THE GLOBE PROGRAM
A worldwide science and education program

Hydrosphere • Electrical Conductivity

Overview

This module:

- Reviews the selection of a GLOBE hydrology site
- Reviews the water sampling technique used in GLOBE hydrology protocols
- Provides a step by step introduction of the protocol method

Learning Objectives

After completing this module, you will be able to:

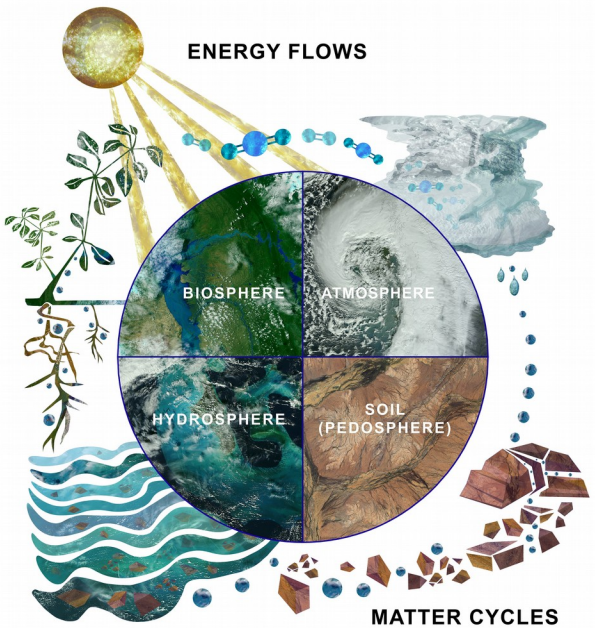
- Define electrical conductivity and explain how environmental variables result in different measurements
- Describe the importance of instrument calibration in the collection of accurate data
- Conduct water electrical conductivity measurements
- Upload data to the GLOBE portal
- Visualize data using GLOBE's Visualization System

Estimated time to complete this module: 1.5 hours.

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.



What is Electrical Conductivity?

- Electrical conductivity measures **the capacity of water to transmit an electrical current**. This capacity is directly related to the concentration of salts in the water. We call the amount of mineral and salt impurities in the water the **total dissolved solids** (abbreviated TDS). We use electrical conductivity as an indirect measure to find the TDS of water.
- Salts **disassociate** into positively and negatively charged ions in solution, and the ions conduct electricity. Inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate are present in water as negatively charged ions (anions). Sodium, magnesium, calcium, iron and aluminum are present in water as positively charged ions (cations). Pure water is a poor conductor of electricity.
- The electrical conductivity meter measures **how much electricity is being conducted through a centimeter of water**.

GLOBE Hydrosphere Measurements

Hydrosphere Study Site

Water Temperature

Water Transparency

Conductivity

pH

Mosquito Larvae

Alkalinity

Dissolved Oxygen

Salinity

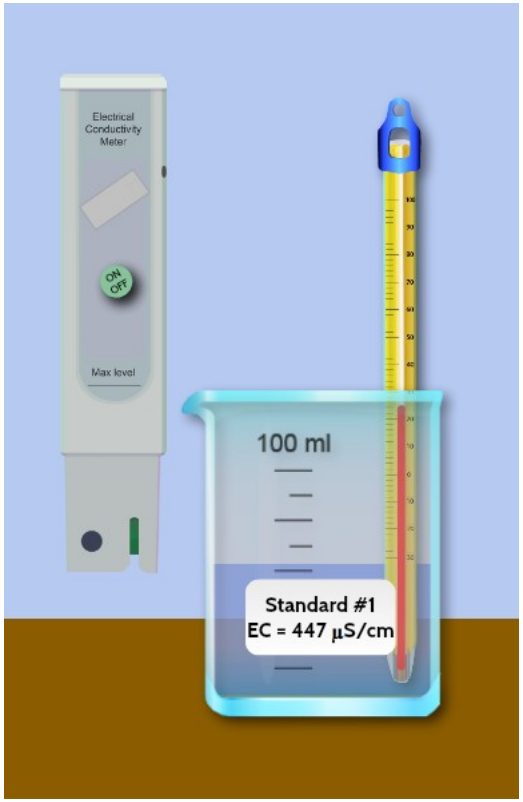
Nitrates

Freshwater Macroinvertebrates

How does temperature affect electrical conductivity?

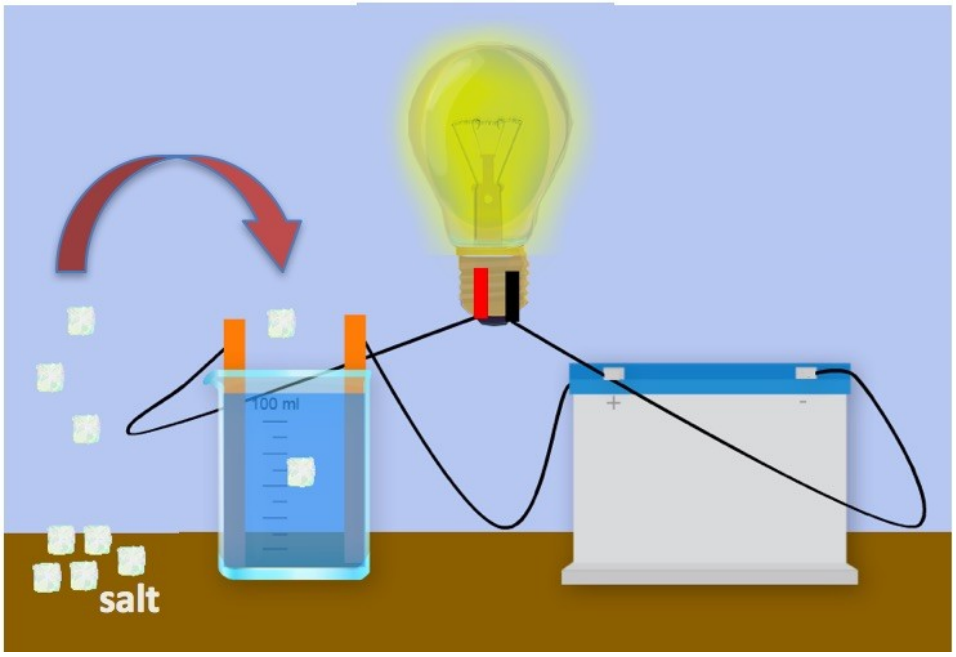
Temperature also affects electrical conductivity: the higher the water temperature, the higher the electrical conductivity would be. **The electrical conductivity of water increases by 2-3% for an increase of 1 degree Celsius of water temperature.** This is why water temperature readings are also taken when measuring electrical conductivity.

Many measured properties of water change at different temperatures. This is why water temperature is often called a **master variable** in water investigation.



What role do dissolved solids play in the electrical conductivity of water?

As stated earlier, electrical conductivity measures the capacity of water to transmit an electrical current and this capacity is directly related to the concentration of salts in the water. If pure water is in the beaker, the electrical circuit cannot be completed because there are no dissolved led ions to conduct the electricity. If salt is added to the water, the dissolved ions of salt can transmit the charge, and the circuit can be completed and the light bulb lights up!



Why is it important to collect electrical conductivity data?

The local geology through which water flows will affect the electrical conductivity. For instance, streams in areas with granite bedrock tend to have lower electrical conductivity because granite is made of components that do not ionize when eroded into water. Streams that run through areas with clay soils tend to have higher electrical conductivity because they contain compounds that ionize when washed into the water.

How Your Measurements Can Help

Electrical conductivity provides a general measurement of stream water quality. After baseline measurements have been collected, significant changes in conductivity can be an indication of pollution or discharge into a water body. For instance, an oil spill might lower electrical conductivity, and discharged sewage may raise the electrical conductivity.

A low number from 10 to about 200 µS/cm, could be considered to be drinking-water quality. Specific conductance measurement of mine waters in a Colorado study range from 100 to 38,000 µS/cm (USGS 2013).

The Animas River between Silverton and Durango in Colorado, USA, within 24 hours of the 2015 Gold King Mine waste water spill. Credit: Riverhugger, Wikipedia Commons.

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

Which is considered a master variable of water, that is, a changeable property of water that tends to have an effect on other properties being measured?

A. Electrical Conductivity

B. Temperature

What is the answer?

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

Which is considered a master variable of water, that is, a changeable property of water that tends to have an effect on other properties being measured?

A. Electrical Conductivity

B. Temperature – Correct!

Were you correct?

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

A water body with a low electrical conductivity would have:

A. Higher total dissolved solids

B. A high salinity

C. Lower total dissolved solids

D. A and B only

What is the answer?

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

A water body with a low electrical conductivity would have:

A. Higher total dissolved solids

B. A high salinity

C. Lower total dissolved solids- correct!

D. A and B only

Were you correct?

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

Significant changes in electrical conductivity of a water body could be evidence for:

A. Pollution or discharge up stream from the sampling site

B. Increase dissolved solids in a water body

C. A downed power wire

D. All of the above

E. A and B only

What is the answer?

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

Significant changes in electrical conductivity of a water body could be evidence for:

A. Pollution or discharge up stream from the sampling site

B. Increase dissolved solids in a water body

C. A downed power wire

D. All of the above

E. A and B only- correct!

Were you correct?

Let's move to GLOBE data collection!

Electrical Conductivity Protocol: What do you need to start?

When	Weekly, if possible
Where	Hydrosphere Study Site
Time Needed	10 minutes
Prerequisites	Defined the Hydrosphere Study Site
Key Instrument	Electrical Conductivity Meter
Skill Level	All
References	Electrical Conductivity Field Guide Protocol Hydrosphere Investigation Data Sheet

Simultaneous or Prior Investigations Required

The Electrical Conductivity Protocol will allow you to determine the capacity of your water to transmit an electrical current. This protocol is conducted at your **GLOBE Study Site**. You will need to define your **GLOBE Study Site** where you will conduct your **Hydrosphere Investigation** prior to beginning this protocol. The **Hydrosphere Investigation Data Sheet** is used to record all the hydrosphere measurements, including alkalinity. You will also want to map your Hydrosphere Site at some point. Since there is a close connection between alkalinity and pH, it would be helpful to collect pH data along with alkalinity. Additionally, atmospheric measurements of temperature and precipitation are helpful in interpreting the data.

Find your documents here:

GLOBE Study Site Definition Sheet

Hydrosphere Investigation Data Sheet

Mapping your Hydrosphere Study Site Field Guide

Overview of the Electrical Conductivity Protocol

Your task is to measure the electrical conductivity of your water sample. Before you begin, make sure that the water conditions are right:

All water should be brought to room temperature (20 ° - 30 ° C) for testing, even if the manufacturer claims that the meter is temperature compensated. It is very important to take the temperature of the water when doing the conductivity measurement.

If the water at your Hydrosphere Study Site is not between 20 ° - 30 ° C, you need to either let the water warm in the sample bucket or separate container while students take other measurements at the hydrosphere study site, or collect a sample in a water bottle and take back to the classroom. After the water reaches 20 ° - 30 ° C, then you can take the conductivity measurement.

Never immerse the meter totally in water. Only the part indicated in the instructions for the meter should be immersed in water.

Most conductivity meters cannot measure the high conductivity characteristic of salt waters.

Assemble Equipment for Calibration of the EC Instrument

Your task is to measure the electrical conductivity of your water sample. Before you begin, make sure that the sample has the right temperature and salinity to produce an accurate reading.

You will need:

- Electrical conductivity meter
- Thermometer
- Distilled water in a wash bottle
- Paper towels or soft tissue
- 2 100-mL beakers or plastic cups
- Protective gloves
- Small screwdriver
- Standard Calibration solution

Document Links:

- Electrical Conductivity Field Guide Protocol
- Hydrosphere Investigation Data Sheet

Electrical Conductivity Meter

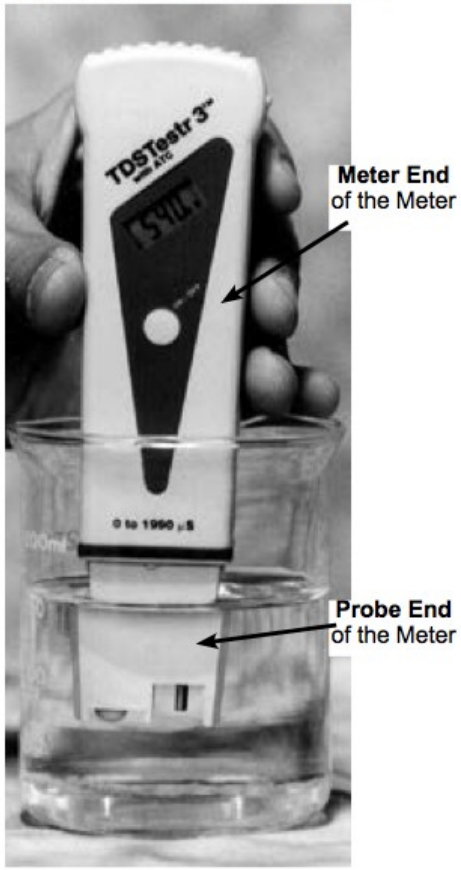
- **Your task is to measure the electrical conductivity of your water sample. Before you begin, make sure that the sample has the right temperature and salinity to produce an accurate reading.**

- The electrical conductivity of a water body can be determined using a portable electrical conductivity meter.

- Conductivity is measured with an electrical conductivity meter. Voltage is applied between two electrodes as the probe end of the meter is immersed in the sample water. The drop in voltage caused by the resistance of the water is used to calculate the conductivity per centimeter.

- There are several manufacturers and models of conductivity meters. Some models may measure conductivity in increments of 10 µS / cm; others in increments of 1.0 µS /cm. If your model measures in increments of 10 µS /cm, you will have to calibrate it as closely as you can to the standard solution.

Figure HY-EC-1: Using the Conductivity Meter



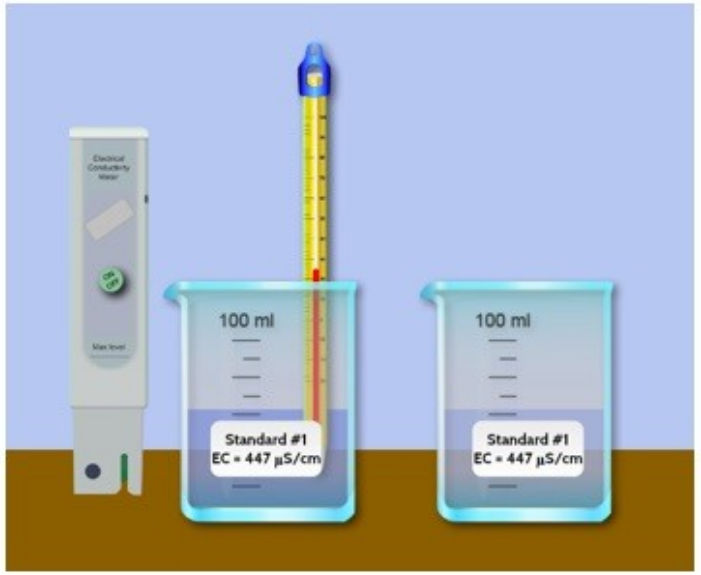
Pay close attention to your calibration procedure. Without the calibration step your electrical conductivity data will not be meaningful or comparable to data collected by others!

Calibration of the Electrical Conductivity Probe (1/2)

Before you take electrical conductivity measurements, you need to ensure that your meter is calibrated and able to take accurate measurements.

Here are the steps:

1. Bring the standard solution to room temperature (about 25° C).
2. Pour standard solution into each of the two clean 100-mL beakers or cups to a depth of about 2 cm.
3. Remove the cap from the electrical conductivity tester and press the On/Off button to turn it on.
4. Rinse the electrode at the bottom of the tester with distilled water in the wash bottle.
5. Gently blot dry with a tissue.



Do not rub or stroke the electrode while drying as it may damage the probe.

Calibration of the Electrical Conductivity Probe (2/2)

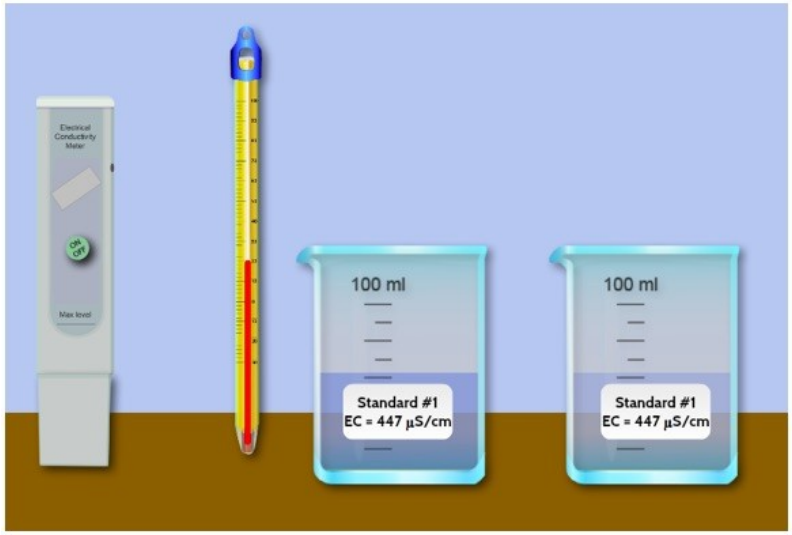
Here are the steps:

Put the probe end of the meter into the first beaker of standard. Stir gently for 2 seconds to rinse off any distilled water.

Take the meter out of the first beaker. DO NOT rinse with distilled water.

Put it into the second beaker.

Stir gently, and then wait for the numbers to stop changing.



If the display does not read the value of your standard solution, you must adjust the instrument to read this number. (For most meters, you can use a small screwdriver to adjust the calibration screw on the meter until the display reads the standard value).

Rinse the electrode with distilled water and blot it dry. Turn off the meter and put the cap on to protect the electrode.

Pour the standard from the beakers into a waste container. Rinse and dry the beakers. **You are done with calibration of your EC meter! Now you are ready to measure the Electrical Conductivity of your sample.**

Assemble Equipment for Electrical Conductivity Protocol

You will need:

- Electrical conductivity meter
- Thermometer
- Distilled water in a wash bottle
- Paper towels or soft tissue
- 2 100-mL beakers or plastic cups
- Protective gloves and eyewear
- Small screwdriver

Links:

- Electrical Conductivity Field Guide Protocol
- Hydrosphere Investigation Data Sheet

Electrical Conductivity Protocol (1/3)

1. Fill out the top portion of the Hydrosphere Investigation Data Sheet.
2. Put on protective gloves.
3. Record the temperature of the water to be tested. If water is **between 20 ° – 30 ° C, go to step 5.**

4. If your water sample is either **below 20 ° C or above 30 ° C,** fill a clean sample bottle (600-700 mL) with the water to be tested. Cap and bring back to the classroom. Allow the water to reach 20 ° – 30 ° C, record the temperature and then proceed to step 5.

Be sure to wear protective gloves And goggles

Electrical Conductivity Protocol (2/3)

5. Rinse two 100-mL beakers two times with sample water.

6. Pour about 50 mL of water to be tested into two 100-mL beakers.

7. Remove the cap from the probe end of the meter. Press the On/Off button to turn it on.

8. Rinse the probe with distilled water. Blot it dry. Do not rub or stroke the electrode while drying.

9. Put the probe in the water sample in the first beaker. Stir gently for a few seconds.

10. Take the probe out of the first beaker. Shake gently to remove excess water, then put it into the second beaker. Do not rinse with distilled water.

11. Leave the probes submerged for at least one minute. When the numbers stop changing, record the value on the Hydrosphere Investigation Data Sheet by Conductivity Test 1.

Electrical Conductivity:
Temperature of water sample being tested: ___°C
Conductivity of standard: ____ MicroSiemens/cm (µS/cm)

Conductivity Test 1: ____ µS/cm

Conductivity Test 2: ____ µS/cm

Conductivity Test 3: ____ µS/cm

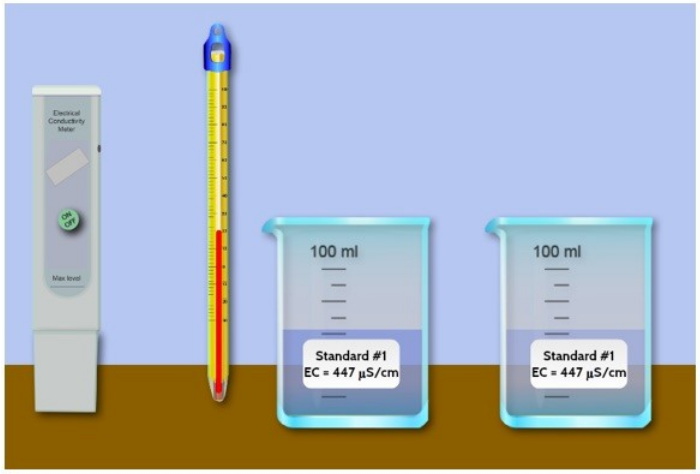
Comments: _____
_____

Do not let the probe end of the meter rest on the bottom of the beaker or touch the sides.

Electrical Conductivity Protocol (3/3)

12. Have two other students repeat the measurement using fresh beakers of water each time. The meter does not need to be calibrated for each student. Record these measurements as Observations 2 and 3.

13. Calculate the average of the three observations.



14. Each of the observations **should be within 40 µS /cm** of the average. If one or more of the values is not within 40 µS /cm, pour a fresh sample and repeat the measurements and calculate a new average.

15. Rinse the probe with distilled water, blot dry, and put the cap on the meter. Rinse and dry the beakers and sample bottle.

You have completed the Electrical Conductivity measurement!

Let's do a quick review before moving onto GLOBE Data Entry! Question 4

What is a critical step you must complete before doing the Electrical Conductivity measurement on your water body?

A. Determine that the water sample is at a temperature of 20° - 30° C

B. Calibrate your Electrical Conductivity Meter

C. Both A and B

What is the answer?

Let's do a quick review before moving onto GLOBE Data Entry! Answer to Question 4

What is a critical step you must complete before doing the Electrical Conductivity measurement on your water body?

A. Determine that the water sample is at a temperature of 20° - 30° C

B. Calibrate your Electrical Conductivity Meter

C. Both A and B- correct!

Were you correct?

Let's do a quick review before moving onto GLOBE Data Entry! Question 5

According to the GLOBE protocol, each of the 3 replicate electrical conductivity observations should be within ___ of the average to be considered valid.

A. within .10 µS /cm

B. within 1.0 µS /cm

C. within 10.0 µS /cm

D. within 40 µS /cm

What is the answer?

Let's do a quick review before moving onto GLOBE Data Entry! Answer to Question 5

According to the GLOBE protocol, each of the 3 replicate electrical conductivity observations should be within ___ of the average to be considered valid.

A. within .10 µS /cm

B. within 1.0 µS /cm

C. within 10.0 µS /cm

D. within 40 µS /cm Correct!

Were you correct?

Let's do a quick review before moving onto GLOBE Data Entry! Question 6

Pure water:

A. Has a high electrical conductivity, and high total dissolved solids

B. Is not a good conductor of electricity

C. Is not a good conductor of electricity except above or below the 20° - 30° C

What is the answer?

Let's do a quick review before moving onto GLOBE Data Entry! Answer to Question 6

Pure water:

A. Has a high electrical conductivity, and high total dissolved solids

B. Is not a good conductor of electricity Correct!

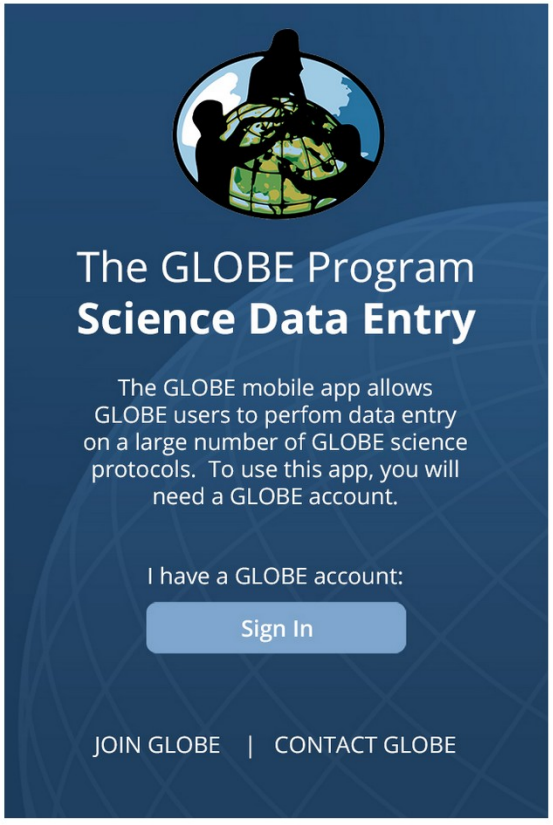
C. Is not a good conductor of electricity except above or below the 20° - 30° C

Were you correct?

Let's move on to GLOBE Data Entry and Visualization!

Submitting your data to GLOBE

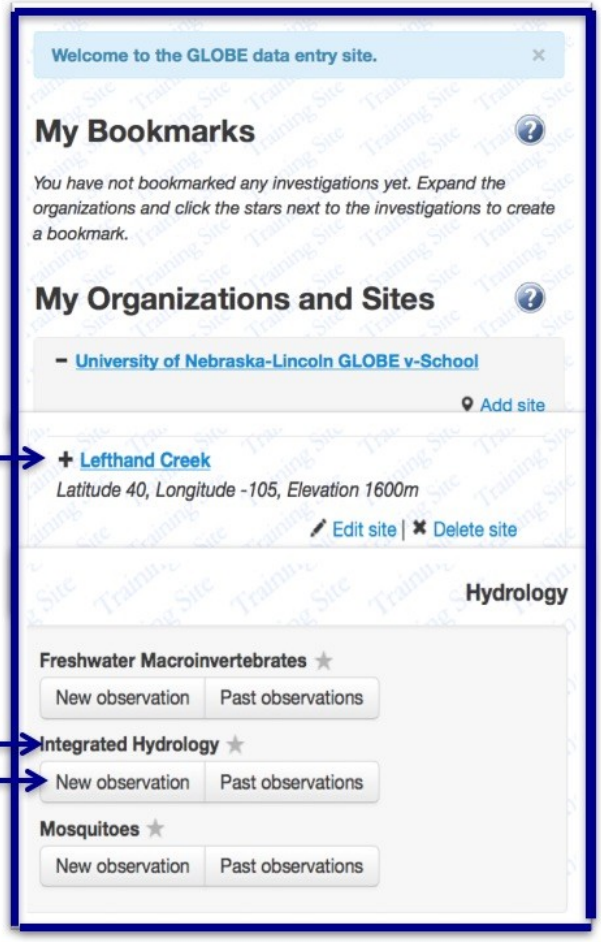
- Live Data Entry: Upload your data to the official
- GLOBE science database
- Email Data Entry: Send data in the body of your email (not as an attachment) to DATA@GLOBE.GOV
- Mobile Data App: Download the GLOBE Science Data Entry app to your mobile device and select the right option.
  - **For Android**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



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

Identify your Sampling site

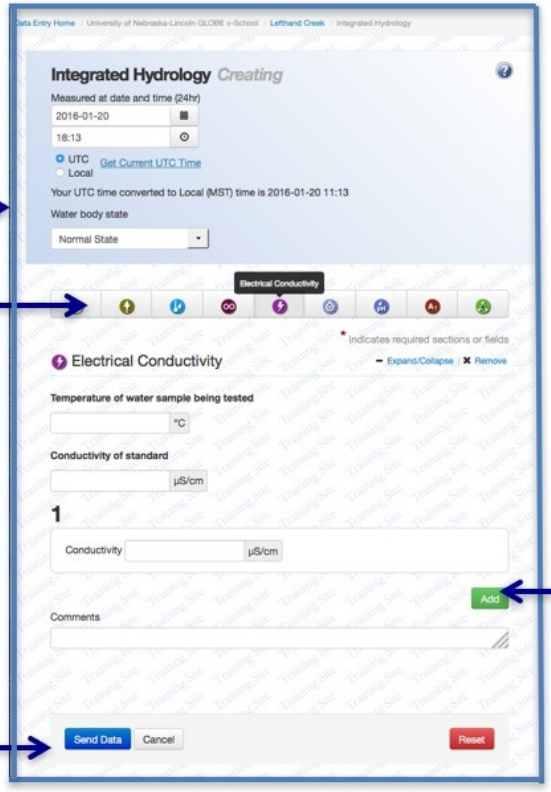
Select *"Integrated Hydrology"* and *"New observation"*



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

1. Select water body state

2. Select protocol



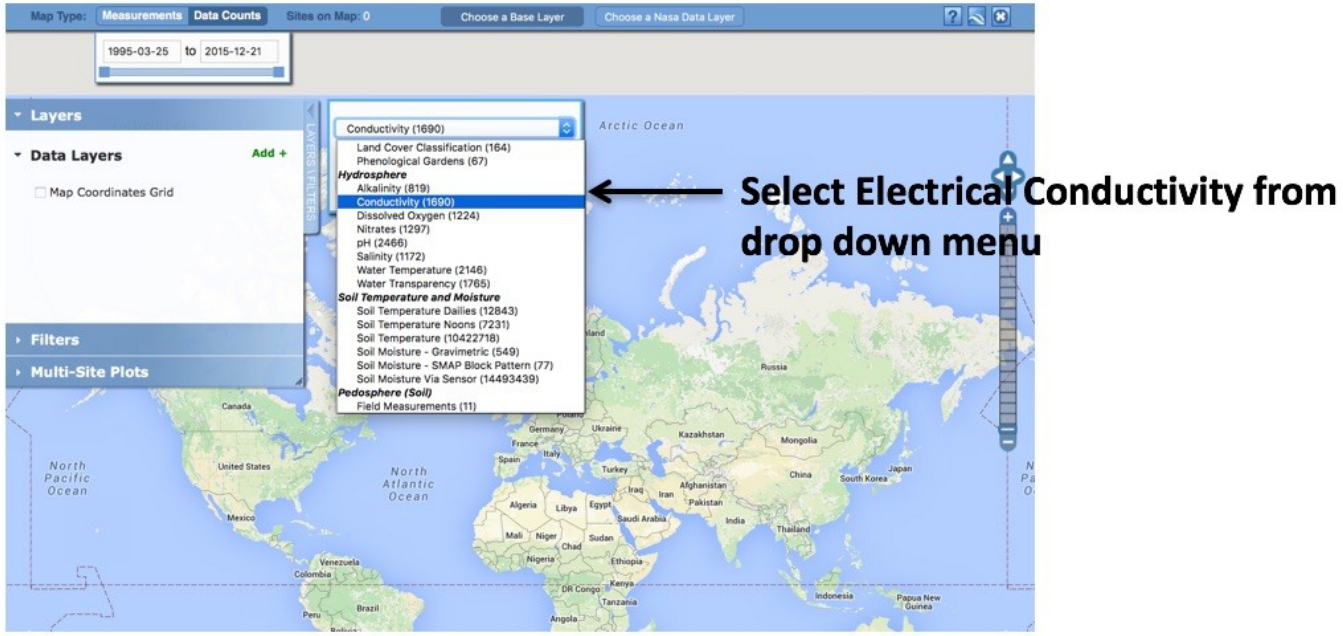
3. Enter each measurement and click "add"

4. Click to send data

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

Visualize and Retrieve Water Electrical Conductivity Data-Step 1

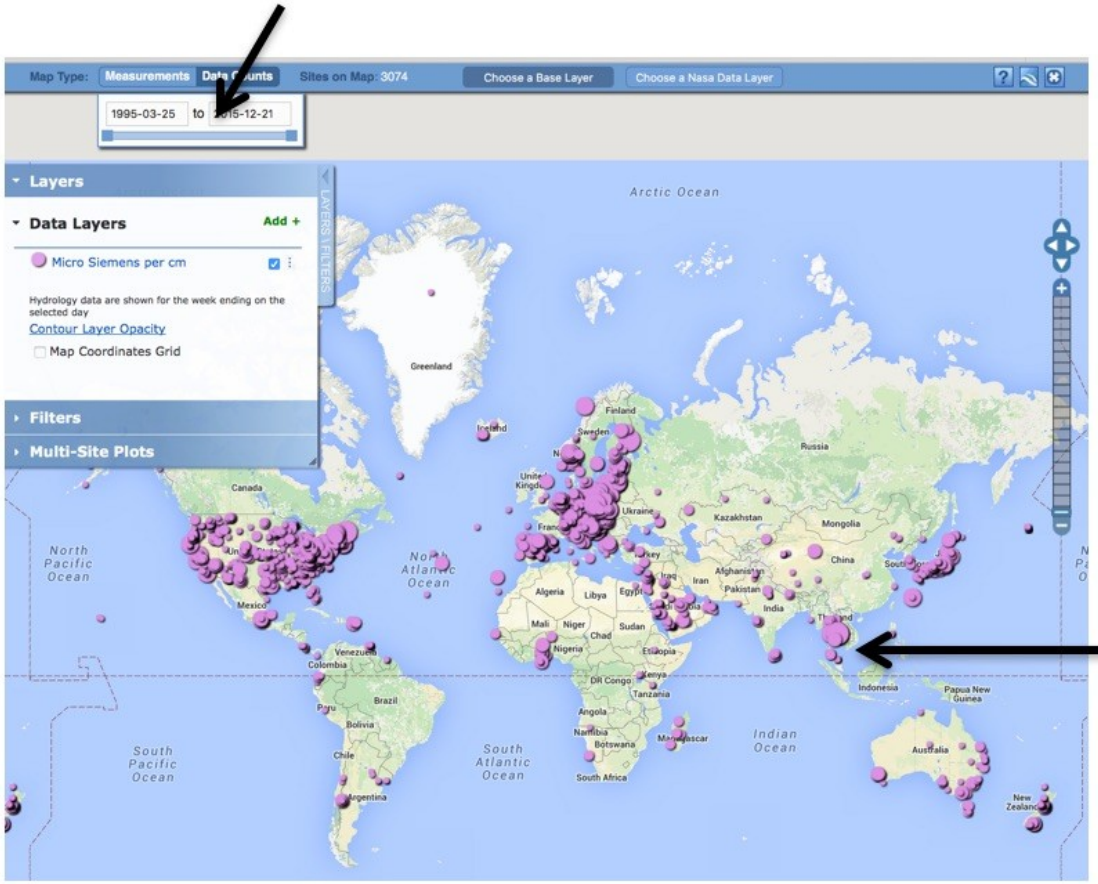
GLOBE provides the ability to view and interact with data measured across the world. Select our **visualization tool** to map, graph, filter and export EC data that have been measured across GLOBE protocols since 1995. Here are screenshots steps you will use when you use the visualization tool:



Link to step-by-step tutorials on Using the Visualization System will assist you in finding and analyzing GLOBE data: PDF version

Visualize and Retrieve Water Electrical Conductivity Data- Step 2

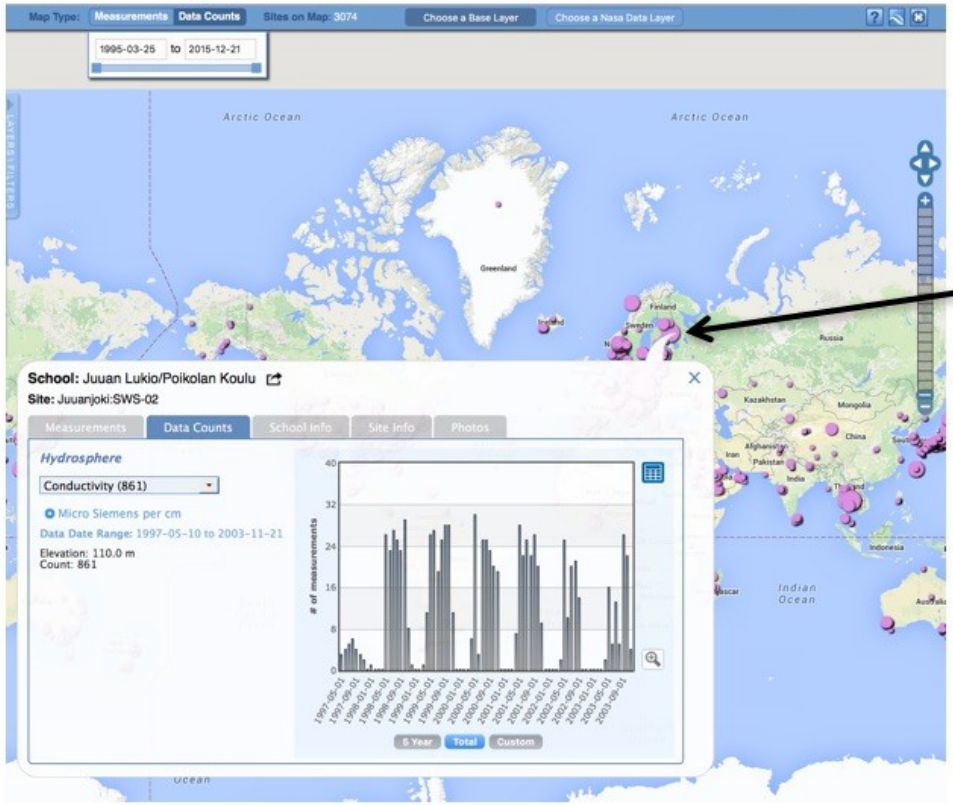
Select the date for which you need electrical conductivity data, add layer and you can see where data is available.



Locations where electrical conductivity data is available

Visualize and Retrieve Water Electrical Conductivity Data- Step 3

Select the sampling site for which you need electrical conductivity data, and a box will open with data summary for that site.



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

Review questions to help you prepare

TEST Your Knowledge

Are you ready to take the Electrical

Some Research Questions for Further Investigation

- Would the conductivity of the water at your site go up or down after a heavy rain? Why?
- Would you expect the conductivity to be greater in a high mountain stream that receives fresh snowmelt or in a lake at lower elevations?
- Why do you think water with high levels of TDS is harmful to plants?

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Questions about module content? Contact GLOBE: help@globe.gov

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