Barometric Pressure Protocol

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Barometric Pressure Protocol

Purpose

To observe air pressure

To provide pressure measurements in support of other GLOBE protocols

Educational Outcomes

Students gain an understanding that barometric or altimeter pressure varies and its increase or decrease indicates an upcoming change in the weather.

Students learn that the air has weight.

Overview

Students record the reading on a barometer or altimeter.

Time

5 minutes

Level

All

Frequency

Daily within one hour of local solar noon or at roughly the same time as the Haze measurement

Key Concepts

Air pressure as a measure of the weight of air

Air pressure decreases rapidly with height

Composition of the atmosphere

Change of pressure over time

Relationship between pressure and present weather (precipitation, temperature)

Skills

Measuring air pressure

Recording data

Reading a scale

Materials and Tools

Aneroid barometer or altimeter

Atmosphere Investigation Data Work Sheet

Preparation

Knowledge of study site elevation

Prerequisites

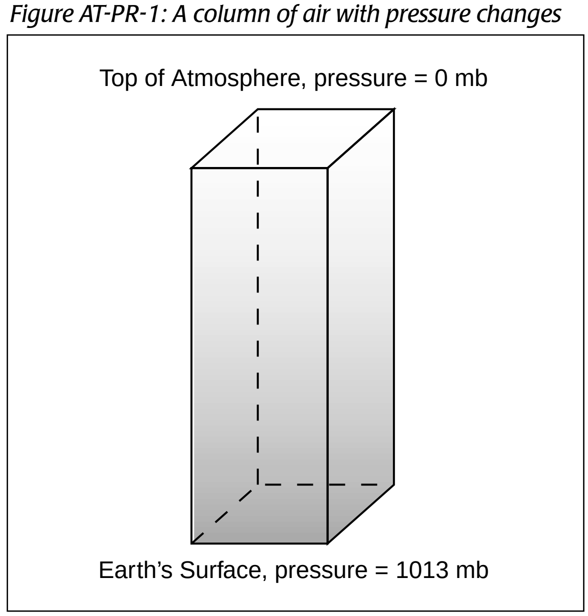
None

Teacher Support

Key Concepts

Air Pressure is defined as the weight of a column of air above an area. Air is made up of molecules of nitrogen, oxygen, argon, water vapor, carbon dioxide, and other gases. Because these gases have mass, air is pulled toward the center of Earth by gravity. This force is what gives us weight, and the air also has weight. The greater the mass of air in a column above a specific area on the ground, the more weight the air has. Pressure is defined as the force acting on a unit of area. Atmospheric pressure is the weight (force) of the air pushing on each unit of surface area on the ground. (A unit of area could be a square meter

Figure AT-PR-1: A column of air with pressure changes

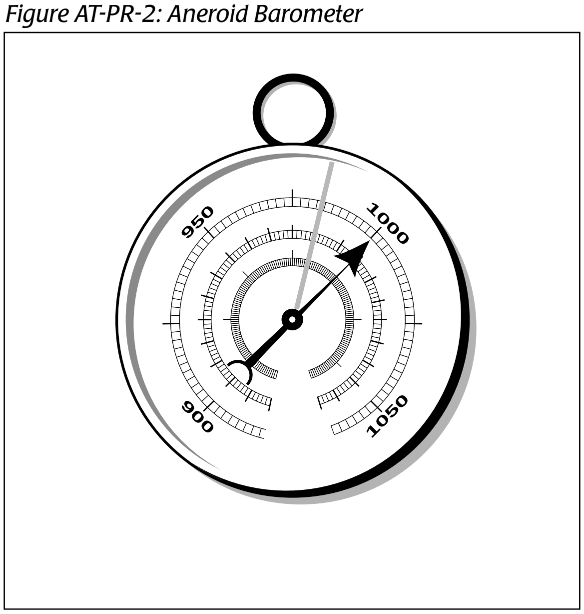


or a square centimeter – in other words, a unit in which area is measured.) Figure AT-PR-1 illustrates the concept of the mass of air in a column over an area.

A device that can be used to measure this pressure is called a *barometer*. The standard way of measuring pressure is to use a very sensitive mercury barometer, but these are expensive and mercury is poisonous. So the *aneroid barometer* was developed, which can provide measurements for meteorologists to use. Figure AT-PR-2 shows the workings of a typical aneroid barometer. An expandable bellows that has had most of its inside air removed will change its size as air pressure is exerted on it. For high pressure values, the bellows will be compressed more. When air pressure is lower, the bellows will expand. Because the bellows is attached to a needle which moves across a scale, the barometer reading will change as the air pressure changes.

Scientists can use the height of the mercury column in a liquid-filled barometer to give one measure of atmospheric pressure; this height would be reported (for mercury) in millimeters, with a standard or average value at sea level of 760 mm. Scientists prefer a unit related to the notion that pressure is a measure of force per unit area; this unit is the Pascal, named after Blaise Pascal. Standard sea level pressure is 101,325 Pascals, which is an awkward unit. So the unit of the millibar is used (which is equivalent to the hectopascal). A hectopascal is 1/100th of a Pascal, and so standard sea level pressure is about 1013 hectopascals (abbreviated 1013 hPa), which can also be expressed as 1013 millibars (1013 mb). The unit of the millibar is derived from the force unit of dynes per square centimeter. Typical values of air pressure for locations near sea level vary from about 960 mb for extremely stormy conditions to about 1050 mb for strong high pressure conditions.

Figure AT-PR-2: Aneroid Barometer



As you go up in altitude, there is less air above you. Less air means less mass and less weight pushing down on the surface. So atmospheric pressure decreases quickly as you go up in the atmosphere, and high altitude locations have lower air pressure values than low altitude locations. A good approximation of this is that for every 100 meters higher you go in the atmosphere, pressure will decrease by about 10 mb. This works well up to about 3,000 meters above sea level. If your altitude above sea level were 1,000 meters, your normal pressure range would be roughly 860 to 950 mb.

Most standard aneroid barometers will be useful for schools at elevations below 500 m; for higher elevation stations, an *altimeter* that also provides barometric pressure readings is recommended. A learning activity on the relationship between pressure and elevation is found in the *Learning Activity* section. Meteorologists typically convert air pressure values at weather stations to sea level pressure, so that the horizontal pressure variations that are so important to wind and weather patterns can be seen more easily. More information is provided found in the section on *Calibrating your Barometer*.

How to Place the Aneroid Barometer or Altimeter

In GLOBE we use a standard aneroid barometer or an altimeter. It should be mounted securely on a wall in the classroom, since air pressure is equal inside and outside the building. It should not rattle or shake back and forth. It should be mounted at eye level on the wall so that students can read it accurately. The barometer must first be calibrated against a standard value, either by calling a local government agency for assistance, or by following the instructions given in *Calibrating Your Barometer*. It should be recalibrated at six month intervals.

Student Support

Scientific Justification

Scientists such as Galileo, Evangelista Torricelli, and Benjamin Franklin wondered hundreds of years ago about how changes of atmospheric pressure from day to day related to variations in the weather patterns they saw. Benjamin Franklin, for example, has been credited with observations that related the movement of low pressure systems (storms) along the northeastern coast of the United States, by comparing weather observations in his diary in Philadelphia with those of his friends in New York City and Boston. A "falling barometer" is generally considered to be an indication of worsening weather. A "rising barometer" indicates improving weather. Meteorologists have long known that high pressure generally brings fair weather, and low pressure is associated with "bad weather" – although most meteorologists tend to like "bad weather" because that is when the weather is most interesting!

Daily observations of barometric pressure will be useful to you as you study your other meteorological observations. You may note how changes in pressure readings from one day to the next are related to the kinds of weather observations that we discussed above. In particular, you may begin to notice how your cloud type and cloud cover observations are related to pressure recordings, how higher values of precipitation are related to low pressure, and that during spells of dry weather, the barometer will be "high."

These pressure measurements provide scientists with measurements of the composition of the atmosphere, which allow for the accurate observations of other variables. For example, we require measurements of atmospheric pressure to make our haze observations. Hydrologists also need good pressure measurements to determine the pressure that air exerts on the water surface.

Synthesis Questions

After recording your pressure readings for a month, make a graph of your pressure observations and also plot the daily precipitation. Do you see a relationship between these observations?

Is there any relationship between your data from the *Cloud Protocols* and barometric pressure?

Use pressure data from several GLOBE schools adjusted to sea level pressure to see if you can locate where high and low pressure areas are for a given day. How well do your findings compare with weather maps from your local newspaper or any other source?

Calibrating Your Barometer

When your barometer arrives, it most likely will have been calibrated at the factory. But it is always a good idea to calibrate the barometer yourself before you install the instrument. First, inspect your barometer; it will most likely have two different scales, one in millibars (or hectopascals) and one in millimeters (or centimeters) of mercury. All of your measurements for GLOBE should be taken in millibars or hectopascals (remember, these are the same unit).

There is a needle that can be set to the current reading each day – you should do this each day after you take your pressure reading. When you take tomorrow's reading, your barometer's set needle will read yesterday's value, and you can instantly compare to see whether pressure is higher or lower now than the day before!

The most accurate way to calibrate your barometer is to bring it to sea level (the ocean shore) and obtain a reading of pressure from an official source there, from a city weather bureau or weather service office. Once you've reset the barometer (using a small set screw on the back of the barometer – this should only be done by the teacher!), you can bring it anywhere and it will read accurately, within the limits of the scale on the barometer. This method may not be practical in most cases, however. The calibration requires that your barometer measure the actual air pressure at your location, which is probably not at sea level. To obtain a calibration, you will have to find a local reliable weather information source, which provides measurements of pressure. A weather service or weather bureau office, agricultural extension office, newspaper, radio, or television station may be useful here. Their readings, however, are likely to be for sea level pressure. For GLOBE, we require actual station pressure readings, which can easily be converted to sea level pressure. Here is how you can do it:

Find the local accurate reading of sea level pressure from a reliable source within approximately 50 km of your barometer location, if possible

Determine your elevation above sea level (see the *GPS Protocol* from your study site determination)

Determine your atmospheric temperature (from your local solar noon measurement). We will use atmospheric temperature at your Atmosphere Study Site in the event more accurate calculations for sea level pressure are needed. But in general, the formula given below will work for most stations that have a station elevation below 3,000 meters.

Here is a formula for converting sea level pressure to actual pressure:

$$\text{Station pressure} = \text{Sea level pressure} - \frac{\text{elevation}}{\text{correction factor}}$$

The pressures are in millibars (hectopascals), and the elevation must be given in meters. The correction factor is 9.2, which is very nearly the change in elevation (vertically) that will correspond to a 1 millibar change in pressure, as given in the U. S. Standard Atmosphere. Although this calculation is temperature (and humidity) dependent, in reality, for GLOBE measurements from stations within 3 km of sea level, this will suffice.

To calculate the station pressure from a given sea level pressure reading, follow the procedure below:

Divide your elevation in meters by 9.2. Subtract this result from the sea level pressure (which is in millibars or hectopascals) and you have your station pressure.

Here's an example. Suppose you call your city's largest radio station and speak to the news department. The news director says that his information says that the pressure today is 1008.5 mb. That is a sea level pressure (because that is how the media and official sources report pressure to the public and to each other). Your station elevation, determined from the GPS protocol, is 228 meters. Now, let's do the math!

Step 1: 228 / 9.2 = 24.8 (we only need to keep one decimal place here)
Step 2: Subtract 24.8 from 1008.5: 1008.5 – 24.8 = 983.7
Step 3: Check your math! 983.7 + 24.8 = 1008.5

What if my units of pressure are not given to me in millibars or hectopascals?

This is quite likely in many locations, depending on the source of the calibration information. Use the table below to change the units of pressure to millibars from the units given.

Convert from	**Multiply by this factor**
Inches of mercury	33.86
Centimeters of mercury	1.333
Millimeters of mercury	13.33
Kilopascals	0.1
Pascals	100

Barometric Pressure Protocol
Student Field Guide

Task

Measure the barometric pressure.

Reset the “set needle” to today’s reading of barometric pressure.

What You Need

❑ A properly mounted aneroid barometer or altimeter

❑ *Atmosphere Investigation Data Work Sheet* OR *Atmospheric Haze/Aerosols Data Work Sheet*

❑ Pen or pencil

In the Classroom

1. Record the time and date on the *Atmosphere Data Work Sheet.* (Skip this step if you are using the *Atmospheric Haze/Aerosols Data Work Sheet.*)
2. Tap gently on the glass cover of the aneroid barometer to stabilize the needle.
3. Read the level of the mercury to the nearest 0.1 millibar (or hectopascal).
4. Record this reading as the current pressure.
5. Set the “set needle” to the current pressure.

Frequently Asked Questions

1. If we missed reading the barometric pressure for a day or more (over the weekend, holiday, vacation, etc.), can we still report the pressure today?

Yes, you are only reporting today's pressure, so please report it as often as possible.

2. I really don't understand the difference between barometric station pressure and sea level pressure.

Since weather stations are spread all over the world at many elevations, and since pressure decreases rapidly with elevation, meteorologists need a way to map horizontal pressure patterns using a constant reference altitude. The easiest way to do this is to convert all observed pressure values to sea level pressure. However, in GLOBE, the atmospheric haze measurements require the actual barometric pressure readings at stations; that is why we have students enter actual barometric pressure readings — station pressure - instead of sea level pressure.

3. Why do we have to reset the "set needle" each day?

The set needle is used to identify the previous pressure reading. Using it, you can instantly compare the current pressure reading to the previous one. For example, if the pressure is lower today than yesterday, you might ask yourself if the weather is stormier?

4. How accurate are these pressure readings, compared to those that might be taken with mercury barometers?

Today's aneroid barometers are not as accurate, in general, as well-made mercury barometers. There are some electronic barometers that have very accurate measurements, but the relatively inexpensive instruments that meet GLOBE specifications have all the necessary accuracy for our pressure measurements (about 3 to 4 mb).

5. Why does pressure always decrease with height in the atmosphere?

Because pressure is a measure of the mass of the atmosphere above you (air does have mass!), as your elevation increases, there is less air above you, so pressure is less.

6. Why do high altitude GLOBE schools have to use an altimeter?

Most aneroid barometers are designed to be used near sea level. Altimeters are special aneroid barometers designed to be used at higher altitudes (including aircraft). At an altitude of 500 m above sea level, we would expect atmospheric pressure to be no greater than 1000 mb and down to as low as 900 mb for intense storms. Most aneroid barometers, however, have 950 mb as the lowest possible measurement.