

Physical Characteristics of the Troposphere

OBJECTIVES

1. Students will learn about environmental trends in the troposphere- temperature, dew point, pressure and wind speed- by checking their hypotheses against data collected by weather balloons launched from the NOAA ship R/V Ronald H. Brown September 15, 2001 by Dr. Rob Cifelli from Colorado State University.
2. Students will practice their skills in obtaining information from graphs by answering questions.

AGE

Grades 8-10

TIME ALLOWANCE

1-2 hours

MATERIALS

- Overhead transparencies of the troposphere graphs. Note: these graphs are for tropospheric properties at 10 degrees north latitude, 95 degrees west longitude. Precise conditions and height of the tropopause will change with latitude, but general trends will be consistent throughout the world.
- Overhead transparency of the layers of the atmosphere

INSTRUCTION:

1. Introduce the layers of Earth's atmosphere to the students. Show them an overhead transparency of the different layers at their relative altitudes. I have found that many students are unaware that we are actually living in the troposphere- they often seem to think that the atmosphere begins somewhere up in the sky. Make sure this is clear to students before proceeding with the lesson.
2. Ask the students what air pressure is, and whether they think it increases, decreases, or stay the same with altitude. As with the rest of this lesson, the emphasis should be on students making educated guesses, not necessarily on the accuracy of the guesses. The students should write their hypothesis in their notes.

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NOTES: If they are unsure about the answer, prompt them by asking what causes air pressure. Well, it's the pressure exerted by the column of air above us. At sea level, there is the maximum amount of air above us, so the air pressure is greatest. If we were 10 miles high in the sky, there would be much less air above us, and therefore, much lower air pressure. Imagine a pile of bricks stacked from the ground all the way into space. If you were at the very bottom of the pile, you'd have a lot more pressure on you than if you only had half the pile on you. Have the students ever been on a tall mountain and ran out of breath after walking up a flight of stairs? This is an example of the human body noting the difference in air pressure with altitude.

Why isn't the pressure decrease linear? Well, the density of the air molecules does not decrease linearly with increases in altitude. For students who have completed Chemistry or Physics, you can relate the Gas Law and Hydrostatics to further explain the logarithmic decrease in pressure with altitude.

3. Show the students the "Pressure in the Troposphere" graph. Have them copy the chart into their notes and answer the following questions:
 - What is the air pressure at sea level?
 - What is the air pressure at the top of the troposphere (16000 meters)?
 - If you were swimming 5 feet under water, the pressure on your body be greater than _____ millibars.
 - If you were in the stratosphere, the air pressure on your body would be less than _____ millibars.
 - The curve on this graph is what type? (Exponential, logarithmic, linear, etc.)
4. Ask the students what temperature is, and whether they think it increases, decreases, or stays the same with altitude in the troposphere. If they are unsure about the answer, prompt them by asking what "temperature" actually measures. The students should write their hypothesis in their notes.

NOTES: Heat is created by the collision of air molecules. At sea level, where air pressure is greatest, the density of air molecules is greatest, so there are more collisions, and more heat. As you go higher into the troposphere, the number of air molecules decreases, so there are fewer collisions, and less heat is produced. Heat is also absorbed by greenhouse gasses in the atmosphere, such as ozone. Where there are more greenhouse gases (at Earth's surface and in

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the stratosphere) the heat is retained. Again, ask the students how the temperature changes when they go to the top of a mountain.

The top of the troposphere is where the tropopause begins. At this point, the temperature stays fairly constant, until it reaches the stratosphere, where the temperature actually increases due to heat absorption by ozone.

5. Show the students the "Temperature in the Troposphere" graph. Have them copy the chart into their notes and answer the following questions:
 - What is the temperature at sea level?
 - What is the temperature at 16000 meters?
 - The curve on this graph is generally what type? (Exponential, logarithmic, linear, etc.)
 - At what altitude does the air temperature go below the freezing point?
 - What happens to the temperature at 1600 meters?
 - How do we know that the entire troposphere is shown on this graph?
6. With the same graph being displayed, explain to the students what "dew point" is. When the temperature of the air is reduced to the dew point temperature, the water vapor in the air condenses into water droplets. The closer together the air temperature and the dew point are, the more humid the air. As soon as the air cools to the dew point, the moisture condenses into clouds. For more information see:
<http://www.ems.psu.edu/~fraser/Bad/BadClouds.html>
7. Students answer the following questions in their notes:
 - Which air is more humid- the air at sea level or the air at the top of the troposphere? Explain why.
 - List 2 ranges of altitudes where the air was relatively humid at the time the weather balloon traveled through it.
 - List 2 ranges of altitudes where the air was relatively dry at the time the weather balloon traveled through it.
 - What happens to humidity in the tropopause (the area above the troposphere)?
8. Finally, ask the students to think about what factors impact wind speed.

NOTES: Wind speed is a reflection of the air pressure gradients. Air moves from high pressure areas to low pressure areas, and the greater the difference, the greater the winds.

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Aside from pressure gradients, there are two additional factors that influence wind speed in the atmosphere. First, you must consider the density of the air. Density and velocity are inversely related. As density decreases, velocity increases. Imagine trying to push a box car full of coal- it would be difficult. The coal is very dense, and a lot of effort would be required. Now imagine pushing a box car full of cotton candy. Even though the volumes are the same, the cotton candy, being less dense than the coal, will be easier to push. Now relate this to the air. Since the air is less dense at higher altitudes, it is easier to push, which means that wind speeds increase.

Second, you must consider friction. If you are standing in an open area with few trees or buildings around (low friction), will the wind have the opportunity to generate a strong force? How about if you are standing in the middle of a forest? Friction is one factor that contributes to wind speed.

9. Ask students to write their hypothesis about how wind speed changes with altitude. Show them the “Wind Speed in the Troposphere” graph. Have them copy the chart into their notes and answer the following questions:
 - What is the wind speed at sea level?
 - What is the wind speed at 16000 meters?
 - If you drew a line depicting the trend of the data, what happens to wind speed as you increase altitude?
 - Why do you think the line is so curvy? (the scientists who obtained this data are not sure, but students should make educated guesses to try to explain the data)
 - At what altitude is wind speed greatest?
 - At what altitude is wind speed lowest?

EVALUATION / ASSESSMENT

As a wrap-up to this lesson, students should write a one-paragraph summary of the physical properties of the troposphere with regard to trends in air pressure, temperature and wind speed.

Students will be assessed on the effort they made in creating hypotheses, and successful completion of the questions that accompany each graph.

LAYERS OF EARTH'S ATMOSPHERE

