A short introduction to this lesson

Geography [from Greek “Γεωγραφία” (Geographia), to write about/to describe the Earth] is the science that studies the Earth and its:

- Lithosphere (land)
- Hydrosphere (oceans, seas, lakes and other water bodies)
- Cryosphere (ice and snow)
- Atmosphere
- Biosphere (flora, fauna and humans)

Two very important elements when describing the Earth are its weather and climate.

In this lesson you will have the chance to collect meteorological data and make your own weather and climate observations, as well as to learn about **global climatic change**. Some of the images you will encounter were taken by ESA-astronaut André Kuipers during his PromISSe mission. Questions that you need to answer are marked with a square (■) and activities that you need to do are marked with an arrow (→).

**Weather or climate?**

The state of the atmosphere in a certain place and at a specific time, is defined as “weather”. This definition implies the condition of the Earth’s atmosphere in terms of temperature, pressure, humidity, as well as any other related phenomena (e.g. Fig. 1).

Meteorology [from Greek “Μετεωρολογία” (Meteorologia), to speak about what’s above the ground/in the air] is the interdisciplinary scientific study of the weather.

![Figure 1](https://via.placeholder.com/150)

**Hurricane Katrina off southern Florida**

ESA

Climate [from Greek “Κλίμα” (Klima), inclination] can be simply defined as the average weather conditions of a region, over a long period of time (a few decades at least). Considering areas of similar climatic conditions, several zones can be identified around the world (Fig. 2).
Europe’s climate and weather

The climate in Europe (Fig. 3) can generally be divided into three parts, from North to South. Northern areas include the polar regions, southern areas the tropical regions, and central areas are located at middle latitudes, where the North-South temperature gradient varies the most. In other words, it is where cold polar air masses encounter warm tropical air.

Latitudes where polar and tropical air masses meet vary greatly, depending on the seasons. They are located relatively to the North (Ireland, Great Britain, Northern France, parts of Scandinavia) in summer (warm air arrives in northern regions) and more to the South in winter (cold air reaches southern regions). Strong atmospheric currents, the so-called Westerly Winds, blow from West to East all along the hemisphere at those latitudes, driven by the Polar Jet Stream.

Westerly winds do not blow at the exact same latitude, but they oscillate along their eastwards direction making N-S waves. These waves generate high pressure systems in their crests and low pressure systems in their troughs (Fig. 4), thereby bringing warm air to the North and cold air to the South, respectively. Warm and Cold Fronts are the meteorological features that correspond, on the ground, to the associated changes in air temperature we can feel and measure.

These fronts are generally characterised by specific cloud types and meteorological phenomena. Warm fronts are associated with stratified clouds (Fig. 5) at different heights and persistent rain and wind, while cold fronts are associated with vertically developing cumuliform clouds (Fig. 6) accompanied by heavy storms and gusty winds.

Extreme weather conditions can also occur, with heavy storms and heavy rain, and can generate dramatic flooding. This has been happening more frequently in recent years.
Figure 3
A cloud-free image of Europe
EUMETSAT/DLR

Figure 4
Westerly winds creating high and low pressure systems in the Northern Hemisphere

Figure 5
Stratified (Stratus) clouds
(Source: Wikimedia Commons)

Figure 6
Vertically developing (cumulus) clouds
(Source: Wikimedia Commons)
We use weather information and forecasts in everyday life and this knowledge is often crucial for our safety or even survival. Can you think of such examples? Think e.g. of how we travel over land, air and oceans and also consider extreme climatic conditions, such as those in the near-polar areas or deserts.

1. .................................................................................................................. 3. ..................................................................................................................

2. .................................................................................................................. 4. ..................................................................................................................

Making weather observations

General description of the weather

Before making measurements and observing the current meteorological conditions, you can give a general description of the weather. You can use the following classification terms: Good Visibility, Mist, Fog, Drizzle, Rain, Snow, Hail and Thunderstorm.

Measuring wind direction and speed

Wind direction is measured in terms of which direction the wind is blowing from, and is indicated in degrees. A wind vane can be used to measure the direction. Most wind vanes have a point, or arrowhead, which faces the wind. Therefore one may simply read the compass direction toward which the arrow is pointing. The reading range is between 0 and 360 degrees (Fig. 7).

Figure 7.
Wind vane (left) and wind directions in degrees (right)

Remember to place the wind vane in such a way that nothing blocks or distorts the airflow.
Wind speed can be measured with an instrument called an anemometer. Many different kinds can be bought. A simple and cheaper way is to observe how features around you react to the wind (see Wind Speed table below).

<table>
<thead>
<tr>
<th>Beaufort</th>
<th>m/s</th>
<th>Knots</th>
<th>Wind</th>
<th>Observations on land</th>
<th>Observations on sea</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0,0-0,2</td>
<td>Less than 1</td>
<td>Calm</td>
<td>Calm, smoke rises vertically</td>
<td>Sea surface smooth and mirror-like</td>
</tr>
<tr>
<td>1</td>
<td>0,3-1,5</td>
<td>1-3</td>
<td>Light air</td>
<td>Smoke drift indicates wind direction, still wind vanes</td>
<td>Scaly ripples, no foam crests</td>
</tr>
<tr>
<td>2</td>
<td>1,6-3,3</td>
<td>4-6</td>
<td>Light breeze</td>
<td>Wind felt on face, leaves rustle, vanes begin to move</td>
<td>Small wavelets, crests glassy, no breaking</td>
</tr>
<tr>
<td>3</td>
<td>3,4-5,4</td>
<td>7-10</td>
<td>Gentle breeze</td>
<td>Leaves and small twigs constantly moving, light flags extended</td>
<td>Large wavelets, crests begin to break, scattered whitecaps</td>
</tr>
<tr>
<td>4</td>
<td>5,5-7,9</td>
<td>11-16</td>
<td>Moderate breeze</td>
<td>Dust, leaves, and loose paper lifted, small tree branches move</td>
<td>Small waves of about 1m, becoming longer, numerous whitecaps</td>
</tr>
<tr>
<td>5</td>
<td>8,0-10,7</td>
<td>17-21</td>
<td>Fresh breeze</td>
<td>Small trees in leaf begin to sway</td>
<td>Moderate waves of 1-2m, taking longer form, many whitecaps, some spray</td>
</tr>
<tr>
<td>6</td>
<td>10,8-13,8</td>
<td>22-27</td>
<td>Strong</td>
<td>breeze Larger tree branches moving, whistling in wires</td>
<td>Larger waves of 2-3.5m, whitecaps common, more spray</td>
</tr>
<tr>
<td>7</td>
<td>13,9-17,1</td>
<td>28-33</td>
<td>Near gale</td>
<td>Whole trees moving, resistance felt walking against wind</td>
<td>Sea swells up, waves of 3.5-6m, white foam streaks off breakers</td>
</tr>
<tr>
<td>8</td>
<td>17,2-20,7</td>
<td>34-40</td>
<td>Fresh gale</td>
<td>Whole trees in motion, resistance felt walking against wind</td>
<td>Moderately high waves of 6-10m in length, edges of crests begin to break into spindrift, foam blown in streaks</td>
</tr>
<tr>
<td>9</td>
<td>20,8-24,4</td>
<td>41-47</td>
<td>Strong gale</td>
<td>Slight structural damage occurs, slate blows off roofs</td>
<td>High waves of 10-15m, sea begins, to roll dense streaks of foam, spray may reduce visibility</td>
</tr>
<tr>
<td>10</td>
<td>24,5-28,4</td>
<td>48-55</td>
<td>Storm</td>
<td>Seldom experienced on land, trees broken or uprooted, “considerable structural damage”</td>
<td>Very high waves of 15-20m with overhanging crests, sea white with densely blown foam, heavy rolling, low visibility</td>
</tr>
<tr>
<td>11</td>
<td>28,5-32,6</td>
<td>56-63</td>
<td>Violent Storm</td>
<td>Widespread damage</td>
<td>Exceptionally high waves of more than 20m, foam patches cover sea, visibility further reduced</td>
</tr>
<tr>
<td>12</td>
<td>&gt;32,6</td>
<td>64+</td>
<td>Hurricane</td>
<td>Excessive damage</td>
<td>Air filled with foam, waves much over 20m, sea completely white with driving spray, visibility greatly reduced</td>
</tr>
</tbody>
</table>
Measuring Cloud Cover

The coverage of clouds over a certain point is assessed to give a measure of current weather conditions. The sky is divided into quarters. So if a quarter of the sky is covered with clouds, or if the clouds are scattered evenly throughout the sky, but still only occupying a quarter of it overall, 'scattered clouds’ are recorded and cover is reported as 1/4.

<table>
<thead>
<tr>
<th>Cloudiness</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Clear</td>
</tr>
<tr>
<td>1/4</td>
<td>Scattered clouds</td>
</tr>
<tr>
<td>2/4</td>
<td>Partly cloudy</td>
</tr>
<tr>
<td>3/4</td>
<td>Mostly cloudy</td>
</tr>
<tr>
<td>4/4</td>
<td>Overcast</td>
</tr>
</tbody>
</table>

Measurement of temperature

Temperature can be rather difficult to measure in a scientifically correct manner. The correct way to measure temperature is with a thermometer placed in a shelter, out of direct sunlight.

A box-like structure (called a Stevenson screen) is often used to protect meteorological instruments against exposure to direct sunlight, precipitation, and condensation, while at the same time providing adequate ventilation. Instrument shelters are painted white, have louvered sides (slats) and usually a double roof. A Stevenson screen may be mounted on a stand several feet above the ground with the door side facing north.

If you don’t have access to such a shelter, you can measure temperature sheltered from wind and sun. Hold the thermometer (especially its base) away from your body or reflecting walls to prevent it from being influenced by other heat sources, e.g. your body temperature.

Summarise the weather conditions, by listing your observations in the table below.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>General description of the weather</td>
<td></td>
</tr>
<tr>
<td>Wind direction</td>
<td></td>
</tr>
<tr>
<td>Wind speed</td>
<td></td>
</tr>
<tr>
<td>Cloud coverage</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
</tr>
</tbody>
</table>
After you have made your observations, you can submit them to the Interactive Meteosat on-line application project database so that they can be shared with others. Each user has to register to be able to submit observations. You will also need to know the approximate location of your school or the site where the observations were made; you can use Google Earth™ in order to find your coordinates (latitude and longitude).

Everyday, Meteosat images of Europe acquired at 09.00 UTC (Coordinated Universal Time) are shown on the Interactive Meteosat on-line application (Fig. 8). Students from participating schools can observe the weather and upload their meteorological observations to the application. The observations are then shown in real time as an overlay on the satellite image.

Figure 8
Interactive Meteosat on-line application [click here]

When many schools participate and upload their information, the application shows the weather observations throughout Europe overlain on the daily Meteosat image, enabling a more detailed interpretation of it.

With the aid of these observations, the Meteosat image, and other meteorological information, students can draw a weather map and predict the weather in their region and elsewhere.

Note that in certain parts of Europe, 09.00 UTC corresponds to 10.00 CET during the winter, and to 11.00 CET during the summer (CET: Central European Time).

Based on your observations and those of others, as well as the satellite images on Interactive Meteosat, can you make a weather prediction over Europe and/or your area for the next 24 hours?
Extended material:
Read the background and perform the exercises on Interactive Meteosat, which can be found on the ESA/Eduspace webpage click here.

Climatic scales:
Macro*-climate is characterized by basic, large scale climatic data such as: temperature, wind, humidity, cloud coverage and precipitation). The variations of a macro-climate, due to local conditions (such as the existence of special topographic relief, water areas or vegetation) comprise the meso*-climate. Micro*-climate refers to local deviations from the normal macro- and meso-climate conditions, mainly due to human intervention, such as urbanization and agricultural activities.

* [from Greek “Μακρός” (Macros), “Μέσος” (Mesos) and “Μικρός” (Mikros), meaning large-, medium-, and small-scale respectively]

What can you say about the climatic conditions (macro-climate) in your area? Can you identify meso- and micro-climatic effect as well?

Global climatic change
When we hear the term “global change”, we often associate it with a drastic change in the global climate caused by the influence of nature and humans. Our climate could in fact be altered by various factors, such as the enormous changes in land cover and the ever-increasing emission of gases from the burning of fossil fuels. Over the past decades, global temperatures have increased, and it has been noted that extreme weather conditions, such as storms and floods, are being experienced more often. Warnings have also reached us about the thinning of the ozone layer which protects us from the harmful ultraviolet radiation of the Sun

→ Check the indicative sunburn time for your area in Figure 9.

Figure 9.
Sunburn time over Europe. (source: click here or click here)
Are the current weather conditions typical of the climate in your area or do you observe any abnormalities? Are you aware of any indications of climatic change in your region (melting glaciers, disappearing water resources, changes in temperature etc.)?

Drastic measures in reducing, for example, gas emissions, have not been taken. Nevertheless, many scientists, politicians and the population in general are very concerned and would like to be better informed about the present situation. This is why international organisations have been requested to measure and monitor all relevant parameters to determine the current status of the Earth's environment, and thereafter to forecast short and long-term trends.

In this context, regular observations from Earth-orbiting satellites covering much of the Earth can be frequently acquired (Fig 10). Satellite images or even a simple photograph taken from the ISS, can provide interesting information (Fig. 11 and 12).
The use of Earth observation data to monitor the environment takes many forms. For example, detailed cloud movement can be identified from geostationary meteorological satellites, which provide half-hourly coverage of practically the entire globe. These data can also be used to provide surface temperature measurements. In addition to meteorological observations, such observations can be very useful for vegetation monitoring.

Extended material:
For primary schools
Check out the climate change pages on the ESA Kids website click here.

For secondary schools
Explore in depth the Global Change section (atmosphere, land, oceans) on the relevant ESA/Eduspace webpage click here.