Oscillation of Air temperature with Altitude

GLOBE		***Related SDGs:***	***Type of activity***
Sphere	**Protocols**		
Atmosphere	Air temperature Optional: -Barometric pressure -GPS	13 (Climate Action)	Exploratory

Overview

The students will learn to relate temperature to altitude and other variables that affect it. They will understand why the temperature is not the same in different places on Earth at the same time and at different altitudes and will be able to explain it.

Prerequisites

To have completed the Air Temperature Protocol or have it explained prior to the activity.

School Level
From the fifth year of Primary and Secondary (11 to 18 years old).

Purpose

To demonstrate to the students that the higher the altitude, the lower the temperature recorded at a given location will be (in the troposphere).

Student Outcomes

- The students will learn the relationship of temperature to altitude, winds, atmospheric pressure and latitude.
- They will develop ideas for measuring air temperature at altitude and present them to classmates.
- The students will make measurements and take data from sites in their region to compare temperatures at different altitudes.
- They will contact other schools and compare temperatures with students from schools located at different altitudes.

Introduction

The Earth receives energy from the Sun, which helps to warm it up, but on the other hand, it loses heat when it radiates it to the atmosphere, and this is called the Earth's energy balance. The closer we are to the ground, the warmer it generally gets. Clouds help to retain the heat from the surface, but the higher we ascend, the thinner and less dense the layer of clouds and air becomes, which causes it to get colder at higher altitudes.

The height measured from sea level is called altitude. As the altitude increases, the temperature decreases by one degree every 154 meters in the temperate zone and every 180 meters in the intertropical zone, this is due to the fact that in the temperate zone the insolation received is less and the atmosphere is thinner. When the latitude increases, the distance between the Earth and the Sun also increases, so the temperature gradually decreases. To give an example, if in a location at sea level (0 meters altitude) it is 24°C at noon, at 462 meters altitude on a nearby hill, at the same time it would be 21°C (3 degrees less). Keeping the same example for a location in the intertropical zone, 21°C would be recorded on the hill but at 540 m. altitude. This variation is known as the vertical thermal gradient**.**

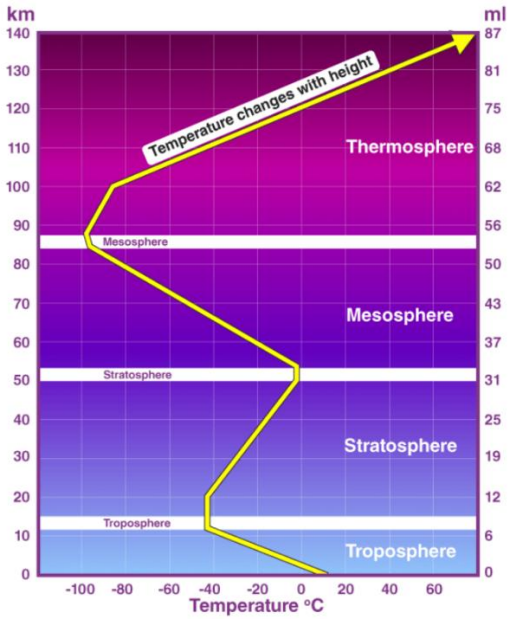
But in some regions of the atmosphere just the opposite happens, that is, the temperature increases with altitude. In this case the vertical thermal gradient is said to be **negative**. This is influenced by issues such as the presence of mountains and the proximity to the sea.

The higher the altitude, the lower the atmospheric pressure. Atmospheric pressure is the weight exerted by the air in the atmosphere as a result of gravity on the Earth's surface or on one of its air layers.

Other factors that also influence the temperature are winds and relative humidity. In places where there is higher humidity, there is lower pressure and vice versa, where there is lower humidity there is higher pressure; this situation is closely related to the altitude.

But what happens in the other layers of the atmosphere?

Temperature gradient diagram of different layers of atmosphere



http://www.atmosfera.cl/HTML/temas/estructura/estructura3.htm

The atmosphere is composed of 5 layers: the troposphere, the stratosphere, the mesosphere, the thermosphere and the exosphere.
The vertical thermal gradient can be altered by several processes: sudden fall or rise of the ground temperature or strong winds. The temperature changes as we ascend.
In the troposphere it has an approximate value of 6º C per kilometer. This means that if, for example, the temperature at sea level is 15º C, at an altitude of approximately 5 km, it will reach the value of -15º C (a decrease of 30 degrees). At the upper limit of the troposphere, which is the tropopause, where the temperature stops decreasing, the temperature is close to -55°C.
Above the troposphere is the stratosphere, which extends up to about 45 km. There the temperature increases with altitude to a value close to 0°C at its upper limit called the stratopause.
In the mesosphere the temperature decreases on average as one ascends, i.e. the vertical thermal gradient is positive. This stops at about 80 km altitude where the temperature approaches -90°C (mesopause).
In the thermosphere, the temperature increases with altitude and, therefore, the vertical thermal gradient becomes negative again in this layer of the atmosphere.
An important issue to consider in the troposphere is thermal inversion, which happens when the ground is rapidly cooled by radiation, which in turn cools the air in contact with it. In turn, the cooler, heavier air in the upper layer cools even more. Thus, the rate at which the two layers of air mix abruptly decreases. This usually occurs in winter, causing persistent fog and frost in the layer closest to the ground.

Guiding Research Questions

- Is the assumption that the closer we get to the Sun, the higher the temperature will be, a correct assertion?
- If the ambient temperature is measured at the foot of a hill and at the same time at the top of the hill, will it be the same for both places?
- What other variables can influence temperature besides height when we measure temperature at different altitudes?
- If Mount Everest in the Himalayan range is 8,848 meters high, what temperature would be expected at the summit if no other variables were involved? Are there any sources/agencies that record the temperature at these altitudes? Which ones?

Scientific Concepts

- Soil absorbs radiation from sunlight
- Altitude / Latitude
- Atmospheric Pressure
- Thermal Gradient
- Layers of the Atmosphere

Materials and Tools

- Alcohol or digital thermometer
- Air Temperature Field Guide
- Air Temperature Data Sheet or field notebook
- GPS application on the mobile device.

What to Do and How to Do It

Activity 1.
Beginning -

Assign your students the task to take the temperature as close to local solar noon as possible at their homes (after school for the morning shift classes, before school for the afternoon shift classes) with an alcohol thermometer following the GLOBE protocol. Also ask them to record the exact location and altitude of where they are taking the temperature, and to record those three pieces of information and bring them to the next class. This assignment will be done by all students on the same day.

Development -

In the next class, on the board write the temperatures you recorded the previous day in one column, and in the other column write the altitude of your geographic location.
Did they all record the same temperature? Why? What factors do you think may have affected it?
Afterwards, ask your students to look up on their computers on the internet what the recorded temperature was for the same time and day they found, but for other locations in the region at different altitudes, for example, a city in the mountains or a town in a low valley.

Ending -
Ask your students to think about how temperature changes at different altitudes and the factors that also affect altitude. Also have them look for similarities in temperature among the different sites.

Outreach Activity

- Assuming that the temperature increases by 1°C for every 154 m. of altitude in temperate zones and every 180 m. in intertropical zones, ask your students to think and develop in writing or orally what ideas they can think of to measure the air temperature at these altitudes to see if there is indeed a change in temperature between the Earth's surface and the altitudes mentioned. For example, hang a liquid thermometer on a drone with a camera and raise it in an open area to record the temperature when it reaches 154 m. and 308 m. high.
- Ask your students to present their ideas to the whole group. Are any of the methods they put forward feasible? Why? Why not? Ask them to discuss options, evaluate possibilities and come to some conclusions.
- For example, you can measure the temperature at the bottom of a hill, then go up and measure the temperature as you reach the altitudes of 154 m. and then about 300 m. They can use the GPS application to determine the altitude at which they want to take the measurements. It can also be three people taking the measurement at the same time at the three different altitudes.
  What difficulties do they encounter? What other variables may play a role?

Ending –

Encourage students to develop some of the ideas or do it yourself and share the results with them afterwards.

Time: one 50-minute class.

Activity 2.
Beginning -

Using the GLOBE website, search for schools within your region that are at different altitudes from your school. Find out if any teachers at those schools are willing to do collaborative work.

Development –

- You can organize a Zoom or Google Meet session in class for students to connect, explain what activities they are doing and what they are interested in working on collaboratively to measure the temperature for the next class or for whenever they can schedule.
- Plan for both groups' measurements to be taken at the same day, at a site with similar characteristics (both in an open location, with grass cover, and if possible,

  on a clear day, or with similar cloud cover). If possible, they should be at local solar noon and may include more measurements at other times to provide more data for comparison.
- Have students record their data in the science notebook and in the next class they schedule to meet online and share the data, analyze the data each group recorded and discuss with the other group their conclusions about how altitude influences temperature.

Ending -

The students can elaborate a poster in each of the educational centers and deepen the research to present their work to the IVSS.

Time: at least two classes in connection with the other school.

Frequently Asked Questions

Why is temperature estimation at high altitudes important?

There are animals that are ectotherms (they depend on external sources of heat, as is the case of reptiles and arthropods) and altitude can affect both their reproduction and distribution, and even their survival. Studying the change in temperature at different altitudes can help to know the right conditions for the propagation and conservation of a species. Another concrete example can be in aviation, since aircrafts must avoid icing conditions (ice formation on the external surfaces of the aircraft) that are caused by low temperature and high humidity in the atmosphere, which would cause, among other things, the loss of the aircraft´s lift and increase its weight. Another applicable case would be for mountaineers: the altitude determines the type of clothing they must wear to withstand those

temperatures, the provisions they must make for sudden changes in weather conditions (blizzards, snowstorms), and even the lower amount of oxygen in the air as they ascend.

Bibliography

https://www.meteorologiaenred.com/variacion-de-la-temperatura-con-la-altura.html