



What's The Connection Between Convection And Inversion?

Convection Currents and Temperature Inversion



Time Needed: 20 - 30 minutes

Student Will:

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

Materials Needed:

- | | |
|-----------------------|---------------|
| __A large shoe box | __Scissors |
| __Plastic wrap | __Tape |
| __Two cardboard tubes | __Clay |
| __Candle | __Ice cubes |
| __A long match | __Paper |
| __Paper towels | __A heat lamp |

Background Information:

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. Because our sparse vegetation allows the ground to cool off nightly and 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.

Problem:

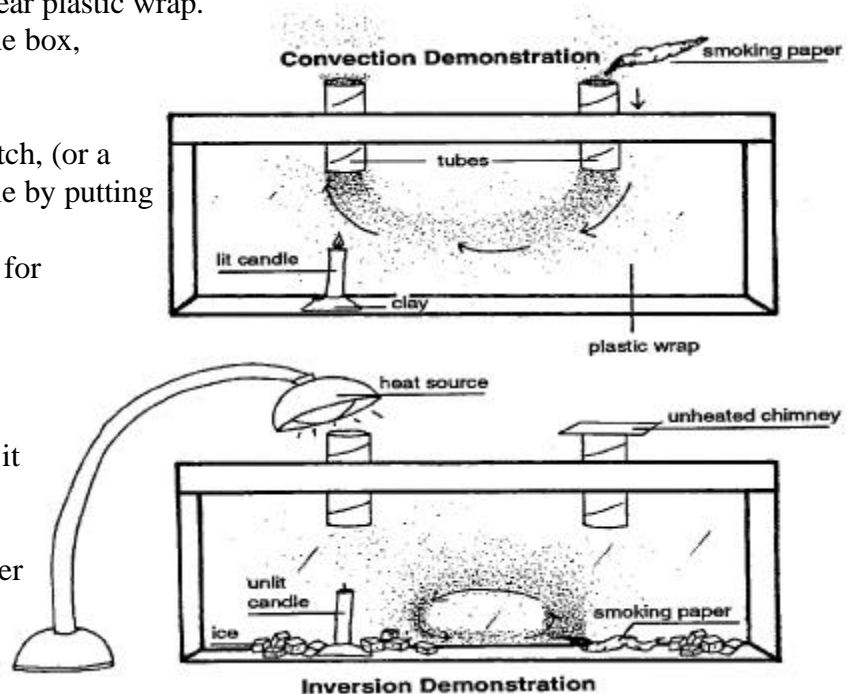
How do convection currents and temperature inversions influence air pollution?

Hypothesis:

Polluted air will be moved and diluted by convection currents, but will remain stagnant during a temperature inversion.

Procedure:

1. Divide your students into small groups and see if they can suggest methods to show how convection currents and temperature inversions influence air pollution. Perhaps their ideas will illustrate this point just as clearly as the following experiments, and the lesson will stick with them longer if they do the brainstorming. In case there are few reasonable suggestions, here's an activity to help you out!
2. Take the top off the shoe box and lay the box on its side. Cut two holes in the top side of the box (one at each end), just large enough for two paper towel tubes. Push the tubes into the holes and seal the openings with tape in order to ensure an airtight seal. You have just made two paper towel tube chimneys.
3. Set a candle in a clay base under one of the paper towel tube chimneys, pressing the clay firmly into place to hold it tight. The candle should be at least 2 inches lower than the chimney. (Make sure the wick is exposed and upright.)
4. Cover the open side of the box with clear plastic wrap. Tape the plastic wrap to the front of the box, forming an airtight seal.
5. Very **CAREFULLY**, using a long match, (or a match taped to a pencil) light the candle by putting it down the chimney. Once the candle is lit, allow the box to warm up for approximately five minutes.
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). Record your 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.

7. 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.
8. While the box is cooling down, put the heat lamp directly over one chimney, not blocking it, but making sure the heat is funneled down into the box.
9. Drop a smoking wad of paper down the other chimney, then place a piece of paper over this chimney. A temperature inversion prevents normal convection. The warmer air mass moves over the cooler ground air and traps it. 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. Record your observations:

Conclusion:

Based on your observations, does this experiment support or reject your hypothesis?
Why or why not?

Follow-up:

1. What, in nature, warms the air like the candle did in the experiment?
2. How does Tucson's geography and weather make it a prime candidate for temperature inversions?
3. What human activity is most responsible for air pollution in our community?
4. Recall that pollution lingers during a temperature inversion, when cool polluted air is trapped under a lid of warm air. At what time of day or night are these conditions most likely to occur?
5. What human activity occurs at this time of day or night and contributes to air pollution?
6. What would cause cold, polluted air to rise and be diluted? At what time of day or night would you expect this to happen?
7. If the sun rose later in the day, what effect would this have on lingering air pollution?
8. At what time of the year would you expect this to happen?