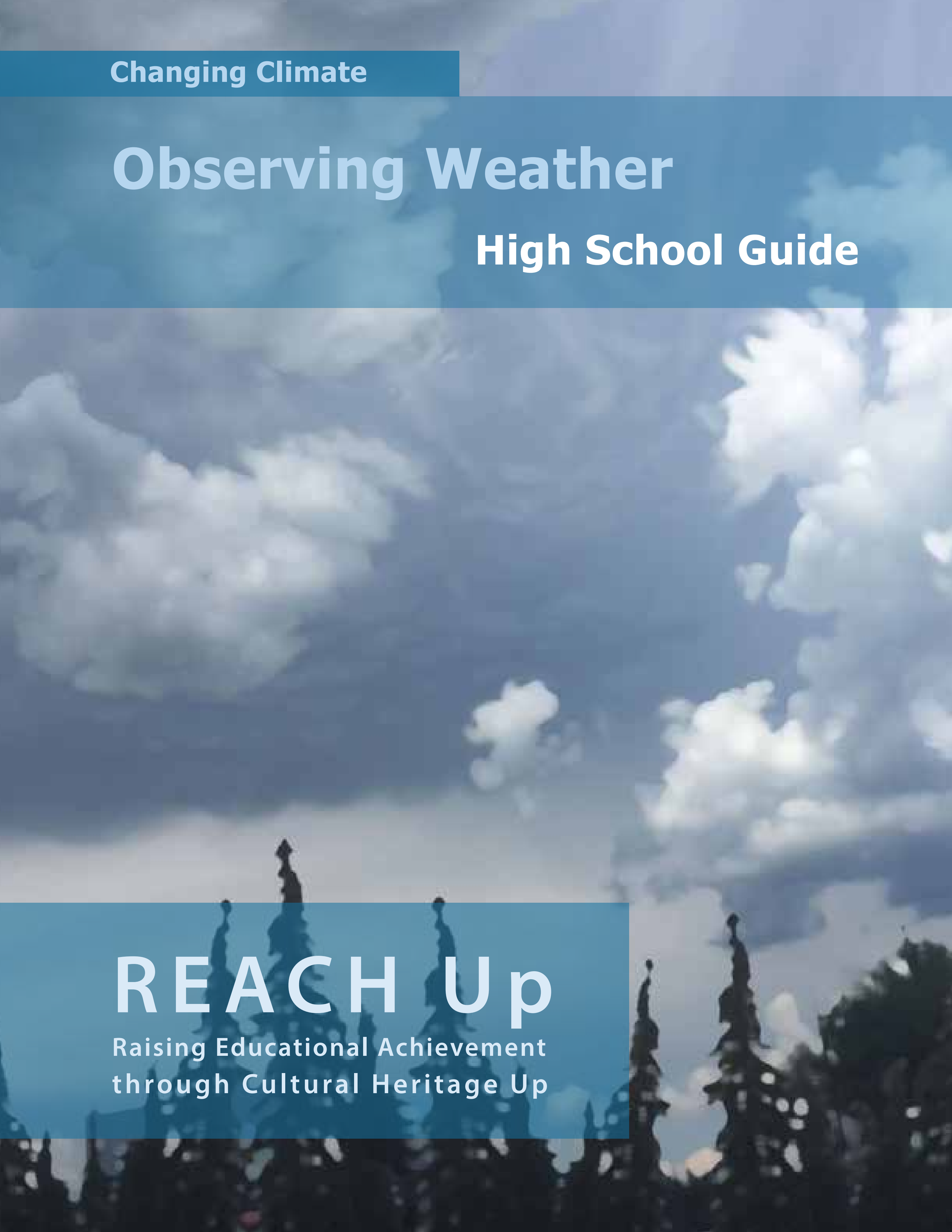


Changing Climate

Observing Weather

High School Guide

REACH Up

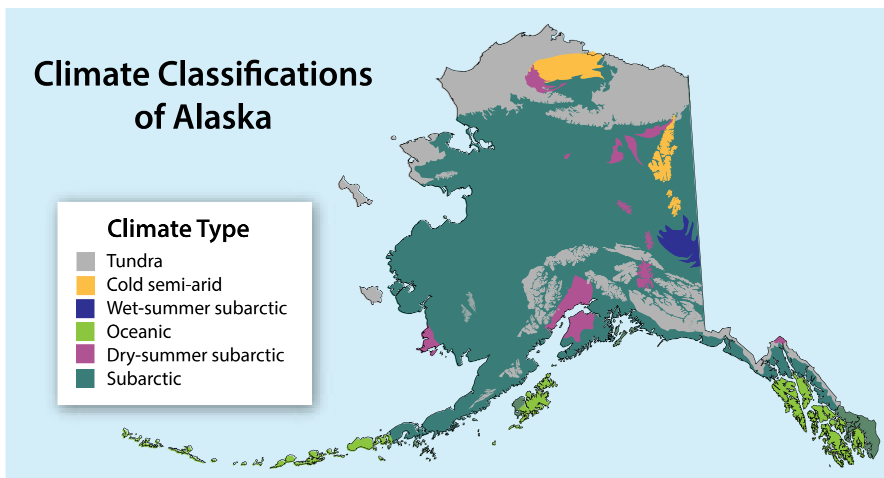
Raising Educational Achievement through Cultural Heritage Up

Changing Climate

What is Climate?

Climate is the long-term average of weather conditions that occur in a particular region. The Bering Strait region of Alaska includes subarctic and tundra climates. Subarctic climates are characterized as having their coldest months average below 0°C (32°F) and at least one month that averages above 10°C (50°F). Much of Alaska has a subarctic climate in which there is no significant difference in the amount of precipitation between seasons. Some areas get most of their precipitation in winter (dry summer subarctic), while other areas get most of their precipitation in summer (wet summer subarctic.) The tundra climate is characterized by temperatures that average below 10°C (50°F) in the warmest months. The tundra climate is a subcategory of polar and alpine climates; the other subcategory of polar climate is an ice cap climate, where all twelve months of the year average below 0°C (32°F). Which climate classification describes your community?

Residents across the Bering Strait region report changes to the local climate. Scientists, both local and distant, are working to understand the changes. The changes have been so extensive and persistent that a New Arctic is emerging. The New Arctic is warmer, with less sea ice and shorter winters. In the New Arctic, permafrost is thawing and glaciers are shrinking.



Map based on Wikimedia map "Köppen Climate Types of Alaska." *Source: WorldClim.org.*

Measuring and understanding climate change requires collecting data about the weather and environmental conditions in the area over a long period of time. Both ***qualitative data*** (the use of words to describe what is observed) and ***quantitative data*** (the use of numbers to describe what is observed) are used in climate science. Qualitative data might include descriptions of visual environmental observations, oral histories of extreme weather events, and photographs of sea ice conditions. Quantitative data about weather, such as temperature, wind speed, and snow depth can be gathered using instruments. What qualitative and quantitative environmental observations do you make? When and why do you observe weather?

How is Weather Changing in Western Alaska?

Weather is the condition of the atmosphere at a particular place and time. Wind, cloudiness, precipitation, temperature, humidity, and atmospheric pressure are characteristics of weather.

People with a lifestyle or profession that includes a lot of time outdoors tend to closely monitor the weather. In Western Alaska, weather patterns are changing. Average temperatures are increasing. Precipitation is increasing, especially during fall and early winter. Warmer temperatures mean precipitation is more likely to fall as rain and less likely to fall as snow than it once was. The weather indicators that people have relied upon for generations are also changing.

What hobbies, subsistence practices and careers in your community are contingent upon weather conditions? Why?

Location of the first-order stations and climatic zones of Alaska (from Hartmann and Wendler). *Source: Alaska Climate Research Center.*

Change in precipitation (%) and temperature (^{o}C) for the climatic zones of Alaska from 1949-2016		
Climate Region	Precipitation (%)	Temperature (^{o}C)
Arctic	8	3.3
West	18	2.1
Central	7	1.9
Southwest	40	1.5
Southcentral	8	2.6
Southeast	8	1.7

Temperatures and precipitation have increased across the state of Alaska since 1949.
Source: Alaska Climate Research Center.

Activity

Ask an Expert

1. Watch the video *Observing Weather* available at *www.k12reach.org/videos.php*.

2. Discuss local weather observation with an elder, parent or other community member.

3. Some questions you may want to ask:
   - Why do you monitor the weather?
   - What observation strategies, methods, tools or resources do you use to monitor the weather?
   - Are there some aspects of weather that you describe using numbers or measurements (such as degrees or knots)? If so, what are they?
   - Besides measurements, what other ways do you describe or discuss weather (such as cloud cover)?
   - How can I become skilled at understanding the weather?
   - Have you noticed any changes in the typical weather for our area during your lifetime? If so, what has changed and how?
   - If there have been changes, how have the changes impacted your lifestyle or the lifestyles of others in our community?
4. Share and discuss what you learned with other groups in your classroom.

If the person you interview speaks an Alaska Native language, ask them what language and dialects they are familiar with. Ask them to translate the following words:

- atmosphere
- cloud
- measure
- observe
- rain
- snow
- sun
- weather
- wind

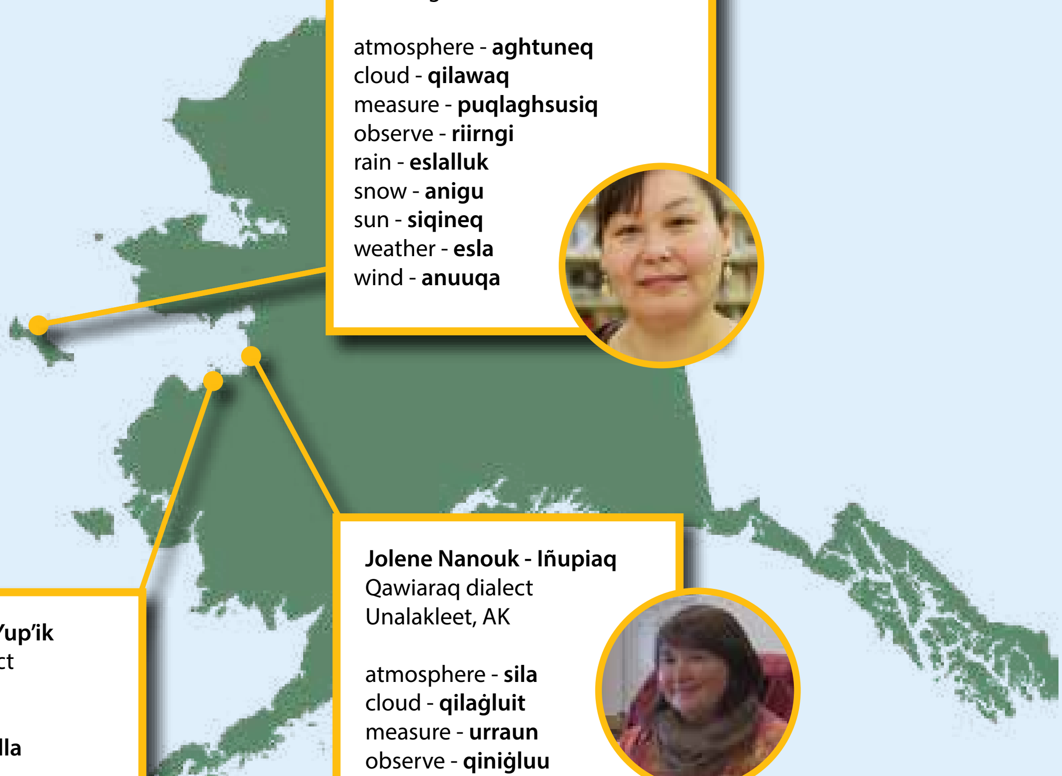
Sharon Aningayou, Gambell, discusses her observations about weather changes in her community. *Photo: Sean Tevebaugh, REACH Up.*

Compare your words with the translations on the Observing Weather Vocabulary page of this student guide. Are any of the terms the same or similar?

Observing Weather Vocabulary

Would you like to know Alaska Native language terms related to observing weather?

Work with a classmate or your teacher to practice weather vocabulary words in English and the indigenous language of your community. Your teacher will give you vocabulary cards with the English word and an illustration on one side. Write the corresponding indigenous term on the blank line on the back of each card. Use the words that you learned from a local elder or cultural knowledge bearer, or choose the translation below that is closest to your community.



Miriam Toolie - Siberian Yupik
St. Lawrence Island Yupik dialect
Savoonga, AK

atmosphere - **aghtuneq**
cloud - **qilawaq**
measure - **puqlaghsusiq**
observe - **riirngi**
rain - **eslalluk**
snow - **anigu**
sun - **siqineq**
weather - **esla**
wind - **anuuqa**

Jolene Nanouk - Iñupiaq
Qawiaraq dialect
Unalakleet, AK

atmosphere - **sila**
cloud - **qilaġluit**
measure - **urraun**
observe - **qiniġluu**
rain - **ivġaniq**
snow - **qannik**
sun - **masaq**
weather - **silagik**
wind - **anuġi**

Becky Atchak - Yup'ik
Northwest dialect
Stebbins, AK

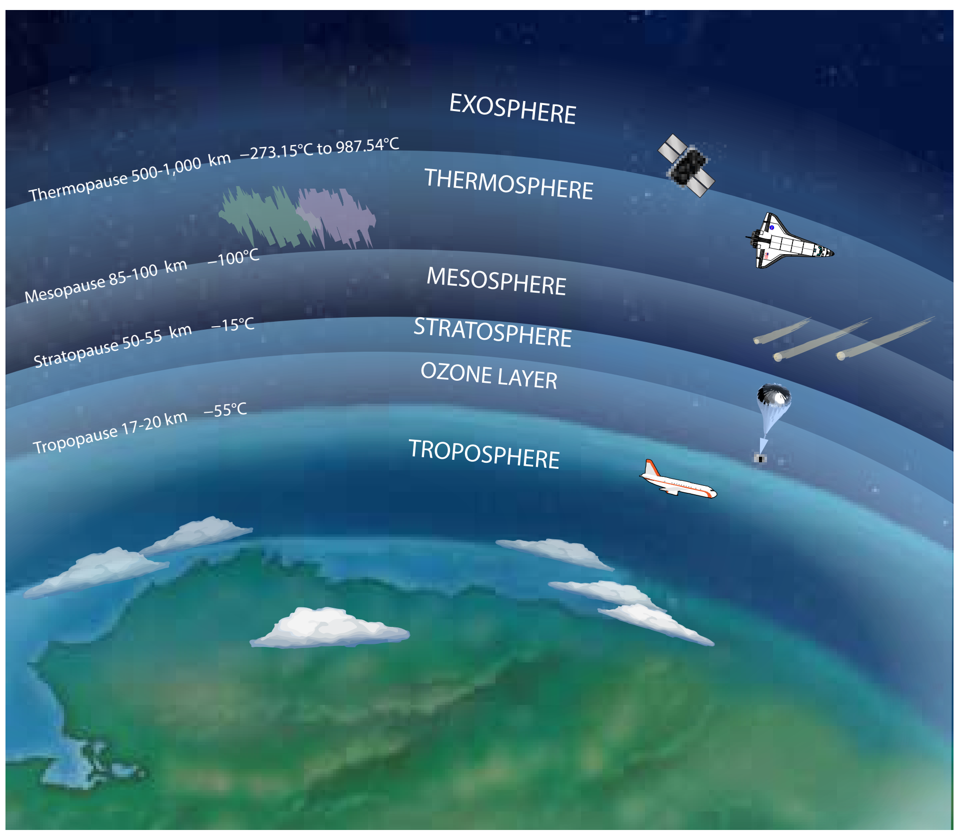
atmosphere - **cella**
cloud - **amirluq**
measure - **cuqteq**
observe - **cumikeq**
rain - **ivsuk**
snow - **qanikcaq**
sun - **ak'erta**
weather - **ella**
wind - **anuqa**

Where Does Weather Occur?

A blanket of gases known as the atmosphere surrounds Earth. The atmosphere is made mostly of nitrogen and oxygen, with small amounts of argon, carbon dioxide and other gases as well as water vapor. The atmosphere protects Earth by trapping heat near Earth's surface and by reducing the amount of harmful solar radiation that reaches Earth.

The atmosphere has layers with unique characteristics. The layer of the atmosphere closest to Earth's surface is the ***troposphere***. It is thickest near the equator and thinner near the poles. Above Alaska, the troposphere stretches from Earth's surface to 7-11 km above Earth. Most weather occurs in the troposphere, and it contains most of the atmosphere's water vapor.

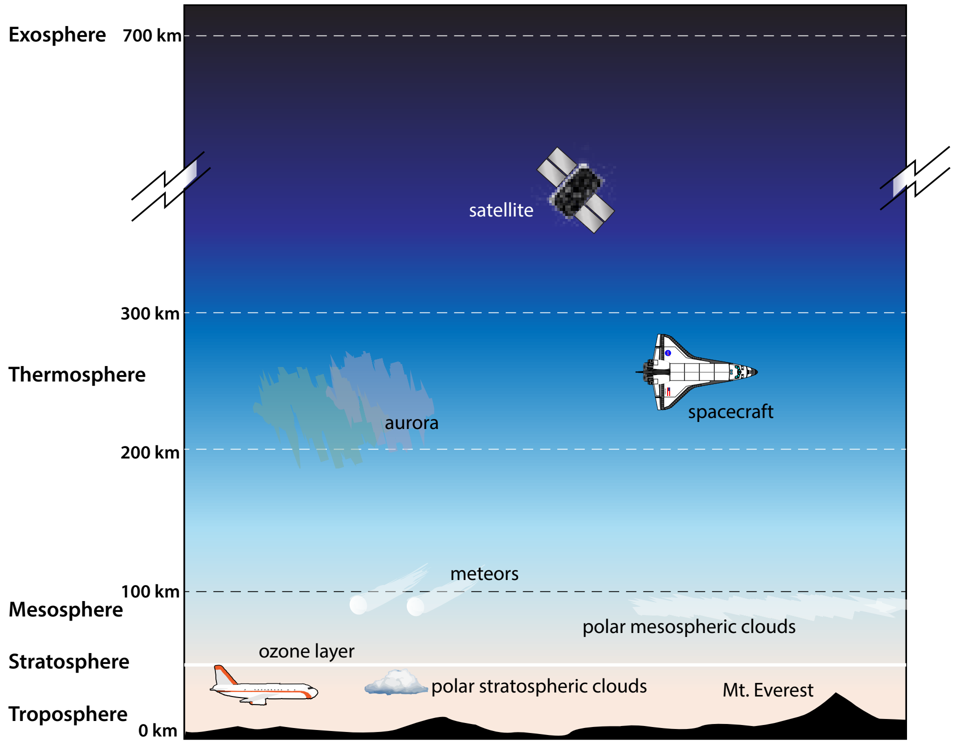
The stratosphere extends from the top of the troposphere to about 50 km above Earth's surface. The base of this layer averages -50 °C (-58 °F) at the bottom and warms to as much as -15 °C (5 °F) at the top. There is very little water vapor in the stratosphere, so the only types of clouds found there are polar stratospheric clouds (PSC) and nacreous clouds. PSCs occur near the poles in winter. Nacreous clouds tend to form when strong winds cross a long mountain ridge or in association with large thunderstorms. Weather balloons carry instruments into this layer to measure weather conditions at high altitudes.



The mesosphere is located above the stratosphere and extends to 85 km above Earth's surface. The coldest temperatures within Earth's atmosphere are found near the top of this layer. Most meteors vaporize within this layer. Next time you watch a meteor shower, notice where the light of the "falling star" winks out. This is most likely in the mesosphere. Noctilucent clouds are thin clouds that form in the mesosphere. They are thought to be made of ice crystals that form on dust particles left behind by meteors. These clouds are sometimes visible from Earth at twilight.

The thermosphere is the layer of Earth's atmosphere where the northern lights occur. It begins above the mesosphere, about 90 km above Earth's surface. The upper boundary of the thermosphere varies with solar activity. Sometimes the sun is more active than at other times. When the sun is very active it sends more high-energy radiation toward Earth. This causes the thermosphere to heat up and expand. The upper boundary of the thermosphere fluctuates at an altitude of 500-1000 km above Earth. The International Space Station and many scientific satellites, including polar-orbiting weather satellites orbit Earth within this layer of the atmosphere.

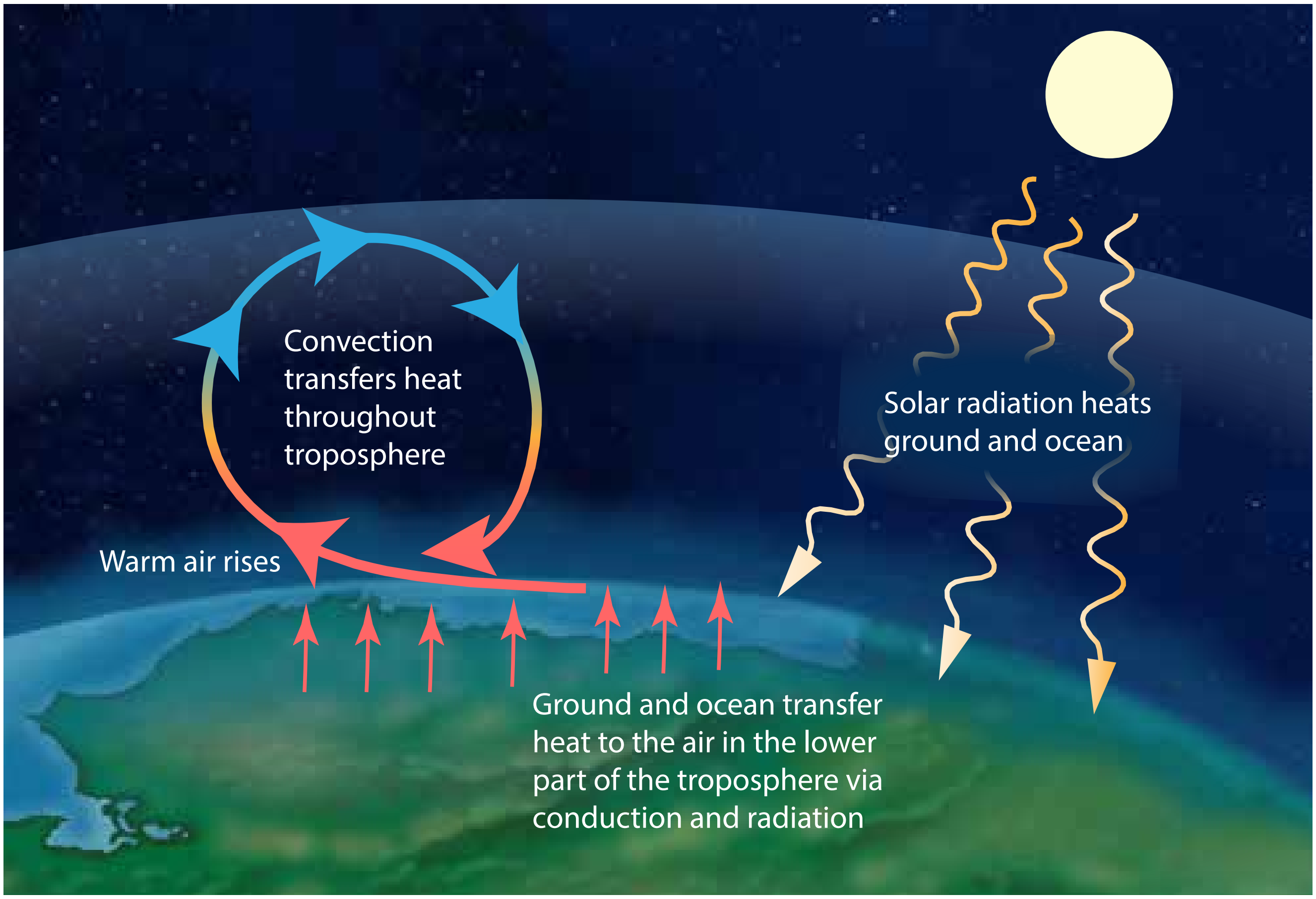
The exosphere is the uppermost layer of the atmosphere. It begins above the thermosphere and gradually fades into space. There is no clear upper boundary of the exosphere. Weather, navigation and communications satellites orbit Earth within this layer. Many of these satellites are stationed about 36,000 km from Earth's surface. At this altitude, satellites orbit Earth at a rate that matches Earth's rotation. This is known as a geosynchronous or geostationary orbit. It is useful for weather satellites because it allows the satellite to continuously observe the same region of Earth.



How Do Atmospheric Events Affect Weather?

Moving air masses

The troposphere is warmer near Earth's surface, where solar radiation heats the ground and ocean, which in turn heats the air near the surface. The troposphere is colder at higher elevations. You may have heard the expression "hot air rises." This is true. When two air masses meet, the warmer air mass will rise above the colder air mass. Because the troposphere is colder near the top than the bottom, air within the troposphere is constantly moving about. A warm air mass in the troposphere is known as a ***low pressure system***. A cold air mass is a ***high pressure system***. The cyclical movement of warm and cool air masses, also known as convection, is responsible for much of the weather we experience on Earth. As warm air in the troposphere rises and cools, clouds form and precipitation occurs. The movement of air masses is also known as wind.



Volcanoes

In Alaska, volcanoes erupt explosively, hurling ash, carbon dioxide, sulfur dioxide and other material into Earth's atmosphere. These eruptions impact weather in the state and sometimes around the world. Near the eruption site, water often condenses on the ash particles, causing clouds and rain. Rain washes the ash out of the troposphere. Thunder and lightning also often occur during eruptions, but the link between the lightning and the eruption is not well understood. World-wide volcanic weather impacts occur when the eruption is powerful enough to throw material all the way up into the stratosphere. When that occurs, the impact on weather and climate varies depending on how large the ejected particles of material are. Large particles increase the greenhouse effect, causing Earth's surface to warm. Small particles block some of the solar energy from reaching Earth, creating a cooling effect.

Pavlof Volcano erupts, March 28, 2016. Pavlof is located on the mainland of the Aleutian Chain, nearest to King Cove, Cold Bay and Belkofski villages. *Photo: U.S. Coast Guard/Nahshon Almandmoss.*

Increased greenhouse gases

Burning fuels, thawing permafrost, and deforestation all increase the amount of greenhouse gases such as carbon dioxide, water vapor and methane in the atmosphere. Small changes in the amount of these gases in the atmosphere can change weather and climate because these gases trap heat near Earth's surface.

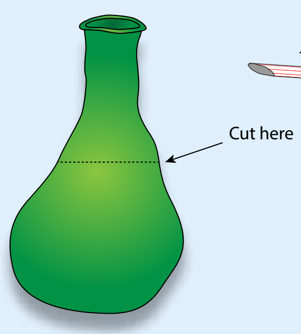
Monitoring Atmospheric Pressure

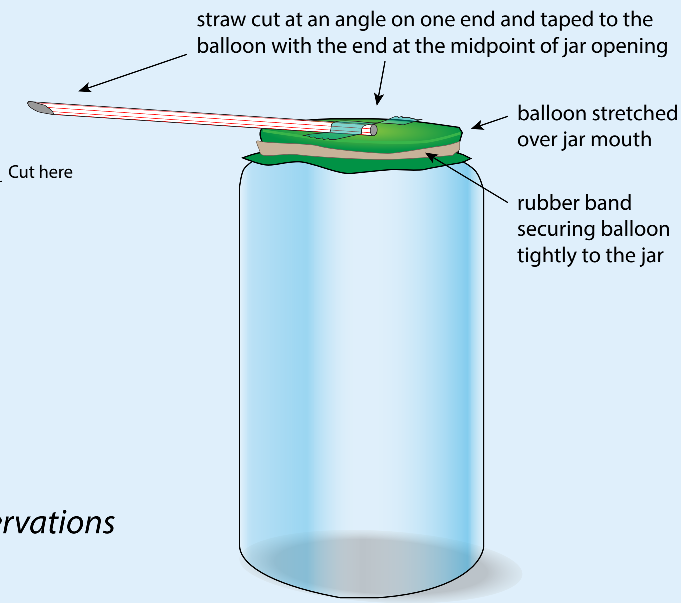
How can we detect changes in atmospheric pressure?

A barometer is an instrument used to measure changes in atmospheric pressure. The air that makes up Earth's atmosphere has mass, and gravity pulls it toward Earth. The pressure of that air against everything around it is known as atmospheric pressure. Atmospheric pressure changes with temperature and elevation. A barometer that remains in one location measures changes in pressure associated with the temperature of the local air mass. Warm air is less dense than cold air because as air molecules warm up, they move farther apart, taking up more space. As air cools, those same molecules move closer together, and take up less space. A body of warm air is a low pressure system because there are relatively fewer molecules (and therefore less weight) in the same amount of space pressing against Earth. A body of cold air is known as a high pressure system. Work with a partner to build a barometer that will detect the expansion and contraction of air associated with low and high pressure systems.

Materials

- jar
- balloon
- scissors
- rubber band
- straw
- tape
- pencil
- 1 sheet of cardstock
- Student Worksheet: *Barometer Observations*

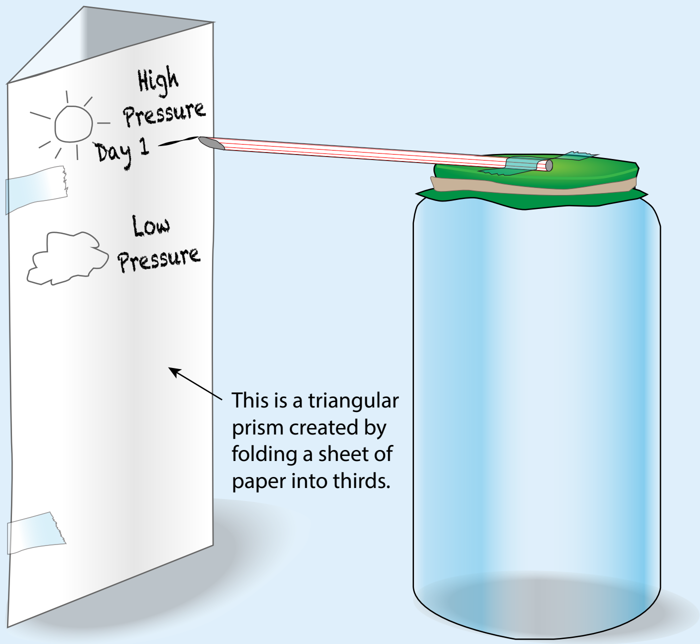




Make a barometer

1. Use the scissors to cut off the neck of the balloon.
2. Stretch the balloon tightly over the mouth of the jar and secure it with a rubber band.
3. Use the scissors to cut one end of the straw at an angle, creating a point.
4. Tape the other end of the straw to the balloon that is stretched over the jar. Make sure that the end of the straw is at the center of the balloon "lid."

5. Fold the cardstock into thirds to create a triangular prism, and stand it near the jar so that the pointy end of the straw is almost touching the cardstock.
6. Use your pencil to make a mark at the level the straw pointer is indicating. This mark indicates today's atmospheric pressure on your scale. Label the mark "Day 1."



This is a triangular prism created by folding a sheet of paper into thirds.

When a high pressure system moves into your area, the pressure around the barometer will increase, the air in the jar will contract, and the balloon will be pushed inward a bit. Your pointer will tilt upward.

7. Write "High Pressure" above the line on your scale.

When a low pressure system moves into your area, the pressure around the barometer will decrease, the air in the jar will expand, and the balloon will be pushed outward a bit. Your pointer will tilt down.

8. Write "Low Pressure" below the line on your scale.

9. Place your barometer in an area of the classroom where it will not be disturbed.
10. Look outside. Is the sky cloudy? Clear? Partly cloudy? Is precipitation falling? Record your observations on the Student Worksheet under "Day 1 Observations."

Monitor air pressure

11. Over the next 2-4 days check your barometer reading each day. Make a new mark on your scale each day and label it Day 2, Day 3, etc.
12. Look outside each day and record your observations of sky and weather conditions on your worksheet.

Discuss

- Did the atmospheric pressure in your community change each day? If so, how?
- How did changes in pressure affect the local weather?
- What do you think would happen to the reading on your barometer if you shined a heat lamp at the jar? Why?

What is the Coriolis Effect?

Have you ever watched the weather channel and noticed that large storms spin as they travel through the atmosphere? A phenomenon known as the ***coriolis effect*** is responsible for this spinning. The coriolis effect describes how Earth's rotation affects the movement of air and objects within the atmosphere, as well as ocean water. This phenomenon causes things traveling long distances above Earth to move at a curve instead of a straight line. In the case of air moving from a high pressure to a low pressure area, the air will attempt to move in a straight line to the low pressure area. However, Earth's rotation distorts this movement.

The image shows the gulf of Alaska on May 2, 2014. Low pressure systems produce swirling cloud formations like these because of the coriolis effect. *Photo: NASA/Norman Kuring, NASA's Ocean Color Web.*

Modeling the Coriolis Effect

How does the coriolis effect impact objects and air masses traveling in Earth's atmosphere?

Earth is constantly rotating. As viewed from the North Pole, Earth rotates counterclockwise. Earth's rotation impacts the movement of the air within Earth's atmosphere and the apparent movement of objects that travel above Earth's surface, such as airplanes. This impact is known as the coriolis effect. Work with a partner to model the coriolis effect.

Materials

- Globe
- Scissors
- Map of Northern Hemisphere
- Ruler
- Pencil
- Metal brad
- Construction paper
- Tape

1. Cut out the map of the Northern Hemisphere. Find the North Pole at the center of the map, and the Equator around the perimeter of the map.
2. Place the map near the middle of the construction paper so that the construction paper is visible on all sides around the map.
3. Poke a small hole at the North Pole and insert a brad into the hole. Fold the back of the brad open and tape it in place to pin the map and construction paper together.
4. Tape the construction paper to the table or desk. Rotate the map a few times to ensure it spins easily on the brad. Do not put any tape on the map.

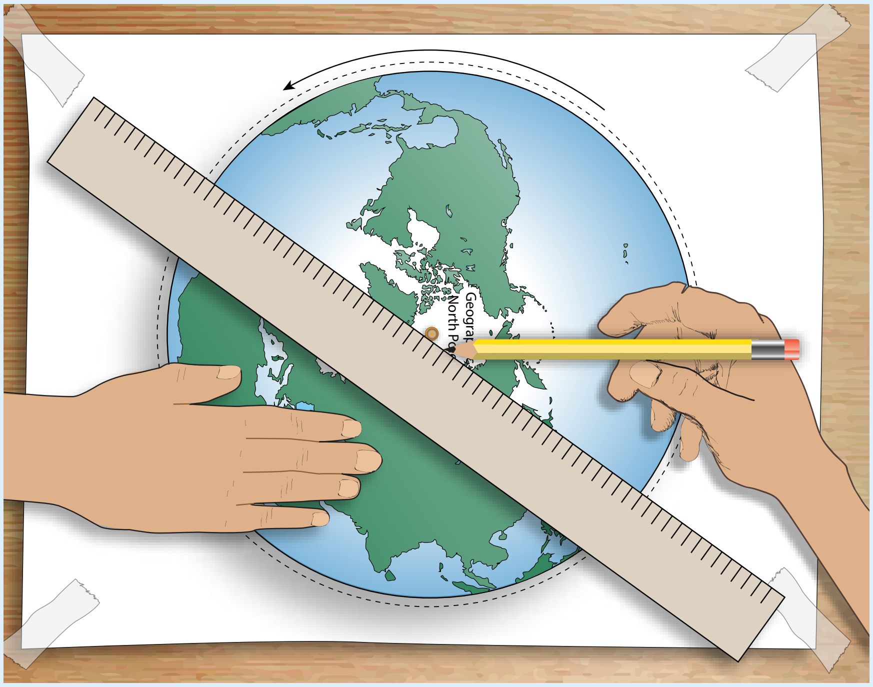
Activity

Model It!

1. Turn the map counterclockwise on the brad. This represents Earth's rotation.
   - Which location moves faster as Earth rotates, Alaska, or the Equator?
   - Which moves faster, Alaska or the North Pole?
2. Stop rotating the map. Place a ruler across the map, near the middle, but not on top of the brad. Use your pencil to draw a line along the ruler from the North Pole to the Equator. Move the ruler and look at your line. You should have a straight line. This is what a strait path through the atmosphere would look like if Earth were not rotating.
3. What will happen if the map is rotating as you draw a line from the North Pole toward the Equator? Try it.
4. Place the ruler over the map again and gently hold it in place. Ask your partner to rotate the map COUNTER-CLOCKWISE as you slowly draw a line along the ruler from the pole toward the equator. Lift the ruler and look at your line. What shape is your line?
5. Draw an arrow at the end of your line, to indicate which direction the line was pointed as you finished it. Discuss how the coriolis effect distorted your line.
6. What will happen if you draw a line from the equator to the pole as the Earth is rotating? Will the line be distorted? How? Try it!

Discuss

- The line you drew can represent air movement (wind), an airplane, or an ocean current. How does Earth's rotation affect wind direction?
- How would the coriolis effect be different if you were in the Southern Hemisphere?



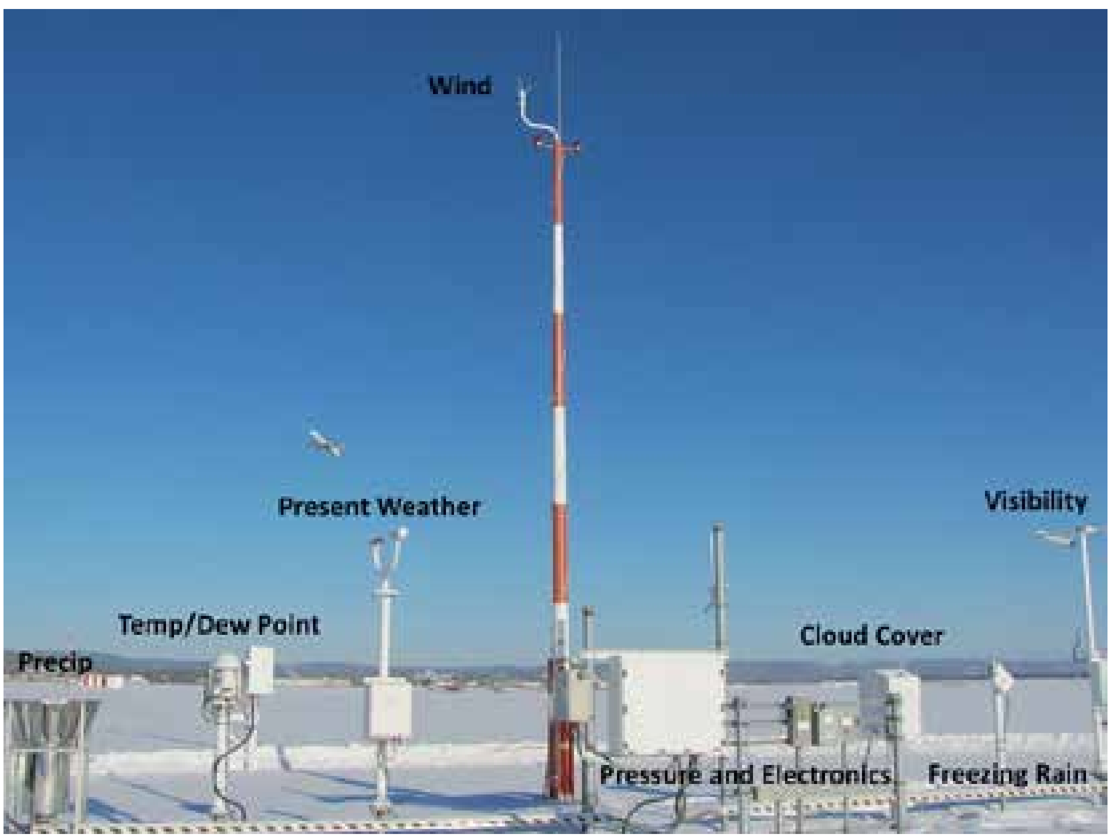
Trace a line along the ruler's edge as your partner rotates the map counter clockwise beneath the ruler.

How do we monitor weather near Earth's surface?

Many people are keen observers of weather. Becoming familiar with weather conditions and the indicators of future weather revealed by those conditions can help you to prepare for and engage safely in outdoor activities. In addition to human observation, many instruments are used to monitor and measure weather. Do you have any weather instruments at your home? Have you noticed any in your community?

Weather Stations

Weather stations such as the one below include an array of instruments that gauge different weather features. This weather station is located in Fairbanks, Alaska, but is similar to the weather stations located at most of the airports in the Bering Strait region. Next time you are near your community airport, observe the weather station from a safe distance. See if you can identify what the instruments on your local weather station measure.



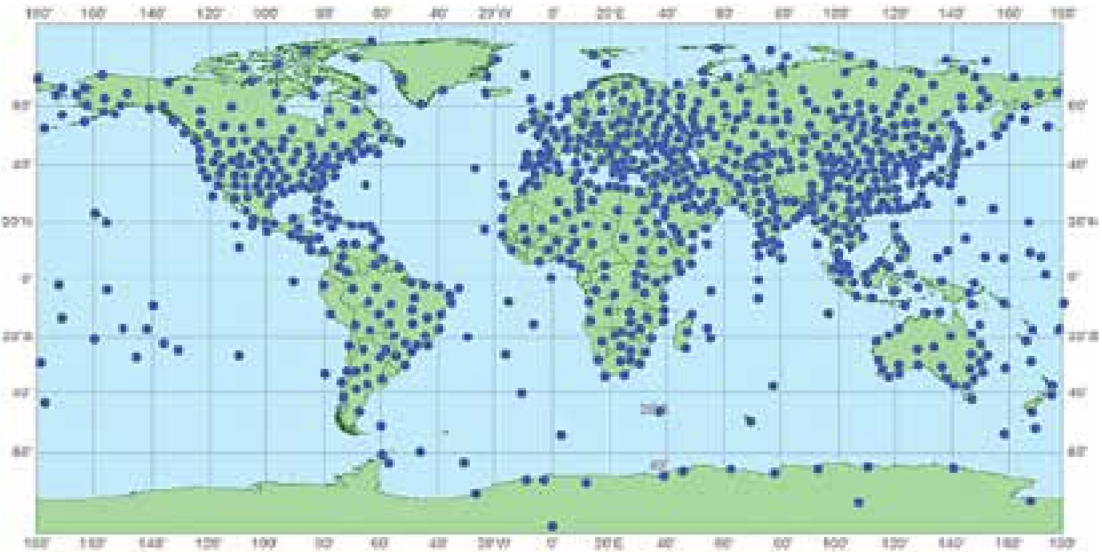
Weather station near Fairbanks. *Photo: NOAA/National Weather Service, Alaska Region.*

How do we measure weather conditions high in Earth's atmosphere?

A technician prepares to release a weather balloon that will carry a radiosonde instrument high into Earth's atmosphere. *Photo: Geophysical Institute, UAF.*

Weather Balloons

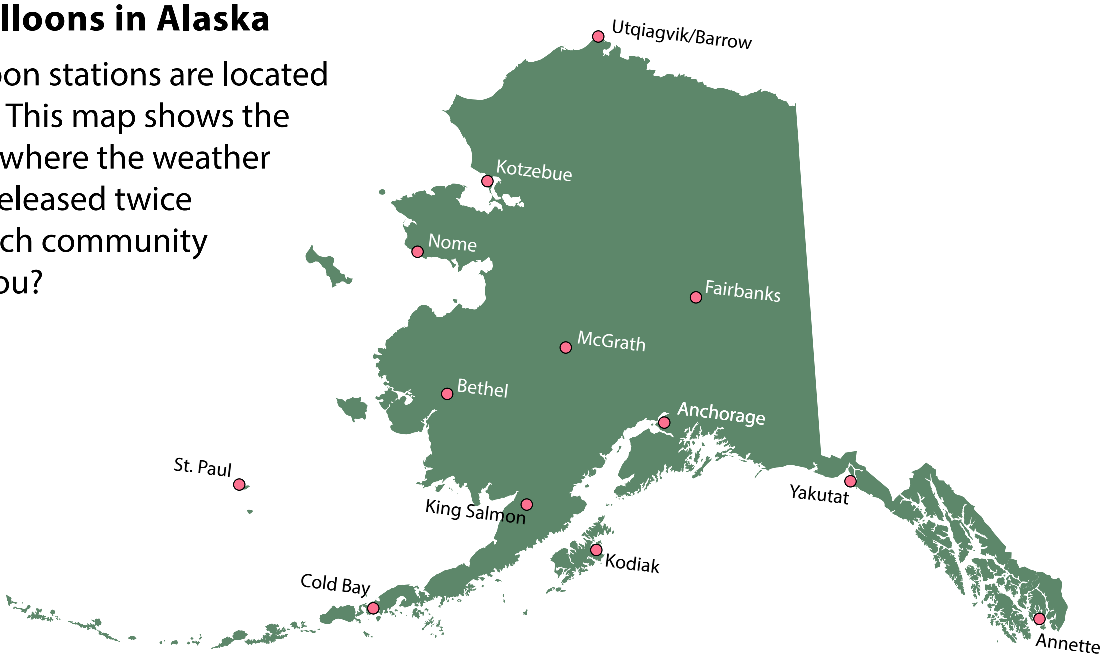
Twice each day, scientists all over the world release weather balloons that carry radiosonde instruments from Earth's surface, through the troposphere, and into the stratosphere. A radiosonde measures altitude, pressure, temperature, relative humidity, wind speed and direction, geographical coordinates and other factors. All of the weather balloons are released at the same time to create a data snapshot of Earth's atmospheric conditions at that moment in time. Data collected by these instruments are used in computer models to help predict weather.



This map shows the locations worldwide from which weather balloons are released twice each day. *Source: Weloveweather.tv (https://weloveweather.tv/wp-content/uploads/2016/10/WeatherBalloons.png).*

Weather Balloons in Alaska

Weather balloon stations are located across Alaska. This map shows the communities where the weather balloons are released twice each day. Which community is closest to you?




The GOES-S weather satellite (illustrated here) was launched in 2018 to provide more accurate weather forecasts and warnings. *Source: NASA.*

Satellites

Weather satellites orbit Earth at different altitudes and send data back to Earth for use in climate and weather forecasting models. Polar-orbiting satellites travel around Earth at an altitude of about 870 km (540 miles) and support long range forecasting by imaging each part of Earth every 12 hours. Geostationary satellites orbit at a much higher altitude and provide constant data on the same region of Earth.

Meteorologist In Training

What is the weather in your community today?

A meteorologist is a scientist who studies weather and the condition of the atmosphere. Work with a small group and use the weather instruments provided by your teacher to help you measure wind speed, humidity, temperature and air pressure near your school. Compare your class averages to the measurements taken by your local weather station.

Materials

- Anemometer
- Hygrometer
- Thermometer
- Barometer
- Student Worksheet: *Meteorologist in Training*
- Computer or tablet with Internet access

Preparation

1. Divide the classroom into 4 groups. Each student in the group should learn to use a different weather instrument before leaving the classroom. If you learn how to use the anemometer, you will lead your group in outdoor wind measurement. The student who learns how to use the barometer will lead the group in measuring atmospheric pressure, etc.

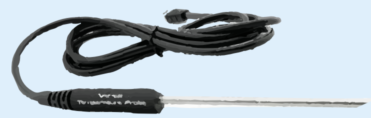
Procedure

1. Select the first instrument for your group. Gear up and go outside. Take the instrument, your worksheet and a pencil with you.
2. Use the instrument to measure an aspect of weather and record your findings on the worksheet in the corresponding area of the chart. After you finish each measurement, trade instruments with another group until you have used all of the instruments.

a. **Anemometer**: Use the anemometer to measure wind speed and wind chill. Be sure to record the unit of measurement (knots, mph, km/hour etc.) that you are using for your measurement.

b. **Hygrometer**: Use the hygrometer to measure relative humidity. Relative humidity describes the amount of moisture in the air as a percentage of the total moisture that the air can hold. Warm air can hold more moisture than cold air.

c. **Thermometer**: Use the thermometer to measure the air temperature. Record the temperature in degrees Celsius (°C) and degrees Fahrenheit (°F).



d. **Barometer**: Use the barometer to measure atmospheric pressure. Record your measurement in millibars (mb).

3. Return to the classroom and calculate the average class measurement for each of the weather variables you measured.
4. Compare your measurements to recent weather station data for your community by visiting *https://www.faa.gov/air_traffic/weather/asos/?state=AK*. Scroll down and click on the link for your community or a community near you. Select "Decoded" and "Most recent only."

Note: If you are in Stebbins, look at the weather station data for St. Michael. If you are in Diomede, look at the data for Wales.

Discuss

- How does the data your class collected compare the data from the weather station? If there are differences, why might that be?

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