Science TEKS: 5.1(A,B), 5.3(A), 5.5(A,B), 5.8(A)
Math TEKS: 5.11, 5.14, 5.15

Name_____KEY_____

Lesson One: Introduction to the Atmosphere

Overview. Today, you will begin to learn about the atmosphere—the air that surrounds Earth. Even though the atmosphere is mostly invisible gases, it plays important roles in protecting the Earth, regulating its temperature, and helping to sustain life. At the end of the lesson, your teacher will show you some cool tools that will let you measure the weather and air pollution outside your school and learn more about the air around you!

Demonstration: Glass of ice and water and the Three States of Matter
Your teacher will show you a glass of ice and water to demonstrate the three states of matter.

What solid do you see in this demonstration?

Ice cubes (also, the glass)

What liquid do you see in this demonstration?

Water in glass and in droplets on side of glass

Even though water vapor gas in the air is invisible, how do we know it exists? (Hint: Think about why the water droplets form on the outside of the glass.)

The water droplets on the outside of the glass came from water vapor gas in the air as the air cooled.

Discussion: Gases. Your teacher will help you brainstorm other examples that demonstrate that air exists, even though most gases are invisible.

Let's brainstorm together!

What are examples of things you can observe to see that air really does exist?

Answers may vary, and include blowing up a balloon, seeing a wind turbine or pinwheel turn, seeing a kite lifted into the air, breathing in and out, etc.

Discussion: Atmosphere. Your teacher will share with you some interesting facts the atmosphere and help you brainstorm why the atmosphere is so important.

Let's brainstorm together!

What are some examples of why the atmosphere is so important for life on Earth?

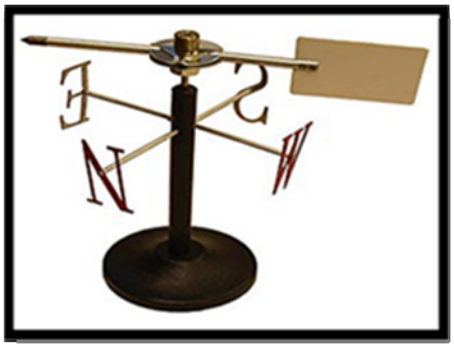
The atmosphere protects the Earth from meteors, is where all of our weather occurs (including rain & other precipitation), provides the oxygen that animals need to breathe, provides the carbon dioxide needed by plants for photosynthesis, etc.

Label each tool and write down what it measures.

Digital hygro-thermometer
(Measures air temperature and relative humidity)

Infrared thermometer
(Measures surface temperature)

Ozone scanner
(Measures ozone concentrations from ozone strips)



Wind vane
(Measures wind direction)

Science TEKS: 5.1(A,B), 5.2(A,B,C,D,E,F,G), 5.3(A,C), 5.4(A,B), 5.5(B)
Math TEKS: 5.11, 5.14, 5.15

Name_____KEY_____

Did you know? Cumulonimbus clouds can hold up to half a million tons of water!

Lesson Two: Physical Properties of the Atmosphere

Overview. Today, you will take your first measurements outside! You will be measuring the amount of ozone in the air, the humidity, the wind direction, the air temperature, and the temperature of some surfaces. You will also be able to observe the types of clouds that are in the sky. You will take these measurements at both the beginning and at the end of the class.

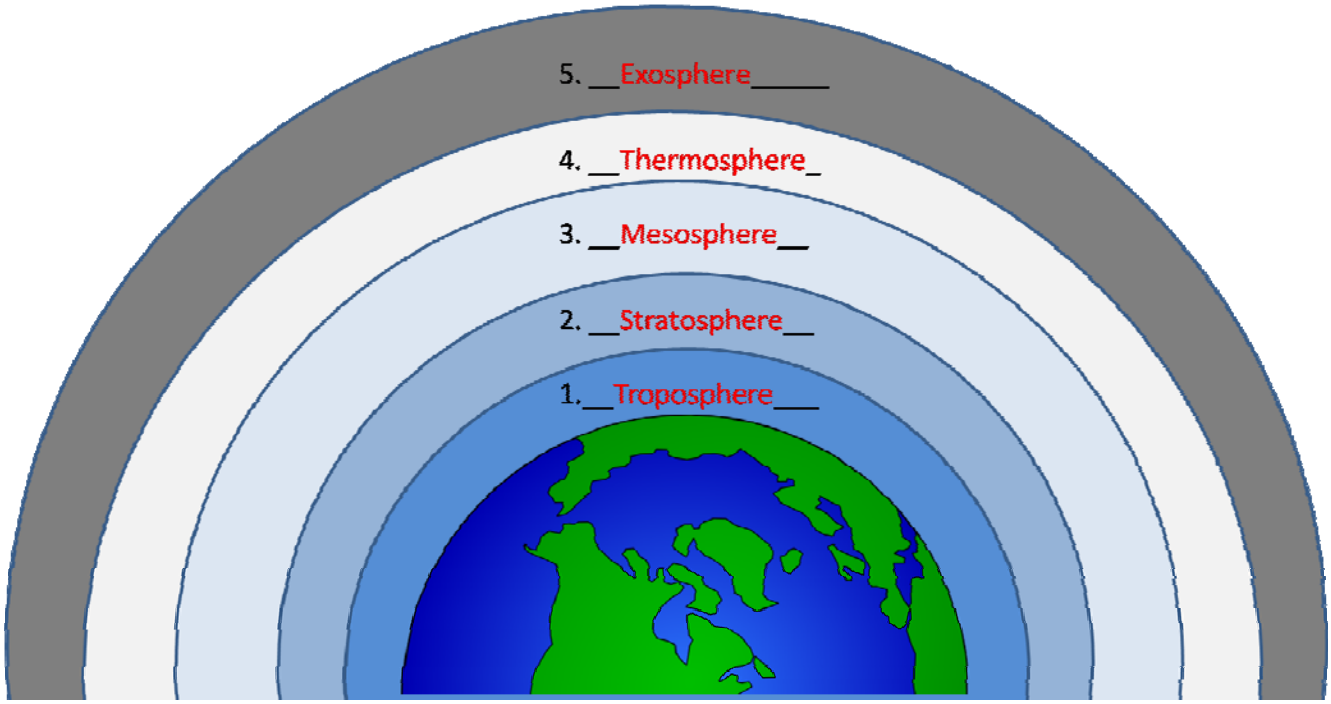
You will also be learning about the layers of the atmosphere and about two physical properties of the atmosphere: temperature and wind.

Which instrument are you most excited to use today?

(Answers may vary)

Label the layers of the atmosphere.

(Note: The actual atmosphere is very thin compared to Earth. It is drawn big here so you can label it.)



What is something that you might find in each layer?

1. Troposphere: Weather, clouds, rain, birds, airplanes, people

2. Stratosphere: Ozone layer

3. Meteors disintegrate

4. Thermosphere: Space shuttle

5. Exosphere: Satellites

Temperature

Which instruments do we use to measure temperature?

Digital (hygro-)thermometer for air temperature, and infrared thermometer for surface temperature.

What is an urban heat island? What causes it to occur?

An urban heat island is when a city is warmer than its surroundings. This occurs because urban surfaces such as asphalt and concrete heat up more quickly and allow less transpiration than vegetation, and because of waste heat from cars and buildings.

Wind

Which instrument do we use to measure wind direction?

Wind vane

What causes the wind to blow?

Differences in temperature lead to differences in pressure, which causes wind. An example of this is the sea breeze circulation that arises due to temperature differences between the land and sea.

You have begun measuring surface temperature and air temperature with your GLOBE measurements.

Which instruments did you use to measure surface temperature and air temperature?

_Surface temperature is measured with the infrared thermometer, and air temperature with the digital hygro-thermometer__

What types of objects did you measure for surface temperature?

_Answers may vary depending on what was__
__measured_____

_____

Which object had the warmest surface temperature? Why do you think that object was warmer than the other objects?

___Answers may vary___

_____

_____

_____

Did you know? The average water molecule stays nine days in the atmosphere!

Name_____KEY_____

Science TEKS: 5.1(A,B), 5.2(A,B,C,D,E,F,G), 5.3(A,C), 5.4(A,B), 5.5(A,B), 5.8(B), 5.9(D)
Math TEKS: 5.11, 5.14, 5.15

Lesson Three: Atmospheric Gases and Their Cycles

Overview. You have already learned a little about Earth's atmosphere – its five layers, and some of its important properties like temperature and wind. Now we wonder, What types of gases make up the air around us? Today, we will learn about some of the important types of gases that make up the atmosphere. We will also learn about the cycles that enable those substances to move around the Earth and its atmosphere.

What are the five main gases that make up the atmosphere?

1. _Nitrogen_____
2. __Oxygen_____
3. __Argon_____
4. __Water Vapor_____
5. _Carbon Dioxide_____

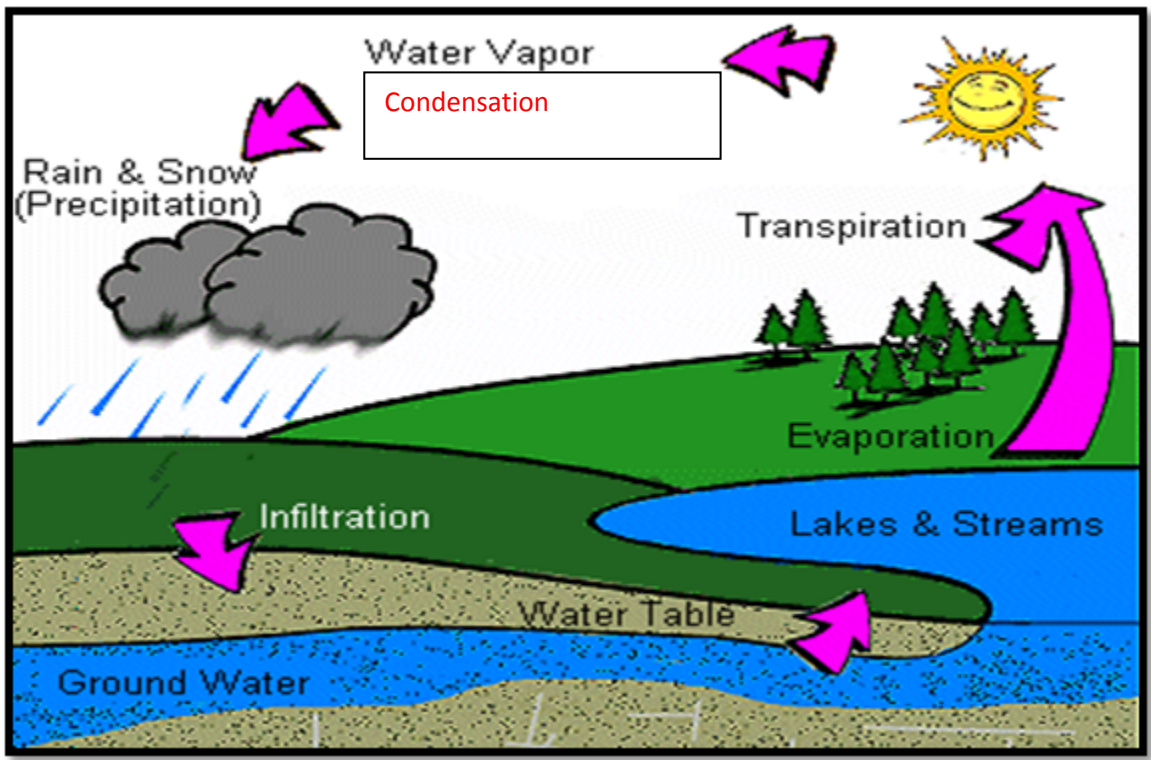
WATER CYCLE

Each of the words below is a process in the water cycle. Define each word and label it in the figure below.

1) Evaporation: Heat energy from sun causes liquid water to convert (evaporate) into water vapor gas
2) Transpiration: Water vapor is released from vegetation

3) Condensation: Water vapor converts (condenses) back into liquid water
4) Precipitation: Water falls from the sky as rain, snow, sleet, or hail

5) Infiltration: Water vapor moves from the surface into the ground water.



Credit: http://www.dnr.state.wi.us/org/caer/ce/eek/earth/groundwater/images/groundwater.gif

HUMIDITY

Humidity is a measurement of how much
_water vapor__ is in the air.

Which instrument do we use to measure humidity?

Digital hygro-thermometer

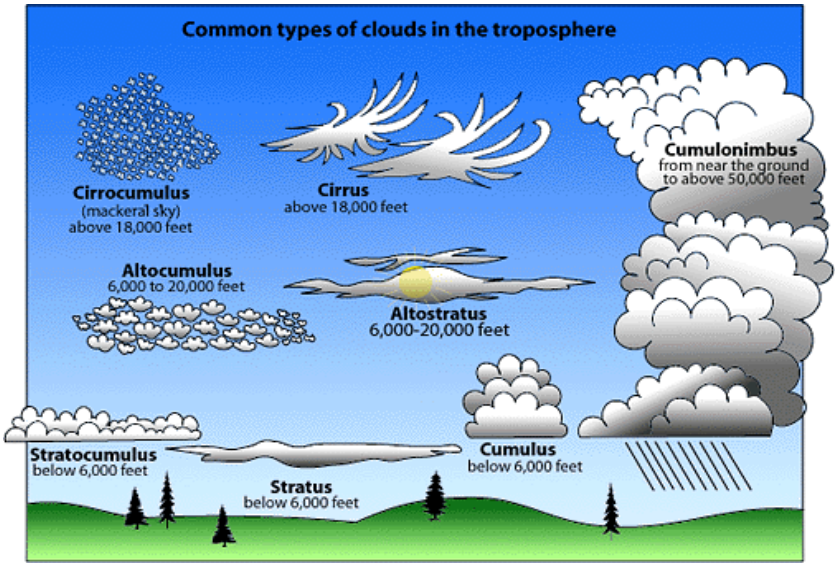
CLOUDS

In what layer of the atmosphere do you find clouds?

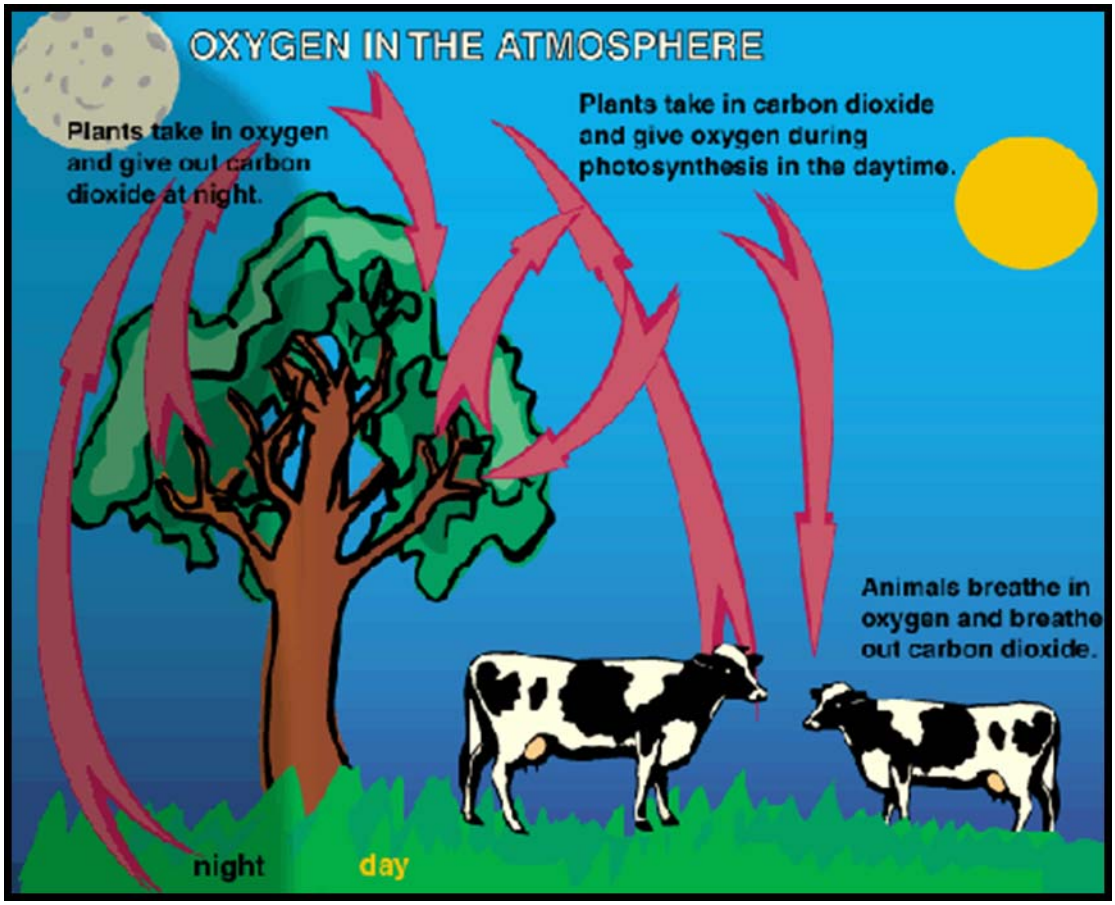
Troposphere

Which types of clouds did you see outside today?

Answers may vary



Credit: http://www.stmarysmedia.co.uk/jb01/project/images/cloudchart.gif



Oxygen Cycle

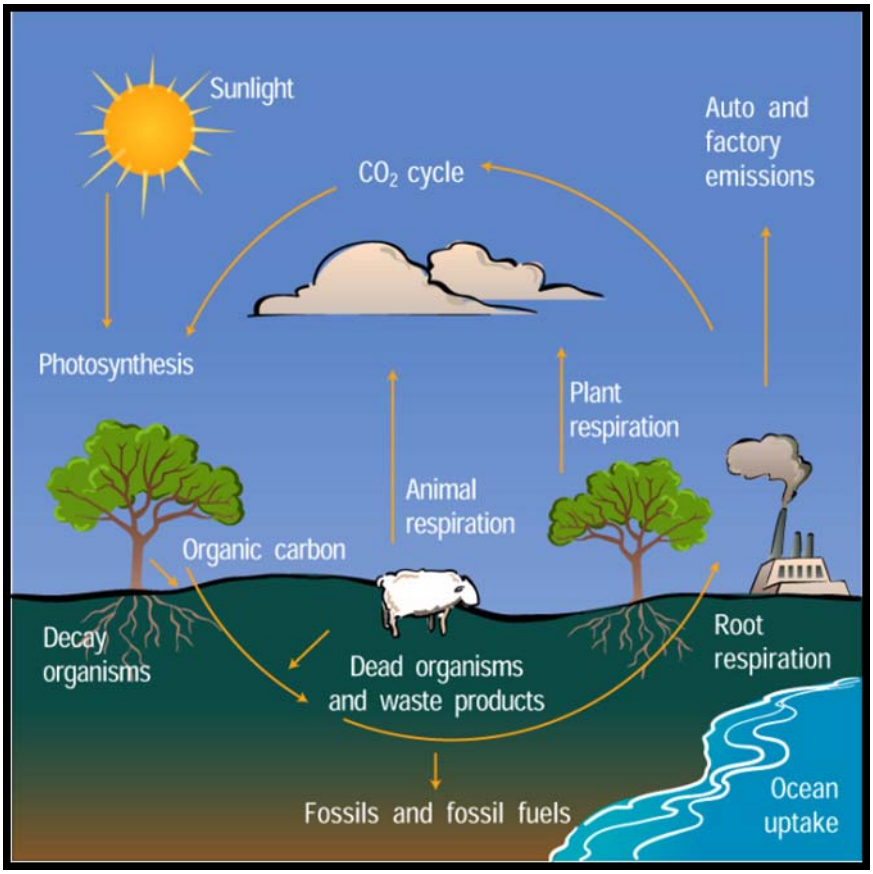
Credit: http://www.kidsgeo.com/geography-for-kids/0160-the-oxygen-cycle.php

What percent of the atmosphere is made up of oxygen?

21%

Why is oxygen important to animals?

Oxygen is needed by animals to breathe and to carry out living functions.



The Carbon Cycle

Credit: http://www.windows.ucar.edu/tour/link=/earth/climate/images/carboncycle_jpg_image.html&edu=elem

In which process do plants take carbon dioxide from the atmosphere?

Photosynthesis

In which process do plants, animals, and roots release carbon dioxide into the atmosphere?

Respiration

How do autos and factories affect the carbon cycle?

Cars and factories emit carbon dioxide into the atmosphere.

What did you find cool or surprising that you learned about the atmosphere today?
Describe a few new facts that you learned.

Science TEKS: 5.1(A,B), 5.2(A,B,C,D,E,F,G), 5.3(A,C), 5.4(A,B)
Math TEKS: 5.11, 5.14, 5.15 Name: _____KEY_____

Lesson Four:
The Dual Nature of Ozone:
Stratospheric Ozone

Overview. Ozone is a gas that is quite interesting because of its dual or "two-sided" nature. Ozone high up in the stratosphere naturally protects Earth from the Sun's harmful ultraviolet light. However, ozone that forms close to the ground is a major air pollutant. This type of ozone can hurt humans and our surrounding environment.

Today, we will focus on the good ozone, which is called stratospheric ozone. You will learn a lot more about the "bad ozone" air pollution near the ground during Lesson Five.

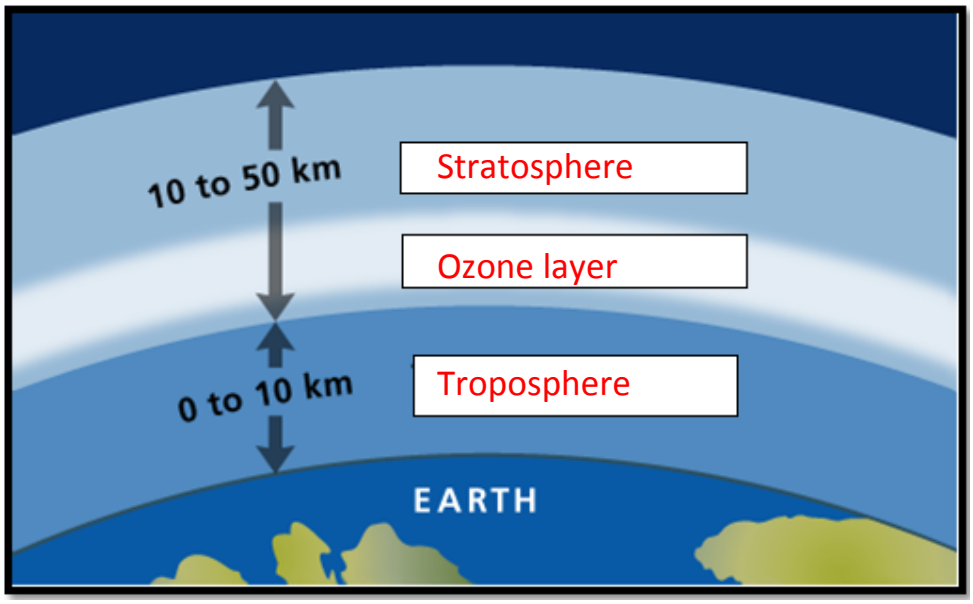
What does it mean that ozone is "Good up high, Bad nearby"?

Ozone up high in the stratosphere protects us from ultraviolet rays, but ozone at the surface can be breathed in by people and hurt our health.

Can you think of another example of something that is good to have in one place, but bad to have somewhere else?

Answers may vary, and include a lion (good at zoo, bad in living room), etc.

Label the stratosphere, troposphere, and ozone layer in the diagram.



What did you learn about the ozone layer in the video?

How does the ozone layer protect life on Earth?

The ozone layer absorbs the Sun's ultraviolet rays that can damage plants and animals.

What chemicals damage "good" stratospheric ozone?

Chlorofluorocarbons (CFCs) can damage stratospheric ozone.

What has been done to preserve the ozone layer?

The Montreal Protocol banned some of the CFCs and other gases that are most harmful to the ozone layer.

In the map that your teacher showed, where was the ozone hole?

Over Antarctica, during Southern Hemisphere springtime (October)

Science TEKS: 5.1(A,B), 5.2(A,B,C,D,E,F,G), 5.3(A,C), 5.4(A,B)
Math TEKS: 5.11, 5.14, 5.15 Name: _____KEY_____

Lesson Five: Tropospheric Ozone and Other Air Pollutants

Overview. Yesterday we learned about the "good" ozone layer high in the stratosphere that protects us from ultraviolet rays. However, ozone can also form near the surface of the Earth where we breathe. This ozone is a harmful air pollutant that can irritate our lungs. Today you will learn about how "bad" low-level ozone is created, its harmful effects, and how we can prevent its creation.

Can you remember a day when you could see that the air was polluted? Describe what you saw that indicated the air was polluted that day.

_____Answers may vary_____

_____

_____

_____

(*Note: Ozone and some other air pollutants are invisible. Thus, you may not always be able to see if the air is polluted. The EPA' Air Quality Index helps tell us how clean the air really is each day. We'll learn more about the Air Quality Index later in this lesson.*)

Air Pollution

Is all air pollution visible, or is some of it invisible?

Some air pollution is:__visible_____

but other air pollution is: ___invisible_____

What are some things that emit pollution into the air?

1. _____Cars_____
2. _____Factories_____
3. _____Construction equipment_____
4. _____Volcanos_____(answers may vary)_____

What are some effects of air pollution on humans and the environment?

1. __Makes it difficult for us to breathe_____
2. __Makes the sky look hazy (reduced visibility)_____
3. __Damages plants_____
4. __Irritates the lungs_____

What is the Air Quality Index?

This Internet Activity will help us learn about the Air Quality Index. This index tells us about the quality of the air, even if air pollution is invisible.

1. Type **http://airnow.gov/index.cfm?action=aqikids.index** into the address bar of the internet browser on your computer.

2. Click on the cloud that says "**What is the AQI?"** Click "next" to read each section so you can answer all of the following questions.
   a. What does the Air Quality Index measure?
      AQI measures how clean the air is that day.

   b. What color means the best air quality? Green

   c. What color means the worst air quality? Brown

3. Now click on the link "Air Pollution & Health." After you read each page, click "Next" to read the next page.

   a. What health word goes with a "Green" AQI? Good

   b. What does EPA recommend that active kids should do on a Red AQI ("Unhealthy") day?

EPA recommends that active kids should not spend a long time playing or being active outdoors on a Red AQI day.

Ozone Scavenger Hunt

1. Type **http://www.airnow.gov/** into the address bar of the internet browser on your computer.

2. Below the map on the homepage there is a link that says “Ozone Now”. Click on it. You should be able see the “Current Hour AQI.” How does it look? Are there any areas in the United States that look very badly polluted? Color the map as you see it:

Date: _____

Time:_____

3. If you look below the map on the screen, you can watch an animation that shows how the Air Quality Index has changed over the course of the day. What time of day has the most green areas indicating clean air? What time of day has the most air pollution?

4. Press the "Back" button to return to the homepage. Click on the map of the United States. Click on Texas. Scroll down until you see Houston-Galveston-Brazoria, TX.

   Look under the column "Current AQI." What is the current AQI number for Houston-Galveston-Brazoria? What color does this correspond to? Is it safe to exercise outside?

   What is tomorrow's forecast? What color does this correspond to? Will it be safe to exercise outside tomorrow?

5. Click on Houston-Galveston-Brazoria, TX. Click on "yesterday's summary" for ozone. Look at the Ozone: 1-hour Average Peak Concentration. What was the highest ozone concentration measured in the Houston region yesterday? Where did it happen?

Smog City 2

Go to **http://www.smogcity2.org/smogcity.cfm?preset=ozone** in your internet browser.

Current emission factors and weather conditions are causing ground-level ozone in Smog City 2 to reach “Unhealthy” levels. The Air Quality Index (AQI) level for ozone is now Red. By following the scenarios below, see how emissions factors, temperature, and sunlight impact ozone levels. The weather factors that you will be able to change around are the following: clouds/sky cover, wind, and temperature. The emission factors that you will be able to change are the following: the amount of energy sources, cars and trucks, off-road vehicles, consumer products, and industries.

Scenario 1: Emissions Factors

Use only the emission controls to reduce the ozone levels to "Yellow" on the AQI, which is "Moderate" air quality. Do not change the weather controls.

Which emission factor affects ozone the most?

Reducing the “Cars and Trucks” factor is the only way to reduce ozone levels to “Yellow” on the AQI. This includes passenger vehicles (all sizes), large and medium trucks, and motorcycles.

Which emission factor has the smallest effect on ozone?

Reducing the “Consumer Products” factor reduces the ozone the least. These products include hair spray, paints and paint thinner, charcoal lighter fluid, glue or other adhesives, and gasoline.

Scenario 2: Weather Factors

Return all emission controls and population control to the middle. These conditions result in an "Unhealthy for Sensitive Groups" value, or "Orange" AQI.

Increase temperature to 110F.
How does the increase in temperature affect ozone levels?

Increasing the temperature increased the ozone levels. Heat increases the chemical conversion of emissions to ozone and particle pollution.

Now try increasing the cloud cover.
How does the increase in cloud cover affect ozone levels?

Increasing cloud cover reduces ozone levels. Sunlight accelerates the chemical reactions that form ozone. Clouds reduce sunlight and slow ozone formation.

Now try increasing the wind speed.
How does the increase in wind speed affect ozone levels?

Faster wind speeds decrease ozone levels

Hypotheses

We saw in Smog City 2 how changes in meteorology caused ozone pollution to increase or decrease. Now let's think about what patterns we expect to see in our daily ozone and meteorology measurements.

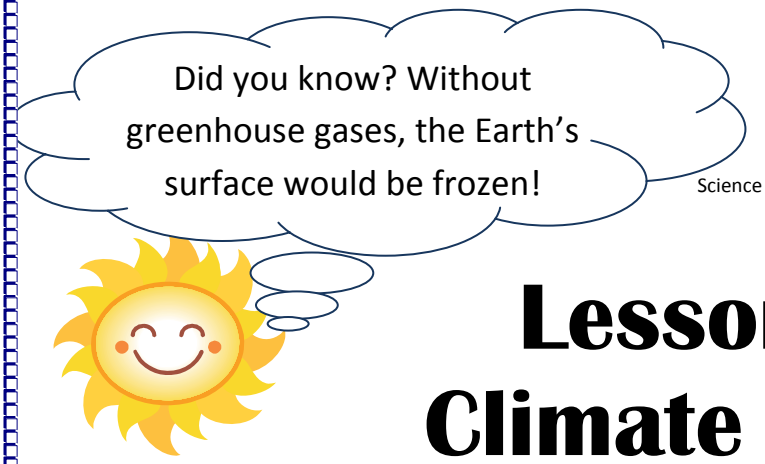
A hypothesis is an educated guess about the results that we expect to find in a scientific experiment. Even though we haven't finished all of our outdoor measurements, we can make hypotheses about how we expect the ozone and meteorology measurements to be related.

Fill in the table below with your hypotheses about your ozone and meteorology measurements.

- Check "positive correlation" if you think that ozone concentrations will be higher on days when that meteorological measurement is high.
- Check "negative correlation" if you think that ozone concentrations will be lower on days when that meteorological measurement is high.
- Check "no correlation" if you think the measurements are not related.

We will evaluate our hypotheses when we analyze all of our measurements in Lesson 7.

	Positive Correlation	Negative Correlation	No Correlation	Reasoning
Ozone and Air Temperature				
Ozone and Humidity				
Ozone and Cloud Cover				



Name: ____KEY_____

Science TEKS: 5.1(A,B), 5.2(A,B,C,D,E,F,G), 5.3(A), 5.4(A,B), 5.7(C), 5.8(A), 5.9(C)
Math TEKS: 5.11, 5.14, 5.15

Lesson Six: Climate Change

What will we be learning about today?

Today, you will be taking your last GLOBE measurements – measuring the amount of tropospheric ozone in the air, the type of cloud cover, the surface and air temperature, wind direction, and humidity.

We are going to learn about global warming, which occurs when Earth's climate becomes warmer. Certain gases in the atmosphere, like carbon dioxide, are called greenhouse gases because they trap in Earth's warmth. Without them, most of Earth's surface would be frozen. However, emitting more of these gases to the atmosphere can contribute to global warming. You will learn about some of the possible impacts of global warming today.

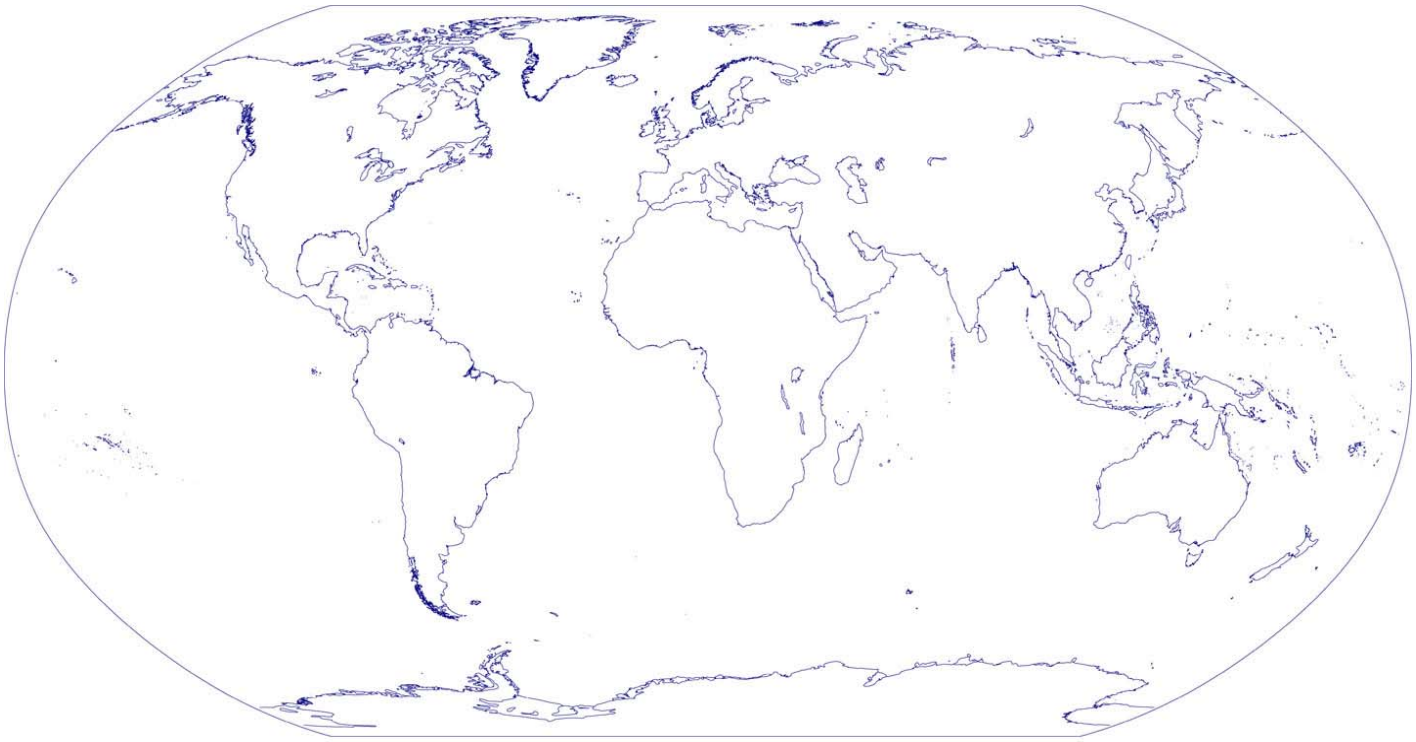
Energy efficiency and alternative sources of energy can help reduce emissions of greenhouse gases. For example if cars can use gasoline more efficiently, less air pollutants and greenhouse gases will be released into the air.

You will also be able to calculate your "carbon footprint." A carbon footprint tells you how much carbon dioxide is emitted as a result of your day-to-day actions. It can also tell you how you could change your actions so that fewer pollutants are released into the air.

Interactive Map: Global Warming Impacts

1. Go to **www.nationalgeographic.com**. Click on "Environment" on the left-hand side of the screen. Then click on the "Effects of Global Warming," found in the dark green box entitled "Environment Topics." Scroll down and click on "Interactive: Map of Impacts."
(The direct link is: **http://environment.nationalgeographic.com/environment/global-warming/gw-impacts-interactive.html**)

2. You should see a world map on the screen. On the map, you can see the effects global warming can have around the world if the climate continues to warm. Mark and write down three effects that you find interesting on the map below.



Click on one of the impacts to go into more detail. What does it say?

_____Answers may vary_____

_____

_____

Measuring Your Carbon Footprint

1. Go to **www.epa.gov/climatechange/kids/calc/index.html**
2. Follow the instructions on the screen, and answer the questions that pop up.
3. On each screen, you can answer "Yes" if you will take that action, "No" if you will not, or "I already do this" if you are already taking this action. You can learn about each action by following the "Find out more" link.
4. When you have completed answering all of the questions, "Your Summary" will come up on the screen. Fill in the blanks with your results:

Based on what you're already doing, you're avoiding _____lbs of CO_2 per year.
This is equivalent to the emissions from driving a car _____ miles.

If you take the additional actions that you checked above, you will avoid another _____lbs of CO_2 per year.
This is equivalent to the emissions from driving a car _____ miles.

Make a list of actions you could take to reduce your carbon footprint. Circle the actions that you think are most realistic to achieve.

1.

2.

3.

4.

5.

Name: _KEY_____

(Note: Answers may vary throughout Lesson 7, depending on student measurements)

Science TEKS: 5.1(A,B), 5.2(A,B,C,D,E,F,G), 5.3(A,C), 5.4(A,B)
Math TEKS: 5.5, 5.11, 5.13, 5.14, 5.15, 5.16

Lesson Seven: Analyzing GLOBE Data

What will we be doing today?

Now that you have finished taking all of your GLOBE measurements, today you will be able to analyze the data you have collected. You have been measuring surface and air temperature, wind, humidity, types of cloud cover, and the amount of ozone outside. Your goal is to understand how the amount of ozone found in the air is related to the measurements.

You will be able to do this by doing simple calculations and creating charts, graphs, and pictures to represent your data. This way you can visually see your data in an easy way and look at different trends.

For example you will be able to answer the following question:

> ***How does air temperature relate to the amount of low-level ozone in the air? Does ozone increase or decrease when temperature is warmer?***

Analyzing the data in this way will help you see whether the data supports the hypotheses you made during Lesson Five. You will then be able to come up with a conclusion that you can share with other students and your teacher.

GLOBE Measurements

Now that you have finished taking five sets of GLOBE measurements, today you will compile the data you have gotten, and look at it for interesting trends.

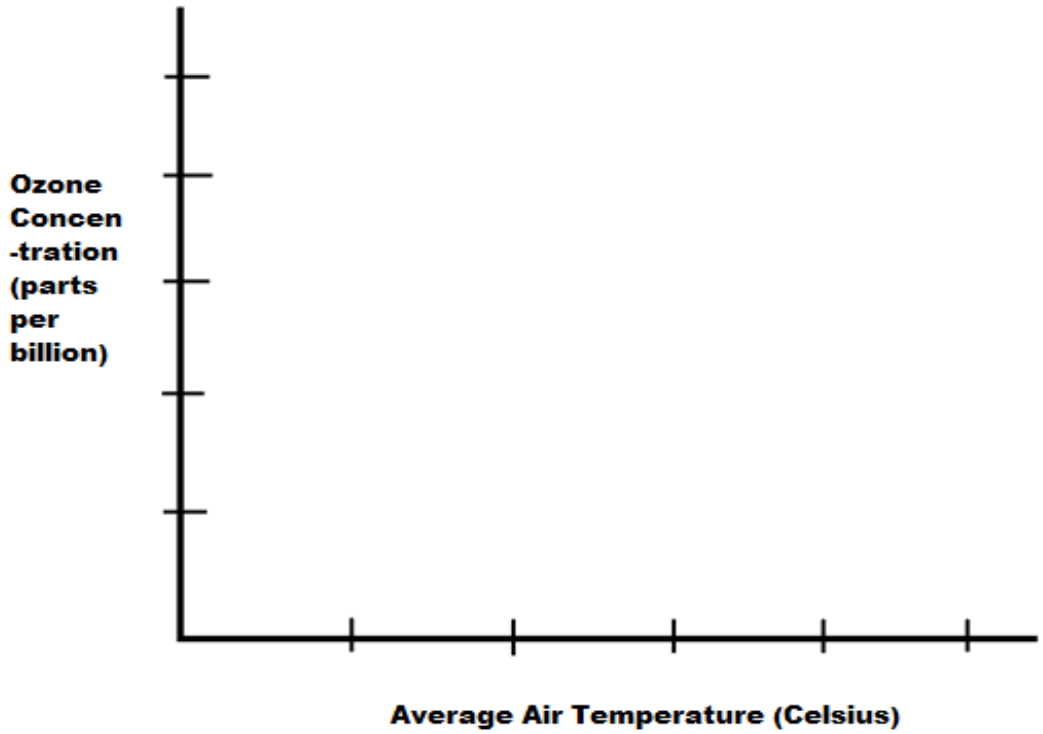
1. Get out your GLOBE Measurement Data Sheets.
2. Fill in the "AQI" row with the correct "Health Word" from the chart below.

AQI Numbers	Ozone Concentration (parts per billion)	Health Word(s)
0-50	0-59 ppb	Good
51-100	60-75 ppb	Moderate
101-150	76-95 ppb	Unhealthy for Sensitive Groups
151-200	96-115 ppb	Unhealthy
201-300	116-374 ppb	Very Unhealthy
>300	> 300 ppb (usually not shown)	Hazardous

3. Find the average air temperature on each measurement day by averaging the air temperature from the beginning and end of class. Record your answers, along with each day's ozone concentration, in the chart below.

Average Air Temperature	Ozone Concentration (ppb)

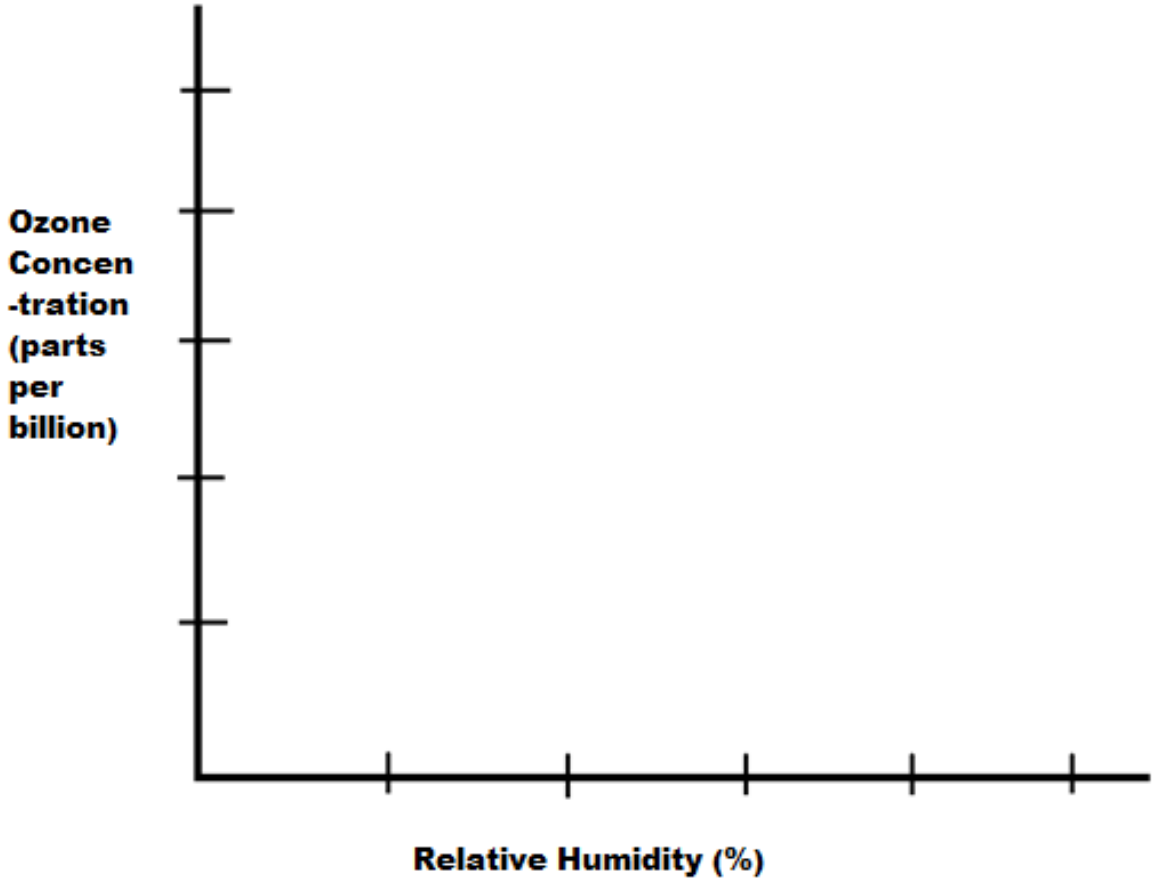
4. Now we are going to make a graph so we can see how the amount of ozone in the air is related to the average air temperature. On the graph below, Average Air Temperature (^{o} C) is the x-axis, and Ozone Concentration (parts per billion) is the y-axis. Plot the data from the chart above onto the graph below. Draw a dot (●) for each day of measurements.



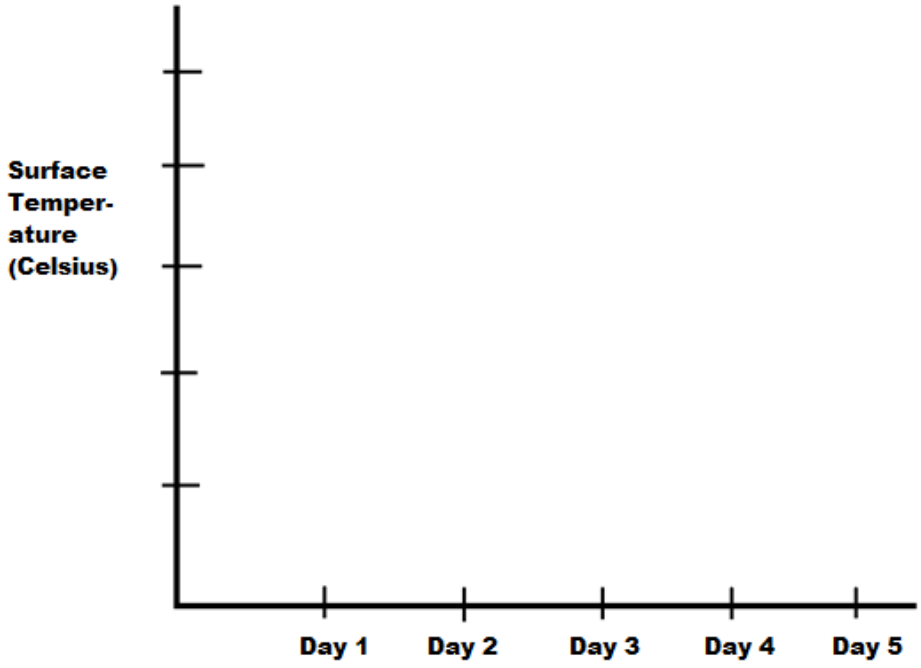
5. How is humidity related to the concentration of ozone in the air? Let's find out by graphing Humidity (%) on the x-axis and Ozone Concentration (parts per billion) on the y-axis.
    a. Find the average relative humidity by averaging the relative humidity when the ozone strip was exposed and when the ozone strip was read for each day.
    b. Record your answers and the ozone concentration for each day in the chart below:

Average Relative Humidity (%)	Ozone Concentration (ppb)

    c. Plot the data from the chart onto the graph below. Draw a dot (●) for each day of measurements.



6. Finally, let's look at the surface temperatures that you took in three different places. Did you perhaps notice that some types of surfaces are consistently hotter or colder than other types of surfaces? Let's create a line graph so that we more easily see if this is true.
   a. The y-axis of the graph will have surface temperature in Celsius and the x-axis will have the days you took the temperature.
   b. Color in the Legend below the graph, choosing one color for each surface. For example, you could choose green for Surface Temperature #1, red for Surface Temperature #2, and black for Surface Temperature #3. Write a name for each surface explaining where it was measured (e.g., "grassy field").
   c. Graph Surface Temperature #1 by drawing 5 dots for the temperature found each day, using the color from your Legend. Connect the dots to create a line graph.
   d. Then, do the same thing for Surface Temperature #2 and Surface Temperature #3. You will end with three differently-colored lines on your graph.



Legend:

☐ **Surface Temperature #1 (_____)**
☐ **Surface Temperature #2 (_____)**
☐ **Surface Temperature #3 (_____)**

Is there a type of surface that is consistently cooler or warmer than the others? Why is this so?

7. Consider your Ozone Concentration versus Average Air Temperature graph. Can you see any relationship between ozone concentration and air temperature? Does ozone increase or decrease when air temperature increases? Fill in the first row of the Table below with your answer.

8. Now consider your Ozone Concentration versus Relative Humidity graph. Do you see any relationship between humidity and ozone concentration? Fill in the second row of the Table below with your answer.

9. Now look at your Data Sheet. Do you see any relationship between Cloud Cover and ozone concentration? Fill in the third row of the Table below.

10. Now look back at the chart you filled in during Lesson Five with your hypotheses. Were your hypotheses supported by the data that you measured?

Remember:

- *Positive Correlation* means that when air temperature, humidity, or cloud cover increased, ozone concentration increased.
- *Negative Correlation* means that if air temperature, humidity, or cloud cover increased, ozone concentration decreased.
- *No Correlation* means that there is no clear relationship in the data.

	Positive Correlation	**Negative Correlation**	**No Correlation**	**Reasoning**
Ozone and Air Temperature				
Ozone and Humidity				
Ozone and Cloud Cover				

Reflection

Now that you have completed all of the lessons and have analyzed all of your measurements, what have you learned? Take a moment to reflect on your experiences in measuring and learning about the atmosphere.

What did you find most fun about the lessons?

What were the 3 most interesting facts that you learned?

Were you surprised by any of the relationships you found in your data? Remember, five days of measurements is only a beginning for evaluating hypotheses, so it's ok if you found some unexpected relationships.