

# AM Radio Ionosphere Station

Middle School Grades

## **Lesson Summary**

Students use an AM radio to monitor changes in the intensity of solar output

## **Prior Knowledge & Skills**

Understanding of:

- The structure of the atmosphere
- Atomic structures including protons, electrons, ions

Ability to:

- Make and record observations for several days at dusk and dawn

## **AAAS Science Benchmarks**

### **The Nature of Science**

*Scientific Inquiry*

### **The Nature of Mathematics**

*Mathematics, Science, and Technology*

### **The Nature of Technology**

*Technology and Science*

### **The Physical Setting**

*Energy Transformations*

## **NSES Science Standards**

### **Science as Inquiry**

*Abilities to do Scientific Inquiry*

*Understandings of Scientific Inquiry*

### **Physical Science**

*Transfer of Energy*

### **Earth and Space Science**

*Earth in the Solar System*

### **Science and Technology**

*Understandings about Science and Technology*

### **History and Nature of Science**

*Science as a Human Endeavor*

## **Mathematics Standards**

### **Measurement**

### **Statistics and Probability**

**Teaching Time:** Long-term project

## **Materials**

- AM radio with tuner knob and volume control knob
- Paper disk of diameter greater than volume knob
- ❖ *Data collection table*  
*Not included*

## **Advanced Planning**

**Preparation Time:** 20 minutes

1. Review lesson plan
2. Practice use of AM radio
3. Create data table
4. Identify period of solar activity via Internet sites

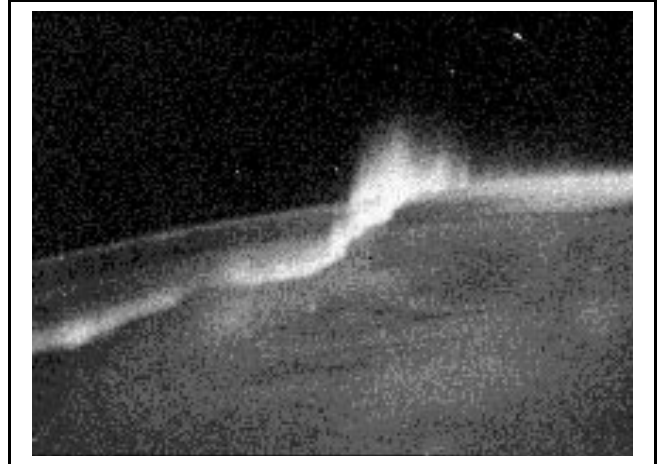
## ***Editor's Note***

Although difficult to implement in a formal classroom setting, this lesson provides interesting extra credit, project, or homework opportunities.

# Auroras and Ionosphere

## Visible Auroral Emission Lines.

Wavelength (Angstroms).	Altitude (kilometers).	Atom.	Color.
3914.	1000.	Nitrogen.	Violet.
4278.	1000.	Nitrogen.	Violet.
5577.	90-150.	Oxygen.	Green.
6300	150.	Oxygen.	Red.
6364	150.	Oxygen.	Red.
6563	120.	Hydrogen.	Red.
6611	65-90.	Nitrogen.	Red.
6696	65-90.	Nitrogen.	Red.
6768	65-90.	Nitrogen.	Red.
6861	65-90.	Nitrogen.	Red.



Aurora have been observed for thousands of years and they are the most dramatic indications of solar activity. They are produced when flows of energetic charged particles collide with the upper atmosphere.

The brilliant colors from reds to purples indicate atoms of oxygen and nitrogen being stimulated by these collisions to give off specific wavelengths of light.

They are produced at altitudes from 65 kilometers to 1000 kilometers, under conditions where the atmosphere is a better vacuum than you would find inside a TV picture tube. Because of the specific way in which the light is produced, it is impossible for aurora to happen in the higher-density layers of the atmosphere below 50 kilometers. Despite the appearances to casual observers, the aurora never reaches the ground.

Auroral activity is most intense during times when solar activity is the highest and the Coronal Mass Ejections make their way to Earth to impact the magnetosphere. They can also be produced as various parts of the magnetosphere rearrange in the

so-called **geotail** region, which extends millions of kilometers into space on the opposite 'night time' side of the earth from the sun.

The ionosphere is a narrow zone of charged particles in the earth's atmosphere. It was not discovered until radio communication was invented around the turn of the century. It has an average density of about 10 electrons per cubic centimeter, but can be 10 to 100 times as 'charged' during solar storms.

At low frequencies below 10 megaHertz, the ionosphere acts like a mirror and allows ground to ground signals to be 'bounced' long distances around the earth. At higher frequencies the ionosphere becomes transparent so that communication via ionosphere bounce becomes impossible. Instead, we must rely on satellite communication to relay signals from point to point on the earth.

The properties of the ionosphere change with the time of day, the season, and especially with the level of solar activity. In the latter case, solar flares can cause radio signal 'fade outs' which are well-known to amateur radio operators.

## Introduction

Above the earth's surface, a layer of charged particles has been used, since the turn of the century, to reflect radio waves for long distance communication. Radio waves, with frequencies less than about 10 megaHertz, are reflected by the ionosphere. They are used for military and civilian 'short wave' broadcasting. The properties of the ionosphere can change dramatically with daytime transmissions being noisier than night time ones. Solar flares also change the reflectivity of the ionosphere. This AM radio project will let students detect and study some of these changes.

## Objective

Students will construct an Ionosphere Monitor by using an AM radio to track solar storms and other changes in ionosphere reflectivity.

## Procedure

1) Break the class into equal groups and have one person in each group bring an AM radio to class.

2) Each group creates a graph of the AM band from 540 kiloHertz to 1700 kiloHertz marked every 50 kiloHertz or so over a 1-foot span.

3) Remove the volume control knob and place the paper disk over the shaft, then replace the knob. Tape the disk onto the radio and mark its edge with the numbers 0-10 counterclockwise.

4) Have the students slowly scan through the AM band and note the location of the station on the graph. Note its loudness by the number on the disk that makes the station hard to hear.

5) Identify the call letters and city of each station you find.

6) Have the groups compare their results to create a combined master plot of the AM band. Locate the most distant station you can hear and its distance in miles from your school.

7) Select a location in the band on the low end between stations. Note the kinds of 'noise' you hear in a journal log for that day. Lighting storms will sound like occasional pops and crackles. Electronic noise will sound like humming or buzzing.

8) Changes in the ionosphere near sunset or sunrise will be heard as a sudden change in the loudness of the background noise. New distant stations may suddenly become detectable. Note the time, the location on the plot, and the city or call letters. This will take some detective work.

## Materials

—An AM radio with a tuner knob and a volume control knob.

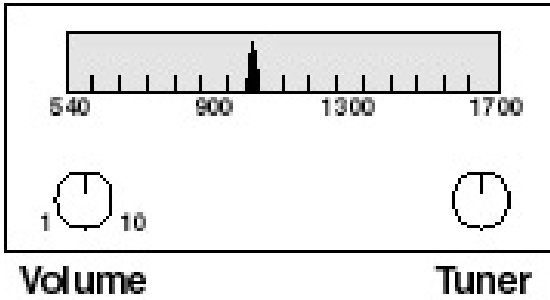
—A paper disk with a hole punched in its center to fit over the volume control.

For more things to do, advanced students may want to visit:

RadioJove at  
<http://radiojove.gsfc.nasa.gov>  
INSPIRE at:  
<http://image.gsfc.nasa.gov/poetry/inspire>

## Conclusion

Students will learn that a simple everyday device can let them listen-in to invisible changes in their environment caused by solar activity.



Note:  
 On the volume control dial, you want to affix a circular scale so that when it is turned to '1', you are not very loud, and on '10' the radio is at maximum volume. When you are studying faint stations, you will typically have the volume control turned 'up' to hear them, so that the scale running from 1-10 will tell you about how loud the weak station is so that you are JUST able to hear it.

This makes a good classroom project and homework assignment (watching the changes during and after sunset). It is also a good long-term science fair project, if you also correlate solar activity with the changes in the daytime radio noise loudness, and faint station reception. Solar flares will cause short-wave 'drop outs' and impaired reception of distant radio stations during the daytime, lasting for several hours.

### Sample Journal Entries:

April 5, 1997 10:45 EST Cambridge, Massachusetts

*"We listened to a radio frequency setting of 610 kilo-Hertz. The noise seemed pretty steady at a loudness of 8.5, but every 10 seconds or so we heard a sharp crackle of noise. We think this was a distant thunder storm, and our TV weather report says that thunder storms were in progress in Kansas at the time."*

February 6, 1997 6:00 PM EST, Dayton, Ohio:

*"Sunset happened about 35 minutes ago, and I selected the same frequency we listened to at in school, to listen for the day/night changes. I can hear a faint station we did not hear in the daytime, and the background hiss is now less loud. Instead of 9.0, I have to put the volume control over to 9.5 to hear it at all. "*

Online Internet resources you may find helpful:

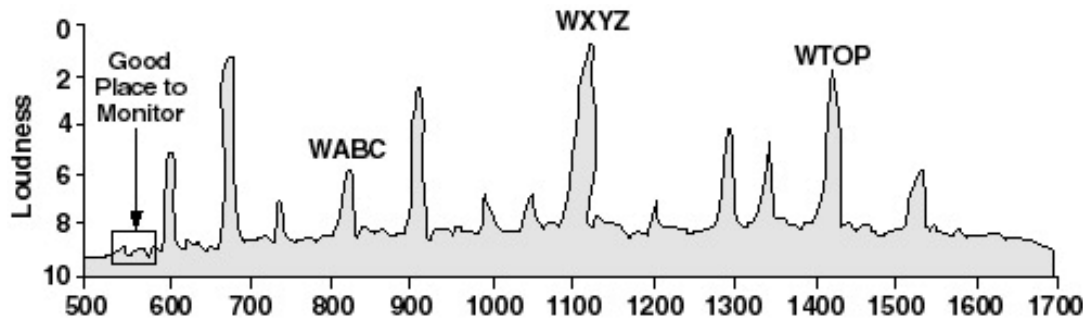
#### Today's Solar Activity:

<http://umbra.nascom.nasa.gov/images/latest.html>

#### Space Weather Forecasts:

<http://www.sec.noaa.gov/today.html>

<http://www.sec.noaa.gov/index.html>



Frequency in kiloHertz (1000 cycles per second)

$$\text{Wavelength in meters} = \frac{300,000}{\text{Frequency in kiloHertz}}$$

## Introduction

When AM radio waves travel from transmitter to a receiver far away, they have to bounce off the underside of the ionosphere to reach a distant receiver. The waves lose some of their energy each time they are reflected. Although this is normally a small amount, less than 5%, it can be several times larger than this during a solar storm. When solar flares erupt, the radiation arrives at the earth 8.5 minutes later and ionizes the D-layer located just below the ionosphere closest to Earth. Radio signals passing through this layer and bouncing off the ionosphere higher up, have some or all of their intensity absorbed. If you were listening to a distant radio station, you would hear its signal suddenly 'fade-out' for 5-10 minutes.

## Objective

Students will calculate the ending percentage of radio wave strength at the receiving station.

## Procedure

1) Introduce the concept of radio waves in the ionosphere. Be sure to include a discussion about the waves reflecting off of the ionosphere layer and the surface of the Earth, and the impact of a solar storm on these waves. A blank transparency of the Student Page may be helpful for student visualization.

2) Explain that the radio waves normally lose about 5% each time they cross the D-layer just below the ionosphere. During solar storms, the radio waves can lose as much as 30% with each crossing of the D-layer.

3) Provide students with the examples given, and check for understanding.

4) Allow sufficient time for the students to calculate the percentages, and to determine the remaining signal strength at the

receiver's location.

5) Discuss the loss of wave strength and how that may affect communication. Some possible responses may include; mobile phone connections, AM radio station signals, and military communications.

**This Lesson can conclude after the discussion, or the following additional procedure may be performed:**

6) Group the students into pairs. Have them measure the given angles. Challenge each pair to vary the angle of the bounce to determine if there is an angle that will provide a stronger signal strength. For example, adjust the angle from the transmitter to a smaller degree, creating an isosceles triangle. This will change the number of bounces

## Materials

- Protractor
- Calculator (if available)

to a fewer number of triangles, instead of the 8 given in the first example. By decreasing the number of bounces, the signal strength is stronger at the receiver's location. Adjusting the angle to greater than the original will increase the number of bounces required, and in turn decrease the signal strength at the receiver.

Example for one bounce with two passes through the D-layer:

Normal 5% loss:

$$100\% \times 0.95 = 95\%$$

$$95\% \times 0.95 = 90\% \text{ (Final)}$$

Solar Storm 30% loss:

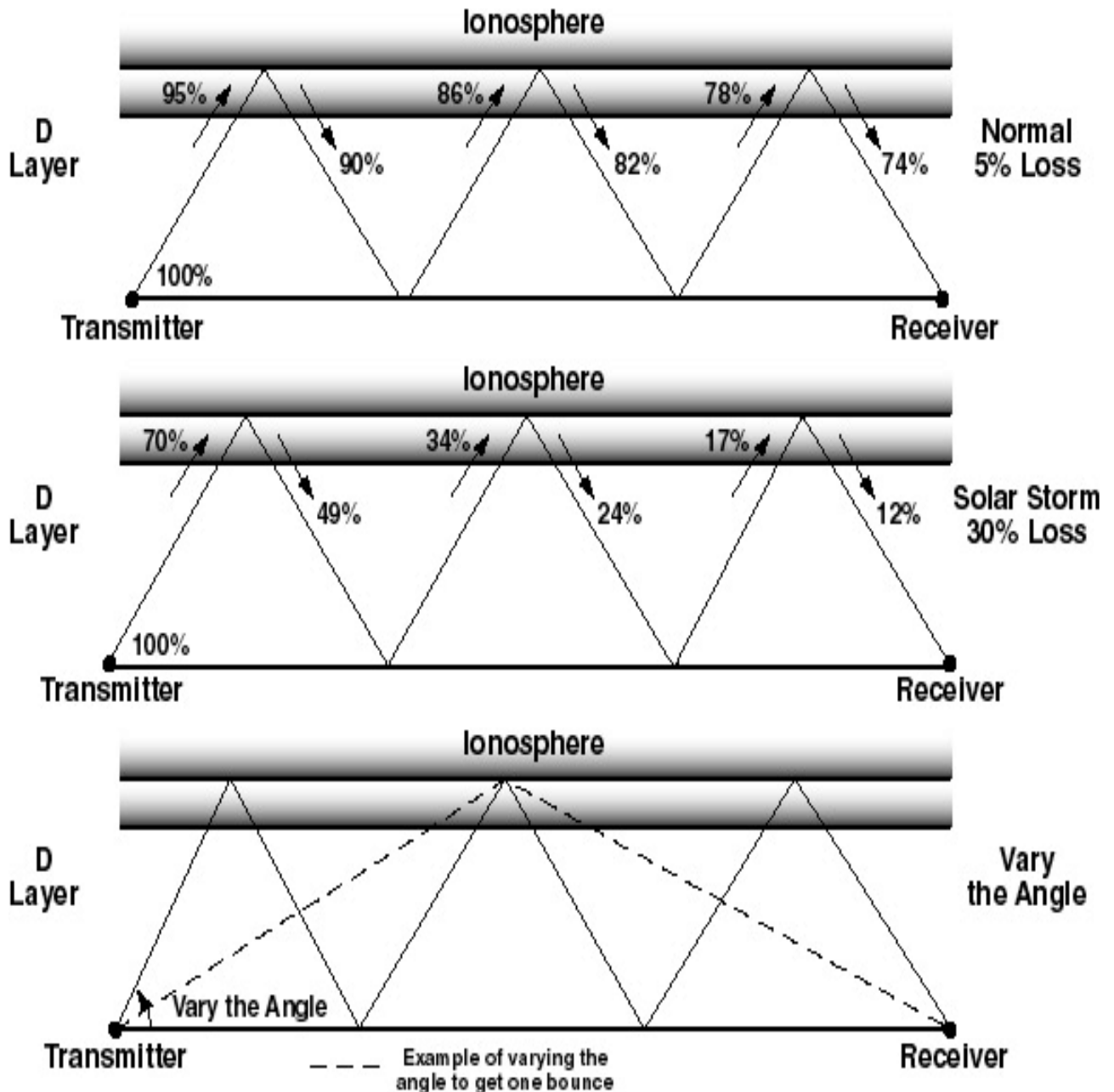
$$100\% \times 0.70 = 70\%$$

$$70\% \times 0.70 = 49\% \text{ (Final)}$$

## Conclusion

Students should learn about real everyday situations that occur with our radio systems. From their discussion, they should address that during a solar flare, the radio waves lose a great amount of strength. Students should realize that solar flares greatly affect daytime long distance communication.

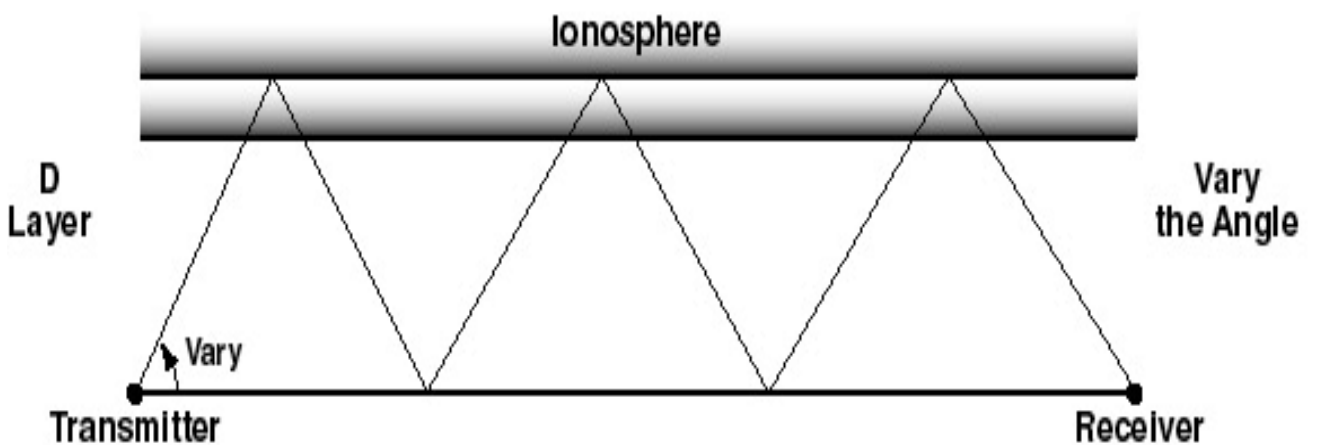
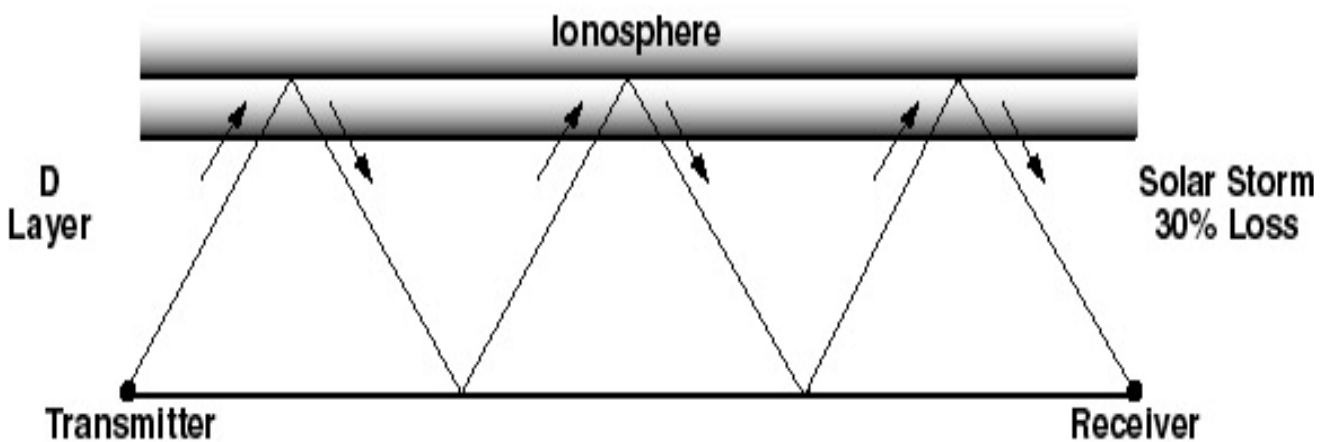
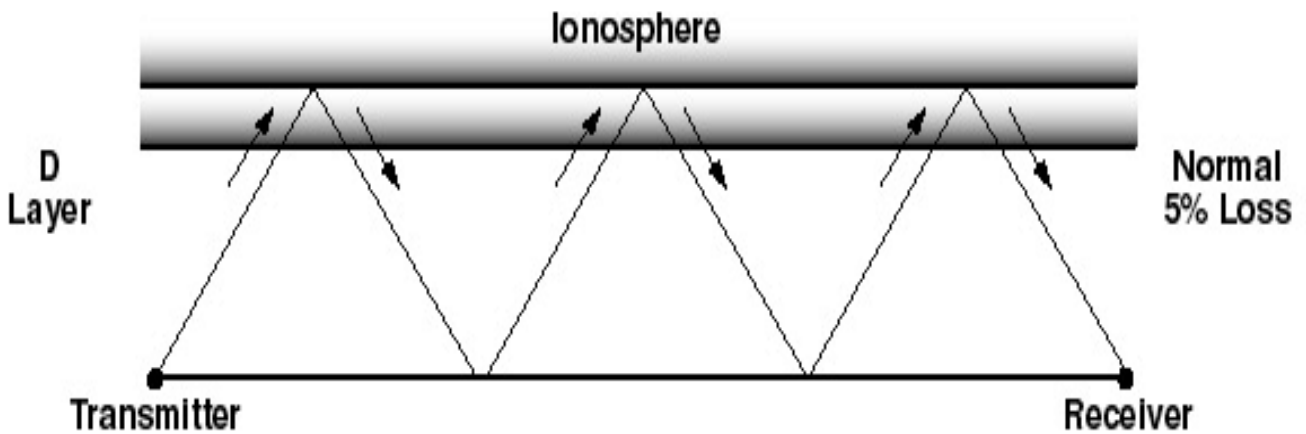
# Teacher Answer Key



Radio waves travel from the transmitter to the receiver. The signal bounces from the ground, through a layer called the D-Layer, and is then reflected from the ionosphere back through the D-Layer to the ground. The waves continue to be reflected in this way until they reach the receiver. When the waves pass through the D-Layer they normally lose 5% of their strength. The loss occurs for every pass through the D-Layer, therefore, there is a 5% loss going up, and a 5% loss going down. When a solar storm occurs, the loss can be about 30%. The engineers have to adjust the angle that the signal is projected to create maximum reception by tilting their 'satellite dish'. The angle of adjustment must permit the triangles to be isosceles triangles. The wave bounces should be adjusted so that the final bounce is a direct hit to the receiver's location. If the signal is above or below the receiver's location, or to either side, there will be no reception.

Name \_\_\_\_\_

Date \_\_\_\_\_



Calculate the remaining signal strength for each bounce from the transmitter to the receiver. Determine the amount remaining at the receiver's location. Round the answers to the nearest whole number.