AEROSPACE PALACE ACADEMY, NIGERIA
(A subsidiary of Aerospace Palace International, Nigeria)

LESSON 49: PREVAILING WINDS

"The wind blows where it wills," as the Bible says, but in the United States there is a good chance that it will blow out of the west. There is a good reason for this: it is a result of the Sun heating the atmosphere, the Earth being as large as it is (and the United States being where it is on the Earth's surface), and the Earth rotating from west to east. Closer to the pole and also closer to the Equator, the prevailing winds are out of the east. This lesson explores why.

Next Generation Science Standards (NGSS):

- Discipline: Earth and Space Sciences.
- Crosscutting Concept: Systems and system models.
- Science & Engineering Practice: Analyzing and interpreting data.

GRADES K-2

NGSS Earth's Systems: Use and share observations of local weather conditions to describe ~~patterns over time.~~

In the United States, weather systems usually move from west to east. This means that very often, a storm in the Rocky Mountains will pass over the Great Plains a day or two later and then move out to the Atlantic Ocean a few days after that. A week or two later, it may very well reach Europe. This does not happen every time, but it is the most likely course of matters.

In the tropics, closer to the Equator, the situation is different. Over that part of the Earth, the winds will more often blow from east to west. This is why hurricanes and tropical storms that form off the coast of Africa almost always move towards the Caribbean and why similar storms that form in the Pacific Ocean off the west coast of Mexico are likelier to go out into the ocean than they are to come ashore.

The Weather Wiz Kids website has an explanation of wind, a list of some wind names (such as scirocco and chinook), and a table of the Beaufort Scale for measuring wind speed.

Suggested Activity: A simple experiment on wind strength is to have students predict how ~~various materials wi~~ll behave when dropped into the air stream from a hair dryer or fan. Create a chart to record predictions and actual results, and then allow volunteers to drop

GRADES K-2(CONTINUED)

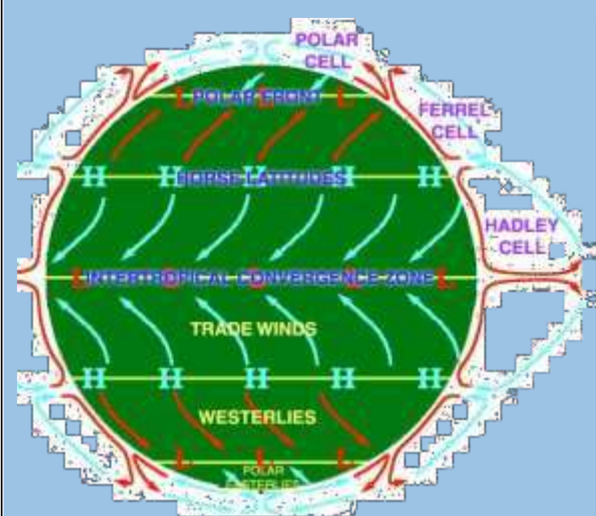
items such as a foam packing peanut, a facial tissue, a small twig, etc. in front of the dryer or fan while it is blowing. You may have them predict which will be blown the furthest or which will drop straight down through the air stream. After the experiment, discuss which predictions were correct and why some materials behaved differently than others. What have they seen being blown by the wind? Leaves, paper, umbrellas...

GRADES 3-5

NGSS Earth's Systems: Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.

The story of Earth's weather begins with the Sun. During the day, the Sun's rays heat the Earth and its atmosphere; during the night, that heat radiates off into the night sky. Because the region near the Earth's equator faces the Sun more directly than the region near the poles, it receives more radiation per unit area and thus gets warmer than the poles do.

Because warm air rises above colder air, the air around the equator tends to rise up higher in the atmosphere. To replace it, air from the latitudes farther from the equator moves toward the equator. Similarly, the cold air near the poles tends to sink down and flow toward the more moderate latitudes.



Because the Earth is so large relative to the height of the troposphere (the lowest layer in the atmosphere where weather happens), this large-scale circulation breaks up into three cells. In the cells nearest the equator, called the North and South Hadley Cells, the air rises near the equator, moves away from the equator at high altitude, sinks down at a latitude near 30 degrees north or south, and then moves back toward the equator at low altitude. Nearest the North and South Poles, the Polar Cells have cold air sinking down at the poles, flowing away from the poles at low altitude, rising up at a latitude near 60 degrees north or south, and flowing back to the poles at high altitude. In between the Polar Cells and the Hadley Cells are the Ferrel Cells, in which air flows downward near 30 degrees latitude (following the Hadley Cell flow), away from the equator and toward the poles at

GRADES 3-5 (CONTINUED)

low altitude, upward near 60 degrees latitude (following the Polar Cell), and back toward the Equator at high altitude.

Now we add in the rotation of the Earth. If you imagine something at the North Pole moving southward, it moves straight away from the pole. As it moves, the Earth turns underneath it; relative to the surface of the Earth, its motion picks up a westward component. This is called the Coriolis Effect. (If you have a turntable of some sort, you can illustrate this by rolling a marble from the center toward the edge.) As the air in the Polar Cells moves away from the poles, its southward motion is pushed towards the west and people feel this as a wind out of the east.

In the Ferrell Cells, the primary motion of the low-altitude wind is away from the Equator and towards the poles. The Coriolis Effect now tends to push the air towards the east, causing the prevailing winds to come out of the south and west.

The Hadley Cells are like the Polar Cells in that the low-altitude air in them moves toward the Equator and away from the poles. Like the Polar Cells, the Hadley Cells have prevailing winds that come out of the north and east.

Suggested Activity: If your playground has a merry-go-round, you can use it to illustrate the Coriolis Effect. Have three kids sit on it equally spaced around the edge of the merry-go-round. Spin it up somewhat and have the kids roll (or toss) a ball to each other. Or you may wish to construct a simple anemometer with your class. Directions may be found at the Science Buddies website.

GRADES 6-8

NGSS Earth's Systems: Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

The prevailing wind in a region governs its overall weather patterns. This is seen most strongly in tropical regions with the seasonal monsoons.

Sub-Saharan West Africa lies between the latitudes of about three and fifteen degrees north of the equator. This latitude range gives it a climate that alternates between a dry season during the Northern Hemisphere's winter and a rainy season during the Northern Hemisphere's summer. One can explain this alternation easily by looking at the prevailing

GRADES 6-8 (CONTINUED)

winds.

During the Northern Hemisphere's summer, the Sun is north of the Equator; the point on the Earth's surface directly underneath the Sun, which receives the most concentrated radiation, is also north of the Equator. This point, or more properly the latitude of this point, is the average boundary between the North and South Hadley Cells. At this boundary, called the Inter-Tropical Convergence Zone (ITCZ), the heated air tends to rise.

As it rises, its water vapor condenses and falls out as rain. The passing of the ITCZ over West Africa during the springtime marks the beginning of the rainy season. Some regions in West Africa then have a short dry season as the ITCZ passes on and its rains move farther north. In other regions, the moist air blowing out of the south and east from the Atlantic Ocean over the West African bulge rises up over the land, cools and drops its moisture, and continues the rainy season in those regions.

During the Northern Hemisphere's winter, the ITCZ moves south of the Equator with the Sun and the prevailing wind in Sub-Saharan West Africa comes out of the north and east. This wind, called the harmattan, comes off of the Sahara Desert and brings dust but little or no moisture. This causes the West African dry season.

The prevailing wind at any given latitude also controls the movement of hurricanes and other cyclones. Tropical cyclones often begin near the equator in the eastern Atlantic Ocean near Africa. The prevailing wind out of the east pushes them westward toward the Caribbean and the Americas. As a cyclone drifts northward, it moves from the Hadley Cell to the Ferrell Cell and its motion becomes first more north-south and then takes an eastward component.

Near the Equator, where the two Hadley Cells come together, the primary motion of the air is upward rather than horizontal. Compounding this is the fact that the Coriolis Effect is reduced to a very small level in this region, going to zero at the Equator itself. This removes the tendency of the wind to blow out of the east. The result of all of this is that the wind frequently drops to nothing; this condition is called the "doldrums." When ships were powered mostly by sails, being caught in the doldrums was a very bad thing to happen.

GRADES 9-12

NGSS Earth's Systems: Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

The prevailing winds leave their mark on the Earth's surface through their effects on the long-term weather. This is apparent if you look at the Google Maps "satellite view" zoomed out as far as one can go. (It is worth noting that this is not what the Earth actually looks like when seen from a satellite; quite apart from the distortions that result from mapping a spherical surface onto a plane, at any given time half the Earth's surface is obscured by clouds.)

Around the Equator, the Inter-Tropical Convergence Zone tends to cause heavier rains than average. Along the Equator on the Google Maps satellite view (about the level of the mouth of the Amazon River in South America and slightly south of the bulge of West Africa), the land is mostly dark green. This is caused by the lush vegetation that results from the abundant rain.

The Hadley Cell and the Ferrel Cell in each hemisphere meet around a latitude of 30 degrees. This latitude in the Northern Hemisphere is called the "horse latitudes" for historical reasons. At these latitudes, the air coming down from the higher altitudes in the atmosphere warms up and, being able to hold more moisture with its increased temperature, tends to have a low relative humidity and thus be thought of as drier air.

About thirty degrees north of the Equator, about the latitude of the Florida Gulf Coast, there is a belt of deserts. These show up as the yellowish and brownish regions. The deserts of the American Southwest, the Sahara and Arabian Deserts, and the drier areas stretching from Iran to Mongolia lie around this latitude.

Thirty degrees south of the Equator, slightly north of the southern tip of Africa, there is another belt of deserts. The Atacama Desert in South America, the Namib Desert in Africa, and the Gibber Desert in Australia are all around this latitude.

The prevailing winds have also affected human history in the voyages of trade and discovery. Centuries ago, traders in east Africa and on the Arabian Peninsula realized that they could ride the monsoon winds to India at one time of the year, trade in India for some months, and the ride the winds home for the rest of the year. This promoted a lucrative trade between Arabia and India.

Christopher Columbus also took advantage of the different wind directions at different

GRADES 9-12 (CONTINUED)

latitudes during his voyages of discovery. On his first voyage, for example, he sailed down to the Canary Islands before striking out westward; he sailed back at a latitude matching the latitude of southern Spain. The winds out of the east at the equatorial latitudes were so important to transatlantic trade that they were named the "trade winds."

Sixty Years Ago in the Space Race:

November 3: The second Soviet satellite, Sputnik II, carried a dog named Laika into orbit. Laika did not survive the mission.