



Weather Field Trip Workshop – Teacher Resources

GRADE LEVELS:

Grades 1-8

OBJECTIVES:

- Participants will explore the science behind weather phenomena.

ACADEMIC CONTENT STANDARDS:

- Earth and Space Sciences 3-5 D: Analyze weather and changes that occur over a period of time.
 - 4.1: Explain that air surrounds us, takes up space, moves around us as wind, and may be measured using barometric pressure.
 - 4.2: Identify how water exists in the air in different forms (e.g., in clouds, fog, rain, snow and hail).
 - 4.3: Investigate how water changes from one state to another (e.g., freezing, melting, condensation, evaporation).
 - 4.5: Record local weather information on a calendar or map and describe changes over a period of time (e.g., barometric pressure, temperature, precipitation symbols, cloud conditions).
 - 4.6: Trace how weather patterns generally move from west to east in the United States.
 - 4.7: Describe the weather which accompanies cumulus, cumulonimbus, cirrus and stratus clouds.
- Earth and Space Sciences 6-8 C: Describe interactions of matter and energy throughout the lithosphere, hydrosphere and atmosphere (e.g., water cycle, weather and pollution).
 - 7.3: Describe the water cycle and explain the transfer of energy between the atmosphere and hydrosphere.
 - 7.9: Describe the connection between the water cycle and weather-related phenomenon (e.g., tornadoes, floods, droughts, hurricanes).
- Physical Sciences K-2 A: Discover that many objects are made of parts that have different characteristics. Describe these characteristics and recognize ways an object may change.
 - 1.1: Classify objects according to the materials they are made of and their physical properties.
- Physical Sciences 3-5 B: Identify and describe the physical properties of matter in its various states.
 - 4.4: Explain that matter has different states (e.g., solid, liquid and gas) and that each state has distinct physical properties.

VOCABULARY WORDS:

Air Pressure – The weight per unit of area of a column of air that reaches to the top of the atmosphere.

Anemometer – An instrument for measuring the speed of the wind, or of any current of gas.

Atmosphere – The layer of air that surrounds Earth and is made up of nitrogen (about 78 percent), oxygen (about 21 percent), and miscellaneous gases (about 1 percent).

Climate – The weather conditions prevailing in an area in general or over a long period.

Convection – The movement caused within a fluid by the tendency of hotter and therefore less dense material to rise, and colder, denser material to sink under the influence of gravity, which consequently results in transfer of heat.

Coriolis Effect – An apparent force that exists because of the earth's rotation. The rotation "yanks" the land out from under the wind. The wind continues to flow straight, but the land beneath it veers away. To us earth bound folks, air moving to the north appears to veer off to the northeast. Or, in general, this effect causes air to deflect to the right in the Northern Hemisphere. IT does not exist at the Equator and is the reason why no hurricanes can form on the Equator.

Dew Point – The atmospheric temperature (varying according to pressure and humidity) below which water droplets begin to condense and dew can form

Evaporation – The process of liquid converting into a gas.

Front – A narrow zone of transition between air masses that differ in temperature or humidity.

Humidity – A measure of the amount of moisture in the air in the form of invisible water vapor.

Jet Stream – A rapidly flowing river of air with maximum speeds found somewhere near the 30 to 40 thousand foot level.

Meteorologist – A scientist who studies the weather.

Precipitation – Moisture that falls from clouds in the form of rain, snow, sleet, or hail.

Supercell Thunderstorms – A thunderstorm with a persistent rotating updraft, usually larger in diameter than most thunderstorms.

Temperature – The measure of the heat energy of the gases in the air.

Unstable Air – An environment where the temperature decreases rapidly with height. If this instability exists to a great enough altitude and the atmosphere is moist, air will rise, cool, condense, and form thunderstorm clouds.

Water Cycle – The cycle of processes by which water circulates between the earth's oceans, atmosphere, and land, involving precipitation as rain and snow, drainage in streams and rivers, and return to the atmosphere by evaporation and transpiration

Weather – The state of the atmosphere at a given point in time and geographic location.

Wind – The movement of air, which tends to move from a high-pressure area to a low-pressure area.

EXTENSIONS AT COSI:

The Weather Station: Weather Show

- Meet the stars of our show, water and air, and see how they work together to unlock the mystery of the world's weather. Feel the power of a vacuum, see the destructive force of a hurricane and take a bath in a real cloud.

Extreme Screen Theater: Tornado Alley 3D

- Tornado Alley is an explosive giant-screen adventure that takes viewers on an epic chase through the "severe weather capital of the world." Narrated by Bill Paxton (Twister, Titanic), the film follows Storm Chasers star Sean Casey and the scientists of VORTEX2, the largest tornado-research project ever assembled, on separate missions to encounter one of Earth's most awe-inspiring events - the birth of a tornado.

SAMPLE TEST QUESTIONS:

1. The climate of a region is based on its_____.
 - a. landforms
 - b. amount of vegetation
 - c. types of natural resources
 - d. temperature and precipitation
2. A mountain can affect climate by
 - a. absorbing more solar energy at the peak than at the base of the mountain
 - b. causing precipitation to fall mostly on one side of the mountain
 - c. pushing a cool air mass back out over the ocean
 - d. interfering with air currents and affecting Earth's rotation.
3. The instrument used to measure air pressure is called a(n)

- a. barometer
- b. thermometer
- c. anemometer
- d. weather vane

ADDITIONAL RESOURCES:

- Learn more about COSI's current feature film, Tornado Alley:
<http://tornadoallemovie.com/>
- View the Jason Project's weather unit, Monster Storms for more lesson ideas:
<http://www.jason.org/public/whatis/start.aspx>

Weather Field Trip Workshop Pre Visit Activities

What's the difference between weather and climate?

INTRODUCTION:

That's a good question! Sometimes the words get used almost synonymously, but there's a real difference. And we can illustrate the difference with a pack of M&Ms.

OBJECTIVES:

- Students will be able to distinguish between weather and climate.

KEYWORDS: Weather, Climate.

MATERIALS:

- Bags of M&M candy, "fun size" or:
- Beads of a mix colors and/or shapes.

INSTRUCTIONS:

1. Review the definitions, similarities and differences of weather and climate. See the "What's going on?" section below.
2. Define a different type of weather for each color of candy. Orange might be cool and cloudy, blue hot and sunny. Use your imagination!
3. Give each group a bag of candy. Each bag will represent the weather in Colorado (or wherever you are!) for a series of days in March for a particular year. You might even assign years—one bag represents 1996, one 2000...
4. Ask each group to tear open a corner of their bags, and tip out one piece of candy. That's the weather on March 1. Now, ask each group what they got. In some groups (that is, in some years...) the M&M is orange (March 1 was cool and cloudy); in others, it's blue (March 1 was hot and sunny.) That's weather. On a given day in a given year, you just can't predict what the weather will be.
5. Now, have each group pour out all of their candy and count: How many orange? How many blue? You'll find that there are some differences between groups, but the differences are reasonably small. Some groups may get a larger percentage orange candy, others will get more blue. But no one will get all orange or all blue! If you look at the weather over a longer period of time, patterns start to emerge. You are starting to pin down the climate....
6. Now, compute an average number for each color in all of the bags. This is climate, the average weather, what you expect. If you give someone a fresh bag, you can't predict the weather—whether the next candy out of the bag will be blue or orange—but you can predict *trends* in the weather. You can say, with

confidence, that there won't be 10 orange candies in a row. That would be very unlikely!

7. If you want a nice extension, you can compare different types of candy. Give some of your groups M&Ms, some of them another kind of candy. That would correspond to different climates.
8. When you are done, ask your students the question we started with: What is the difference between weather and climate?

WHAT'S GOING ON?

Weather is what it is doing *right now*. It might be raining, it might be sunny.

Climate is a bit harder to define. Here are a couple of characteristics:

- Climate describes the range of what you might expect in a given location—the limits of what the weather might be. In Fort Collins, where we are, it might be cold in March or it might be hot. It might be 25°F or it might be 75°F. But it's never 0°F or 100°F in March.
- Climate describes average weather. On any given day, it might be hot in Denver and cool in Miami, but, on most days, it's hotter in Miami than it is in Denver.
- Climate describes long-term trends. If it's cold for a few days, that's weather. If it's an ice age, that's climate.

In Ohio, our weather is pretty changeable. It might be rainy one minute and sunny the next. But our climate is pretty stable. It's warm in the summer, and cold in the winter.

FURTHER EXPLORATION:

1. View the Center for Multiscale Modeling of Atmospheric Processes' website for both student and teacher resources about weather and climate:
<http://www.cmmmap.org/scienceEd/>

CONTENT STANDARDS:

- Earth and Space Sciences 3-5 D: Analyze weather and changes that occur over a period of time.
 - 4.5: Record local weather information on a calendar or map and describe changes over a period of time (e.g., barometric pressure, temperature, precipitation symbols, cloud conditions).

ACTIVITY SOURCE:

CMMAP, the Center for Multi-Scale Modeling of Atmospheric Processes:
<http://littleshop.physics.colostate.edu/activities/atmos1/WeatherClimate.pdf>



What's in a map?

INTRODUCTION:

Understanding weather maps and making predictions are vitally important. People depend on weather news to grow their crops, conduct business, and plan leisure activities. In this lab, you will interpret a weather map and develop your own prediction.

OBJECTIVES:

- Students will read a weather map.
- Students will predict weather.

KEYWORDS: Weather map.

MATERIALS:

- Weather Map
- Paper and Pencil
- Internet Access
- "What's in a Map?" Lab Worksheet

INSTRUCTIONS:

See the student activity sheet below for step by step instructions of this activity.

FURTHER EXPLORATION:

1. Determine four locations at least 200 miles away from you in various directions. Select locations that would be good predictors of the weather you are likely to experience in the near future. Then go back to the NOAA website to gather weather data at these four locations. Click on the "2 Day History" link below "Current Conditions" for each of these locations and note the recent weather there. Describe your weather in the next 24 hours, and explain why you chose these particular locations as predictors.

CONTENT STANDARDS:

- Earth and Space Sciences 3-5 D: Analyze weather and changes that occur over a period of time.
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 - 4.6: Trace how weather patterns generally move from west to east in the United States.

- 4.7: Describe the weather which accompanies cumulus, cumulonimbus, cirrus and stratus clouds.

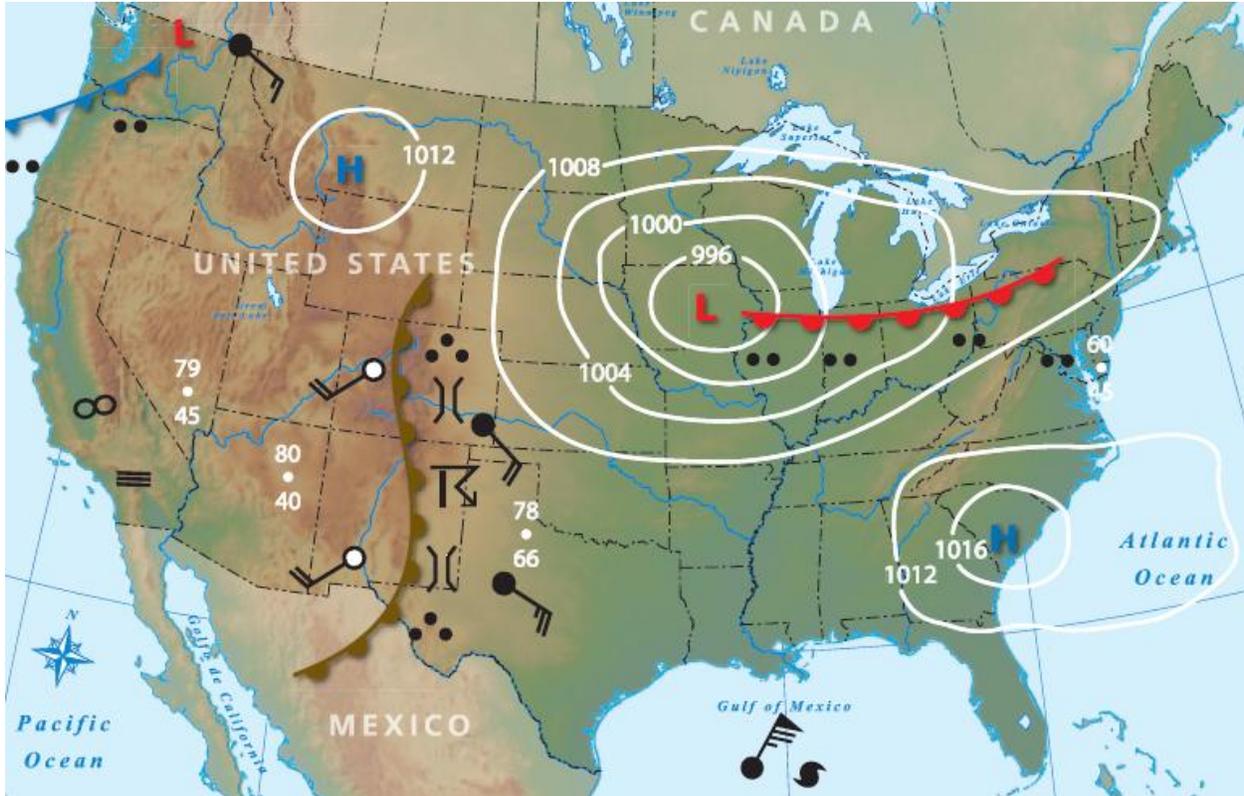
ACTIVITY SOURCE:

The JASON Project <http://www.jason.org/public/whatis/start.aspx>

What's in a map? Student Activity Sheet

Lab Prep

Practice interpreting a weather map. Refer to the key and the "Common Weather Symbols and their Meanings" chart. Use these questions to guide you.



L = Low Pressure Air pressure measured in millibars	H = High Pressure Air pressure measured in millibars	= Warm Front
= Cold Front	= Stationary Front	= Dry Line
= Thunderstorms	= Hurricane	
= Smoke	= Tornado or Funnel Cloud	
= Haze	= Heavy Fog	
= Freezing Rain	= Rain	

Station Model Symbols



1. Look at the map above. Does it make sense that New Mexico and Colorado are experiencing tornadoes? Why?
2. The weather map shows high and low pressure centers across the United States. Research wind direction around pressure centers and draw indicators to show your best estimate of air flow around these pressure centers. Note the **isobars** indicating areas of equal pressure measurements around each pressure center.
3. Write a brief, current weather report for regions of the United States (Northeast, South, Midwest, Central Plains, Rockies, West, and Northwest) based on your interpretation of the symbols on this weather map.

Northeast:

South:

Midwest:

Central Plains:

Rockies:

West:

Northwest:

4. Based on your interpretation of the weather map, write a brief weather forecast for the next 24 hours for the same regions of the United States (Northeast, South, Midwest, Central Plains, Rockies, West and Northwest). Do you see a link between weather events and weather **fronts**? Look at other weather maps and discuss your observations with your teacher.

Northeast:

South:

Midwest:

Central Plains:

Rockies:

West:

Northwest:

Make Observations

1. Go to <http://www.noaa.gov> and type your zip code into the "Local Forecast" search box. The page you now see has your "Current Conditions" in the right-hand column. Record the weather data in your area.
2. From your browser, click the Back button, and the national "Warnings and Forecasts" map will appear. Click on the map as close to your city as you can,

and a regional map will appear. Click on at least four other cities from this regional map, and find and record their local current weather conditions.

3. Using either a map from the NOAA website or your own drawing, plot the current conditions of each town using the appropriate weather symbols. Is the weather the same at each location? Why do you think this is so?

4. Using the current conditions, predict how the weather will change in your town and in the other towns you researched over the next 8 hours. Be specific about wind speed, direction, and dew point. Record your predictions.

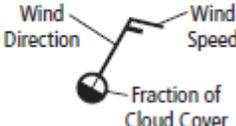
5. Before you go to bed tonight, go back to the NOAA website and look at the current conditions for each town. Were your predictions correct? Why or why not?

6. Using this data as evidence, how do you think the weather in your town will change in the next 24 hours?

7. Why do you think it is important to use more than one town's data for predictions?

8. By using the data you collected, could you predict weather conditions in the other towns you looked at?

Common Weather Symbols and Their Meanings

Systems and Fronts						Cloud Cover		
L	Center of a Low Pressure System . Air (barometric) pressure of the air mass is low. Expect clouds and precipitation.					Cloud cover is often reported in increments of 1/8 of the viewable sky overhead.		
H	Center of a High Pressure System . Air (barometric) pressure of the air mass is high. Expect clear and calm.					Clear		
	Warm Front . Transition zone between advancing warmer, moister air behind the front line, which is replacing cooler, drier air ahead of it.					1/8		
	Cold Front . Transition zone between advancing cooler, drier air behind the front line, which is replacing warmer, moister air ahead of it.					Scattered		
	Stationary Front . A boundary between cooler, drier air and warmer, moister air that is at a standstill. Neither air mass is moving.					3/8		
	Occluded Front . This front forms when a faster-moving cold front overtakes and passes under a warm front, lifting the warm air above Earth's surface.					Partly cloudy		
	Trough . An elongated region of relatively low atmospheric pressure, indicated by a brown dashed line.					5/8		
	Dry Line or Dew Point Front . Like a frontal zone, this is a boundary between dry and moist air. Its occurrence and movement are important factors in severe weather formation in the Great Plains of the central U.S.					Mostly cloudy		
Wind Speed								
Shaft indicates direction that wind is coming from.								
Observed wind speed		Rounded to the nearest 5		Plotted as				
0–2 knots (0–2 mph)		0 kts						
3–7 knots (3–8 mph)		5 kts						
8–12 knots (9–14 mph)		10 kts						
13–17 knots (15–20 mph)		15 kts						
18–22 knots (21–25 mph)		20 kts						
23–27 knots (26–31 mph)		25 kts						
48–52 knots (55–60 mph)		50 kts						
73–77 knots (84–89 mph)		75 kts						
98–102 knots (113–117 mph)		100 kts						
Station Model Symbols								
			<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  Temperature, °F 75 </div> <div style="text-align: center;">  Dew Point, °F 49 </div> </div>					

Severe Weather	
WS999	Severe Thunderstorm Watch. Designated by the National Weather Service by a blue box with the code WS and a unique number for each watch issued. A watch means that conditions are favorable for severe weather to develop. On a map, the watch area will be a four-sided region defined by specified distances to either side of a center line.
WT999	Tornado Watch. Designated by the National Weather Service by a red box with the code WT and a unique number for each watch issued. A tornado watch implies a severe thunderstorm watch for the same area as well.
Severe Thunderstorm or Tornado Warning. A warning indicates that severe weather is currently happening. In the U.S., the National Weather Service issues severe storm warnings on a per county basis.	

Pushing Up with Pressure

INTRODUCTION:

Take a deep breath. As you inhale, your lungs fill with a mixture of molecules and a small number of single atoms. Did you know that the air around us is actually pushing down with an immense amount of pressure?

OBJECTIVES:

- Students will observe the effects of air pressure on everyday objects while completing this short, simple experiment.

KEYWORDS: Air pressure, weather, hurricane.

MATERIALS:

- Lab 2 Data Sheet
- Small paper or plastic drinking cup
- Small basin (such as a bowl)
- Index card (or playing card)
- Pushpin
- Piece of tape

INSTRUCTIONS:

See the student activity sheet below for step by step instructions of this activity.

WHAT'S GOING ON? (Also appears on Student Activity Sheet.)

Air is composed of many different molecules and atoms in a gaseous state. On average, nitrogen molecules make up about 78 percent of the gases in air. Oxygen molecules account for another 21 percent of air. Carbon dioxide, argon, and other rare gases make up the remaining one percent. The amount of water vapor in the atmosphere varies. Depending on the weather, water vapor can make up from zero to four percent of the gases in air.

Although you cannot see it, you live at the bottom of an ocean of air. Every molecule and atom of air is pulled down by gravity. At Earth's surface, the accumulated weight of all of this air produces a pressure of one atmosphere. Meteorologists, however, usually use other units to measure air pressure. Scientists more often use the unit millibar (mb) or the unit hectopascal (hPa) to measure **air pressure**. We experience a standard air pressure of $1013.25 \text{ mb} = 1 \text{ atmosphere}$ at sea level. Converting this value to hectopascals is easy. One millibar is equal to one hectopascal, so Earth's standard air pressure in hectopascals is 1013.25 hPa .

Unlike solids and liquids, gases are easily compressed. The weight of the air above compresses, or squeezes together, air closer to the Earth's surface. Because more molecules and atoms are in a smaller space, collisions occur more frequently. Every time a molecule or an atom of air strikes something, it exerts a force. When atoms and molecules are squeezed closer together, more collisions occur and the force is greater. The greater force produces a higher air pressure, which is the force exerted on an area or surface in contact with the air.

When air pressure changes, the weather usually changes. An increase in air pressure typically indicates clear skies, more sun, less wind, and drier weather ahead. If the air pressure begins to decrease, just the opposite is probably ahead—clouds, less sun, more wind, and possibly precipitation of some kind. Many scientists use Aerosonde to collect air pressure data in the atmosphere. These measurements recorded along the flight path can help researchers understand a storm and predict its behavior. Is the storm intensifying? Is it weakening? The low air pressure measurements collected by Aerosonde typically occur in strong tropical storms and hurricanes.

CONTENT STANDARDS:

- Earth and Space Sciences 3-5 D: Analyze weather and changes that occur over a period of time.
 - 4.1: Explain that air surrounds us, takes up space, moves around us as wind, and may be measured using barometric pressure.

ACTIVITY SOURCE:

The JASON Project <http://www.jason.org/public/whatis/start.aspx>

Pushing Up with Pressure: Student Activity Sheet

Lab Prep

1. Air pressure is caused by moving molecules and atoms. Do you think that air pressure acts in all directions? Why or why not?
2. If the air pressure outside a container is higher than the air pressure inside the container, an overall inward push exists on the container. What would happen if a hole were made in the container?
3. Do you think it is possible to keep water in an upside-down cup using only a piece of paper? Why or why not?



Make Observations

1. Fill a small drinking cup to the top rim with water and place the index card on top of the cup. Hold the cup over a basin or sink. CAREFULLY turn the cup upside down while holding the card firmly in place. Then release your hand from the card while still holding the cup. What happens?
2. Why does the water behave as it does?

3. Try the activity again, but first use a pushpin to poke a small hole in the bottom of the cup. Cover the hole with tape, and then repeat step one. While the cup is upside down, remove the tape from the bottom of the cup. What happens?
4. Why is the behavior of the water different when the tape is removed from the cup?
5. What do you think would happen if you put the hole in the side of the cup instead of the bottom?
6. Does the size of the cup matter? Why or why not?
7. How much air can you let into the cup while it is upside down and still keep the water in the cup?
8. If you use a liquid other than water, will the activity still work? Try it! What happens?
9. Using your knowledge of air pressure, explain what happens as you drink through a straw.

What's going on?

Air is composed of many different molecules and atoms in a gaseous state. On average, nitrogen molecules make up about 78 percent of the gases in air. Oxygen molecules account for another 21 percent of air. Carbon dioxide, argon, and other rare gases make up the remaining one percent. The amount of water vapor in the atmosphere varies. Depending on the weather, water vapor can make up from zero to four percent of the gases in air.

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Weather Field Trip Workshop Post Visit Activities

Measuring Weather

INTRODUCTION:

In this lab, you will build and use a several weather measurement tools to do your own weather study.

OBJECTIVES:

- Students will build their own weather tools and will use them to measure their local weather.

KEYWORDS: Weather, Air Pressure, Hurricane

MATERIALS:

- Lab Data Sheet
- Barometer Tool (See Below)
- Wind Vane Tool (See Below)
- Anemometer Tool (See Below)
- Rain Gauge (See Below)
- Thermometer
- Compass

INSTRUCTIONS:

See the student activity sheet below for step by step instructions of this activity.

WHAT'S GOING ON? (Also appears on Student Activity Sheet.)

Scientists use weather measurements such as wind speed, wind direction, air pressure, air temperature, and precipitation amounts to help them understand the weather. Data must be collected at many locations in order for forecasters to predict future weather events. Placing measurement tools at various locations on the ground and in the air at different altitudes can help make weather forecasts more accurate. The important thing for scientists is gathering enough information at the right locations and then making a prediction based on their experience and the data they have gathered. This is not as easy as it might sound. In the case of a hurricane, each measurement indicates something different about the behavior of the storm. As each measurement is considered, patterns may begin to reveal the future of the storm. For instance, the lower the air pressure at the center of the hurricane, the stronger the storm is at that time. As air pressure in the hurricane begins to rise, scientists may predict that the storm is beginning to weaken. Forecasters can use this information to make predictions about a hurricane's formation, growth, and decay that are useful for emergency planning. How else can air pressure

figure into a typical weather forecast? When air pressure is higher at one location than at another, the air will move from the higher pressure zone to the lower pressure zone. This movement of air creates wind. We can use a tool called a barometer to measure the rise and fall of air pressure at a given location. Measuring air pressure can help us predict the weather in the near future.

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ACTIVITY SOURCE:

The JASON Project <http://www.jason.org/public/whatis/start.aspx>

Measuring Weather: Student Activity Sheet

Lap Prep:

Build, calibrate, and practice using your barometer, rain gauge, anemometer, and wind vane. Familiarize yourself with using your thermometer and compass. Then, answer the following questions.

1. How does your barometer tool work? Include as much detail as possible.
2. What are the measurement limitations of your barometer? How accurate is your barometer? How can you test the accuracy of your barometer?
3. If the barometer needle drops, how would you expect the weather to change? Why?
4. If the barometer needle rises, how would you expect the weather to change? Why?
5. Could a barometer data alone be used to predict the weather? Why or why not?
6. Research other types of barometers. How are they similar to and different from the one you built?
7. Could your wind vane be used to forecast the weather? Could the anemometer or thermometer be used without the other tools to forecast the weather? Explain why each tool can or cannot be used to forecast weather on its own.
8. Why do you need all of the tools to establish the current and future weather? What are the limitations of each of your tools for data gathering?

9. Discuss the difference between accuracy (correctness of your findings) and precision (repeatability of your findings) when collecting data. How accurate and precise are the tools you built? Explain.

10. If you had access to weather data collection tools that you knew to be accurate, how do you think your data would compare to data collected by those tools? Could you use those tools to calibrate your tools? Why or why not? Would it improve the accuracy of the data you collect? Explain.

Make Observations:

1. Use your tools to measure atmospheric pressure, wind speed and direction, temperature, and rainfall for a period of at least one week. Why is it important to collect data for more than one day?

2. What can you tell about the weather during this time period? Is it changing? How?

3. Construct graphs for the following data sets: temperature, wind speed, rainfall, and barometric pressure. Plot each set of data versus time. Indicate wind direction for each data point on your wind speed graph. Do you see any trends among these graphs?

4. Can you use your measurements to make any inferences or predictions about the weather?

5. Use the National Weather Service Web site (<http://www.nws.noaa.gov/>) to compare your observations with official recorded data. Go to the Web site and enter your zip code in the "Local Forecast" box.

6. How different were your measurements from those you found online? Why are they different?

7. Your barometer tool cannot measure pressure in millibars. How can you compare your air pressure measurements to those you found online?

8. Now that you have gathered these measurements, make some weather predictions for the next seven days. What measurements will be most helpful in making predictions?

9. Compare your predictions with the weather that actually occurs. What measurements proved to be the most informative about upcoming weather? What conclusions can you draw about your measurements and the weather you observed?

10. Would using data from the Internet allow you to make better predictions for your location? Why or why not?

11. Do you see any relationships among the measurements taken? Explain what you observed and why you think relationships do or do not exist.

WHAT'S GOING ON?

Scientists use weather measurements such as wind speed, wind direction, air pressure, air temperature, and precipitation amounts to help them understand the weather. Data must be collected at many locations in order for forecasters to predict future weather events. Placing measurement tools at various locations on the ground and in the air at different altitudes can help make weather forecasts more accurate. The important thing for

scientists is gathering enough information at the right locations and then making a prediction based on their experience and the data they have gathered. This is not as easy as it might sound. In the case of a hurricane, each measurement indicates something different about the behavior of the storm. As each measurement is considered, patterns may begin to reveal the future of the storm. For instance, the lower the air pressure at the center of the hurricane, the stronger the storm is at that time. As air pressure in the hurricane begins to rise, scientists may predict that the storm is beginning to weaken. Forecasters can use this information to make predictions about a hurricane's formation, growth, and decay that are useful for emergency planning. How else can air pressure figure into a typical weather forecast? When air pressure is higher at one location than at another, the air will move from the higher pressure zone to the lower pressure zone. This movement of air creates wind. We can use a tool called a barometer to measure the rise and fall of air pressure at a given location. Measuring air pressure can help us predict the weather in the near future.

Build a Barometer

Although you cannot see a change in air pressure, you can observe its effect on the surface of a stretched balloon skin. Here is how.

Materials

- wide-mouth glass jar
- large balloon
- scissors
- two drinking straws
- tape
- toothpick
- heavy stock paper
- metric ruler

Assembly

- 1 Stretch out a balloon by inflating and deflating it several times, then cut off the balloon's neck.



- 2 Stretch the remaining balloon membrane over the mouth of the jar, forming a tight, flat, drum-like surface.
- 3 Insert one straw into another.
- 4 Tape a toothpick to one end of this length.
- 5 Tape the other end to the top of the jar at the center of the stretched membrane.
- 6 Draw a scale with 1-mm increments onto heavy stock paper and tape it to a vertical surface. Position the assembly so the toothpick pointer registers on the scale. Label this starting point as 0 on the scale. From that point, label every fifth mark above 0 in increments of 5. Label every fifth mark below 0 in increments of -5.

Calibrate the Barometer

- 7 Observe how changes in air pressure and weather affect the position of the pointer. Keep a daily log of these readings as you complete the *Monster Storms* curriculum.

Build a Wind Vane

Materials

- card stock
- drinking straw
- pin
- pencil
- directional compass
- scissors
- metric ruler

Assembly

- 1 Cut one small equilateral triangle from your card stock paper that is 2 cm (3/4 in.) long on each side. Also cut out a circle with a radius of about 3 cm (1 in.)



- 2 Cut two 2-cm-long slits directly opposite each other in one end of a drinking straw. Cut two 1-cm-long slits opposite each other in the other end of the straw.
- 3 Slide any side of the triangle into the 1-cm slits and the circle into the 2-cm slits in the straw. Push in both pieces until they are snug. This is the wind vane.
- 4 Place the wind vane on your finger to determine its balance point. Use a pin to anchor the straw into a pencil's eraser at the vane's balance point. Blow on the straw to make sure that it rotates freely. If it does not, make the holes in the straw slightly larger until it will rotate freely.
- 5 Use a directional compass to determine the orientation of the wind.

Build an Anemometer

Materials

- tape
- foam packing peanut
- protractor with hole at measurement vertex
- paper clip
- straw
- fan

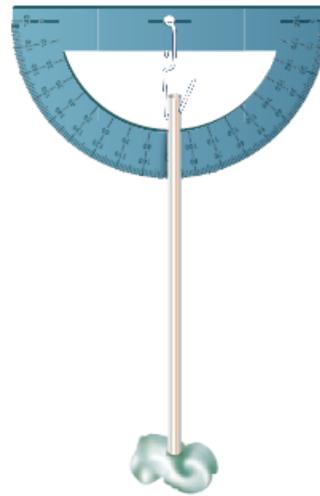
Assembly

- 1 Use a piece of tape to attach a foam packing peanut to one end of a drinking straw.
- 2 Bend open a paper clip so that it has an "S" shape.
- 3 Poke the paper clip through the side of the straw, and then loop the clip through the vertex hole in the protractor. The paper clip should act like a chain link that allows the straw to swing freely at this pivot point on the protractor.

Calibrate the Anemometer

- 4 Stand 1 m (3 ft) directly in front of a 3-speed fan on a table. Have another student turn the speed up from low speed, to medium speed, to high speed.

- 5 Hold your anemometer with the straight edge of the protractor in a horizontal position as shown, so that when the straw is at rest, it measures an angle of 90 degrees.
- 6 Record the maximum angle measured at each speed. This will be the difference between 90 degrees and your reading on the protractor. This is your wind speed scale.



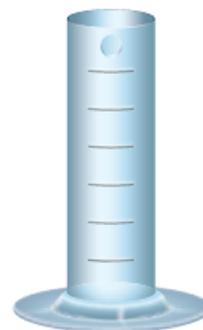
Build a Rain Gauge

Materials

- clear, flat-bottom vial with same diameter from the bottom to the mouth
- permanent marker
- metric ruler

Assembly

- 1 At 1-cm intervals, mark off the depth of the vial, starting from the bottom.
- 2 Place the vial in an open location to collect precipitation.





Dew Point

INTRODUCTION:

In this lab, you will measure dew point to determine the impact this temperature has on weather. In the map shown, air temperatures appear over dew point temperatures, both of which are more commonly recorded in English units (°F) in the United States

OBJECTIVES:

- Students will build their own dew point tools and calibrate them.
- Students will analyze the relationship between dew point and humidity after taking readings over a period of time.

KEYWORDS: Dew Point

MATERIALS:

- Lab Data Sheet
- Dew Point Tool (See Below)

INSTRUCTIONS:

See the student activity sheet below for step by step instructions of this activity.

WHAT'S GOING ON? (Also appears on Student Activity Sheet.)

When looking for tornadoes to chase, storm chasers need to know about dew point. Knowing where high and low dew points exist helps define where severe storms and tornadoes are likely to occur. Storm chasers use temperature and dew point data to find a **dry line**, a particular margin between two air masses of different characteristics. In order for a thunderstorm to form, the air mass ahead of the dry line needs to have plenty of water vapor. This condition is indicated by a high dew point temperature. The air mass behind the dry line needs to have less water vapor. As this drier mass pushes ahead, it acts like a wedge, driving the high dew point air upward. As this vapor-rich air ascends, it cools rapidly and releases its store of energy. It is this energy transported aloft that drives the formation of the powerful storm systems.

CONTENT STANDARDS:

- Earth and Space Sciences 3-5 D: Analyze weather and changes that occur over a period of time.
 - 4.2: Identify how water exists in the air in different forms (e.g., in clouds, fog, rain, snow and hail).

- 4.5: Record local weather information on a calendar or map and describe changes over a period of time (e.g., barometric pressure, temperature, precipitation symbols, cloud conditions).
- Earth and Space Sciences 6-8 C: Describe interactions of matter and energy throughout the lithosphere, hydrosphere and atmosphere (e.g., water cycle, weather and pollution).
 - 7.3: Describe the water cycle and explain the transfer of energy between the atmosphere and hydrosphere.
 - 7.9: Describe the connection between the water cycle and weather-related phenomenon (e.g., tornadoes, floods, droughts, hurricanes).

ACTIVITY SOURCE:

The JASON Project <http://www.jason.org/public/whatis/start.aspx>

Dew Point: Student Activity Sheet

Lab Prep:

Answer these questions before you go into the field with your dew point tool.

1. Build your dew point tool. Practice measuring the dew point in your classroom several times. Where did the moisture on the outside of the can come from? Did you and your teammates observe the same dew point temperature?
2. From your classroom measurements, what would you say about the water vapor content of your room? Do you have high or low humidity? What could you do to lower the amount of water vapor in your classroom? What could you do to increase it?
3. What is the relationship between dew point and humidity?
4. What is the relationship between the rising of warm, moist air and cloud formation?
5. Research other types of boundaries between air masses. Collectively, these are called **fronts**. Complete the definition table in the Lab 1 Data Sheet for the fronts you research. Indicate and compare the characteristics of the air masses you would expect to see ahead of and behind each front.

Make Observations:

1. Use the dew point tool to measure the amount of water in the air in several locations in your school over several days. Before you take measurements, think about and answer these questions:
 - a. In which places would you expect to see differences? What characteristics make you think this?

- b. What time(s) of day will be best to take measurements? Does time matter? Why?
 - c. How many times and from how many places do you need to collect data before you can use your findings to make predictions? Discuss this with your mission group to decide your answers. Make sure you can justify your answers to your teacher!
 2. Design an experiment using your dew point tool, the data you collected, and a map of the school to determine where dry lines exist.
 - a. What data, in addition to air temperature and dew point temperature, do you need to collect?
 - b. Where do you expect to see dry lines?
 3. Design an experiment to observe the relationship (if any) between dew point, air temperature, and weather. Observe clouds and make note of the type of weather that occurs before and after temperature and dew point changes.
 - a. Decide as a class how long the experiment should be conducted.
 - b. Decide as a class where you should take your measurements and make your cloud cover observations.
 - c. After collecting your data, discuss changes you observed in the weather and how dew point and air temperature might be related to your observations.

Interpret Data:

1. In your school, you probably found dry lines, but you did not find tornadoes. Explain why thunderstorms do not form inside your school. Consider what other weather conditions are necessary for these storms to form.

2. Why might dew point in an area change?
3. If you observed dew point changes, how often did they occur? Why did these changes happen?
4. How does dew point impact your life other than indicating the potential of storm formation?
5. Tornadoes can form near fronts and dry lines. What conditions do each of these boundaries have in common that make the tornado formation possible?
6. You know that dew point is the temperature at which the air is saturated, and that relative humidity is the percentage of how saturated the air is for a measured air temperature. Why would scientists use dew point, rather than relative humidity, to determine where storms might be found?

WHAT'S GOING ON?

When looking for tornadoes to chase, storm chasers need to know about dew point. Knowing where high and low dew points exist helps define where severe storms and tornadoes are likely to occur. Storm chasers use temperature and dew point data to find a **dry line**, a particular margin between two air masses of different characteristics. In order for a thunderstorm to form, the air mass ahead of the dry line needs to have plenty of water vapor. This condition is indicated by a high dew point temperature. The air mass behind the dry line needs to have less water vapor. As this drier mass pushes ahead, it acts like a wedge, driving the high dew point air upward. As this vapor-rich air ascends, it cools rapidly and releases its store of energy. It is this energy transported aloft that drives the formation of the powerful storm systems.



Build a Dew Point Tool

Materials

- metal can (1 liter or larger)
- water
- stir stick
- ice
- thermometer

Assembly

- 1 Read the thermometer and record the air temperature.
- 2 Fill the can about halfway with water and allow the temperature of the water to reach equilibrium with the air temperature.
- 3 Add ice to the water and stir with the stir stick. Do not use the thermometer to stir the ice water!

- 4 Observe the sides of the can and watch for condensation to appear.
- 5 Record the temperature of the water when condensation first forms on the outside of the can. This is the dew point temperature.

