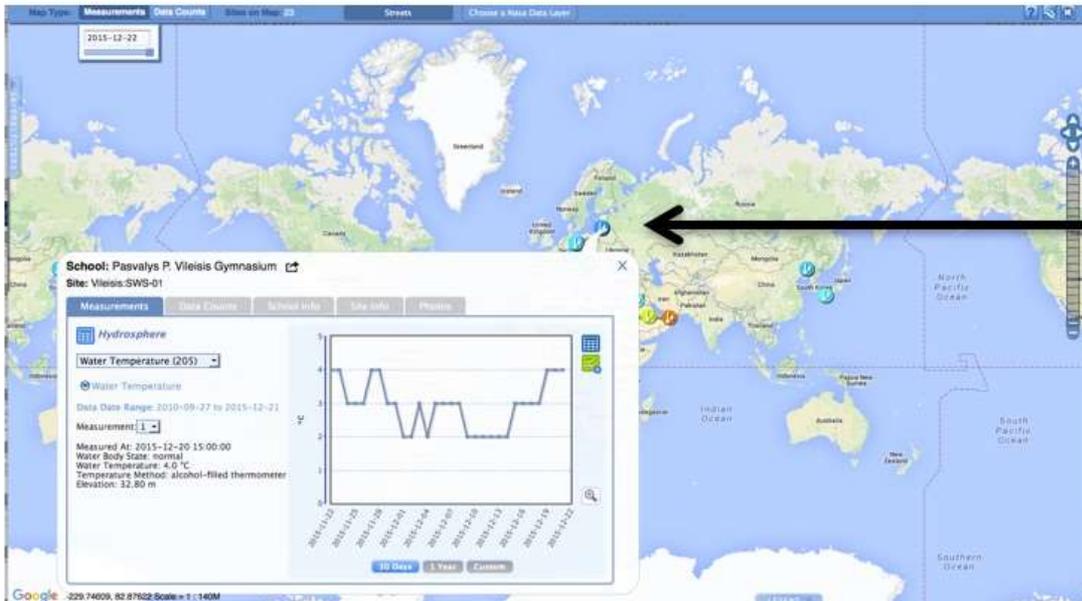
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Visualize and Retrieve Water Temperature Data- Step 3

- Select the sampling site for which you need water temperature data, and a box will open with data summary for that site.



Clicking on a location will open to a map note providing water temperature data for that location and time. Follow instructions in the tutorial to download data as a .csv file for analysis.

A. What is water temperature?

B. Why collect water temperature data?

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H. Additional resources



Review questions to help you prepare to conduct the water temperature protocol

1. Which measurement should you take first, if you are conducting water protocols: dissolved oxygen, pH, or temperature?
2. Do you read the water temperature measurement when the probe or thermometer is in the water, or held just above the water surface?
3. What step must be conducted on the instruments before the water temperature measurement is made?
4. All three replicate measurements should be within ____ ° C of the average.
5. Water has a (higher/lower) heat capacity than air, so it heats and cools more (slowly/quickly).
6. Warmer water tends to have higher/lower concentrations of dissolved oxygen.
7. Where would you get the most representative water temperature sample: from a still area of the water, from rapids, or from a riffle?
8. What are the safety precautions you should take when doing any of the hydrology protocols?

A. What is water temperature?

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Are you ready to take the quiz?

- You have now completed the slide stack. If you are ready to take the quiz, sign on and take the quiz corresponding to **Water Temperature Protocol**.
- You can also review the slide stack, post questions on the discussion board, or look at the FAQs on the next page.
- When you pass the quiz, you are ready to **Water Temperature Protocol** measurements!

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

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F. Understand the data.

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FAQ: Frequently Asked Questions

A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

E. Entering data on GLOBE Website.

F. Understand the data.

G. Quiz yourself

H. Additional resources

- **I noticed on the GLOBE Web site that some schools were reporting water temperatures below 0.0° C. Is this possible?**
- Yes. Distilled water will freeze at 0.0° C, but adding dissolved particles in the water may lower the freezing point.
- **Why is the water temperature sometimes colder and sometimes warmer than the air temperature?**
- Water has a higher *specific heat than* air. This means it takes water longer to heat up and longer to cool down than it does air. As a result, air responds much more quickly than water to changes in temperature.



Please provide us with feedback about this module. This is a community project and we welcome your comments, suggestions and edits!

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Questions about the content in the module? Contact rlow@ucar.edu

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More Information:

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[NASA Global Climate Change: Vital Signs of the Planet](#)

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A. What is water temperature?

B. Why collect water temperature data?

C. How your measurements can help

D. How to collect your data.

E. Entering data on GLOBE Website.

F. Understand the data.

G. Quiz yourself

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