# Activity 4: Climate, Weather...What's the Difference?

## What You Will Do: Make an Electronic Temperature Sensor

### Big Idea

**Climate varies in space and time through both natural and man-made processes.**

(Climate Science Principle 4)

### What You Will Need

- Adult partner
- 1 – Multimeter capable of measuring volts, milliamps, and ohms (such as Extech MN35)
- 1 – 9 volt battery
- 1 – Battery snap (such as Radio Shack 270-324)
- 1 – Resistor, 10K ohm, 1/2 watt (such as Radio Shack 271-1126)
- 1 – Thermistor, 10K ohm (such as Digi-Key 490-4660)
- 2 – Clear glass jar, beakers or plastic cups, about 250 ml (8 oz) capacity
- 1 – Wire strippers
- 1 – Thermometer (such as Forestry Suppliers #89323; you may want to order two of these, since you will use them again for Activity 6; these thermometers have an aluminum case which makes them useful for field investigations as well as in your laboratory)
- Speaker wire, 24 gauge, about 1 m (3 ft) (such as Radio Shack 278-1301)
- Liquid electrical tape (from a boating supply store or hardware store)
- Conductive Glue (keyword search "wire glue" to find suppliers; if you or your partner know how to solder, you can use solder and a soldering iron instead of conductive glue)
- Needle-nose pliers
- Ice
- Hot water

Weather describes what is happening in the atmosphere over a short period of time (days or hours) at a specific place. Weather descriptions include temperature, humidity, winds, cloudiness, and atmospheric pressure. Climate is the average of these weather conditions over many years. The National Weather Service uses 30 years of weather measurements to calculate the average climate for a city, state, or region. An easy way to summarize the difference is "climate is what you expect; weather is what you get," or "weather tells us what kinds of clothes to wear, climate tells us what kinds of clothes to buy."

When scientists talk about climate change, they mean that there has been a significant change in the average or extreme (or both) climate conditions, and that this change has continued over a long period of time. We all know that climate conditions (air temperature, precipitation, and wind) change with the seasons. There are also natural cycles such as El Niño that cause climate conditions to be different from year-to-year. These differences are part of natural climate variability, but they are not the same as climate change.

Earth's climate has changed many times in the past, and is changing now. Studies of tree rings show that Earth's average temperature is now as warm or warmer than it has been for at least the past 1,300 years. Scientific weather observations from around the world show that average temperatures have increased rapidly during the past 50 years, especially in the Arctic region. In the past, climate change has happened over periods of decades to thousands of years. It is very unusual to have a rapid temperature change in only 50 years, because few natural processes affect climate this quickly. The rapid rate of 20th century warming, and the increase above the millenium baseline in the absence of natural forcing, are consistent with the warming caused by increased greenhouse gases. One way that this is happening is that human activities are adding carbon dioxide to the atmosphere much more rapidly than natural processes can remove it. You'll find out more about how carbon dioxide affects climate in Activity 6.

### How It Works

An electric current is the flow of electrons through a conductor such as a wire. An electric circuit is a path for an electric current. One way to imagine an electric current is to think of water flowing through a pipe. The voltage of an electric current is the force of the current, similar to the pressure of the water in the pipe flowing through the imaginary pipe. As you may have guessed, voltage is measured in volts.

Resistance is a force that opposes the flow of an electric current. You can think of resistance as a valve or obstruction in the imaginary pipe. Resistance is measured in ohms; the more ohms, the higher the resistance. Resistors are electronic components that resist the flow of electric currents.

A thermistor is a type of resistor whose resistance changes when the temperature changes. When a thermistor is in an electric circuit, the voltage of the electric current changes when the thermistor's resistance changes. We can measure the voltage of this type of circuit, and use this measurement to find the temperature of the thermistor. Compared to liquid-filled thermometers, thermistors are less expensive, more rugged, and do not require someone to look directly at them to get a temperature measurement. Because of these advantages, thermistors are used in cooking appliances, indoor/outdoor thermometers, doctors' offices, fire alarms, refrigerators, wind turbines, weather balloons, aircraft, space vehicles, industrial facilities, and many other places where temperature measurement or control is needed.

## How to Do It

1. Remove about 2 cm (1 in) of the insulation from both ends of the two wires in the speaker cable, and also from the two wires of the battery snap. Twist the strands of each wire so that they are tightly wrapped (Figure 1).

Figure 1.

2. Connect the wires from one end of the speaker cable to the wires coming from the thermistor. Use a Western Union splice as shown in Figure 2.

3. Use a Western Union splice to connect one of the wires from the other end of the speaker cable to one of the wires coming from the resistor (it doesn't matter which wire).

4. Use a Western Union splice to connect the other wire from the speaker cable to one of the wires from the battery snap (it doesn't matter which one).

5. Use a Western Union splice to connect the other wire from the battery snap to the remaining wire coming from the resistor. This completes the thermistor circuit, which should resemble Figure 3.

6. Brush a small amount of conductive glue onto each of the splices, and allow the glue to dry (or solder these splices).

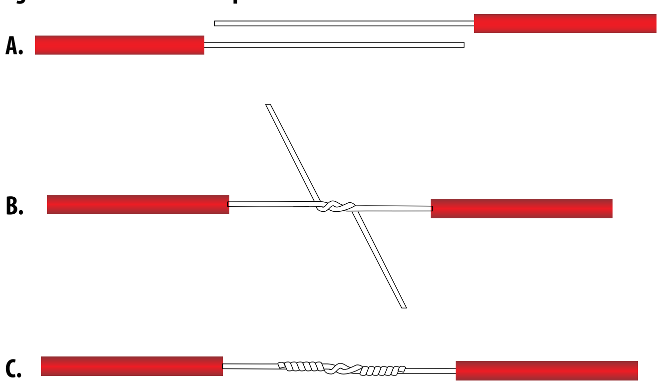
7. Brush liquid electrical tape onto the thermistor splices so that all of the bare wires are covered (Figure 4).

8. Set your multimeter to measure volts. Set the voltage range on your multimeter to at least 10 volts (check the instructions that came with your meter for exactly how to do this). Check the voltage of your battery by touching the positive lead from the meter to the positive terminal of the battery, and the negative lead from the meter to the negative terminal of the battery.

9. Connect the 9-volt battery to the battery snap. Touch one of the multimeter leads to one wire of the resistor, and touch the other multimeter lead to the other resistor wire. If the voltage reading is negative, reverse the multimeter leads. Your Electronic Temperature Sensor is finished!

10. Now you need to calibrate your Electronic Temperature Sensor to so that you can use voltage measurements to find the temperature of the thermistor. Put some ice in one of the glass jar (or beaker or plastic cup), and add water so that the container is almost full.

Figure 2. Western Union splice.




The Western Union Splice. Bring ends of wires to be spliced together so that the ends are pointing in opposite directions (A). Twist each wire 3/4 of a turn in opposite directions (B). Turn the ends so they are at right angles to the wires being spliced, and twist each end to form at least five more turns spaced as tightly as possible (C). It is easier to make these twists with a pair of needle-nose pliers. Cut off the ends and twist them close to the center wire.

Figure 3.

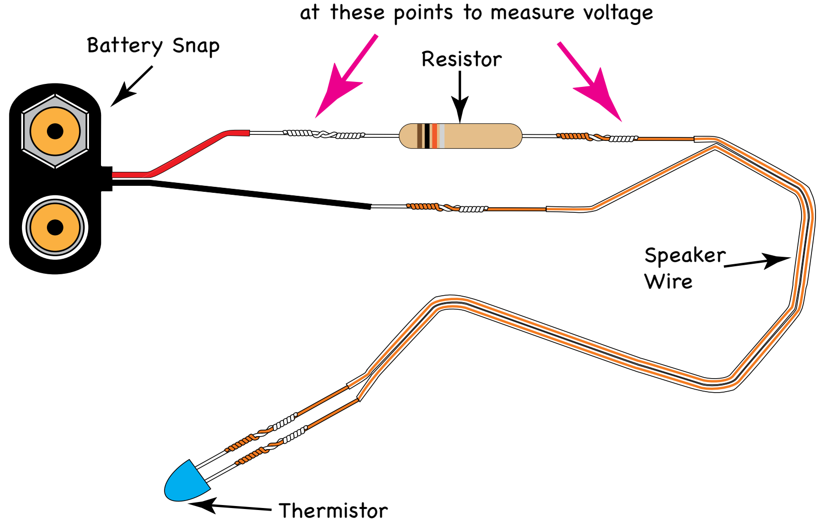



Figure 4.

11. Put some hot water in the other container, and put the thermistor into the water. Wait about ten seconds, then measure the voltage as in Step 9. Check the temperature of the water with the thermometer, and record the voltage and temperature in the Calibration Table.

12. Reduce the temperature of the water from Step 11 by adding a small amount of cold water. Put the thermistor into the water, wait about ten seconds, then measure the voltage and check the temperature of the water. Record the voltage and temperature in the Calibration Table. Repeat this step until you have at least eight different readings. The highest temperature should be around 80° C, and the lowest should be near 0° C.

13. Graph the data from the Calibration Table with temperature on the vertical axis (y-axis) and voltage on the horizontal axis (x-axis). Now you can use this graph to find the temperature that corresponds to any voltage reading from your Electronic Temperature Sensor.

**Calibration Table**

| Voltage | Temperature |
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## Want to Do More?

The University Corporation for Atmospheric Research Web site has links to interactives, simulations, games, and virtual labs about weather and climate: *https://spark.ucar.edu/interactives* and *https://spark.ucar.edu/activities*

## Using Your Temperature Sensor

Your temperature sensor is useful when you want to record a series of temperature measurements from the same place over a long period of time, and to measure temperature in places that can't be reached with a liquid-filled thermometer. Here are three ideas (you can probably think of many more!):

### Your Daily Weather

Climate is the average of weather conditions over many years, but regular weather measurements are needed to calculate this average. Measurements of air temperature along with other weather observations help improve weather predictions, and also help us understand how current weather conditions compare to climate averages. To investigate local temperature conditions with your temperature sensor, talk with your adult partner to select a sheltered location on a north-facing wall, which provides some protection from rain and direct sunlight. Install the sensor 1.2 to 1.8 m (about 4 to 6 ft) above ground, and try to make temperature measurements at the same time each day. Record your measurements in a notebook along with other observations about the weather at the time the measurements were made, such as rain conditions, cloud cover, wind, and barometric pressure (see Activity 5, "How Do We Know" for more weather instruments). For more about weather, climate, and temperature measurements and ideas for analyzing your data, see *http://globe.gov/sda/tg/maxmin.pdf*.

### Explore a Microclimate

Microclimates are places whose climate is different from the surrounding area. They may be very small or as large as lakes or cities. Air temperatures over large bodies of water can be less extreme than temperatures over nearby land areas. Cities are often warmer than surrounding areas with fewer humans. Microclimates may also exist in valleys, where the bottom of a valley may be much colder than the slopes. Smaller microclimates are also found in home gardens where buildings, fences, rocks, raised beds, paved surfaces, and other features can change wind conditions, water flow, and sun exposure. Some microclimates are deliberately created to provide conditions needed by garden plants, and also to improve energy efficiency of buildings. See if you can find microclimates near your own home, and use your temperature sensor to compare their temperature with the temperature of nearby locations. Make daytime and nighttime measurements to see whether the microclimate effect changes with the time of day. Can you design a microclimate that might improve the energy efficiency of your home? Try a Web search on "energy efficiency" and "microclimate" for some ideas.

### Investigate Water Quality

Your temperature sensor makes it easy to measure water temperature, and temperature is one of the most important characteristics of aquatic ecosystems. Temperature affects the biological activity of most species, and some species have very specific temperature requirements. Water temperature also affects dissolved oxygen levels and pH. High water temperatures can contribute to outbreaks of bacteria, harmful algae, and submerged aquatic vegetation. Talk with your adult partner about nearby water bodies that might be interesting to investigate. For more information about this kind of investigation, see *http://archive.senseit.org/files/Addon_Water_quality_and_temperature.pdf*.