

What's The Connection between Convection and Inversion? : Convection Currents and Temperature Inversion

By: Air Info Now

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Abstract

During this lesson students will watch a demonstration and conduct an experiment to see the relationship between temperature and inversion layers. The purpose of the lesson is to explore the relationship between temperature and inversion layers.

Objectives

Students will be able to:

- i. Observe a demonstration that illustrates convection currents and temperature inversions.
- ii. Conduct an investigation that demonstrates how warm air rises.
- iii. Make a jar of smog to demonstrate how contained smoke will not disperse.

National Science Education Standard

Content Standard D - STRUCTURE OF THE EARTH SYSTEM

- The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations.

Arizona Science Education Standards

Strand 6 - Earth Science

Concept 1 – Structure of the Earth

PO 1. Describe the properties and the composition of the layers of the atmosphere.

PO 5. Describe ways scientists explore the Earth's atmosphere.

Teacher Background

Once you have lived in Tucson/Pima County for a while, you become familiar with the haze that sometimes forms over our city. A drive to larger cities reveals persistent smog with the whole city sitting in a brown haze. What causes this brown haze or smog that can cause burning, itching eyes and shortness of breath? And why does it appear in greater amounts in regions surrounded by mountains? Sources of smog may include motorized vehicles, industries, airplanes, trains, wood stoves, wildfires and blowing dust. In Tucson/Pima County, approximately 70 % of the air pollution is caused by motor vehicle use.

To begin to understand where smog is more likely to linger, we must understand convection currents and temperature inversions. Warm air is lighter (less dense) than cold air. As warm air rises, cold air moves to take its place. This cyclic nature of moving air is called a convection current. Convection causes currents of air to move around outdoors (and inside buildings as well.) Birds float upward on rising currents of warm air and gliders stay up in the air in the same way. Convection currents help disperse air, including any pollutants in the air. This natural force moves polluted air rising from urban centers and dilutes it in less-polluted air above. Due to convection, air pollution does not remain isolated or localized. But a temperature inversion can obstruct normal convection currents. A temperature inversion occurs when a mass of warm air moves over stagnant, cooler, surface air. This warm air mass forms a lid over the area, trapping all the polluted surface air left from the city's transportation systems, industries, and homes. If a temperature inversion traps pollutants, then a visible layer of smog will result. Our sparse vegetation allows the ground to cool off nightly and because our city is surrounded by mountains, smog is very likely to linger until the morning sun warms the air enough to begin the mixing (convection) cycle. The following experiment demonstrates convection currents and a temperature inversion.

Related and Resource Websites

<http://www.airinfonow.org/pdf/CurriculaConvectionWithGraphic.PDF>

<http://www.airinfonow.org/html/Visibility.html>

Asthma and Allergies Health Observance Package

Time	1 class period (45 minutes)	
Preparation Time	5-10 minutes setting up shoe box	
Materials	A large shoe box Scissors Plastic wrap Tape Two cardboard tubes Clay Candle	Ice cubes A long match Paper Paper towels A heat lamp Overhead: Inversion Questions

Teacher Preparation

Prior to class, assemble the inversion demonstration box. This should take 5-10 minutes. Use the Convection and Inversion Set-Up Sheet.

Activity

1. As students enter the room, have the following question on the board. "How do convection currents and temperature influence air pollution?"
2. Allow students time to formulate and record two hypotheses (they will share these later on in the lesson).
3. Ask students how they might test their hypotheses.
4. After students share their ideas, set up the convection experiment. Ask students to watch carefully as you use a long match, (or a match taped to a pencil) to light the candle by putting it down the chimney.
5. Once the candle is lit, allow the box to warm up for approximately five minutes. While the box is warming, have students share their predictions about how air convection will affect pollution.
6. Take a tightly wadded up paper towel and light it with a match. Let it burn for a few seconds, and then blow it out. It should be smoking profusely. Note that the smoke rises (warm air). Now hold the smoking paper down over the second chimney (without the candle).
7. Have students record their observations. [The cold (heavier) air above the smoking paper will push the smoke down through the chimney. The smoke will then warm, rise toward the candle, and exit the convection box via the opposite chimney. This demonstrates the cyclic nature of convection and how warm air rises and cold air sinks.]
8. Now, to simulate a temperature inversion, blow out the candle, place the ice cubes down both chimneys and let the box cool down for five minutes. While the box is cooling, have students share their hypotheses regarding how temperature affects pollution. You will also need to put the heat lamp directly over one chimney, not blocking it, but making sure the heat is funneled down into the box.
9. Once the box has cooled, drop a smoking wad of paper down the other chimney, and then place a piece of paper over this chimney. Compare the heated chimney with the unheated one, after 30 seconds of viewing the trapped smoke, by lifting the unheated chimney's cover and watching the smoke escape.
10. Have students record their observations.

Embedded Assessment

Invite students to share their observations and thoughts with the rest of the class. As students are sharing, take care to clarify any misconceptions through questioning.

Tell students that what they observed in the second scenario is called a temperature inversion. "A temperature inversion prevents normal convection. The warmer air mass moves over the cooler ground air and traps it.

Have students write a conclusion explaining what they learned about the relationship between convection and pollution and inversion and pollution. Sample conclusion: [Polluted air will be moved and diluted by convection currents, but will remain stagnant during a temperature inversion.]