3 The challenge of climate change

▲ Climate cha
is a global pr

LEARNING SITUATION

Humanity is currently experiencing a climate emergency. Deforestation, the use of fossil fuels, our consumption habits, etc. are changing the Earth's environment. This change is occurring at a speed and on a scale never experienced before in history. The planet is warming at an alarming rate.

The decisions we make today will determine the climate of the future and the planet we leave to future generations. This is why we are at a time when it is absolutely essential to act to reduce climate change. Every individual action helps in the fight against climate change.

LET'S GET STARTED

- Look at the trends that the
show. What relationship ca
see between the graphs of h
activities and those related
environment?
- What is global warming? Is
related to human activity?
- Is it necessary to act and st
global warming? Why or wh
- How can the climate crisis a
your daily life?

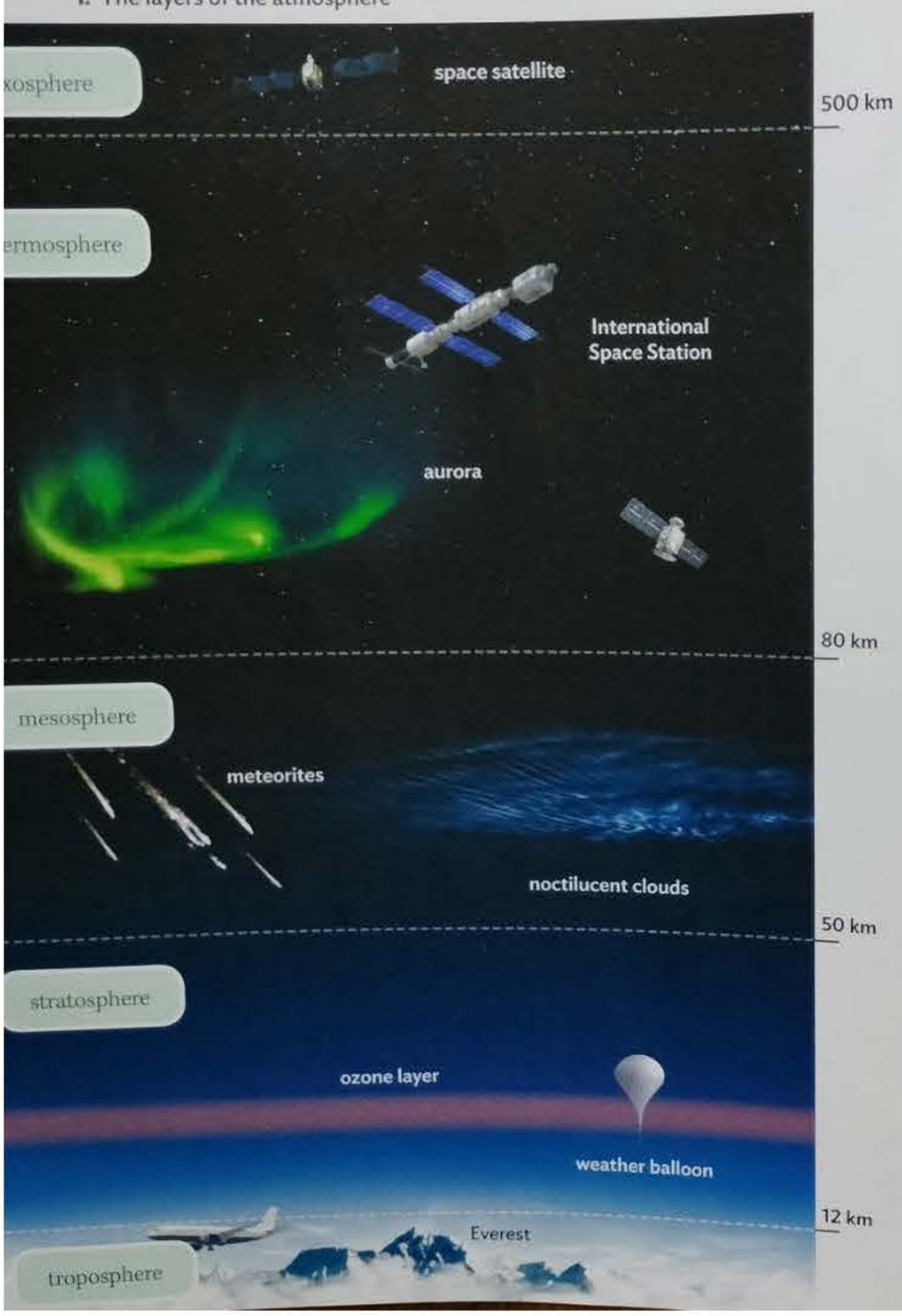
1. The atmosphere is essential for life on Earth

What is the atmosphere?

The **atmosphere** is a layer of gases that envelops the Earth. It consists mainly of nitrogen and oxygen. The atmosphere regulates the Earth's temperature and we breathe the oxygen it contains. The atmosphere prevents the Earth from getting too cold at night and prevents overheating from the Sun's radiation during the day.

The atmosphere is usually divided into **five layers** in which temperatures rise and fall. (1)

1. The layers of the atmosphere



WORK WITH THE IMAGE

- **List** the layers of the atmosphere in order from the layer closest to the Earth's surface to the layer furthest away.
- **State** one characteristic of each layer of the atmosphere.

5. EXOSPHERE

This is the **outer limit** of the atmosphere. This is where some types of artificial satellites orbit.

4. THERMOSPHERE

Solar radiation is so strong that it strip electrons from gas particles. The upper part of the thermosphere is where man space missions take place.

3. MESOSPHERE

Chemical reactions occur due to interference from solar radiation. The temperature is very low.

2. STRATOSPHERE

It contains **ozone**, a gas that absorbs harmful ultraviolet radiation from the Sun.

1. TROPOSPHERE

This is the lowest layer of the atmosphere. It is in contact with the Earth's surface and is where life exists.

It contains 80 % of the gases in the atmosphere and 99 % of the water vapour. This is where most **meteorological phenomena** (rain, cyclones, etc.) occur.

The study of the atmosphere

Meteorology is the science that explains how the atmosphere works. Meteorologists observe and analyse weather phenomena in the atmosphere, especially in the lower layers. With their observations, they develop mathematical models to produce weather forecasts.

Atmospheric or meteorological weather is the state of the atmosphere at a specific time and place. It is different from **climate**, which indicates the typical state of the atmosphere at a particular place. To know the climate of a place you have to study its daily weather over many years.

Weather changes continuously. Therefore, weather forecasts are more reliable for the near future than for the distant future.

KEY QUESTIONS

- If the atmosphere did not exist, would life on Earth be possible? **Explain** your answer.
- What is the relationship between the atmosphere, weather and climate?
- **Describe** the layer of the atmosphere that is in contact with the Earth's surface.
- If someone says that it rains in London in spring, are they talking about the weather or the climate? **Discuss** with your partner.

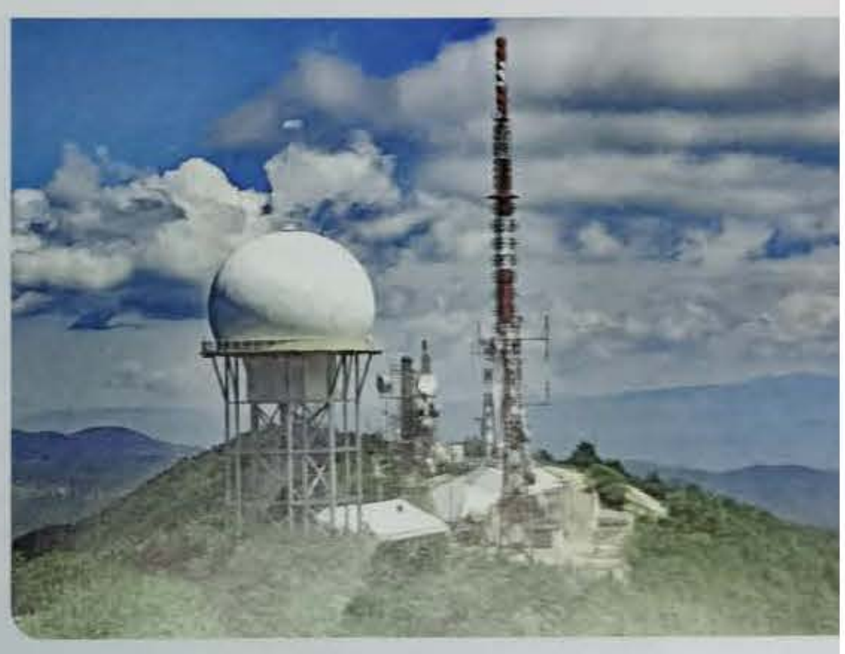
EXPLORE

How weather data is obtained

Meteorological stations are installations that measure daily maximum and minimum temperatures, wind, pressure, air humidity and precipitation. There are meteorological stations all over the world. (3)

Meteorologists also rely on **meteorological satellites** that orbit the Earth. These satellites transmit millions of pieces of data to ground stations every day. For example, sea surface temperature, cloud cover, winds, ozone and carbon dioxide (CO_2) concentration.

These satellites take photos of the atmosphere. (2) By analysing the photos we can see, for example, where large cloud masses are located, where they are moving to and what kind of clouds they are.



3. Weather station in Croatia

2. **Image sent by the Meteosat satellites.** This set of satellites orbits over the Atlantic Ocean and provides meteorological information for Africa and Europe.

Investigate

- Develop your creativity. Could you build a weather station at school? How would you do it?
- Watch on www.meteosat.es how the weather images evolve in Spain.

2. Air pollution

How does the atmosphere become polluted?

Impurities and waste gases, mainly from human activities, concentrate in the atmosphere. This pollution poses a major **global risk** to the health of living things and causes serious **environmental problems**.

Acid rain

It is rain that contains dissolved acids due to rainwater that combines with pollutant gases present in the air. When acid rain falls, the chemicals it contains are deposited on the Earth's surface.

The **effects** of acid rain are **very harmful**:

- It destroys the leaves of plants, causing them to die. (4)
- It increases the acidity of soils and river and lake water. This is harmful to the living things that live in these habitats.

4. Forest affected by acid rain in Germany

Photochemical haze or smog

Smog is fog mixed with smoke and other substances suspended in the air, which reduces visibility. Smog mainly affects large cities in winter, when emissions from motor vehicles are combined with emissions from heating systems. (5)

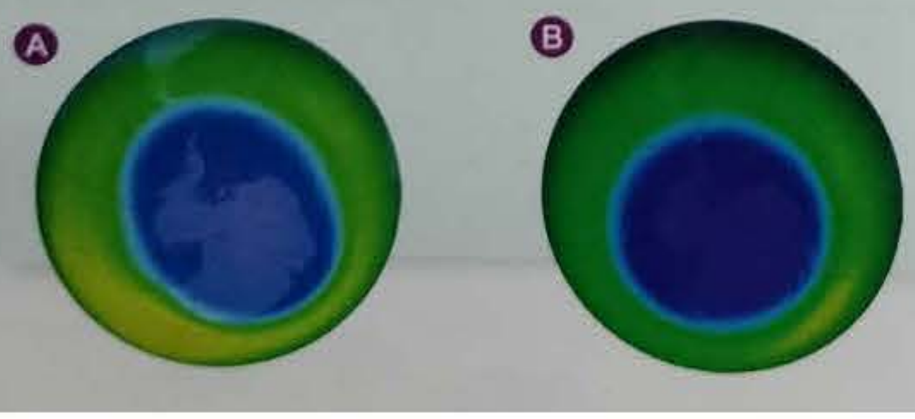
Smog irritates the eyes and airways and can cause or worsen diseases such as asthma. It also causes damage to natural vegetation and crops.

5. Smog over Los Angeles (USA)

The destruction of the ozone layer

Ozone is a gas in the atmosphere that absorbs much of the Sun's ultraviolet radiation, which is harmful to health. The ozone layer naturally depletes over the polar regions in autumn and winter and recovers in spring and summer.

However, the **emission of chlorofluorocarbons (CFCs)**, chemical compounds found in aerosols and refrigerants, breaks this natural cycle. CFCs cause further thinning of the ozone layer and prevent it from recovering. (6)



6. Ozone layer in (A) 1994 and (B) 2020. The hole in the ozone layer originally formed in the Antarctic because the very low temperatures favour the destruction of ozone. The colours in the images represent the amount of ozone in the atmosphere.

7. Greenhouse effect

Global warming

The Earth naturally retains heat in a similar way to a greenhouse:

- Some gases in the atmosphere, called **greenhouse gases (GHGs)**, allow heat from the Sun to reach the surface of the planet.
- Greenhouse gases prevent some of the heat from escaping back into space. This prevents the planet from becoming too cold.

However, this natural greenhouse effect is increasing as a result of the increase in some human activities. (7) For example:

- The extraction of raw materials and industrial production processes generate numerous gases and toxic waste.
- Transportation that uses fossil fuels emits many polluting gases.

As a result, **global warming** is occurring. This means an increase in the average temperature of the Earth's surface. In just over a century, the Earth's temperature has risen by 1.1 °C. In the last decade the temperature has risen by 0.2 °C.

Global warming is one of the causes of **climate change**: a change in the Earth's climates, which is caused directly or indirectly by human activities.

ENVIRONMENTAL AWARENESS

- Use the drawing to explain the greenhouse effect and how it is intensified. How is the greenhouse effect related to global warming? Explain your answer.
- Search for information on Sustainable Development Goals 3, 7, 11 and 13. Explain how these Goals relate to air pollution.

DIGITAL TASK

- Visit the website www.ica.mitecо.es and check the air quality near where you live.

KEY QUESTIONS

- List different types of air pollution. What human activities contribute to the pollution? What can we do to help keep the atmosphere clean?
- Is air pollution a local or a global problem?
- Explain how these concepts are related: *atmosphere*, *global warming* and *climate change*.

THESE ARE THE KEY ELEMENTS OF THE CLIMATE

3. The Earth's temperatures

RESOLUCIÓN

In order to study the climate, four main elements are analysed: **temperature**, **precipitation**, **atmospheric pressure** and **wind**.

Temperature according to latitude

Temperature is the amount of heat contained in the air. It is measured with a **thermometer** and is usually expressed in **degrees Celsius (°C)**.

Temperatures vary from place to place, depending on several factors: **latitude**, **altitude** and **distance from the sea**.

Latitude changes temperatures. Temperatures are highest at the Equator and fall progressively as we move from the Equator towards the poles in both hemispheres.

- In the area near the Equator, the Sun's rays reach a relatively small area of Earth at right angles and warm the surface significantly.
- The Sun's rays reach Earth obliquely between the tropics and the poles. Therefore, the Sun's energy is distributed over a larger area and this area warms up less.

For this reason, the Earth is divided into **five climate zones** according to latitude: one hot zone, two temperate zones and two cold zones. (8)

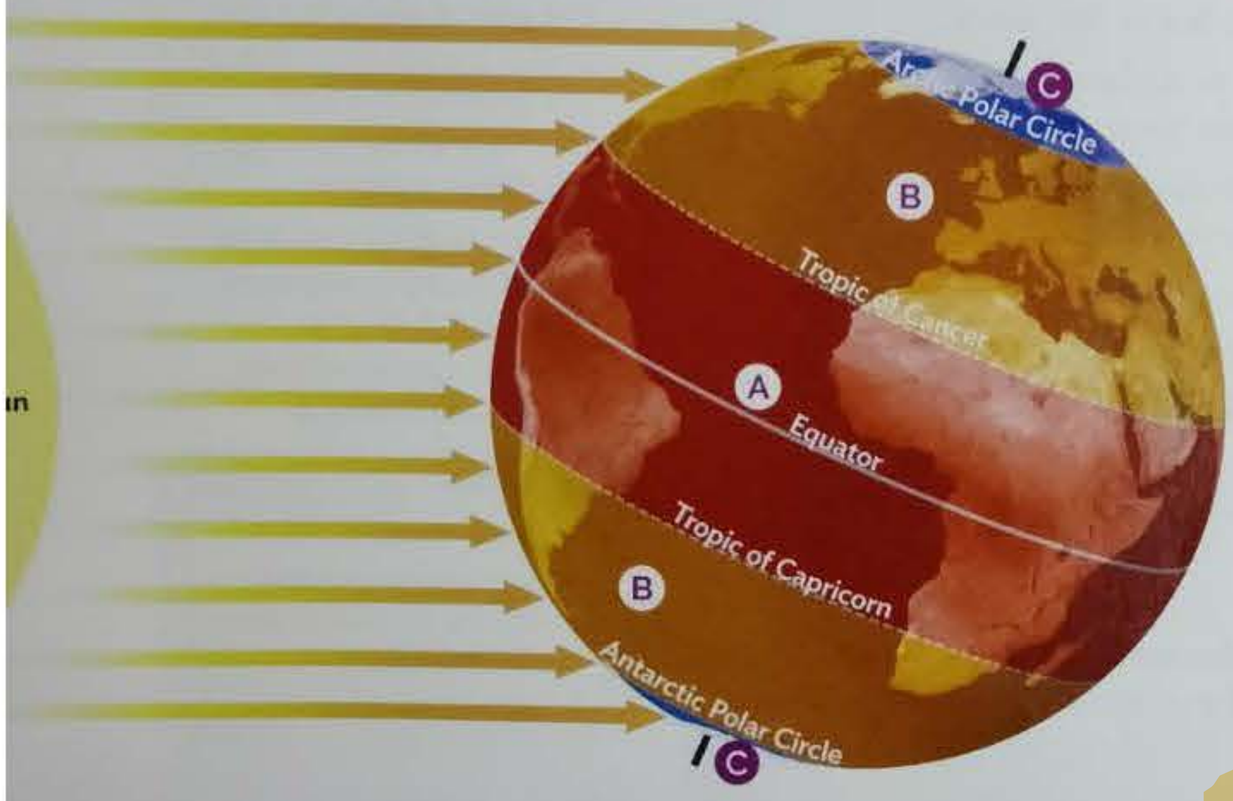
COMMUNICATION

- **Look for** information and **make** a glossary of terms related to temperatures. You can **include** concepts such as absolute maximum and minimum temperature, temperature variance, annual and monthly average temperature, extreme temperatures, etc.

WORK WITH THE IMAGE

- **Look at** how the Sun's rays reach different areas of the planet. **Explain** what consequences this has on temperatures.

8. The Earth's climate zones



A. ONE HOT ZONE

The Sun's rays arrive at right angles all year, so temperatures are always high. Temperatures vary little between day and night. Temperatures do not change much from season to season.

Watch this video; from 3'50" ahead

C. TWO COLD ZONES

The Sun's rays arrive at a very oblique angle throughout the year, so temperatures are always cold.

B. TWO TEMPERATE ZONES

The Sun's rays arrive more obliquely than in the hot zone, so temperatures are lower. Temperature varies between day and night and between seasons.

Other factors that affect temperature

Land temperatures also vary according to altitude and distance from the sea.

- **Altitude** influences temperatures: for every 100-metre increase in altitude, temperatures decrease by an average of 0.6 °C.
- **Distance from the sea.** The sea makes temperatures milder. The Earth's surface heats up and cools down faster than water. In summer, inland areas heat up much faster than the sea, which makes coastal areas cooler than the interior. In contrast, the land surface cools rapidly in winter, while the sea retains heat for longer. As a result, the temperature range in coastal areas is low.

KEY QUESTIONS

- **Explain** what temperature is. What factors modify temperature and how?
- Which factors do you think most influence temperatures in your community?
- **List** the Earth's climate zones and **describe** the temperatures in each.

BE A GEOGRAPHER

TO BE ANSWERED IN THE CLASS

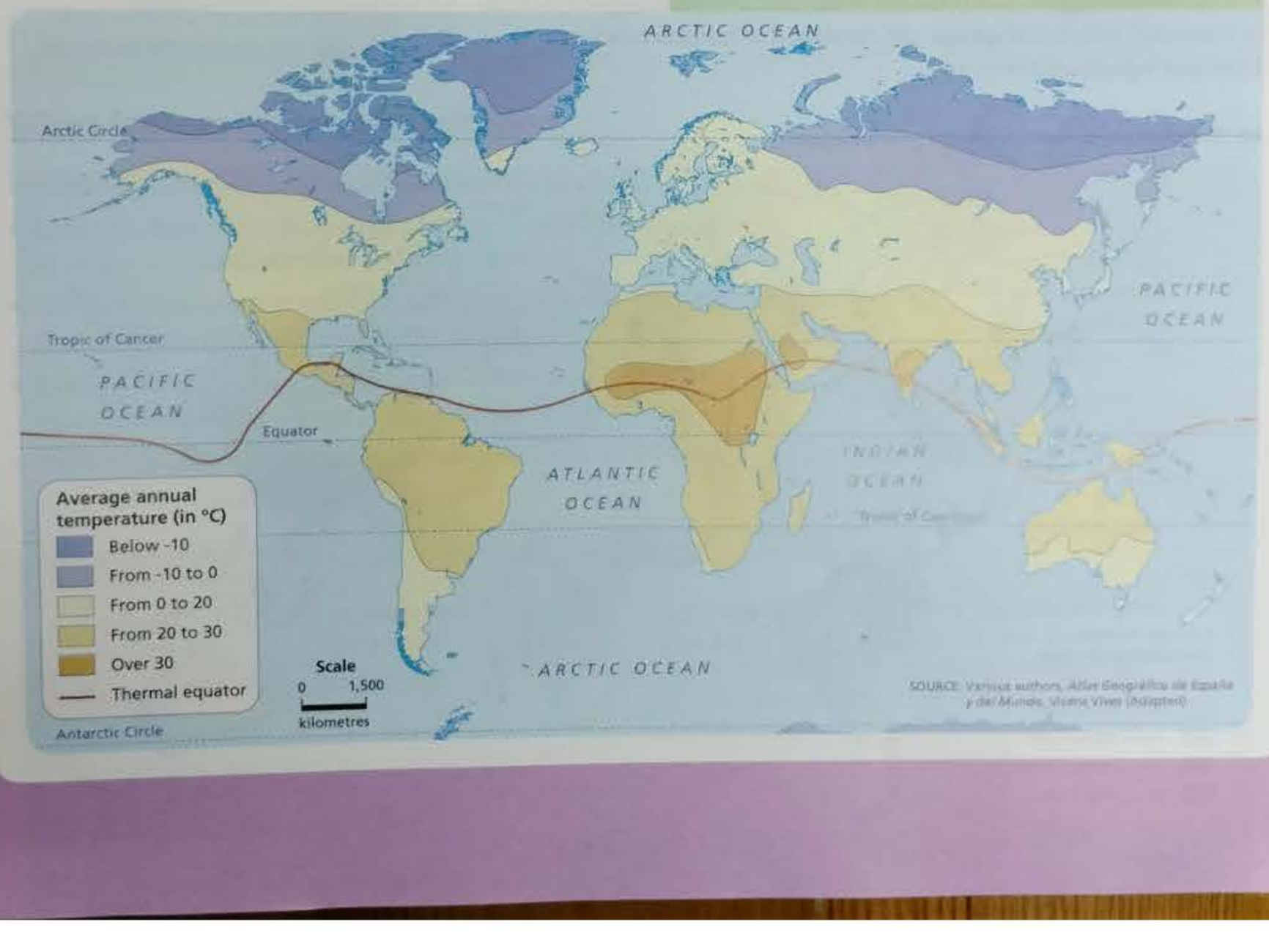
Analyse a world map of isotherms

Temperatures are represented on maps by isotherms. **Isotherms** are lines connecting points of equal temperature. (9)

Your turn

- **Identify** the areas with the highest and lowest average annual temperatures on the planet.
- **Use** the map to **explain** how latitude influences the distribution of temperatures.
- **Locate** the main parallels and **say** in which climate zone Europe is located.

9. Distribution of annual average temperatures



4. What causes precipitation?

Humidity and precipitation

TYPES OF CLOUDS

Humidity is the amount of water vapour contained in air. This water vapour originates from evaporation from seas, oceans, rivers, lakes, etc. When water vapour cools, it condenses: vapour turns into a liquid state in small droplets. These droplets form different types of **clouds**:

Cumulus clouds are large and white. They look like cotton wool and can bring short periods of rain.

Cumulonimbus clouds are large, dark clouds. They produce very heavy precipitation.

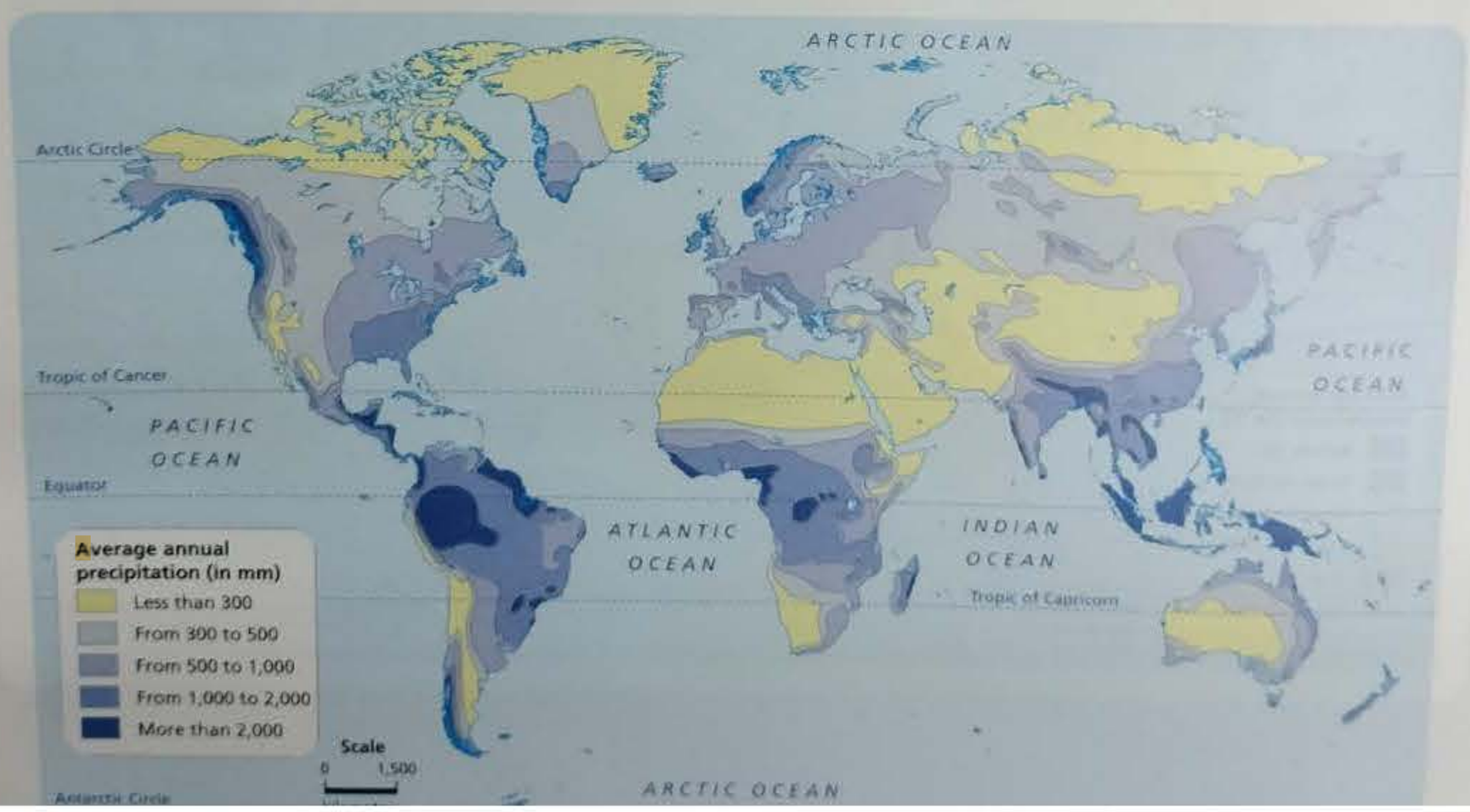
Cirrus clouds are very high, thin, white clouds. They are usually associated with worsening weather.

If the water droplets in clouds are small, they remain suspended in the atmosphere. However, when the droplets are large and heavy, they fall. **Precipitation** is water falling to the Earth's surface from the atmosphere. Precipitation can be liquid (**rain**) or solid (**hail** and **snow**). Precipitation is measured with a **rain gauge** and expressed in **millimetres** (mm) or **litres per square metre** (l/m^2).

WORK WITH THE IMAGES

- Look at the sky today. Are there clouds? Do they look like the ones in the pictures?

10. Distribution of average annual precipitation



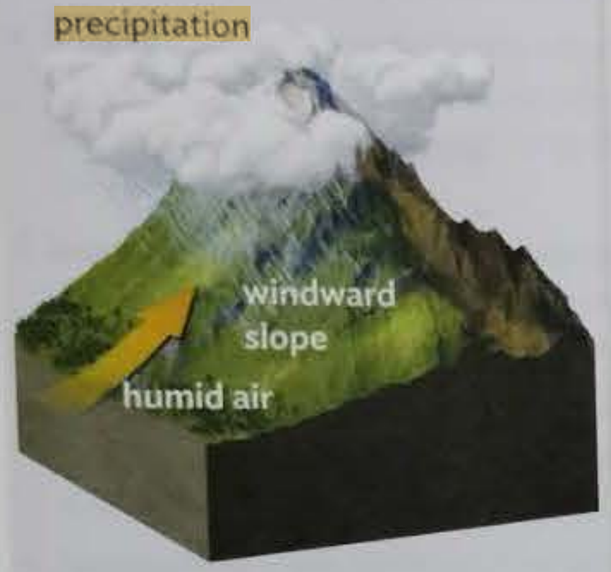
Different origins of precipitation

Precipitations by Study.com

Precipitation is produced in different ways:

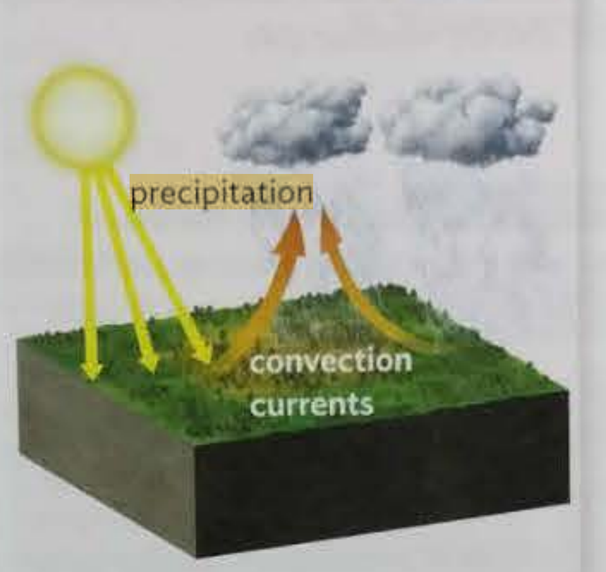
Relief precipitation

It occurs when a humid mass of air moves up the side of a mountain. As the air rises, it cools and the water vapour it contains condenses. Precipitation falls on the windward slope.



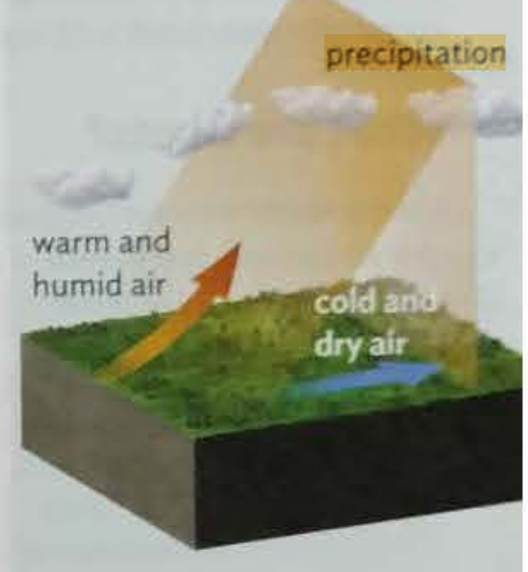
Convectional precipitation

It occurs when strong sunshine causes high evaporation and the air to warm quickly. As the warm air is lighter, it rises in convection currents and cools. This causes the water vapour to condense and precipitation to fall.



Frontal precipitation

It occurs when two masses of air with different temperatures and humidity levels come into contact. The warmer, more humid air slides over the colder air and produces moderate, long-lasting precipitation.



What factors affect precipitation?

Precipitation depends on several factors: (10)

- **Latitude.** Areas near the Equator receive more precipitation. These areas are warmer and evaporation is greater.
- **Altitude.** Precipitation increases with altitude. For this reason, it rains less at lower altitudes than at higher altitudes.
- **Distance from the sea.** Precipitation is more abundant on the coast than inland because the sea is a source of humidity.
- **Ocean currents** and **prevailing winds** in an area can alter the distribution of rainfall.

WORK WITH THE IMAGES

- Analyse the map and compare it with the distribution of average annual temperatures:
  - In which regions is rainfall higher?
  - Do those regions coincide with warm or cold zones?

KEY QUESTIONS

- Explain the difference between humidity and precipitation.
- Describe how clouds form.
- Define: *cumulus*, *cumulonimbus* and *cirrus*. What atmospheric weather is associated with each?
- Look at the physical map of Oceania in your atlas. Why do you think the east coast of Australia receives more precipitation than the west coast?

Difference Between Humidity and Precipitation

- **Humidity** is the **amount of water vapor** in the air.
  - It tells us how "moist" or "dry" the air feels.
  - Measured as **relative humidity** (a percentage of how full the air is with moistur
- **Precipitation** is when water **falls from the atmosphere** to the ground.
  - This can be in the form of **rain, snow, sleet, or hail**.
  - It happens when clouds become too heavy with condensed water droplets.

How Do Clouds Form?

1. Warm, moist air rises into the atmosphere.
2. As the air rises, it **cools**.
3. When it cools enough, the water vapor **condenses** into tiny droplets around particles like dust or smoke.
4. These droplets group together to form a **cloud**.

Types of Clouds and Associated Weather

Cloud Type	Description	Associated Weather
Cumulus	Fluffy, white clouds with flat bases	Fair weather (nice, sunny days)
Cumulonimbus	Tall, dark, towering clouds	Thunderstorms, heavy rain, lightning
Cirrus	Thin, wispy clouds high in the sky	Change in weather, often before a storm

5. What is atmospheric pressure and wind?

Atmospheric pressure

Atmospheric pressure is the weight of air at any point on the Earth's surface. It is measured with a **barometer** (13) and is expressed in **hectopascals** (hPa) or **millibars** (mb). Atmospheric pressure is not the same all over the planet.

- Pressure varies according to **altitude**. At lower altitudes pressure is higher than at higher altitudes because there is more air above.
- Pressure also varies with **temperature**. Warm air weighs less than cold air. So atmospheric pressure is lower in warm temperatures.

The normal air pressure at sea level is 1,013 mb. Areas with a lower pressure are called **low-pressure systems** or **depressions**: they are usually associated with unstable weather and precipitation. Areas with a pressure above 1,013 mb are called **high-pressure systems** or **anticyclones**: they are usually associated with stable and dry weather. (14)

11. Weather vane

What are fronts?

Low pressures are usually associated with fronts. A **front** is the area of contact between two masses of air with different temperatures and humidity. Depending on the temperature of the air, the front can be warm or cold.

When warm air slides over cold air, a **warm front** forms. Warm fronts usually cause intermittent precipitation of variable duration.

When cold air slides under warm air and forces it upwards, a **cold front** forms. It causes heavy and brief precipitation, which may be stormy.

WORK WITH THE IMAGES

- **Look at** the photo and explain how a weather vane works.
- **Interpret** the map of monsoon winds.
  - Is the winter monsoon a dry or a wet wind?
  - What about the summer monsoon?

BE A GEOGRAPHER

Analyse an isobar map

Isobar maps show the atmospheric pressure on the Earth's surface.

How to do it

- **Isobars** are lines on a map that join points of equal pressure. **Note** their values and analyse the proximity between them. Isobars that are close together indicate stronger winds.
- **Locate** the centres of **anticyclones** (H) and **low-pressure systems** (L).
  - In anticyclones, the pressure is greater than 1,013 mb. Pressure gets higher towards the centre.
  - In low-pressure systems, the pressure is lower than 1,013 mb. Pressure gets lower towards the centre.

Note that wind blows from high to low pressure.

- In the Northern Hemisphere the air in anticyclones rotates clockwise. At low pressures it rotates in the opposite direction.
- In the Southern Hemisphere the winds rotate in the opposite direction to the Northern Hemisphere.

If the wind comes from a continent, it will be drier. If the wind comes from the sea, it will be wetter.

- **Analyse** the fronts, what type they are and what weather is usually associated with them.

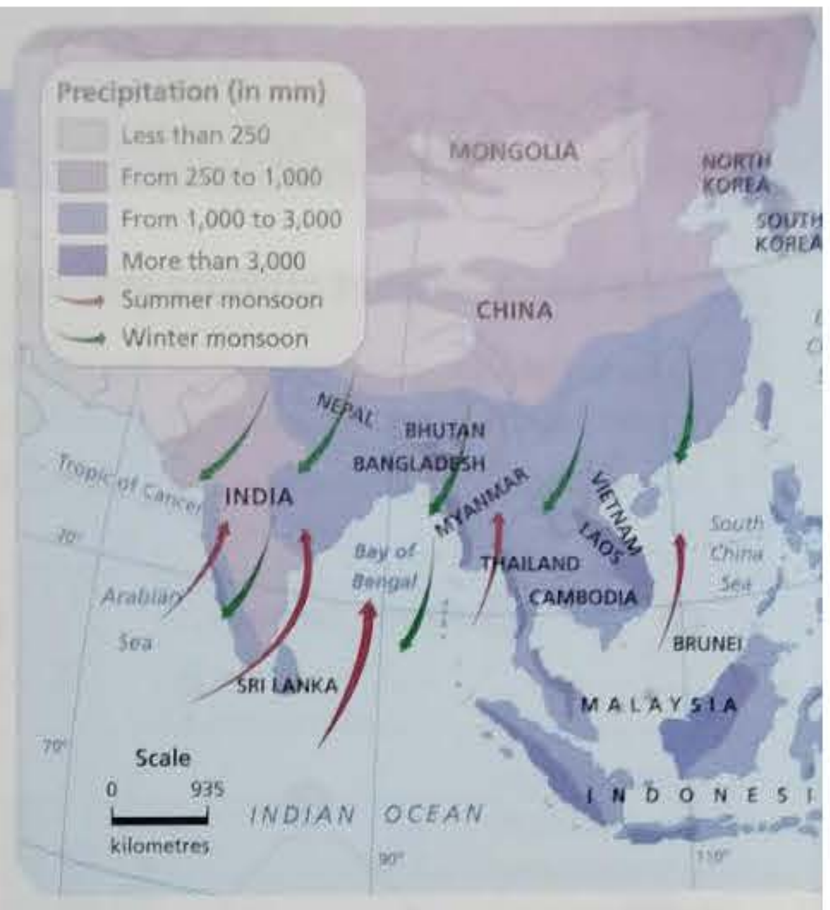
Wind

Wind is air that is moving because of differences in atmospheric pressure. Wind blows from areas of high pressure to areas of low pressure. In order to study the wind, two elements must be taken into account:

- Its **direction** or **course**, which we can find out by looking at a **weather vane**. (11)
- Its **speed**, which is measured with an **anemometer** and expressed in **kilometres per hour** (km/h). The Beaufort scale classifies the wind according to its intensity, from 0 (calm) to 12 (hurricane force).

There are very different types of winds. For example:

- **Steady winds**, such as the **trade winds**, in the intertropical belt. They blow from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere.
- **Seasonal winds**, such as the **monsoon winds** in South and Southeast Asia, which reverse direction depending on whether it is summer or winter. (12)
- **Winds that change daily**, such as **sea breezes**. They blow from the sea towards the land during the day and in the opposite direction at night.
- **Local winds**, such as **el cierzo**, which is a cold, strong and gusty wind that usually blows in the Ebro Valley.

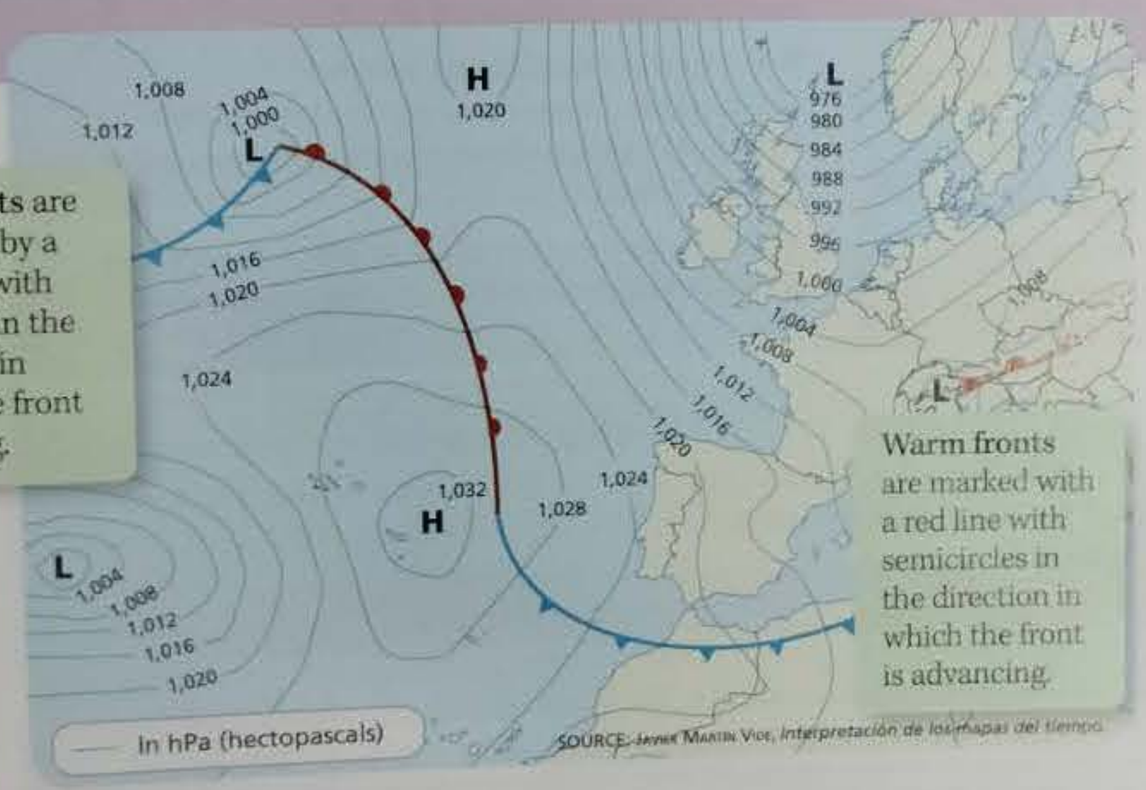


12. Monsoon winds

KEY QUESTIONS

- **Explain** atmospheric pressure and its importance in meteorology.
- **Compare:** What differentiates a warm front from a cold front?
- **Define** *wind*.
- Graphically **represent** how sea breezes work.

13. Barometer



Cold fronts are indicated by a blue line with triangles in the direction in which the front is moving.

Warm fronts are marked with a red line with semicircles in the direction in which the front is advancing.

14. Isobar map

Your turn

Identify the areas with low-pressure systems and the areas with anticyclones. Indicate the value of the pressure in each case.

Look at the fronts. Indicate where they are located and whether they are warm or cold.

Imagine that you work in a meteorological institute. Use the map to explain to your group what the weather is like in Spain.

🌬️ What Is Atmospheric Pressure?

Atmospheric pressure is the **weight of the air** pressing down on Earth.
Even though we can't see air, it has weight because it's made of tiny particles.
Meteorologists (weather scientists) use pressure to help **predict the weather**!

- **High pressure** = usually brings **clear, sunny** weather ☀️
- **Low pressure** = usually brings **clouds and rain** 🌧️

🌡️ Warm Front vs. Cold Front

Feature	Warm Front 🌤️	Cold Front 🌧️
What is it?	Warm air moves over cold air	Cold air pushes under warm air
Speed	Moves slowly	Moves quickly
Weather	Light rain or drizzle, then warm	Thunderstorms, then cooler air

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💨 What Is Wind?

Wind is **moving air**! 🌬️
It happens when the Sun heats Earth unevenly, making **air pressure different** in different places.

- **Air moves** from high pressure to low pressure.
- That movement is what we feel as **wind**!

🌊 How Do Sea Breezes Work? (Simple Graphic)

Let's picture a beach on a sunny day:

vbnet — Copiar — Editar

```
DAYTIME: SEA BREEZE

     ← ← ← ←  Wind from Sea to Land

  Ocean 🌊       →      Beach 🏖️
[Cooler]              [Warmer]
Air above ocean     Air above land heats up,
stays cooler        rises (less dense)

Air from the sea moves in to replace it
```

Why it happens:

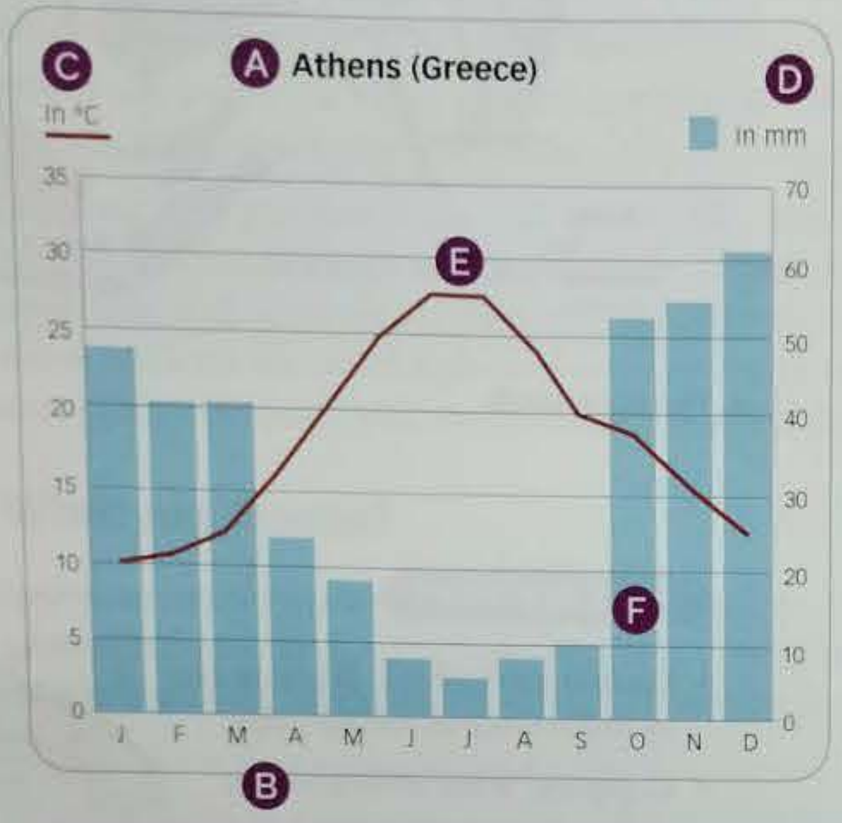
- Land heats up **faster** than the sea during the day.
- Warm air over land **rises**.
- Cool air over the sea **moves in** to take its place — that's a **sea breeze**!

BE A GEOGRAPHER

Create and interpret climate graphs

Climate graphs are graphs that show the climate of a place. They are made from the values collected at weather stations over several years. Climate graphs show two variables:

- Average monthly temperatures
- Total monthly precipitation



ELEMENTS OF A CLIMATE GRAPH

- A. **Title:** indicates the location.
- B. **Horizontal axis:** the months of the year are marked on this axis.
- C. **Left vertical axis:** it shows the temperatures in proportional intervals.
- D. **Right vertical axis:** this axis shows the precipitation values in mm. Its scale is double that of the temperatures.
- E. Monthly average **temperature line**.
- F. Monthly total **precipitation bars**.

How to do it

To make a climate graph:

- **Draw the horizontal axis with a ruler. Divide** it into 12 equal parts, one for each month of the year. **Write** the initials of the months below.
- **Draw the left vertical axis. Divide** it into regular intervals of five or ten degrees and write the values of the temperatures. **Label** the axis to show that the temperatures are expressed in °C.
- **Draw the right vertical axis. Mark** the precipitation values in mm. They should be double the temperatures at the same height on the axis.
- **Transfer the temperature values to the graph. Draw** a point, at the corresponding height, in the centre of each month and connect the twelve points with a red line.
- **Transfer the precipitation values to the graph. Draw** a blue bar for each month. The height of the bar will indicate the total precipitation for that month.
- **Write the name of the place to which the climate graph corresponds** and its altitude, if you know it.

Your turn

- **Draw** the climate graph of Aberdeen (UK) from the data in the table.

Look at this

This is interesting, but the axis are changed

ABERDEEN (65 m)

Months	J	F	M	A	M	J	J	A	S	O	N	D
T (°C)	3.2	3.4	4.5	6.3	8.8	11.8	13.6	13.4	11.5	8.7	5.6	3.9
P (mm)	63.6	50	53.8	49.3	53.5	50.3	70.2	70.2	64.4	76.3	78.7	74

How to do it

To interpret a climate graph:

- **Locate** on a world map the place to which the graph corresponds and **note** in which hemisphere it is located and at what altitude.
- **Analyse the temperatures.**
  - **Calculate** the average annual temperature.
  - **Look at the** temperature values for each month and **state** which months are warmer and which are colder.
  - **Calculate the** temperature variance and **state** whether it is high or low.
  - **Explain** whether temperatures change with the seasons or remain practically unchanged throughout the year.
- **Analyse precipitation.**
  - **Add up the** precipitation for all months to **calculate** the total annual precipitation.
  - **Observe whether** precipitation is evenly distributed throughout the year or whether it is concentrated in one season.
  - **Assess whether** there is a dry season. Months in which the top of the precipitation bar is below the temperature curve are considered dry months.

If the temperatures in all months are higher than 18 °C, it is a **hot climate**.

If there are distinct seasons related to important changes in temperature values, it is a **temperate climate**.

If the temperatures remain low in every month of the year, it is a **cold climate**.

In hot climates:

- If rainfall is regular all year round, it is an **equatorial climate**.
- If rainfall is concentrated in just a few months and the rest are dry, it is a **tropical climate**.
- If rainfall in all months is very low, it is a **desert climate**.

In temperate climates:

- If the summer months are dry it is a **Mediterranean climate**.
- If rainfall occurs mainly in summer, it is a **continental climate**.
- If rainfall is evenly distributed throughout the year, it is an **oceanic climate**.

Your turn

- **Analyse** the climate graph of Aberdeen that you have created:
  - **Note** where Aberdeen is and its altitude.
  - **Look at** the temperatures. What is the temperature in the hottest and the coldest month? Are the temperatures generally high, low or moderate? Can you distinguish seasons?
  - **Look at** the precipitation. **Calculate** the total for the year. How is it distributed throughout the year? In which months does it rain the most? In which months does it rain the least? Are there any dry months?
  - **Interpret** the data. Is it a hot, temperate or cold climate? What type of climate do you think it corresponds to? Why?
- **Select** one of the climate graphs from the unit and **explain** it to your group.

6. How are climates distributed?

Hot climates

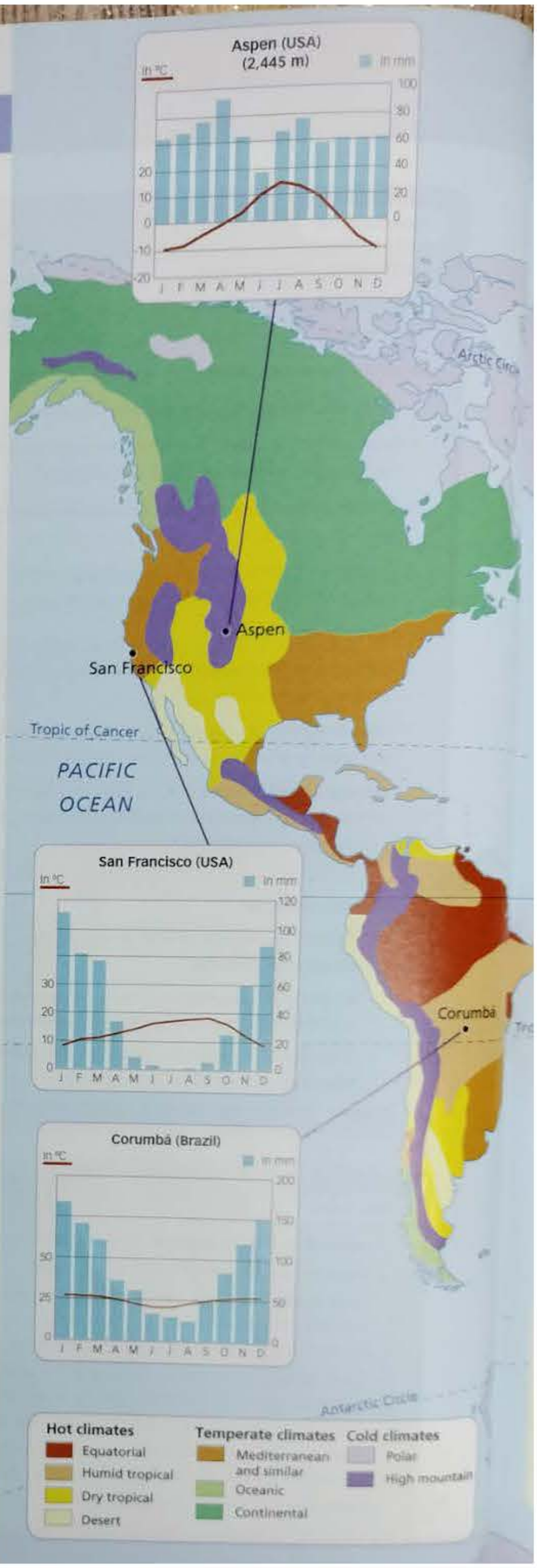
- **Equatorial climate.** Temperatures are always warm. Average annual temperature is around 25 °C and the temperature variance is very low. Rainfall is abundant and regular and usually exceeds 2,000 mm per year.
- **Tropical climate.** Temperatures are high, averaging more than 20 °C per year. Temperature variance increases as we move away from the Equator. Rainfall ranges from 2,000 mm in Southeast Asia to less than 400 mm near the deserts. There are alternating dry and wet seasons and, depending on the predominance of one or the other, a distinction is made between a **dry tropical** climate and a **humid tropical** climate.
- **Desert climate.** The average annual temperature is high (over 20 °C) and the temperature variance between day and night is very high. Rainfall is less than 250 mm per year.

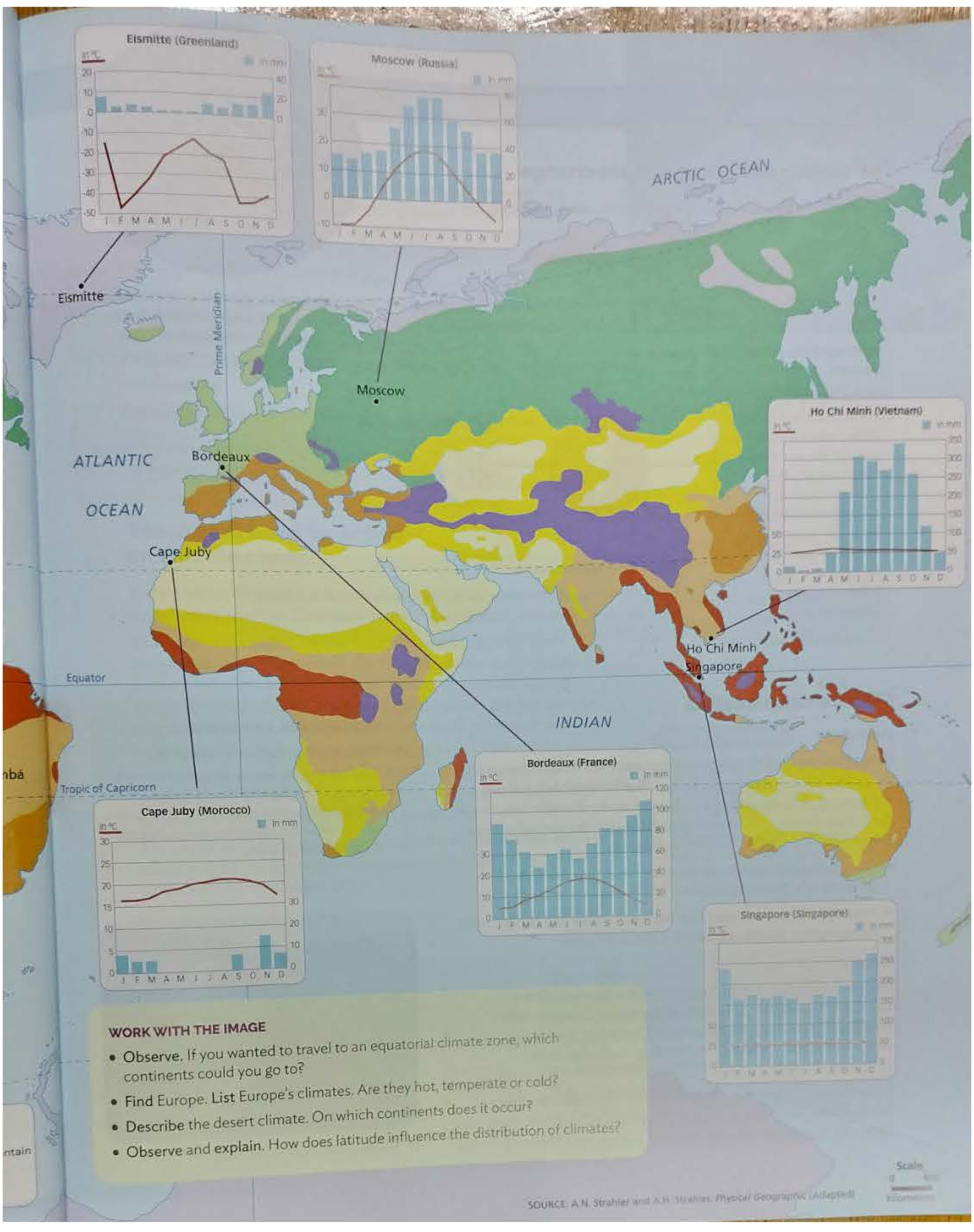
Temperate climates

- **Mediterranean climate.** Winters are mild and summers are warm. The average annual temperature varies between 10 and 18 °C, and the annual temperature variance is between 12 and 16 °C. Precipitation is low (between 300 and 900 mm per year) and irregular, with very dry summers.
- **Oceanic climate.** Winters are mild and summers are cool, with an average annual temperature between 10 and 15 °C and a low temperature variance. Precipitation is regular and abundant, around 1,000 mm per year.
- **Continental climate.** Winters are long and cold. Summers are short and hot. The average annual temperature is between 0 and 10 °C. The temperature variance is very high. Precipitation is between 750 and 300 mm and falls mainly in summer.

Cold climates

- **Polar climate.** Temperatures are very cold all year. There is almost no precipitation.
- **Mountain climate.** Winters are long and cold. Summers are short and cool. Precipitation is abundant and often falls as snow.

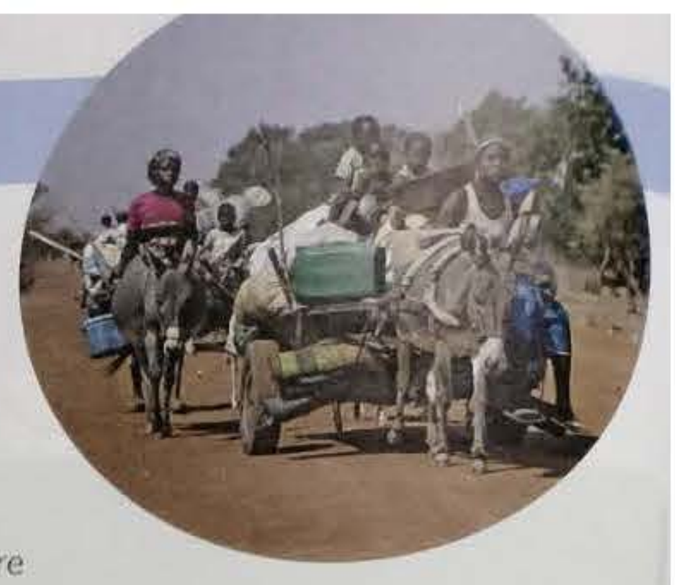



Eismitte (Greenland)
Moscow (Russia)
ARCTIC OCEAN
Eismitte
Prime Meridian
Moscow
ATLANTIC
OCEAN
Bordeaux
Cape Juby
Ho Chi Minh (Vietnam)
Ho Chi Minh
Singapore
Equator
INDIAN
Tropic of Capricorn
Bordeaux (France)
Cape Juby (Morocco)
Singapore (Singapore)
WORK WITH THE IMAGE
• Observe. If you wanted to travel to an equatorial climate zone, which continents could you go to?
• Find Europe. List Europe's climates. Are they hot, temperate or cold?
• Describe the desert climate. On which continents does it occur?
• Observe and explain. How does latitude influence the distribution of climates?
Scale
SOURCE: A.N. Strahler and A.H. Strahler, Physical Geography (Adapted)

7. The challenges of climate change

The serious effects of climate change

The effects of climate change are numerous and devastating.



16. In 2020, there were an estimated 23.9 million people displaced by climate-related factors.

Climate migration

Many people are forced to leave the place where they live as a result of drought, desertification and land degradation and depletion. (16)

Melting of the polar ice caps

Global warming has intensified the melting of the polar ice caps. As a result, sea levels have risen from less than 1 mm per year in the 1960s to more than 3 mm per year currently. At the current rate, the sea could flood some islands and coastal areas.

Loss of biodiversity

Ecosystems are altered, leading to the disappearance of animal and plant species and, therefore, to a loss of biodiversity.

Extreme weather events

Prolonged droughts, torrential rains, heat waves, etc. are occurring with increasing frequency, leading to climate catastrophes.

Climate catastrophes

Droughts

Droughts occur when a region experiences less rainfall than is usual for that climate. For example, in the UK, a total rainfall of about 400 mm per year would be considered a severe drought; however, in the Sahara Desert, this level of rainfall is twice the normal amount. The **effects** of a drought are very significant:

- Crops fail and livestock cannot drink what they need. Food production is therefore reduced, which can lead to famine.
- Water for human consumption becomes scarce and the soil loses its vegetation. People are forced to leave the area.

Floods

Floods occur when it rains heavily in a short period of time and the soil is not able to absorb all the water. This can cause rivers to overflow, people, vehicles and tonnes of mud to be swept away, pipes, power lines, buildings and crops to be destroyed, etc. (17)

Some human activities, such as deforestation, make the effects of floods worse. Land that is cleared of vegetation holds less water than land with vegetation because roots act like sponges to absorb water.

ENVIRONMENTAL AWARENESS

- How would a rise in the level of the Mediterranean Sea as a result of climate change affect Spain? Would it damage ecosystems and the species that inhabit them? Would it have economic effects? Explain your answers.

17. Floods in Germany in July 2021

Hurricanes and tornadoes

Hurricanes (also known as **tropical cyclones** and **typhoons**) are strong depressions that cause very heavy rainfall. They can cause gusts of wind with speeds of 300 km/h or more. Up to 600 mm of rainfall can fall in just a few hours. This is equivalent to the total annual rainfall in many areas of Spain.

Hurricanes usually form over the oceans, in tropical areas and at the end of the summer, when sea temperatures are very high. (18) Hurricanes travel hundreds of kilometres and, when they come into contact with colder waters or land, they lose strength and disappear.

Tornadoes are funnel-shaped columns of air that spin around at high speed and travel kilometres. They are common in the winter in the USA when the warm, humid air of the Golfo de México comes into contact with the cold, dry air of the Rocky Mountains.

18. Satellite image of Hurricane Blanca in 2015. (A) The centre is called the *eye* of the hurricane. The eye of a hurricane is calm and there are no clouds.

The urgent need for action on climate change

The problems arising from climate change affect the entire planet, regardless of where on Earth they occur.

The poorest countries are the most vulnerable and they face the greatest risks. For example, the World Bank has worrying data on forced changes in the location of productive agricultural land driven by climate change. There could be 40 million internal climate migrants in South Asia by 2050, and Africa could experience as many as 86 million internal climate migrants.

Poor countries also contribute the least to climate change. The poorest half of the world is estimated to be responsible for only 10% of carbon dioxide emissions into the atmosphere.

The urgent need for global action to curb climate change has led to **climate summits**, where countries make commitments and agreements on the climate. (19)

ENVIRONMENTAL AWARENESS

- Climate change deepens inequalities: it makes the poorest countries poorer. Explain why and propose measures to prevent it.

KEY QUESTIONS

- List the effects of climate change. Which ones do you think are most worrying? Explain why you think so.
- Tell your group what climate summits are. Name some of the most significant climate summits.

19. Major climate summits and agreements

Montreal Protocol (1987)
Almost all countries committed to reducing emissions of ozone-destroying gases.

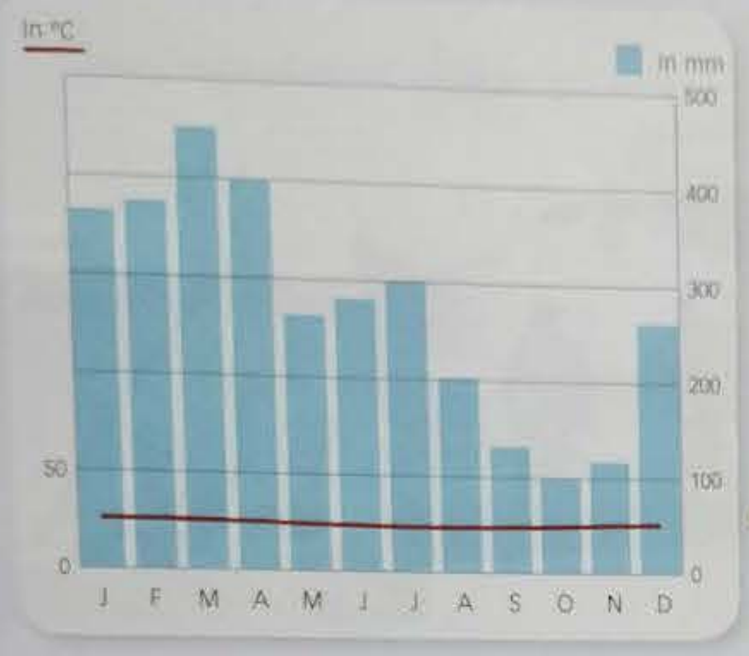
Earth Summit (1992)
It was an agreement to create the UN Framework Convention on Climate Change.

Kyoto Protocol (1997)
The industrialised countries decided to limit GHG emissions into the atmosphere.

Paris Agreement (2016)
196 countries signed up to a plan to keep the global average temperature increase below 2 °C with respect to pre-industrial levels.

7 In your notebook, **make** a drawing that represents the Earth's five climate zones. **Write** a short description of the drawing to **explain** it.

8 **Analyse** the climate graph and **deduce** the climate.



- Look at the monthly temperatures. Can you identify any seasons?
- Calculate the total annual precipitation. Is it regular throughout the year? Is there a dry season? If so, when is it?

9 **Define:** *climate, atmospheric pressure, front, wind, climate summit, troposphere, cloud, snow.*

11 **Analyse** the map. **Answer** your group's questions about what the weather the map shows.

12 **Explain:**

- How and where hurricanes form.
- What a tornado is.
- How altitude and air temperature affect atmospheric pressure.

13 With your group, **make** a visual weather and climate dictionary. Then, each member of the team should explain at least five terms.

10 **SEE, THINK, WONDER**

- In November 2019, Venice experienced one of its worst floods in 100 years. Do you think the photo represents the effects of climate change? If so, how?
- Ask your partner three questions about this photo.

WHAT DID I LEARN?

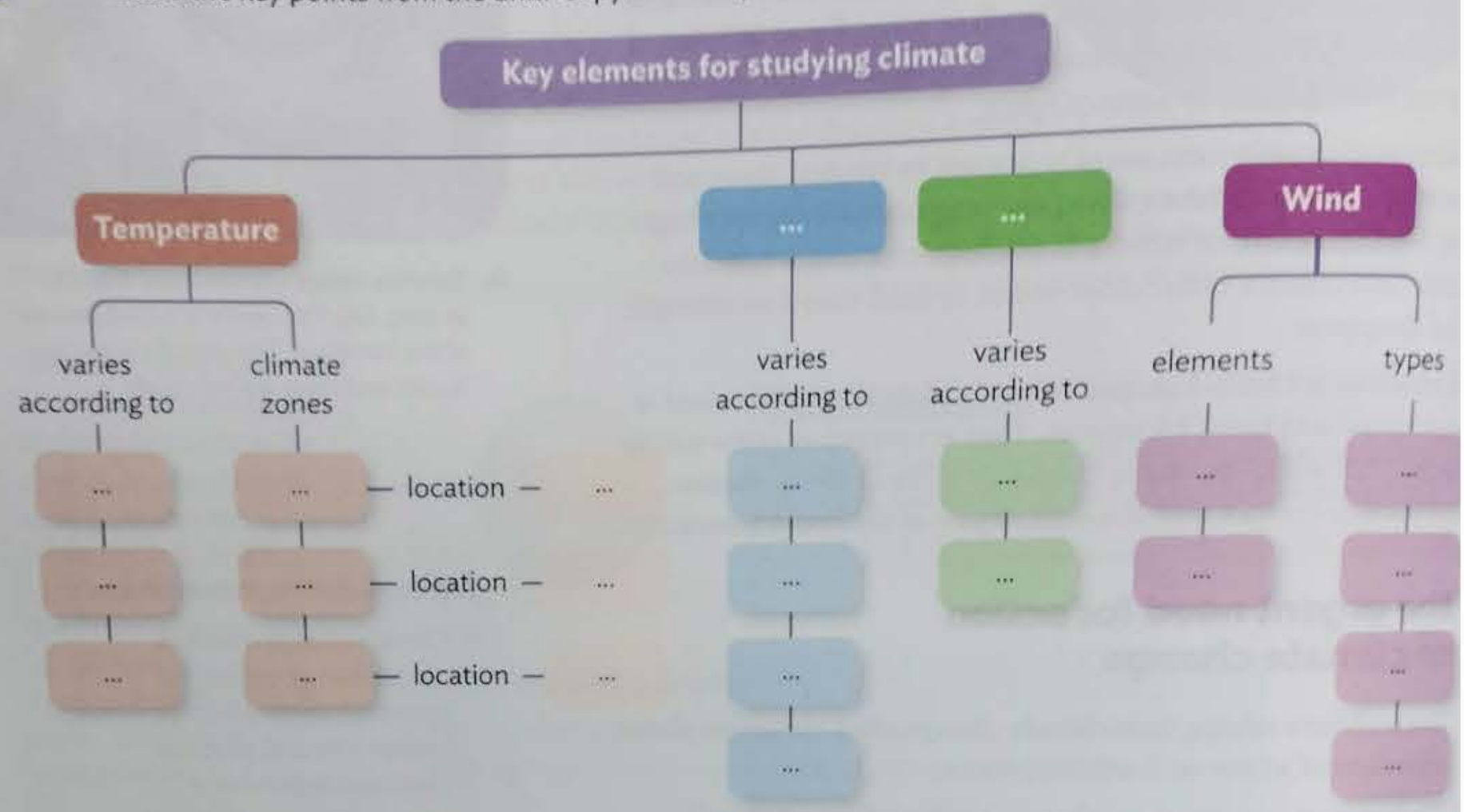
- **Choose** five concepts from this unit that you think are essential for understanding climate. What other key concepts would you add? Why?
- What did you know about climate before you read this unit? What have you learnt?
- How important do you think climate change is in your life and for your future? What responsibility do you have in fighting climate change? Are you already involved?
- **Think of** one word, one idea and one phrase that summarise this unit. **Write** them in your notebook.

CHECK YOUR PROGRESS

Use the STUDY NOTES to review the content of this unit.

ORGANISE YOUR IDEAS

1 **Summarise** the key points from the unit. Copy and complete the diagram in your notebook.



2 **Classify** Earth's climates. In your notebook, **copy** and **complete** a table like this for each climate zone on the planet.

HOT ZONE		
Climates	Temperatures	Precipitation
...	...	...
...	...	...
...	...	...

APPLY YOUR KNOWLEDGE

3 **Explain** what the atmosphere is and why it is important when studying climate.

4 **Describe** smog, the hole in the ozone layer and acid rain. **Analyse** the effects of each on the environment and on people's health.

5 ENVIRONMENTAL AWARENESS. **Explain** climate change. Then **discuss** the following questions with your group and **write down** your conclusions.

- How will the rise in sea levels affect the environment and people? What will the economic consequences be?
- Are climate summits necessary? Do all countries commit equally at these summits?

6 **Interpret** the graph about heat waves.

- How has the number of heat waves changed over time? What do you think causes this trend?
- How do you think Spain will be affected if this pattern of heat waves continues?

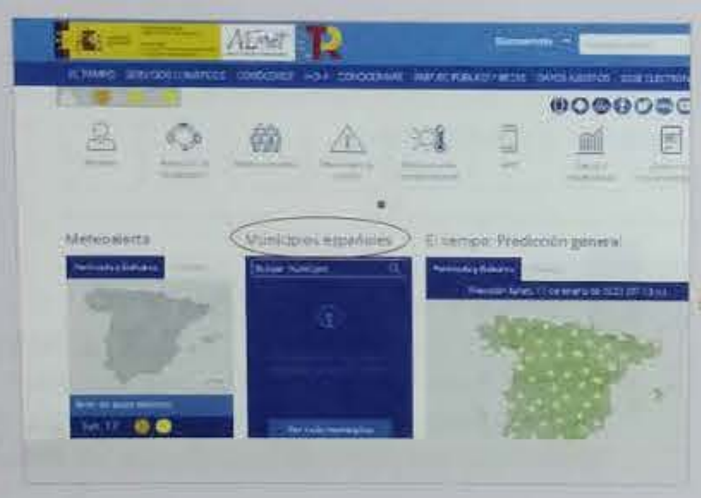
GEOGRAPHY IN MY LIFE

Check the weather forecast before making plans

Imagine that next weekend you have plans to go with your group or with your family on a hot-air balloon ride, on a trek in the mountains, bike riding around your city or town, or to an outdoor birthday party. The success of these plans depends largely on the weather conditions.

This is why knowing how to interpret weather forecasts can help us, among other things, to make plans, choose the most suitable clothing and even to prevent accidents.

14 DIGITAL TASK. **Go to the Agencia Estatal de Meteorología's website (www.aemet.es). Analyse the weather forecast for the weekend.**



- In the section *Municipios españoles*, type in the name of your city or town.
- Write down the probability of precipitation, the high and low temperatures and the wind direction and speed.
- Using the data you have collected, prepare a weather forecast.
- Are there any weather alerts for your autonomous community or city?
- Have a look at the rest of the website and look at any other data that catches your attention. Share what you find with your partner.

15 **According to the forecasted weather conditions, select which of these activities you could do at the weekend. Explain why. Can you think of any other activities suitable to the weather?**

- participate in a sailing regatta
- fly a kite
- have a picnic in a park
- go to an outdoor concert
- go for a walk in the woods

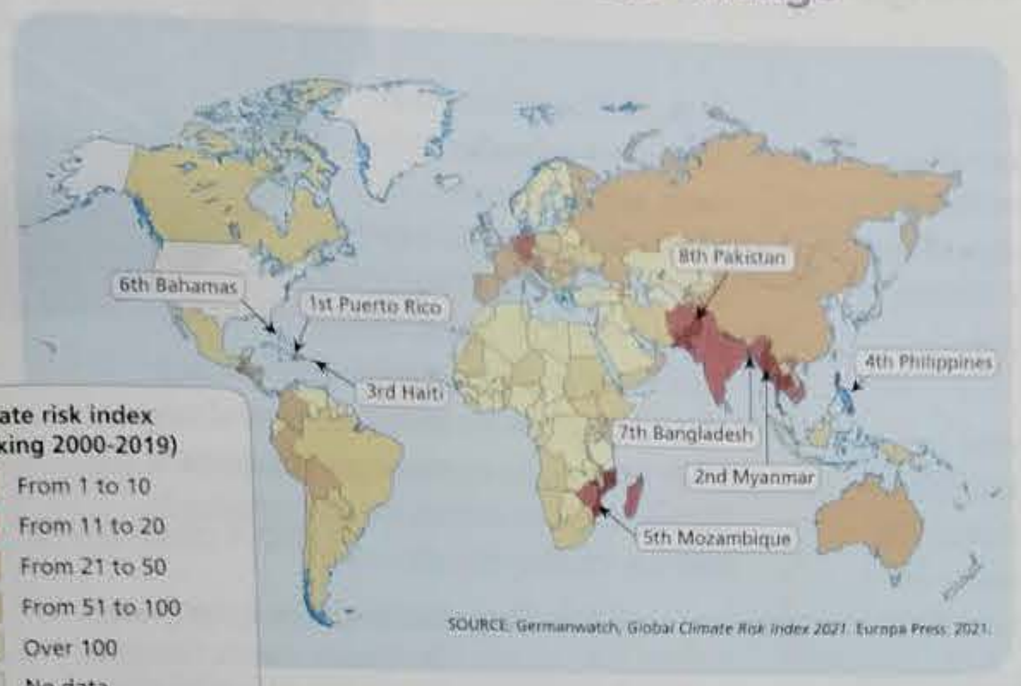
16 **Find out about other websites you could check for weather forecasts and share them with your group. Which websites are the most practical in your opinion? Why?**

17 MAKE CONNECTIONS. **Think about and explain why these groups and businesses should regularly check the weather forecast.**

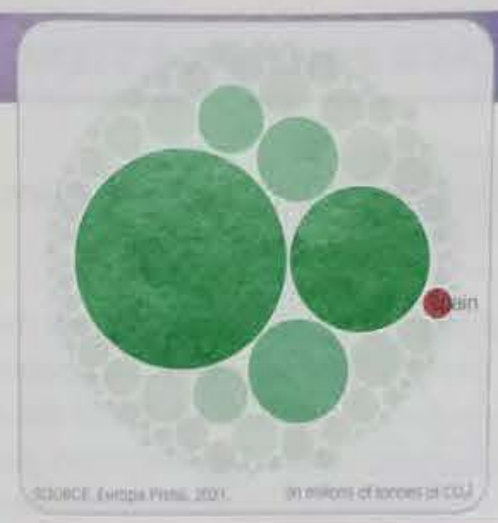
- a company that organises cultural events and tourist activities
- an airline
- a farm
- a mountain rescue team

18 MAKE CONNECTIONS. **Think about situations in your everyday life where you need to check the weather forecast. Discuss your answers with your group.**

Write an article about climate change



20. Climate risk index and countries most at risk



Millions of tonnes of CO_2	
China: 10,668	Spain: 209
USA: 4,713	Afghanistan: 12.2
India: 2,442	Malawi: 1.4
Russia: 1,577	Burundi: 0.6

21. CO_2 emissions from fossil fuels in 2020

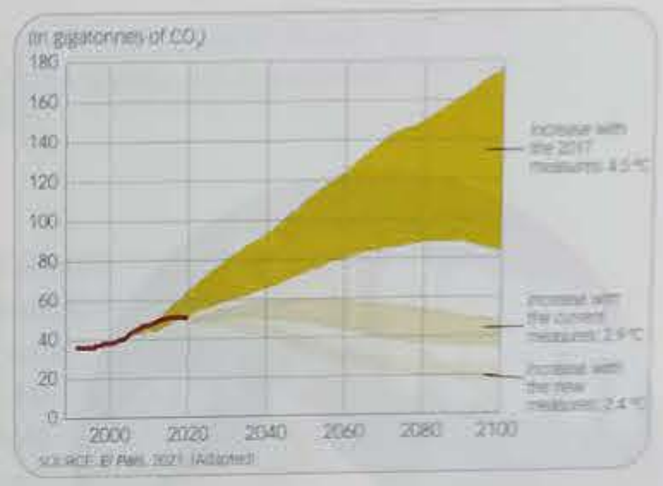
19 Analyse and select data.

- Interpret the map and the graphs. Note the most interesting data.
- How are the data related?

20 Choose the content for your news article.

- What do you want to communicate? What is the main idea? What data will you use to support your article?
- Make a note of some secondary ideas you could also include.

21 Write the text for the news article. Include a catchy headline.



22. Predictions for the rise in land temperatures

TRUE OR FALSE?

CRITICAL THINKING

Is climate change part of Earth's natural lifecycle?

The Earth's climate has changed continuously for millions of years. However, these changes in the climate usually take thousands of years.

22 INVESTIGATE

- Find out and explain the rate of global warming on Earth since the 1980s. Where did you find data? Does it seem reliable? Explain why or why not.

23 CONTRAST

- According to the scientific community, what is causing climate change? What measures must be taken to prevent climate change?
- Is it possible there are groups interested in casting doubt on climate change?

24 DECIDE

- Answer this section's headline question using scientific arguments.

Speaking out against climate change

It is easy to forget that ultimately the climate emergency comes down to a single number – the concentration of carbon in our atmosphere. The measure that greatly determines global temperatures and the changes in that one number is the clearest way to chart our own story. For it defines our relationship with our world. [...]

Perhaps the fact that the people most affected by climate change are no longer some imagined future generation, but young people alive today. Perhaps that will give us the impetus we need to rewrite our story, to turn this tragedy into a triumph.

DAVID ATTENBOROUGH's speech at the opening ceremony of the climate summit in Glasgow, 2021

It should be obvious that we cannot solve the crisis with the same methods that got us into it in the first place. [...] The COP has turned into a PR event, where leaders are giving beautiful speeches and announcing fancy commitments and targets, while behind the curtains governments of the Global North countries are still refusing to take any drastic climate action.

GRETA THUNBERG's speech at the Fridays for Future march, Glasgow, 5th November 2021

Time is fast running out for my islands, and we will accept no more excuses or failures from world leaders. We know they are not doing enough. [...] COP26 must deliver concrete solutions urgently, and we are here to force them to act. [...] For a decade now, the storms in the Pacific have been getting more violent, the droughts have been longer and the floods deeper. Fishers cannot feed their families. Family-owned shops that are flattened in a cyclone are rebuilt, only to be destroyed by rising water. [...] We know that if one part of a canoe is damaged, the whole thing sinks. What is happening now to the Pacific Islands is a warning to the rest of the world.

BRIANNA FRUEAN speaking about the climate summit in Glasgow, 2021

25 Investigate.

- Look for information about David Attenborough, Greta Thunberg and Brianna Fruean. Summarise with one word, one idea and one phrase each of their commitments to the fight against climate change.
- Find out about other climate activists.
- Find out what decisions were made at the climate summit that took place in Glasgow in 2021.

26 Read and analyse the excerpts.

- What is the main message of each person?
- What do they all agree on? How do they differ?
- Which do you like the most? Why?

27 UNDERSTAND OTHERS. Imagine you could speak with David Attenborough, Greta Thunberg and Brianna Fruean.

- What would you ask them?
- Do you think they are satisfied with the outcome of the Glasgow climate summit? Why or why not?

28 DEBATE. Think and comment.

- Is more activism needed to speed up the fight against climate change?
- The world's wealthiest countries are responsible for the highest emissions. Should they make a bigger effort than poor countries in the fight?

TAKE ACTION Organise a climate summit

3

CHALLENGE

13

Climate change makes us think about the future of the Earth, and what planet we are going to leave for future generations. We are becoming more aware of the need to change our production methods and our lifestyles. The first step is to discuss possible solutions. Organise a climate summit in the classroom and speak out in favour of a more sustainable planet.

STARTING POINT

1. **Each group will be a delegation that represents one of these countries:**

China · USA · Spain · Tuvalu · Burundi · Peru · India

2. **Before you begin, choose:**
   - A person to chair, or lead, the summit. This person will be in charge of introducing the different delegations, moderating the debates and opening the summit with an explanation of the climate emergency.
   - Two climate activists. They will give the opening speeches.

3. **The main topics of the summit will be:**

Can CO_2 emissions in the atmosphere be reduced by 50 %?	Is it possible to limit global warming to 1.5 °C?	How can economic and environmental interests be balanced to preserve the planet's health?

PREPARE YOUR PROJECT

4. **Gather information about the country you are representing.**
   - General information: location, capital, languages, type of government, currency, etc.
   - Socioeconomic information: population, human development index, greenhouse gas emissions, etc.

5. **Prepare your contribution to the summit.**
   - Your country's role and responsibility in climate change.
   - How climate change affects your country.
   - Your capacity to reduce emissions.

SHARE YOUR PROJECT

6. **Debate and try to reach an agreement. Remember:**
   - You must represent your country's interests, not your own opinion.
   - Justify your statements.
   - Come to an agreement.

7. **Prepare a document with your conclusions. Specify the commitments to which all the participating countries have agreed.**

4 The sustainable use of Earth's waters

▲ Living in Madagascar

LEARNING SITUATION

We live on the "blue planet". We give it this name because three-quarters of the Earth's surface is covered by water. However, water stress is a serious problem in many parts of the world.

According to the United Nations (UN), three out of ten people in the world do not have access to safe drinking water. The UN estimates that in 2050 over half of the Earth's population will suffer from water shortages.

We all recognise the importance of water for life on Earth and everyone's right to have access to it. However, it is essential to manage water properly and protect its quality so that everyone has access to clean water.

LET'S GET STARTED

- What is water stress? What is the level of water stress in Europe? What about Sub-Saharan Africa?
- Do you think water stress and water scarcity are the same thing? Explain your opinion.
- What do you find most surprising from the data on these pages? Why?
- What percentage of the global population does not have access to safe water? How can this affect development?

most 70 % of the Earth's face is covered by water

97.5 % is salt water

2.5 % is fresh water

Access to drinking water by region

Global water stress

6 out of 10

More than 4.5 billion (4,500,000,000) people in the world do not have water sanitation systems.

1 out of 3

More than 2.1 billion (2,100,000,000) people in the world do not have access to drinking water.

A country suffers from water stress when the demand for water is greater than the amount available or when the water is poor quality and cannot be used.

263 million people in the world, mainly women, spend more than 30 minutes a day collecting water.

Types of access to water (% of the global population)

74 % — **Safe access**
There is an accessible, immediately available, uncontaminated water source.

17 % — **Basic access**
Uncontaminated or immediately available water is not guaranteed.

4 % — **Limited supply**
Access to the water supply is over 30 minutes away.

6 % — **Fairly unsafe access**
The water is without protection against contamination.

2 % — **Unsafe access**
There is only unsafe surface water that causes illnesses.

IN THIS UNIT...

- You will learn about the types of water on Earth and their characteristics.
- You will analyse and understand the problems that affect water today.
- You will take action. You will evaluate the impact that the construction of a hotel complex can have on the surrounding water.

CHALLENGE

6 CLEAN WATER AND SANITATION

Will preserving water guarantee our future?

In 2018, action began to solve the water problems on the planet: droughts, floods, pollution, etc. **Analyse the impact of a hotel on surrounding waters** to raise awareness of the importance of water and achieve sustainable development.