Why doesn't the wind blow from high pressure to low?

A laboratory experiment from the
Little Shop of Physics at
Colorado State University

Overview

The wind blows because of differences in air pressure caused by uneven heating of the earth's surface -- the equator is hot, and the poles are cold. So why doesn't wind blow directly from areas of high pressure (the poles) to areas of low pressure (the equator)? This would happen, but for one fact: The earth rotates. The spin of the earth causes the air to spin, and we call this the Coriolis effect.

Necessary materials:

- A clear area such as an open field or gym
- Students

This works best in smaller groups but can be done with 30 - 40 people at once if you have a large enough space.

Theory

The sun heats up the equator and the poles unequally. Air at the equator warms and rises, moves toward the poles, and finally cools and sinks, as in Figure 1. However, the earth is rotating, complicating the otherwise easy flow of air to balance the energy between the equator and the poles. This "sideways" motion of the earth causes air to deflect to the right as it moves in the Northern Hemisphere. In the Southern Hemisphere air is deflected to the left. This deflection of air produces the jet stream that travels east-west in direction! Storms and fronts are left to finish the job of transporting energy from the equator to the poles.

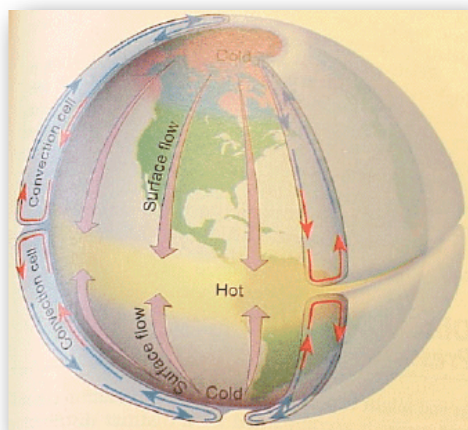

Figure 1: If Earth did not rotate, energy would travel directly from equator toward poles.

Doing the Experiment

Show students weather maps portraying air traveling clockwise around a high pressure system, and counter-clockwise around a low pressure system. Ask them to hypothesize about why air would behave differently around these two systems, and whether there are there any situations in which this wouldn't be the case.

To start, explain to your class that they will be taking part in a kinesthetic activity to demonstrate why air doesn't blow directly from high to low pressure in macroscopic situations, where the rotation of the Earth must be considered.

Have the students form a large circle facing inward. Explain that person is going to pretend to be a parcel of air able to be influenced by differences in air pressure and the Coriolis effect.

Start by telling the class to pretend that there is low pressure at the center of the circle, and high pressure outside the circle (at their backs). If pressure difference was the only factor in wind direction, the low pressure system would collapse, with students all congregating at the center, and that would be the end of it. However, we have the Coriolis effect to consider, so as students start moving toward the center of the circle, they are also deflected to the right, as the Coriolis effect always deflects objects 90 degrees to the right of the direction of travel. They'll end up walking in a counter-clockwise circle (as seen from the top), showing the Coriolis effect balances with the pressure force.

Try several scenarios. Tell them that now there is high pressure at the center of the circle and low pressure outside the circle. (Have them turn around to face outward so they're not walking backwards). Ask them how they should move. (Clockwise!) Have them act this out for storms in the Southern Hemisphere. What would be different? (The Coriolis effect would now act 90 degrees to the *left*!) What would be the same? Have them act this out. In each case, keep track of the direction of movement.

Participants rotating clockwise around a high pressure system.

Summing Up

This is a great way to illustrate how wind direction, on a macroscopic model, varies not only with pressure but also the direction of the Coriolis effect. Once students have done this, they will be able to visualize more readily the reason why high pressure systems spin in opposite directions of low pressure systems.

For More Information

CMMAP, the Center for Multi-Scale Modeling of Atmospheric Processes: http://cmmap.colostate.edu

Little Shop of Physics: http://littleshop.physics.colostate.edu