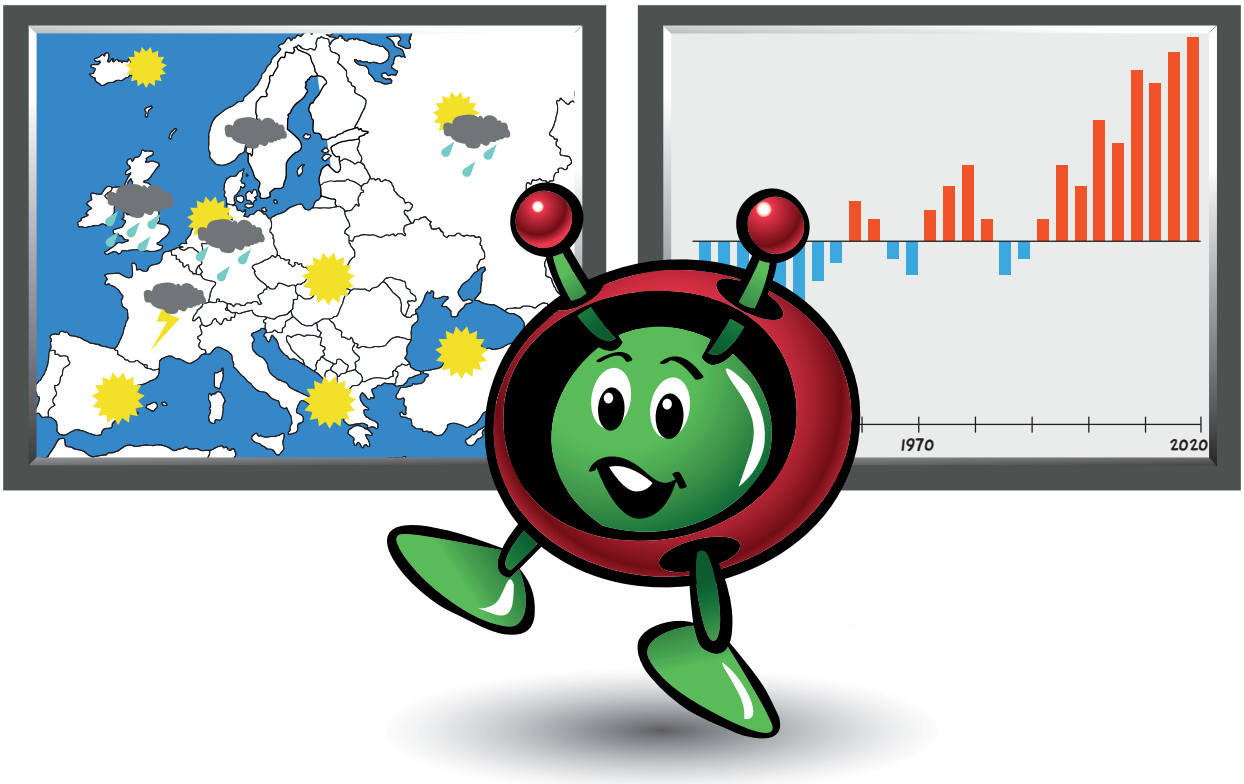
primary | PR54

teach with space

→ WEATHER VS CLIMATE

Understanding the difference between weather and climate



teacher guide & student worksheets

European Space Agency

Teacher guide

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→ WEATHER VS CLIMATE

Understanding the difference between weather and climate

Fast facts

Subject: Mathematics, Science
Age range: 8-12 years old
Type: Students activity
Complexity: easy
Lesson time required: approximately 45 minutes per activity
Cost: low (0-10 euros)
Location: indoors and outdoors
Includes the use of: thermometer/weather station, calculator, internet
Keywords: Mathematics, Science, Climate, Climate Scenarios, Weather, Weather Elements

Brief description

In this set of activities, students will learn the difference between weather and climate. They will identify different climatic zones and collect their own weather data. They will analyse and compare daily and monthly air temperature measurements. Finally, they will learn about different climate scenarios and identify what it means for the monthly average temperatures in their area/ country.

Learning objectives

- Understand the difference between weather and climate
- Identify the elements and factors of climate (wind, temperature, atmospheric pressure, rainfall)
- Identify the world climatic zones by detecting some basic characteristics
- Compare weather and climate data
- Learn how to take and collect weather measurements
- Calculate the average weekly/monthly air temperature
- Interpret tables and graphs, and drawing conclusions

→ Summary of activities

activity	title	description	outcome	requirements	time
1	Is it weather or climate?	Pupils analyse different statements about weather and climate and examine images of different places on Earth with different climates.	Pupils learn the difference between weather and climate and understand that the Earth can be divided into climate zones with different ranges of temperatures and precipitation.	None	45 minutes
2	Weather Detectives	Pupils collect air temperature data for a period Afterwards, collected data is graphed and averages are calculated.	Pupils learn skills in data collection and practice handling data mathematically.	Knowledge in graphing data	Data collection: 5 -10 minutes per day Data analysis: 45 minutes
3	Climate Reporters	Pupils analyse climate projections and write a short climate report for the year 2050.	Pupils learn about climate projections and acquire some understanding of how a future increase in temperatures may affect their lives.	None	45 minutes

→ Introduction

The concepts of weather and climate are often thought to be the same thing. This conceptual confusion makes it difficult for many people to understand what is meant by climate change. To clarify this, it is essential to understand that when we speak about weather conditions we are referring to short periods of time, such as hours, days or weeks; when we talk about climate we are implying long periods, such as 30 years or more. Climate refers to the weather pattern, using statistical data, of a place over a long enough period to yield meaningful averages

The European Space Agency (ESA) has been dedicated to observing Earth from space ever since the launch of its first Meteosat weather satellite in 1977. Since then, ESA has operated three different families of weather satellites: Meteosat First Generation; Meteosat Second Generation (MSG); and Meteorological Operational satellite programme (MetOp).

Satellite observations are used for both weather forecasting and modelling climate. The ESA Climate Change initiative makes use of Earth Observation satellite data (including weather satellite data and measurements taken on Earth) to track changes in the climate and understand how and why the climate is changing. Computer climate models are used to provide predictions and projections from tens to hundreds of years in the future. These projections also help us to understand the changes we observe and attribute them to specific causes. Climate models are tried and tested in a number of ways, one of the most important of which is to see if they are able to reproduce the climate of the recent past.

Figure 1

↑ Meteosat Third Generation (MTG) satellites will guarantee the continuity of data for weather forecasting into the next decades, and also provide other services , such as improved air quality or UV-radiation and sever storm warnings.

→ Background

Weather is the state of the atmosphere at a particular place and time. The weather is frequently defined using different parameters, such as temperature, humidity, precipitation, wind and atmospheric pressure.

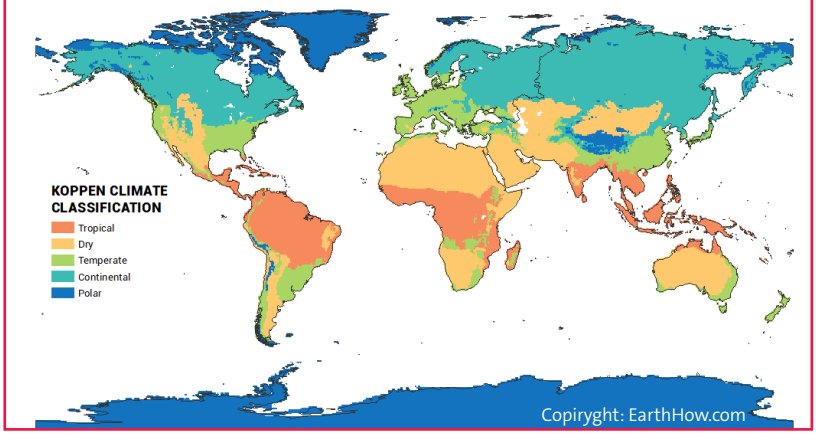
Weather forecasting is the application of science and technology to predict the state of the atmosphere for a future time and a certain location. In weather forecasting, the future time is restricted to hours, days or weeks in advance. Weather forecasts rely on powerful supercomputers to process hundreds of thousands of observations and measurements taken by satellites in orbit and weather stations on the ground. Using this data, the supercomputer models how the atmosphere will evolve and what weather this will bring.

The difference between climate and weather has to do with the length of the period considered. According to the Intergovernmental Panel on Climate Change (IPCC) and to the World Meteorological Organization (WMO), "Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years." The classical period for averaging these variables is 30 years and the relevant quantities are most often surface variables such as temperature, precipitation and wind.

Additionally, the Earth can be divided into climate zones with different ranges of temperatures and precipitation which depend on latitude, altitude, location on the continent and distance from a large water body (e.g. the ocean or a lake). Different climate classification systems can be used to describe the climate of a region. The Köppen climate classification (Figure 2) divides climates into five main climate groups: polar; continental; temperate; dry and tropical.

The Sun's energy is the main driver of the climate system. Because the Earth is roughly spherical, the Sun's rays distribute this energy unequally across the planet, with the tropics receiving more energy on average than the poles. The atmosphere and the ocean maintain a stable climate by transporting this additional energy from the tropics towards the poles.

Figure 2



↑ Köppen climate classification map

Climate varies not only by region but also over time. Palaeoclimatologists reconstruct the Earth's climate over billions of years. To be able to do so, they rely on the help of alternative or indirect measurements of climate, also known as proxies. These proxies can be found as organisms in the sediment of lakes and oceans, in glaciers, in fossils, and as rings inside trees and corals. These climate reconstructions form – in combination with recent climate observations and climate models – the basis for researchers to predict our future climate.

→ Activity 1: Is it weather or climate?

In this activity, pupils will learn the difference between weather and climate by analysing different statements. Finally, pupils will observe pictures from different places on Earth and link them to different climate zones.

Equipment

- Pupil activity sheet

Exercise

The concepts of weather and climate can be introduced by asking pupils about the weather on their last birthday. Can they remember if it was the same two years ago? As homework pupils can ask their parents about the weather on their earlier birthdays, when they were too young to remember. As a memory-helper pupils can look for photographs of their birthday day (outdoors) and discuss the weather.

When talking about birthday weather, pupils who have birthdays in the same month could pair up to compare if the weather was the same on their birthdays. This will consolidate the idea that weather is ever changing.

Start with exercise 1. Pupils should categorize the statements into weather- or climate-related:

Weather-related: A, B, E and G
Climate-related: C, D, F, H and I

Exercise 2 asks pupils to describe weather and climate in their own words. Pupils should be directed to conclude that the term "weather" implies a short period of time (hours or days) and that "climate" implies much longer periods (years, decades). Pupils should conclude that the definition of climate or can only be established when temperatures and other data have been measured over a long time period.

For older pupils, it is possible to extend the activity by introducing the concept of climate zones (see Annex I - Extension). Start by asking pupils if they can identify a country in which the weather on their birthday would be completely different (different temperature; different amount of rain). On their pupils worksheets, the pupils will find a map of Earth's five main climatic zones. Ask them to look at pictures A to F and work out where they should be placed on the map. Pupils should describe the picture and explain why they think they are related to a specific climate zone. They should describe elements like lack of precipitation; distance from the ocean; distance from the tropics.

Results: Polar – A ; Tropical – B ; Dry - C; Continental -D; Temperate – E, F

→ Activity 2: Weather Detectives

In this activity, pupils will make their own weather observations by measuring air temperature and analyse the data afterwards. The activity is split into two parts: measurement and analysis.

Equipment

- Thermometer
- Pupil activity sheet
- Calculator

Exercise

Measurements

Start by asking pupils to pair up and reflect on what factors need to be considered when taking temperature measurements. Pupils should come up with the following list when combining their answers:

- A thermometer is required to take measurements.
- It is important to make sure that the temperature measurements are taken in the same place and at the same time every day (preferably at noon).
- The location should be shaded (so that the Sun does not heat the thermometer directly,) and well-ventilated, such that the wind can blow freely (not in a porch or a partially-covered shed, for example).

It is also important that the measurements are not accidentally tampered with, for example by holding the thermometer in warm hands. The thermometer will also need some time out in the air - about five minutes - for it to adjust properly to the actual outdoor temperature.

Continue the exercise by asking pupils if they can think of a place at the school that is suitable to place a thermometer. If there is a thermometer already present on the premises, have pupils evaluate if all the aspects above are covered or if the thermometer should be moved to another location.

Conclude the exercise by instructing pupils to measure temperatures at the agreed time. This task can be divided between the pupils to give each one the responsibility and opportunity. It is advisable to measure temperatures at noon every day but it is also possible to take measurements multiple times per day and calculate the average for each day.

It is advisable to run the exercise for at least one week, ideally one month. The table provided in Annex I can be used as a template to display in the classroom.

This activity can be adapted or reformulated according to the age and knowledge of the pupils. The teacher may provide tables with data related to the daily, monthly and annual air temperatures and/or precipitation of the students' location and also include charts, if he/she finds the activity needs more visualizations to aid comprehension.

Analysis

1. Start by handing out the measured results to everyone in the class. Pupils should draw a diagram with the number of days on the x-axis and the temperature in °C on the y-axis.

2. Ask pupils to calculate the average temperature throughout the period. If multiple measurements were taken within a day, pupils should calculate the daily average first before determining the overall average.

3. Afterwards, pupils should note the calculated average as a straight line in their diagram. They should note that some values are above and below the average temperature. If some measured values vary significantly from the calculated average, pupils should connect these with very cold/warm days they experienced during the observation period.

4. As all pupils worked with the same values, there should be no difference between the graphs. However, the scale of the graphs could vary, for example.

5. Now ask pupils to research average monthly temperatures for the measuring period. A quick online search with “average temperature + city name” provides a long list of results. The national meteorological institute could also be a good data source. Pupils should conclude that results may vary depending on the location of weather stations and periods of measurements.

→ Activity 3: Climate Reporters

In this activity, pupils will look at future climate scenarios and analyse how these will impact temperatures. They will also discuss actions to help lessen or raise awareness of the impacts caused by an increase in temperatures.

Equipment

- Pupils activity sheet
- Internet access

Exercise

Before starting this activity it's important to assess student's knowledge about greenhouse gases. Younger pupils may start the activity by watching Paxi's video about the greenhouse effect. Ask pupils what a greenhouse gas is and how they are produced. Explain the difference between the natural and anthropogenic (resulting from human activities) greenhouse effect.

Spark a discussion about how scientists predict what Earth's climate will be like in the future. Explain that scientists use observations from the ground, air and space, along with computer programs called climate models, to monitor and understand how Earth's climate is changing. Around the world, different teams of scientists have built and run models to project future climate conditions under various scenarios for the next century. A climate scenario is a plausible representation of the future climate that has been constructed to investigate the potential consequences of human-induced climate change. The amount of future greenhouse gas emissions is a key variable in the different scenarios.

Divide the class in groups. Each group will work a different scenario (a low emissions scenario and a high emissions scenario). Ask pupils to calculate monthly average temperatures based on the respective scenario. For this they can explore the C3S Climate & Energy Education Demonstrator (C3S Edu Demo), a project supported by the Copernicus Climate Change Service. Before using this tool we recommend watching the video about the different scenarios used in the tool. If pupils don't have access to the Internet, teachers may download the data in advance.

Pupils should acquire some understanding of how a future increase in temperatures may affect their lives. In groups they can come up with ideas and suggestions on how to lessen the impacts of climate change in their area. They present their ideas and conclusions to the class.

→ WEATHER VS CLIMATE

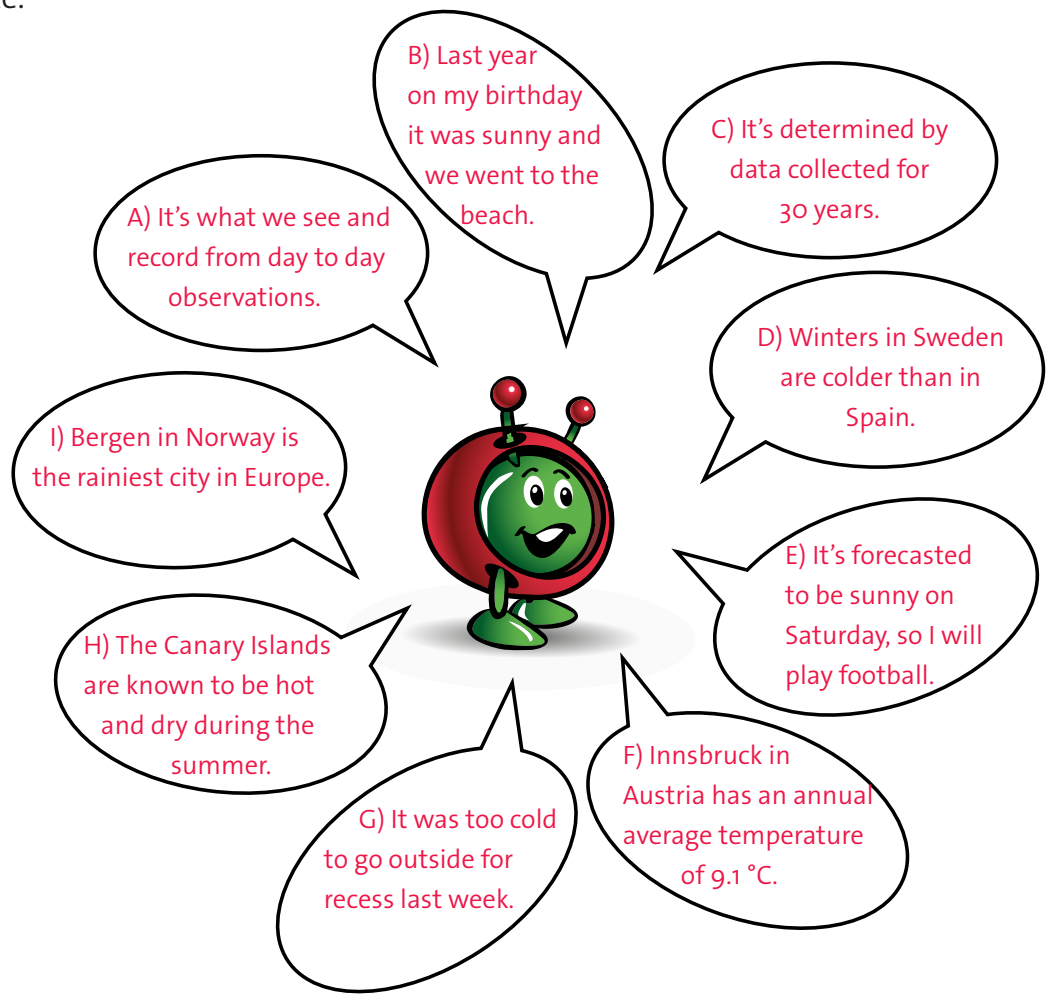
Understanding the difference between weather and climate

→ Activity 1: Is it weather or climate?

Have you ever wondered why meteorologists use the word weather and not the word climate when they speak about their predictions on TV? We even refer to them as weathermen or weatherwomen. You might have heard about 'climate change' too. So, what does climate mean? And how can we distinguish weather from climate? You will explore these topics in this activity.

Exercise

1. In groups of two, review the following sentences and determine if they concern weather or climate.



2. Complete the following sentences using your own words.

Weather is _____

Climate is _____

3. Discuss the following sentence with your classmates:
Climate scientists say that the temperature is increasing but the **weather** today is rainy and cold.

→ STUDENT WORKSHEET

→ Activity 2: Weather Detectives

Your assignment is to explore the weather in your area for a period. To do this, you are going to measure a very important weather element: air temperature.

Exercise

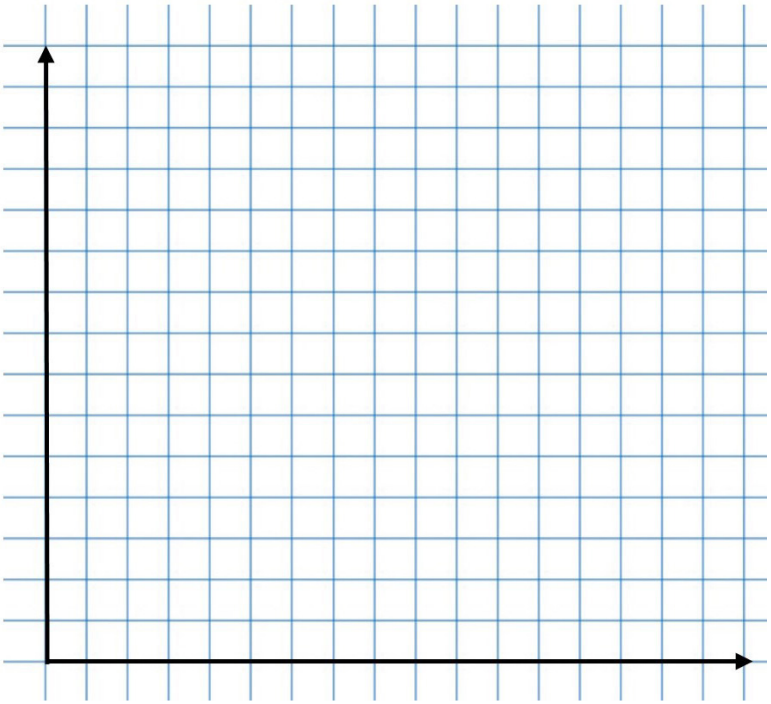
1. What do you need to remember before starting to take measurements? Discuss with your classmates and note below what steps are necessary for your investigation. Think about what instrument you want to use for your observations and what else you need to take into consideration.

2. Register your measurements in your notebook or on the whiteboard. You can use the table in Annex II as a template.

Results

You will now work with the data that you collected.

1. Create a graph with the temperatures that you measured. On what axis would you put the temperatures and on what axis the day of the month? Remember to include the units.



1.1 When looking at the graph, were the temperatures constant during the period you investigated? Can you note any periods that were very hot or very cold?

2. You will now calculate the average temperature.

The average is defined as $m = \frac{\text{sum of the terms}}{\text{number of terms}}$. To simplify it, you can break it down into two parts.

Calculate the sum of measured temperatures:

How many days did you measure temperatures?

The average temperature was: _____

3. Add the average temperature to your graph. Are there any days that deviate greatly from your calculated average? Are those the days you remember as being particularly cold/warm?

4. Compare your graph to others in your class. Identify the reasons for any differences between graphs.

5. You will now research online the average temperature for the period that you measured.
According to the _____ the average temperature in _____
_____ (location) in/for the period _____ is: _____ °C.

6. Did the value that you found differ from some of your classmates' values? Can you think of reasons why?

7. Do your calculated average and the internet value differ? Calculate the difference if applicable. Can you think of reasons why your measured temperature might differ from the researched average?

→ Activity 3: Climate Reporters

In the following activity, you will work with climate predictions and discuss what effect global warming may have on our planet in the future. You will write a climate summary for the year 2050!

Did you know?

The climate has been changing for billions of years. Long periods of colder or warmer climate occurred long before humans were on the planet to influence it. Scientists work like detectives to figure out what the climate used to be like. These scientists are called paleoclimatologists. They use clues found in the sediments of lakes and oceans, in glaciers, in fossils, and as rings inside trees to study Earth's climate. Concordia research station in cold and dry Antarctica is one of the most isolated human outposts on Earth and a perfect place to investigate our planet's climate past.

Exercise

1. Around the world, different teams of scientists have built and run computer models to project future climate conditions under different scenarios. You will now take a look at what two of these scenarios would mean for the monthly average temperatures in your area.

   1.1 Open the C3S Climate & Energy Education Demonstrator online tool and select air temperature as the climate variable:

   edudemo.climate.copernicus.eu

   1.2 Select the Spatial Resolution (country or sub-area) according to your localization.

   1.3 Complete Table 1 with the values for the monthly mean temperature. Remember to indicate the country/sub-area and the emissions scenario.

Did you know?

When paleoclimatologists combine their reconstructed history of Earth's climate with observations of Earth's modern climate and put them into computer models, they can predict future climate change. These models require more than 3 quadrillion calculations that require Supercomputers. Supercomputers are used for a wide range of computationally intensive tasks in several fields, including weather forecasting, climate research, and physical simulations (such as those probing the origin of asteroids).

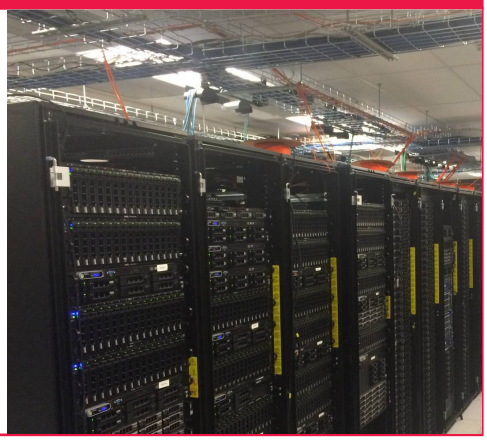


Table 1

Area: _____ Emissions Scenario: _____	Historical monthly mean temperature (°C) 1981–2010	Projected monthly mean temperature (°C) 2035–2064	Projected monthly mean temperature (°C) 2050	Difference between projected temperatures	Difference between projected (2035–2064) and historical temperatures
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					

2. You will now write a climate summary for the year 2050. Complete the script below based on the data from table 1:

   In _____ (insert area) the mean temperature for _____ (insert month) 2050 was _____ °C. This temperature was _____ °C warmer/colder than the 2035-2064 average and _____ warmer/colder than the average for 1981-2010.

3. Analyse the difference between the historical and the projected monthly temperature for the period 2036-2064. Can you think of any effects that could have on your daily life? Think about your birthday; would anything change? Can you think of actions you and the people around you could take to help lessen the problem? Present you results to your class.

→ LINKS

ESA resources

Climate Detectives classroom resources
https://climatedetectives.esa.int/classroom-resources

Paxi animations
esa.int/kids/en/Multimedia/Paxi_animations

ESA Meet the Experts videos – Weather vs Climate
esa.int/Education/Expedition_Home/Weather_vs._Climate

ESA space projects

ESA's Earth Observation missions
esa.int/Our_Activities/Observing_the_Earth/ESA_for_Earth

ESA's Meteorological missions
esa.int/Our_Activities/Observing_the_Earth/Meteorological_missions

ESA Climate
https://climate.esa.int

Extra information

C3s Climate & Energy Education Demo
https://c3s-edu.wemcouncil.org

Monthly climate bulletins from Copernicus Climate Change service
https://climate.copernicus.eu/climate-bulletins

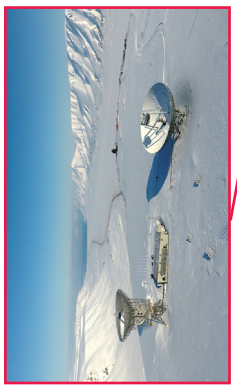
FAQ about climate from the World Weather Organization
http://www.wmo.int/pages/prog/wcp/ccl/faq/faq_doc_en.html

List of national meteorological services
https://en.wikipedia.org/wiki/List_of_meteorology_institutions

→ Annex 1 : Extension activity 1

Exercise

The map below shows an illustration of the Earth's main climatic zones. Look at the pictures on the following page and place them on the map.



1

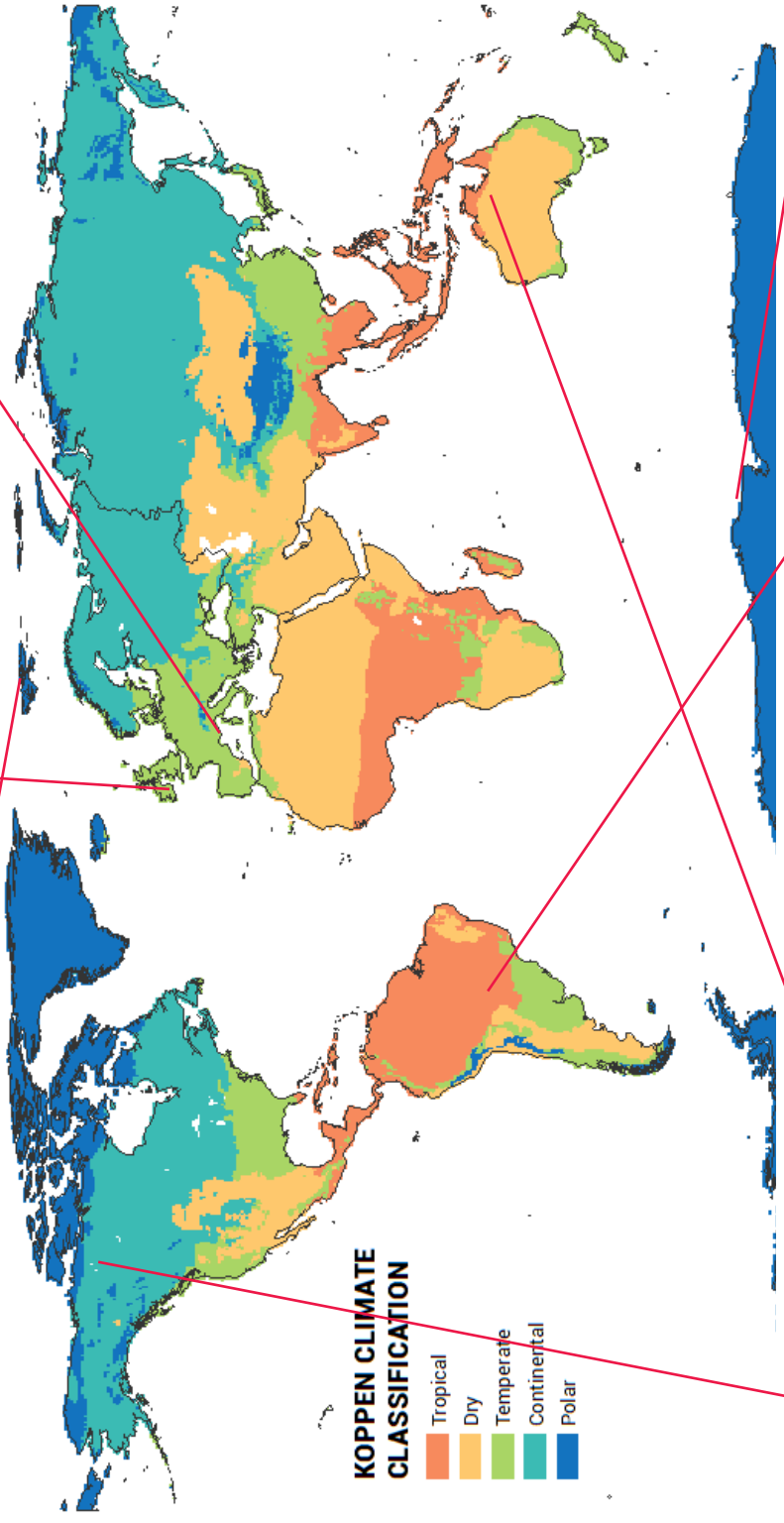
2

3

4

5

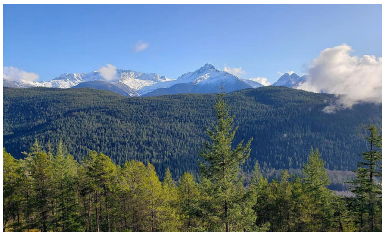
6



A

B

C



D

E

F

→ Annex 2

The following table may be used to note your air temperature observations.
You can use the following words to describe the weather:

Sunny, cloudy, showers, thunderstorm, windy, foggy, snowy.

Date	Day of the week	Temperature	Weather