EclipseMob

LESSON TITLE: THE ECLIPSEMOB EXPERIMENT

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LESSON GOALS AND OBJECTIVES:

Students will be able to:

1. Describe where the ionosphere is in the atmosphere
2. List the three different parts of the ionosphere and explain how they are different
3. Explain what happens to radio waves sent from one place to another on Earth when those waves come to the different layers of the ionosphere
4. Describe the hypothesis and results of a radio wave and eclipse experiment of 1999 in England

BROAD GOALS:

As you go through the activities in this lesson, you will work to understand:

- Where the ionosphere is in the atmosphere
- The three different parts of the ionosphere and how they are different
- What happens to radio waves sent from one place to another on Earth when those waves come to the different layers of the ionosphere
- The hypothesis and results of a radio wave and eclipse experiment of 1999 in England

NGSS STANDARDS:

MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of the lunar eclipses of the sun and moon, and seasons.

HS-PS4-2. Evaluate questions about the advantage of using a digital transmission and storage of information.

HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic

radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

MATERIALS REQUIRED:

Graph paper

BACKGROUND INFORMATION:

This lesson works best after going through Lesson 3: The Atmosphere and Radio Waves.

LESSON PLAN OUTLINE:

Part I: Layers of the Atmosphere: A Radio View

As it turns out, the ionosphere also has layers. The layers depend on how many free electrons are in the layer. More specifically, the layers depend on the *concentration* of free electrons. (For an activity to help students understand the concept of concentration, visit **Lesson 3: The Atmosphere and Radio Waves**)

ACTIVITY:
This activity challenges reading skills and visualization. Students will make a graph of the atmosphere layers based on the descriptions below. This description divides the atmosphere into two basic parts: The Lower Atmosphere and the Upper Atmosphere. Have students draw a vertical line on graph paper. Then have students label miles on it, dividing up the graph paper such that the line can go from 0 miles at the bottom to 70 miles at the top. Then, based on the descriptions below, students will draw atmosphere layers and label how each layer behaves relative to radio waves.

Descriptions are based on Thurber, Karl T. (1998). “A Beginner’s Guide to Radio Propagation.” *Popular Electronics*.

LOWER ATMOSPHERE
Troposphere:
From Earth’s surface to as high as 11 miles.
VHF (Very High Frequency) and HF (High Frequency) radio waves can move through it; see Lesson #3 for a discussion of VHF and HF radio waves.

Stratosphere:
From 11 miles to 30 miles high

UPPER ATMOSPHERE:
Mesosphere and Thermosphere:
This is where the Ionosphere is. (See Lesson #3 for lessons on understanding the layers of the atmosphere.)

The ionosphere has three different parts:
Ionosphere: D LAYER:
Between 30 and 55 miles high DURING THE DAY (highest concentration of ions is at noon)
This layer can absorb HF radio waves
This layer of the ionosphere mostly disappears at night (the ions bond again with other gas molecules and become neutral without the sun’s UV rays shining on them. See Lesson #3).
The D Layer is the focus of the EclipseMob experiment.

Ionosphere: E and F LAYERs
Between 60 and 70 miles high DURING THE DAY (highest concentration of ions is at noon)

This layer can refract HF radio waves (see the WAVES REDIRECTED activity below to help students understand refraction and reflection of waves)

This layer does not completely disappear at night; radio waves can actually “bounce off” this layer and thus travel vast distances …. If they aren’t first absorbed by the D layer.

How is each layer of the ionosphere different?

In Lesson 3: The atmosphere and radio waves, students learned that ultraviolet radiation from the sun affects the gas molecules of the atmosphere. Specifically, it can knock electrons from the atoms. The result is free electrons and ions --- the ionosphere. Usually, ions can easily combine again with each other to be neutral again.

Reviewing properties of the atmosphere, the atmosphere becomes less dense as you go up from the surface. That means there are fewer and fewer molecules as you go higher and higher.

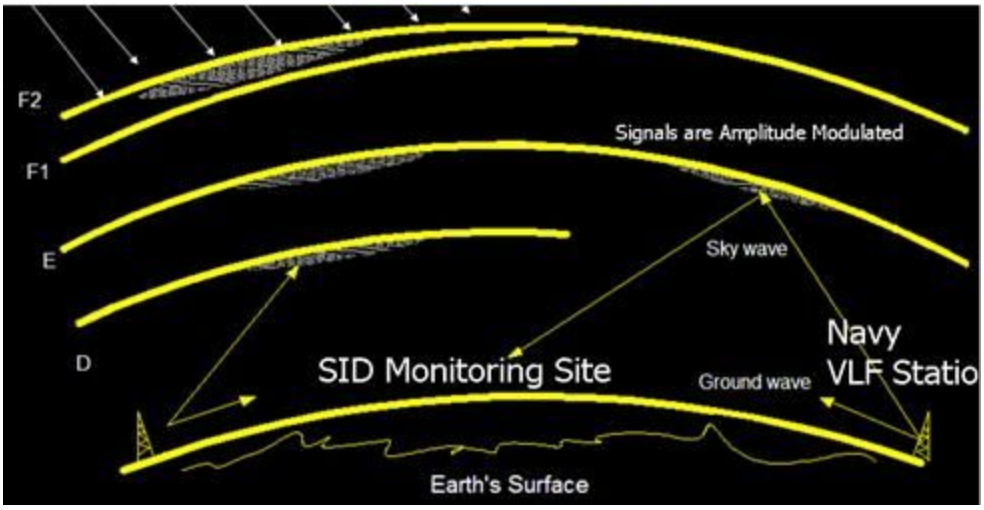
The result is that when parts of the atmosphere get ionized, the molecules are so far from each other that they rarely bump into each other and bond back together into neutral atoms.

So, these layers of the atmosphere stay ionized for a long time. The ions stick around for a while and remain ions.

The D layer does not stay ionized as long as the E and F layers do. Ask students to explain why this is (they should use the concept of density in their answer).

At night, when the Earth is facing away from the sun, which layer of the ionosphere will lose its ions fastest? Why?

Radio Waves Redirected: What does the D Layer do to Radio Waves? Why is it a big deal?
The D LAYER absorbs radio waves. So during the day, some radio signals traveling from a place on Earth's surface (such as a radio station) will not be able to travel as far as they can at night. This is not true of radio signals that have high frequencies (see the lesson on the electromagnetic spectrum). During the day, the D layer is likely to absorb low-frequency radio waves, so the signal can travel only a short distance. At night, though, with the D layer gone, the signal can travel up to the E or F layer and be reflected off those layers. The signal can in this way use the E and F layers to propel itself vast distances.



Before proceeding, be sure students understand the electromagnetic spectrum, frequency and wavelength. **Lesson 1: The Electromagnetic Spectrum** provides several lessons and activities to help students understand these concepts.

Radio waves are the lowest energy part of the electromagnetic spectrum. Still, this energy spans a wide range of wavelengths and frequencies. Radio waves, like visible, can be divided into different types based on their wavelengths and frequencies.

MAIN TYPES OF RADIO WAVES:

VHF or very high frequency: 30-300 MHz
HF or High Frequency: 3 to 30 MHz
MF or LF: medium frequency and low frequency: 3 kHz to 3 MHz
The Extremely Low, Very Low and Low Frequency bands (ELF, VLF and LF, <3kHz to 300kHz) can reflect off the D layer of the ionosphere. The E layer is the layer in between these two and the Low, Medium and High Frequencies (LF, MF and HF 30kHz to 30MHz) can reflect from this layer.

Literacy Activity: Analyzing and Understanding Scientific Data

On August 11, 1999, a total solar eclipse was visible from the United Kingdom. In other words, the moon's shadow traveled through the part of the atmosphere that is over the United Kingdom. A group of scientists wanted to find out what happened to radio signals during the eclipse.

The researchers asked people to indicate whether they could hear a certain radio station during the eclipse, and whether they could usually hear this station during the day. About 1,700 people sent in a response, which included their postal code (like a Zip code).

The radio station was Radio La Curuna. It sends out radio waves of **629 kHz (kilohertz) f**rom Northern Spain. These are VLF, or very low frequency, radio waves, the type that can be absorbed by the ionosphere during the day but not as much at night. Could the eclipse have the same effect as nighttime? The researchers knew that people in England are able to hear this radio station at nighttime.

Based on what you've learned, write down what you think the team's hypothesis was about whether or not people would be able to hear this radio station in England during the eclipse. (students will answer this question on the worksheet).

STUDENT HANDOUTS:

Based on what you've learned, write down what you think the team's hypothesis was about whether or not people would be able to hear this radio station in England during the eclipse:

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ANSWER KEYS:
Available upon request. Email : eclipsemob2017@gmail.com

ASSESSMENT:
Coming soon...