B4 Wind

Subexperiment B4.1 Measuring air pressure
Subexperiment B4.2 Wind erosion

1 Main question

The following questions underlie the subexperiments and guide the activities:

- Is wind a component of weather?
- What is air pressure? And how is it measured?
- What is (wind) erosion? How can we protect ourselves from it?

2 Background

2.1 Relevance to the curriculum

Using the subexperiments on the topic of wind, you can begin to introduce the topic of weather to the students. They will learn that air is significant for the habitat Earth and that air is an essential part of life on Earth. They will perceive air as a substance. Air is understood to be a gas mixture, and the significance of oxygen in the air for humans will become clear. In subexperiment B4.2, the students will grapple with the topic of environmental protection. Through this hands-on experiment, the students will learn how strong wind can affect ground soil. They will develop ideas about protective measures that can be taken to protect the soil from wind erosion. You can discuss with the students which protective measures are best suited for our Earth.

Topics and terms

Air particles, air pressure, air pressure gauge, barometer, erosion, high-pressure area, low-pressure area, weather, wind erosion

2.2 Skills

The students will ...

- be capable of making a tool to measure the air pressure.
- be knowledgeable about the dangers of wind erosion.
- find possible solutions to protect landscapes from wind erosion.

3 Additional information on the experiment

You will find additional media for preparing or for further study of this experiment on the Siemens Stiftung Media Portal: https://medienportal.siemens-stiftung.org

4 Conducting the experiment

Note: The listed materials are designed to allow **one** group of maximum **five** students to conduct the experiment.

4.1 Subexperiment B4.1 Measuring air pressure

4.1.1 Required materials

Material	Quantity
Ink	A couple of drops
Modeling clay	1
Packing tape	1
Pen	1
Pipette	1
Plastic bottle with neck, empty (0.5-liter PET bottles are quite well suited)	1
Ruler	1
Thin tubing, approx. 25 cm (tubing length = approx. 1.25 x bottle height)	1
Water (room temperature)	0.5 liters

4.1.2 Organizational aspects

Facilities	At a simple table in the classroom
Time required	Setup: 45 minutes Conducting and observation: 1 week to several weeks Analysis and documentation of the results: approx. 30 – 45 minutes
Safety instructions	See the “Safety instructions on the topic of the environment” in the guidebook. Possibly ask the school custodian for help with hanging up the barometers.
Cleanup	The students can take their homemade barometers home after the experiment is complete.

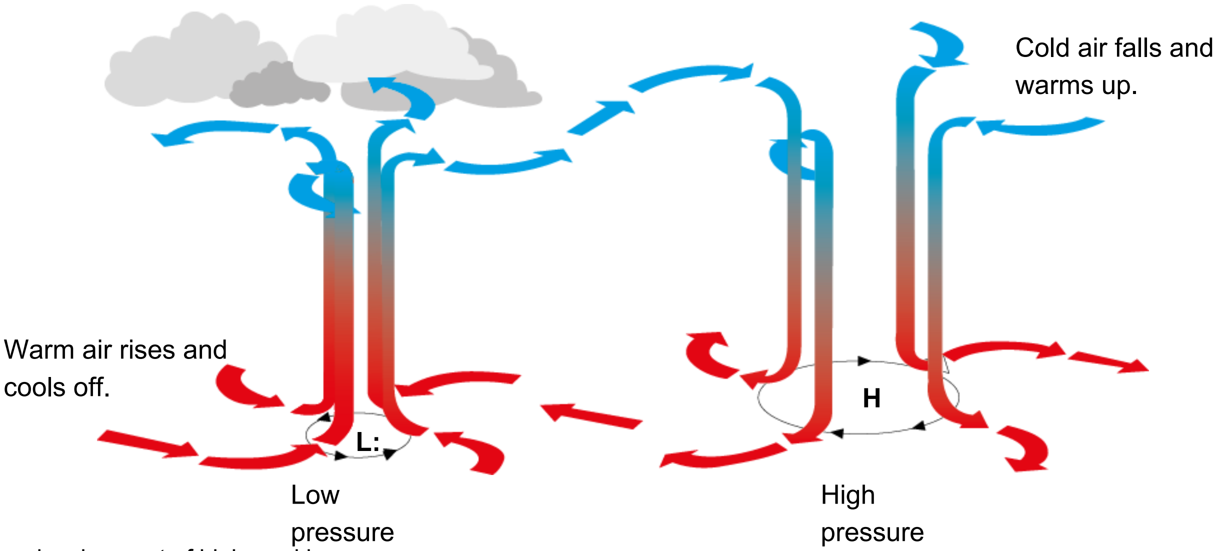
4.1.3 Explaining the subexperiment in the teaching context

The students will build a barometer and learn to make statements about changes in the weather based on the air pressure measurement.

Technical background

Air pressure is a scientific phenomenon that is rarely consciously perceived. Even though people’s ears “pop” on a drive over a mountain pass or on a gondola ride in the mountains, very few adults – not to mention the students – can explain the exact connection with air pressure. The air pressure comes about because the air exerts a pressure on the Earth’s surface due to its weight. How high or low the air pressure is at a specific location depends on sunlight. Sunlight passes through the layers of air and hits the Earth. The air is not heated in the process, but the Earth’s surface is (it absorbs the solar energy).

The Earth's warmed surface gives off this energy (heat) to the air near the ground. When the air heats up, it expands (the air density decreases) and rises as a result (see "thermal lift," which is used by glider pilots and birds of prey to soar into the air). The rising air cools off, causing the water vapor contained in the air to condense, which results in clouds and rain. Low air pressure prevails near the ground (low-pressure area). When the rising air reaches the higher layers of the atmosphere (tropopause), it then flows in a horizontal direction. In the process it cools off further and falls again. As it sinks, the air warms up and becomes dry. High air pressure then prevails near the ground (high-pressure area). A pressure gradient develops between the high-pressure area and the low-pressure area, causing the air near the ground to flow toward the low-pressure area. This flow is called wind. The air therefore circulates in a cycle.



The development of high- and low-pressure areas.

Regarding weather conditions, the change in high- and low-pressure areas is more critical than the absolute air pressure values, since increasing air pressure brings better weather and decreasing air pressure brings worse weather. So when the weather is nice and the air pressure is high, the weather will probably stay nice. In contrast, when the weather is nice and the air pressure falls rapidly, the weather will probably worsen. Conversely, if the weather is bad and the air pressure rises considerably, the weather will probably improve.

A **barometer** is an apparatus that can be used to measure air pressure. The barometer to be made in this subexperiment is a liquid barometer:
It is a liquid-filled container (in this case an old plastic bottle) that has a spout (in this case a piece of tubing) coming up from the bottom. This type of barometer is also known as a "weather glass" or "Goethe barometer." It is important that the "spout" remain open to the ambient air, while the container of the barometer that contains the liquid is sealed. When the external air pressure decreases, the level of the liquid in the spout rises. When the external air pressure increases, the level of the liquid in the spout falls. Strictly speaking, this applies only when the water temperature and the temperature of the ambient air are approximately equal. Otherwise, a temperature difference would also affect the air pressure measurement.
Even though this barometer does not allow measurements of absolute air pressure, it is good for observing changes in the air pressure over several days.

4.1.4 Ask about the students' prior knowledge and ideas

The students may be familiar with a thermometer from everyday life. Changes in temperature can be read from it. Building on this knowledge, the students may be able to deduce the functioning of a barometer.
However, it is to be assumed that the students' prior knowledge is rather basic; for example, they have heard of or read about high- and low-pressure areas in a weather report. Air pressure and the connection with high- and low-pressure areas are unfamiliar to many students and should be discussed in detail beforehand to ensure successful experiments.

4.1.5 The research cycle

Important aspects and information regarding the individual process steps of the research cycle during the experiment for students:

Recognizing the problem/phenomenon	This experiment is about the phenomenon that air pressure changes depending on weather conditions.
The research question	The following alternatives to the research question stated in the student instructions are possible: ▪ What is air pressure? ▪ What are high- and low-pressure areas? ▪ What device can be used to measure air pressure? ▪ What does the barometer indicate? ▪ What does air pressure reveal about the weather?
Collecting ideas and guesses	Some possible guesses: **Related to the research question:** "Building a barometer is complicated and difficult." **Related to the experiment:** ▪ "The level of the liquid in the tubing changes, but there is not a connection with the air pressure." ▪ "A connection cannot be established between the weather and air pressure." ▪ "High- and low-pressure areas are found only in weather reports and have nothing to do with "good" or "bad" weather." In general, the students will be able to express only superficial prior knowledge and experience regarding the topic, since air pressure and the connection to the weather are a rather complex topic that even many adults have difficulty explaining. Segue from the guesses to the experiment.

Experimenting	**Experiment setup:** ▪ Work precisely and carefully, especially when sealing the bottle. ▪ The ink is needed so that the students can clearly see the differences in the water level. **Conducting the experiment:** ▪ Provide assistance as needed. Some may find the task of building the barometer too complex or lack the necessary motor skills. ▪ The students can be creative when it comes to hanging up the barometer. One example: Tie a string around the neck of the bottle and hang the barometer in the school yard in a location protected from wind and rain.
Observing and documenting	Make sure that changes in air pressure actually can be read on the barometer. If this isn't possible within one week, extend the observation period and ask the students to continue documenting their observations carefully.
Analyzing and reflecting	During the analysis and reflection, it is especially important to make sure that the students rely on their documentation, since the experiment is to be observed over a period of at least one week. It is also especially important that the students make a connection between the alternation of high- and low-pressure areas and the weather. **Results to be expected:** 1. When the water level in the tubing has risen, the air pressure has decreased. Consequently, the weather will worsen. 2. When the water level in the tubing has fallen, the air pressure has increased. Consequently, the weather will improve. 3. Decreasing air pressure heralds a low-pressure area, which is normally associated with clouds and rainy weather. Increasing air pressure heralds a high-pressure area, which is associated with sunny weather. **Reference to the story to get the students thinking about the topic:** In the experiment, you have learned how to build a barometer. You can read the water level of this barometer to know what the weather will be like and can then decide whether you would like to go swimming or not.

4.1.6 Further information

In the student instructions

Doing further research	The students should observe the barometer over a period of several weeks. Further research should focus on solidifying the complex topic of air pressure and its key concepts. It would also be beneficial for the students to revisit the results after the analysis. If possible, integrate the topic of air pressure in various class discussions. In the event of extreme weather changes, encourage the students to observe the barometer again and have them explain the changes.

4.1.7 Reference to technology

In the student instructions

Since few industrial applications rely directly on natural atmospheric air pressure, we will concentrate on the meteorologically significant air pressure measurement technologies for weather forecasts.

Tracking down technology	Two photos are shown in the student instructions: ▪ As a reference to everyday life: **aneroid barometer** ▪ As another idea: **digital weather station** for a desk The students should name the devices shown and discuss their purposes and functioning. Questions and tips are offered to help the students. The work assignment serves to reinforce the insights gained from building the bottle barometer and segues to the technology used to create professional weather forecasts.

The photos in the student instructions show a mechanical barometer and a digital weather station. These can be found in many households today and are therefore familiar to some students. What the students may lack is an understanding of the underlying principle, namely the **aneroid box**. This can be explained initially based on examples from the students' world of experience, such as canning jars or ketchup bottles with twist-off caps. They are difficult to open because the air has been evacuated from the inside; therefore, the lid is pressed on the glass container by the external air in addition to the screw thread effect. There is a trick for opening such containers: Using the handle of a spoon, lift the lid out to the side until the air can flow inside. Then the pressure inside the jar is equal to the external air pressure and the lid can be opened easily. In a tin can filled with air, the air pressure is the same both inside and outside the can, so it will not be deformed.

For a mechanical barometer, a box is made from very sturdy, flexible metal. The air is pumped out, and then the box is tightly sealed (for example, through soldering). The higher the external air pressure, the more the box curves toward the inside. Conversely, if the external air pressure decreases, the box curves toward the outside.
In mechanical barometers, this box deformation is transferred directly to a needle via a system of levers and gears so that the air pressure can be read directly on a scale.
In a digital weather station, the air pressure sensor consists of an electronic component called a capacitor. In principle, it can be understood as an aneroid box whose two halves are electrically isolated and whose curvature is recorded as a change in capacity.
The air pressure sensors of modern professional weather stations work according to the same principle, but the sensors are larger, and the recording and analysis of the capacity values are much more precise than with simple desktop weather stations.

Can you forecast the weather from air pressure values?
The simple rule “low air pressure – bad weather, high air pressure – good weather” is not correct. The sun may well shine at relatively low air pressure, and it may rain at relatively high air pressure. However, the rule is correct to the extent that if, for example, very high air pressure and nice weather prevail regionally for an extended period, this weather will continue until the air pressure drops significantly. This means that large changes in the air pressure make a change in the weather very likely. Accordingly, simple desktop devices generally do not display the air pressure value, but usually display symbols (sun, clouds, rain) to indicate the trend in which the weather is likely to develop based on the changes they record in the air pressure.
In contrast to professional weather forecasts, however, this is quite imprecise and inaccurate. Professional weather stations record not only the local air pressure, but the air pressure and its changes over a radius of several thousand kilometers, plus temperatures, wind directions, wind speeds, cloud formation, and cloud movement. Today, complex computer programs are able to analyze all of these data and forecast the weather with approximately 90 percent accuracy up to 48 hours in advance, and 100 percent accuracy for a period of up to approximately 12 hours for a region. The forecasts are still rather poor for longer periods (for example, will it be a cold winter?).

You will find the answers to the questions asked in the student instructions on the answer sheet in the guidebook. In the “Experimento | 8+: Tracking down technology” media package, which is available on the Media Portal, you will find additional technical information compiled in an information sheet and a link list. This media package also includes all of the individual photos as well as the work assignment as a prepared worksheet.

4.2 Subexperiment B4.2 Wind erosion

4.2.1 Required materials

Material	Quantity
Branches	As needed
Leaves	As needed
Plant (optional)	1
Sand	Enough to cover a tray
Small stones	As needed
Soil	Enough to cover a tray
Large tray	1

It is recommended that you encourage the students to bring the tray and materials (for example, plant, leaves, branches) from home or look for them on the school grounds. They should be instructed not to dig up any plants.

4.2.2 Organizational aspects

Facilities	At a simple table in the classroom or outdoors. The latter option is recommended to keep from dirtying the classroom. In addition, it might be possible to use the actual wind outside.
Time required	Approx. 45 minutes
Safety instructions	See the “Safety instructions on the topic of the environment” in the guidebook.
Cleanup	All used materials can either be returned to the students or disposed of in the organic waste/compost.

4.2.3 Explaining the subexperiment in the teaching context

The students will simulate wind erosion on a small homemade landscape and come up with protective measures for their landscape.

Technical background

The removal of soil by water or wind is called **erosion**.
This removal can range from soil depletion (land degradation) to soil destruction (devastation).
An environmental incident triggered by wind erosion can be intensified by people. Improper farming practices, such as the removal of protective vegetation through overgrazing or large-scale deforestation, are largely responsible for erosion.
Wind erosion (deflation) occurs mostly on lightweight soils. The soil is lifted into the air in the process. The wind then carries away the top layers and deposits them in other locations. The erosion or change in the soil structure, however, is also caused by sand. When the wind blows sand over the soil, the sand acts like sandpaper, changing the vegetation and even sculpting rocks over the long term. The degree of erosion depends on the wind speed and other climatic and weathering factors such as precipitation or sunshine. Wind erosion is playing an increasingly important role in issues related to environmental protection and the sustainable use of our Earth.

4.2.4 Ask about the students' prior knowledge

The students know how they can protect themselves against strong wind: They stand on the lee side of a large object (a building, a tree, etc.) that blocks the wind. In addition, they may already be familiar with protective measures against forces of nature, for example, dikes against flooding or nets on mountain slopes in avalanche regions.

4.2.5 The research cycle

Important aspects and information regarding the individual process steps of the research cycle during the experiment for students:

Recognizing the problem/phenomenon	This experiment is about the problem that land lacking vegetation is unprotected and can be eroded by the wind.
The research question	The following alternatives to the research question stated in the student instructions are possible: ▪ What protective measures exist to protect against wind erosion? ▪ Why do we need protection against wind erosion?
Collecting ideas and guesses	Some possible guesses: **Related to the research question:** ▪ "Only walls and buildings offer protection against wind." ▪ "You can't protect yourself against wind." **Related to the experiment:** ▪ "The wind only blows the sand and soil off of the tray." ▪ "If everything is pressed together firmly enough, nothing happens." ▪ "The smaller objects blow away; the stones and the plant don't move at all/barely move." ▪ "The stronger the wind, the greater the effects." Segue from the guesses to the experiment.
Experimenting	**Experiment setup:** No difficulties are to be expected with the experiment setup. The students should think about the structure of the ground in advance and base their setup according to the ground's structure. **Conducting the experiment:** ▪ If the experiment is conducted in the classroom, the students should refrain from generating excessive wind to keep from creating a big mess in the room. ▪ The students' creativity should not be limited when they construct the protective measures. Whether the constructed measures were useful can be discussed in the reflection.

Observing and documenting	**Most important observations:** ▪ Using different materials, the students will see which materials provide better protection from the wind. Solid, stable materials in particular block the wind. Plants provide good protection against wind erosion and are also a natural barrier. ▪ The students will recognize that some protective measures are useful while others are not. They will also recognize that the soil is not protected without materials. **An important aspect is the transfer of the model to the real world.**
Analyzing and reflecting	The students will recognize the protective functions of the barriers they built. They will draw conclusions about the best possibilities for protecting landscapes from wind. They will recognize which measures are not useful and which human behaviors can lead to increased erosion. **Results to be expected:** 1. The landscape is best protected from erosion when plants are located on the surface. Stones and branches also protect the soil from erosion. In addition to these natural protective measures, walls can also protect the soil. 2. The higher the barrier, the better the protection. Other protective measures, such as the prevention of forest clearing, can also be addressed at this point. **Reference to the story to get the students thinking about the topic:** Now you know that Mia's mother was right with her guess that the wind swirled up more sand where the trees and bushes had been cut down.

4.2.6 Further information

In the student instructions

Doing further research	If the experiment took place in a closed room, it is important to demonstrate to the students the effects of the protective measures in reality. A walk in the forest or across a field makes sense for understanding the insights gained during the experiment and reinforcing the knowledge.

4.2.7 Reference to values

What is your opinion?

In the discussion about values for this experiment, the teacher can provide a prompt or tell a story in which a problem is posed. Both actions lead to a discussion based on reflections. What's important is that the reference to values can be established in the experiment. The discussion can focus either on learning-process-related values (for example, working reliably in groups) or on object-related values (for example, handling paper as a resource). The student instructions for **B4.2 Wind erosion** address object-related values.

Object-related dilemma:

An object-related dilemma can be integrated in the discussion of the values “initiative” and “acceptance of responsibility” at the end of the student instructions. The students should express their opinions about it.

Dilemma related to a tent: Your best friend Mara, you, and both sets of your parents go camping by the sea. You have nearly finished setting up your tent on the sand when you suggest setting it up closer to the nearby bushes. Mara thinks this idea is silly and laughs. “Why do you want to be back by the bushes? I would rather have a nice view of the water.”

Think about it: What is your opinion?

Possible statements by the students for and against the bushes:

Reasons for the bushes	Reasons against the bushes
▪ The wind doesn't carry the sand inside. ▪ The tent has greater stability due to the firmer ground (especially carabiners). ▪ The entire tent is better protected against the wind.	▪ The view is not as nice. ▪ It takes too much time to take down the tent and set it up again. ▪ You don't want to jeopardize your relationship with your friend.

	Objective: The students should reflect on how they can handle the environment responsibly and on their own initiative. The values of initiative and acceptance of responsibility are addressed. **Alternatives:** Statements or questions as prompts related to the story told in the student instructions are also suitable for encouraging discussion. The values of initiative and acceptance of responsibility remain the same. ▪ **For discussion:** Some trees and bushes are going to be cut down on a sandy campground by the sea. What is your opinion? ▪ **Question for discussion:** How can erosion of the Earth/soil be prevented? **Notes:** The students should reflect on values and express their opinions. It may turn out that several values are addressed.