## SNC2D/2P Climate Change/Earth’s Dynamic Climate

# Teacher Demo: Convection

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| Topicsconvectiontemperature differenceatmospherehydrosphere | Timingpreparation: 5 minactivity: 5 min |

## Introduction

This demo models how convection occurs in the atmosphere and hydrosphere by showing what happens at the interface of a hot fluid and a cold fluid. This simulates what happens when cold and hot air masses meet, as well as why/how the ocean regulates climate.

The ocean regulates climate by absorbing the Sun’s energy in the top layer of water, which heats up and stays on top of the layer of deeper, colder water. The most energy absorption occurs around the equator. As winds and ocean currents move the warm water to different latitudes (north and south), the top warm layer of water loses energy to the colder atmosphere and surrounding colder water, becoming cooler and denser. Eventually this layer of water will become so dense that it will sink and the layer below it will rise, and the cycle will begin again. This is oceanic convection. Since air is a fluid, a similar process occurs in the atmosphere and this demo therefore also demonstrates atmospheric convection.

## Materials

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| safety goggleslab coat/apronthermal gloves hotplate1 L beakerwater  | thermometerred food colouring in a dropper bottle4 identical plastic bottles (about 0.5 L) with 4 cm openingsindex card or old playing cardblue food colouring in a dropper bottle |

## Safety Considerations

* Be careful when using hot water as it can cause burns.

## Procedure

Wear appropriate PPE: safety goggles, lab coat or apron, thermal gloves.

1. Using the hotplate and beaker, heat 1 L water to about 50° C.
2. Pour the hot water into two of the four bottles and add a couple of drops of red food colouring to each bottle.
3. Fill the other two bottles with cold tap water and add a couple of drops of blue food colouring to each bottle.
4. Put 1 index card on top of one hot-water bottle.
5. Holding card tightly, invert the hot-water bottle and place it on top of one cold-water bottle.
6. **Predict/Explain**

Students engage in Think, Pair, Share (see Teaching Suggestions/Hints):

* Think: What do you expect will happen when the card is pulled out from between the two bottles? Why?
* Pair: Discuss the question with a partner.
* Share: Hold a brief class discussion on the prediction.

Ask students to justify their predictions based on their knowledge of states of matter, kinetic molecular theory, and/or any other relevant concepts.

1. **Observe**

Holding the bottles together at the mouths, carefully remove the index card. Note what happens.

1. **Explain**

Ask students to explain their observations using their knowledge of density, the kinetic molecular Theory, and any other relevant concepts.

1. Repeat Steps 4 to 8 with the remaining bottles of hot and cold water, only this time with the bottle of cold water on top and the hot water at the bottom.
2. Ask students how, in the oceans and atmosphere, layers of warm and cold air might mix—or stay separate.

## Disposal

Water and food colouring can be poured down the sink. The bottles can be stored for reuse or recycled.

## What happens?

When the hot water bottle is placed on top of the cold water bottle, no mixing will occur. This will be evident because the red and blue colours stay separate: no purple colour is formed.

When the cold-water bottle is placed on top of the hot water bottle, the water at the interface of the two temperatures will mix. This will be evident when the red and blue colours mix to form purple.

## How does it work?

Cold water is more dense than hot water. When the hot-water bottle is placed on top of the cold-water bottle, the less dense layer of hot water is already above the more dense layer of cold water. Therefore, no mixing will occur.

At the interface of the cold water bottle on top of the hot water bottle, the more dense cold water sinks, forcing the less dense hot water to rise. This mixing of the two layers will be evident when the (red) hot water and the (blue) cold water form purple water in the area where they mix.

## Teaching Suggestions/Hints

1. Bottles that contained 20 oz sports drinks or vitamin water are suitable.

2. The larger the temperature difference between the hot and cold water, the more effective the demo. Warm tap water may not give a good result.

3. It may be wise to perform this demo over a sink, plastic basin, or large towel in case of spills.

4. Normally, in the atmosphere, temperature decreases with altitude. This demo models a thermal inversion in the atmosphere, when a layer of warm air traps a layer of colder air close to the ground, preventing mixing. Inversions are most evident during the winter, reducing air quality and sometimes resulting in freezing rain.

5. *Think/Pair/Share*: In this learning strategy, students individually consider a concept, question, or prediction, and then discuss their ideas with a partner. This can be followed by small group discussions or a whole class discussion. The purpose of the strategy in this demo is to:

* activate prior knowledge;
* think about ideas/concepts first and then share with other students for feedback;
* pace student thinking and discussion; and
* include all students in explaining and confirming predictions.

## Additional Resources

1. A detailed write-up of this demo with images - <http://www.stevespanglerscience.com/experiment/colorful-convection-currents>
2. Information about thermal inversions - <http://www.wrh.noaa.gov/slc/climate/TemperatureInversions.php>

**Specific Expectations**

**SNC2D**

**A1.1** formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research

**A1.8** analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty

**A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

**D2.1** use appropriate terminology related to climate change, including, but not limited to: *albedo*, *anthropogenic*, *atmosphere*, *cycles, heat sinks*, and *hydrosphere* [C]

**D2.6** investigate, through laboratory inquiry or simulations, how water in its various states influences climate patterns (e.g., water bodies moderate climate, water vapour is a greenhouse gas, ice increases the albedo of Earth’s surface) [PR, AI]

**D2.7** investigate, through research or simulations, the influence of ocean currents on local and global heat transfer and precipitation patterns [PR, AI]

**D3.1** describe the principal components of Earth’s climate system (e.g., the sun, oceans, and atmosphere; the topography and configuration of land masses) and how the system works

**D3.2** describe and explain heat transfer in the hydrosphere and atmosphere and its effects on air and water currents

**SNC2P**

**A1.1** formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research

**A1.8** analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty

**A1.11** communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

**D2.1** use appropriate terminology related to Earth’s dynamic climate, including, but not limited to: *anthropogenic, atmosphere, carbon footprint, carbon sink, climate, greenhouse gases, hydrosphere,* and *weather* [C]

**D3.1** describe the principal components of Earth’s climate system (e.g., the sun, oceans, and the atmosphere; the topography and configuration of land masses)

**D3.3** describe how heat is transferred and stored in both hydrospheric and atmospheric heat sinks