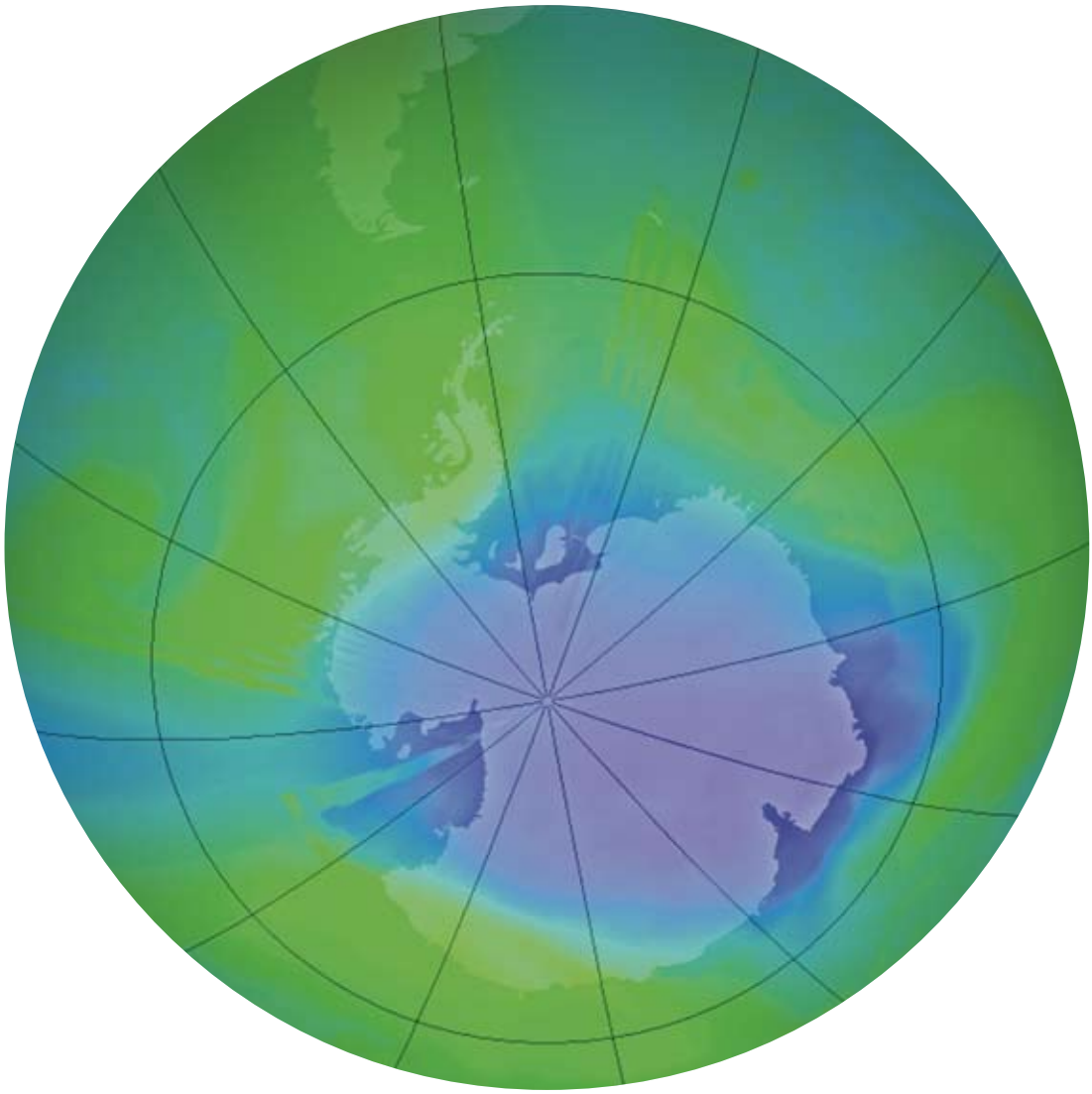
Pedagogical dossier:

IMPACTS OF CLIMATE CHANGE ON HUMANS



IMPACTS OF CLIMATE CHANGE ON HUMANS

NB: This file only deals with the impacts of climate change on humans and the environment. To understand how climate and climate change work, download the educational file on Climate and climate change or view the various climate-related animations.

All of the facts dealt with below refer to the current knowledge and scientific understanding of climate change, as established by the experts of the IPCC (Intergovernmental Panel on Climate Change) in their Fourth Assessment Report (2007).

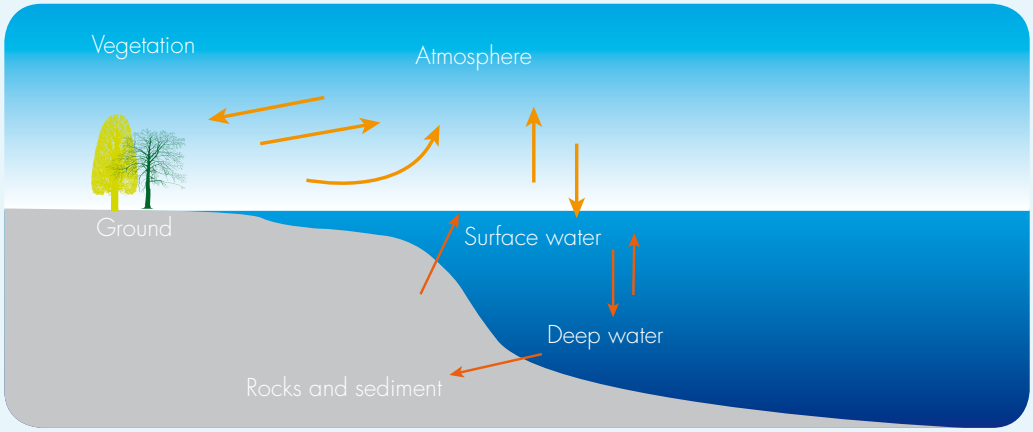
Theoretical note

The conclusions of the latest IPCC[1] report no longer leave reason to doubt the reality of global warming. Scientists base their results on observations and measurements that were either sampled from the environment or observed directly and which can be attributed to recent climate change.
The rise in average worldwide temperatures, both in the atmosphere and in the oceans, the increased snow and ice is melt and the rise in average sea levels worldwide are established facts (see animation on Impact on humans, www.educapoles.org).
What are the impacts of these changes on our environment and on humans?

1 The role of the **Intergovernmental Panel on Climate Change, IPCC** "is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. It does not have a mandate to undertake research work, nor to monitor changes to climate-related variables or other relevant parameters. Its evaluations are based principally on scientific and technical publications whose scientific value is widely recognised." (Source: wikipedia)

Short reminder – The pet peeve of global warming: CO2

In a natural system, carbon dioxide (CO_2) is exchanged between the atmosphere, the oceans, the continental biosphere (plants and organic matter in the ground) and the lithosphere. When the earth's system is in proper equilibrium, the quantity of carbon dioxide released by the oceans and continents is practically equal to that which is captured (see animation on the complexity of the climate: www.educapoles.org).



Based on the readings of ice cores that were extracted from deep ice deposits, scientists know that the concentration of carbon dioxide has remained stable over the past 10,000 years. (See animation "Climate archives" (www.educapoles.org) and the educational file dealing with Polar Science)., They have also been able to observe that, over a longer timescale, atmospheric variations in carbon dioxide concentrations have a direct link with climate variations. An increase in the level of carbon dioxide in the atmosphere corresponds to a period of warm climate on Earth.

Ever since the Industrial Revolution, economic development has required a high level of energy consumption (wood, coal, oil, gas). The result of this has been a significant increase in the atmospheric concentration of carbon dioxide. With a 25% rise over the past 150 years, it is clear to say that concentration levels have increased much faster than natural variations observed by scientists in ice "archives". This, of course, is without taking into account the fact that these exclusively human-induced emissions are continuing to rise – so much so that the concentration of carbon dioxide which is generated by humans alone is eight times higher than that of the beginning of the twentieth century. One very recent study[2] demonstrates that this increase has even accelerated over the past ten years…
This abrupt upheaval in carbon dioxide concentration is having a serious effect on the world's global climate system: an overall increase of approximately 1°C since 1850.

As a result, future changes to the climate depend on this increase of atmospheric concentration in carbon dioxide. This, in turn, depends on the level of the carbon dioxide emissions generated by humans. This is why IPCC experts use a range of scenarios for evaluating carbon dioxide levels over the future and produce future climate models.

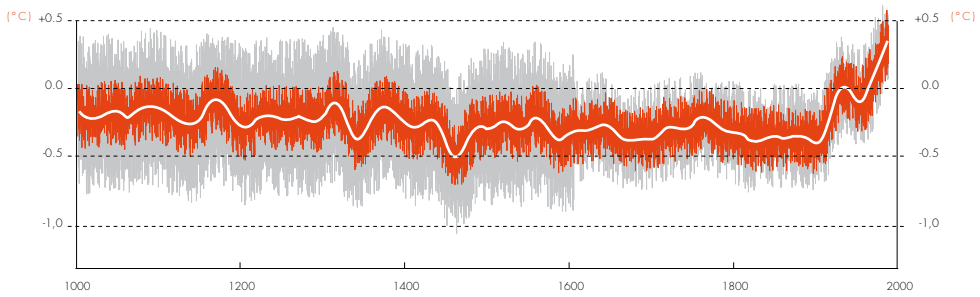
2 Raupach M.R., 2007. Global and regional drivers of accelerating CO_2 emissions. PNAS, vol. 104 n°24.

CURRENT IMPACT OF CLIMATE CHANGE

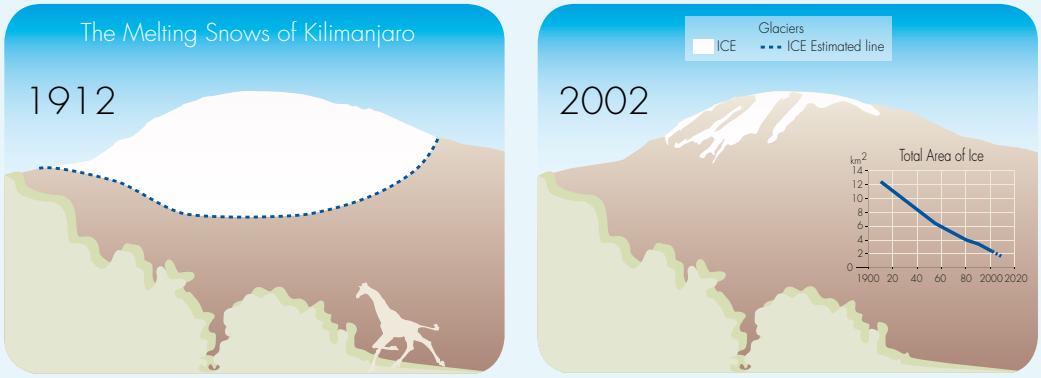
The current impact caused by overall global warming can be observed on every continent and in every ocean. A large number of natural systems are affected by regional climate changes that are caused by an increase in temperatures. The effects of major weather events, the increase in sea levels and the impact on natural systems and the biosphere all have repercussions for human populations.

Changes to the weather

In the majority of Earth's regions, global warming can be noticed by an **increase in average temperatures**. The readings taken by scientists indicate that temperatures have risen all over the planet, although not in the same manner in all areas of the world (as a general rule, warming is minimal at the equator and increases progressively as you move away from it). Readings taken over the past 157 years show that the planet has warmed up, on average, 0.74°C these past 100 years (1906 – 2005).



Average temperature curve (°C) since the year 1000. The zero (vertical scale) is at the height of the average temperature for the years 1961 to 1990 in the northern hemisphere. (Source: Federal Office for the Environment, Switzerland)



Reduction in the snow cover on Mount Kilimanjaro (Source: UNEP-GRID / NASA / AAAS)

However, this overall average does not reflect regional temperature change which can be much more severe in certain regions such as the Arctic (1.2°C temperature increase). Similarly, warming has been more noticeable in the centre of Asia and the northern part of North America. Some regions have even cooled slightly, such as part of the North Atlantic, to the south of Greenland. We are already seeing an average temperature increase in our own environment with the Alpine glaciers melting, and in the Arctic with the shrinking of the pack-ice.

Scientists are also interested in knowing the **extreme temperatures** (highest and lowest values), which may (or may not) indicate altered periods of night frost. These readings are important for predicting when spring arrives which, in turn, determines the organic activity. These records indicate that the number of very cold days and nights have both decreased, whereas the number of extremely hot days and hot nights have increased. The length of the periods without frost have increased in mid and high latitudes of both hemispheres of the earth. Spring is arriving earlier and the summers are lasting longer.

With the increase in temperatures, the water at the surface of our oceans is also becoming warmer. This increases the amount of ocean evaporation, particularly in low latitudes, such as the tropics. This water vapour enters atmospheric circulation. When it comes into contact with a colder area, the water vapour then condenses to form clouds. It falls back down to earth as rain, snow, hail, etc. (See the animation on The water cycle, www.educapoles.org)
As a result of this additional evaporation, the increase in temperature causes an overall **increase in precipitation**: when temperatures rise, rainfall also tends to increase, although not evenly across the planet or in time.

Scientists have recorded variations in:

- Quantity and frequency: the tendency over the past 100 years is a significant increase in precipitation over the north-west of North America, South America, northern Europe, and the north and south of Asia.
  By contrast, some regions have seen their rate of rainfall diminish, such as in the Sahel, southern Africa, the Mediterranean and southern Asia.
- Intensity: violent rain, snow and other events are being recorded in all regions of the world, even though the total amount of precipitation has decreased.
- Type of precipitation: in northern regions, rain is often replacing snow, particularly during the mid-season.

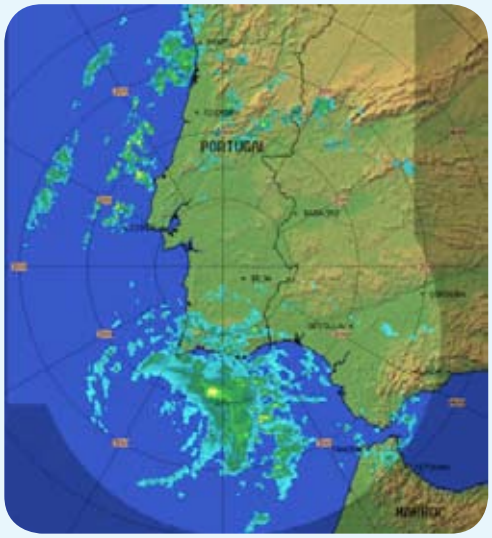
You might think that an increase in precipitation would be good for farming or freshwater reserves. But, when the ground is already water-saturated from heavy rains or frequent showers, its capacity to absorb further rainfalls is minor. This excess water then runs off over the surface and either swells the rivers or pools quickly where the ground is low, thereby causing floods. In dry regions, ground that has not had any rain for a long period of time and which is suddenly swamped (as with monsoon rain) quickly becomes saturated – which also creates a risk of flooding.
In addition, the replacement of snowfall by rain contributes to a reduction in snow cover. Yet, in many regions, snow cover provides freshwater reserves during drier and warmer periods. This effect is already being felt in some mountain regions where watercourses that used to be permanent are sometimes drying up completely in the summertime.

Humans mainly notice this temperature increase through the number of **extreme or unusual weather events** that they hear about: heat waves, droughts, floods and hurricanes. All of these extreme events are caused by the rise in temperatures (heat waves and droughts), i.e. as the direct result of the additional energy which is produced by the rise in temperatures (heavy rain, floods, storms and hurricanes). A weather event is called extreme if it is equal to at least 90% of the highest or lowest value ever recorded.

Over the past 50 years, scientists have recorded an increase in the number of heat waves of temperate regions due to a rise in extreme hot temperatures. The latest IPCC report (2007) considers the 2003 **heat wave** in Europe to be a consequence of the current climate change. That particular summer (2003) is now recognized as the hottest since 1500.

Flooding in Dresden (Germany) before and after, August 2002.

As we have already seen, a rise in temperature can also cause an increase in precipitation. Over the same period of time, weather events featuring extremely heavy rain have increased, even in places where the average annual rainfall has not varied. This has caused regular **floods** to occur in temperate zones which, historically, have been less susceptible to this type of event than other regions of the world. In August 2002, a large number of rivers in central Europe burst their banks and created astonishing floods. The ground and the rivers were saturated with the amount of rain that had fallen and became unable to absorb the abnormal additional amounts of rain.



Radar image of tropical storm Vince, southern Spain, October 2005

(Source: http://www.nhc.noaa.gov/pdf/TCR-AL242005_Vince.pdf)

In tropical regions, when the surface water of the ocean is sufficiently warm, when the air temperature falls rapidly with increasing altitude and when the air is loaded with humidity, cyclones can form. The high level of energy that develops from the increase in surface water temperature helps to fuel these **cyclones and hurricanes**. Even though it has not been clearly established whether the frequency of these extreme weather events has increased in line with global warming, the storms have become more intense, which has increased their potential for destruction. This also applies to the winter storms that raged along the Atlantic coastline during the winter of 2005 and which sometimes sustained their intensity until they were a long way inland over the continent.
2005 also saw hurricane Katrina and the damage caused in New Orleans and at the mouth of the Mississippi. That year, the North Atlantic experienced the longest and most violent season of tropical storms and hurricanes ever reported. For the first time, a tropical storm reached the coast of Portugal and Spain. Scientists explain these exceptional events by the record temperature of surface water caused by global warming.

Lake Eucumbene (Australia) during the drought of 2002-2003

The climate is a complex system. While the regions located in the mid-latitudes are experiencing a seasonal increase in rainfall, Africa and other regions are suffering **serious droughts**. Africa, central and south-east Asia, Australia and the north-east part of North America have all seen periods of extreme drought in recent years. The reasons for this lack of rainfall (which has persisted in certain regions) stem from conditions that are specific to each location, although they are all part of the global warming context.

Interestingly, these extreme phenomena can also take on other faces… For some communities, for instance, the rise in temperature can result in unusual weather events… In the north of Quebec; the elders of the Inuit villages have only just discovered thunder, ever since temperature rise has made summers warmer and more humid. Storms have started to appear in regions where they had not been known previously – perhaps paving the way for new legends…

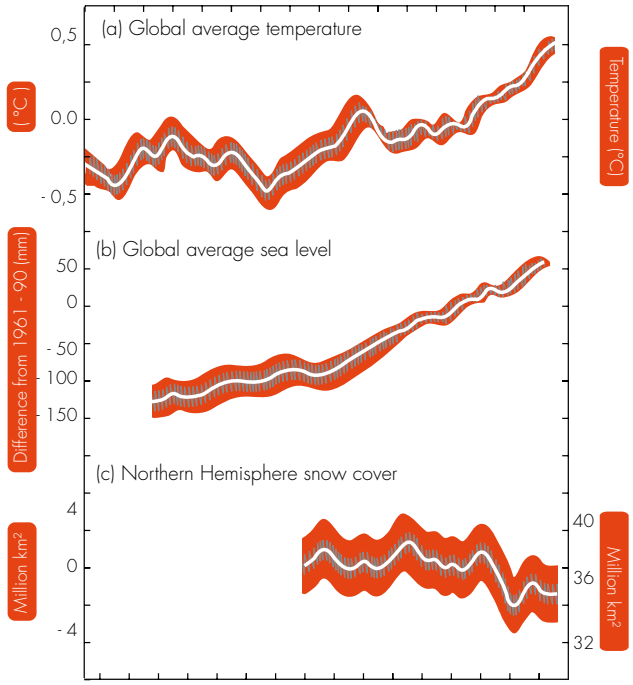
The weather events caused by climate change we have just mentioned have a direct impact on the quality of life of human beings. Our technological knowledge has, for the time being, been able to help us face some of the changes. In other cases, though, the damage they can cause is so serious that it is hard to know how to limit them.

The oceans

Over the course of the Earth's geological history, sea levels have varied significantly. These variations have been caused by natural factors which scientists distinguish as follows:

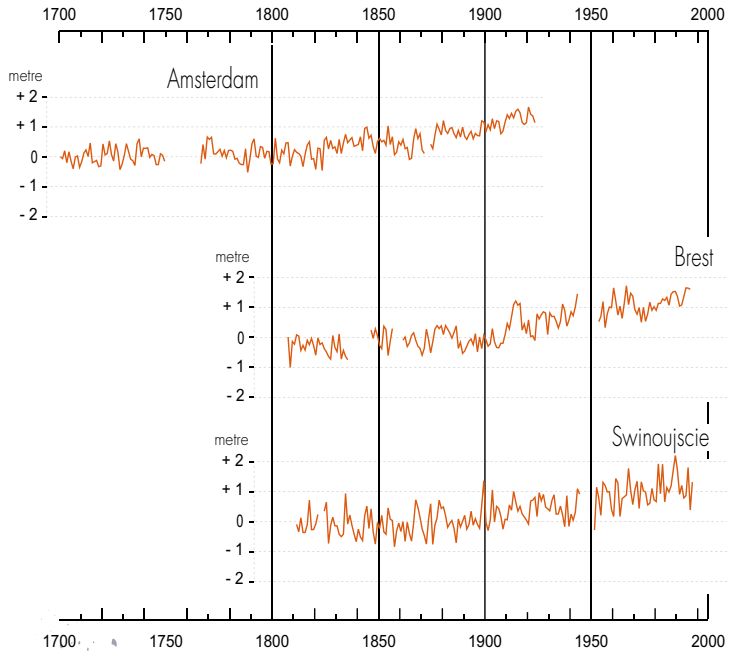
- variations known as "eustatic" changes, which are caused by changes in the volume of water of our oceans. This happens for example, when the climate warms up and when the mountain glaciers melt or the water dilates due to temperature rise.
- "isostatic" changes, in which the sea level alters without the amount of water in the ocean changing. For example, thousands of years after the melting of an enormous glacier that covered Scandinavia during the last ice-age, the continental base, freed from the weight of the ice, continues to rise a few millimetres in height every year.
- "relative" changes, the cause of which is unknown.

The current rise in atmospheric temperatures is also having an effect on the temperature of the ocean's surface. When water is heated, it takes up more room (like the mercury in a thermometer). Consequently, there is more volume for the same mass. This phenomenon, known as thermal dilatation, is currently under way in our oceans.
There is another phenomenon happening in addition to this: the melting of glaciers and of polar icecaps. As it melts, the mass of continental ice is turned into water and flows towards the sea. We should emphasise in passing that the melting of the Arctic pack-ice does not change the amount of water in the ocean because the ice is already in the water and has a similar density to that of water. (A glass of water with ice cubes does not overflow when the ice melts.)



Changes in temperatures, the average sea level and the snow cover in the northern hemisphere (IPCC Report 2007 SPM-Figure 3)

Based on geological and archaeological observations, scientists have the proof that over the past 3000 years, sea levels have varied very little (no more than 0.1 mm per year).
For the past hundred years or more, though, tide gauges have been recording the movements of the tides and the variations in sea levels. Basing themselves on these readings, researchers have been able to estimate **the rise in world sea levels** over the past century. They have observed that, since 1950, the sea level has risen an average of 1.8 mm a year across the planet. Since the 1990s and the advent of satellites, observations of sea level variations have become even more accurate, showing that the average overall sea level has risen by 3.3 mm per year since 1993. This amount is significantly higher than the values recorded by the tide gauges over the past century.



Records from different tide gauges over the past 3 centuries (Source: GRID – Arendal)

As it is the case with temperature rises, sea level does not increase uniformly across the planet. In some regions, the sea level has risen by several centimetres, whereas elsewhere it has fallen. In both cases, changes to the environment have had an impact on the living habits of the people inhabiting the region, either directly or through an accumulation of events. Scientists have already observed a reduction in humid coastal areas or mangroves, as well as an increase of the damage caused by coastal flooding.

Inuit village in Alaska. The rise in sea level has already caused a lot of damage. (Source: AFP/Gabriel Bouys)

Natural systems

Numerous natural systems are already suffering from the rise in temperatures, implying significant impacts for humans.
The natural systems that are most sensitive to climate change are those in the cold regions of the world, or at high altitude. The melting of glaciers, reduction in snow cover and decrease in polar ice-caps are a direct cause of either temperature rise or snowfall deficiency.

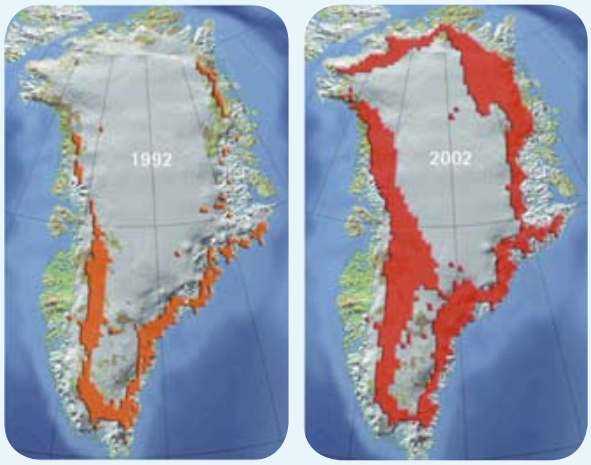
Chacaltaya glacier (Bolivia) between 1996 and 2004. (Source: usatoday/weather/climate)

The mountain glaciers in Europe have receded since the Little Ice Age in a process which began very slowly and was steadily maintained. Around the 1940s, the process picked up speed. Over the past 25 years, the retreat of mountain glaciers has become considerably greater. In recent years, measurements carried out by scientists have shown that mountain glaciers are becoming smaller across the entire planet. The Chacaltaya glacier in Bolivia, for example, has lost 90% of its surface area since the Little Ice Age, receding 1 metre a year since the 1980s. In central Africa, the Ruwenzori glacier has retreated 20 metres in 2 years.

One of the causes for glacier retreat is the lack of snowfall. This caracteristic has a direct effect on the reduction of permanent and seasonal snow cover in many of the world's regions. The most affected are, of course, the mountain ranges and high latitudes of the north. Satellite observations taken between 1996 and 2005 show that, compared with other years, the snow cover has become thinner all year round, except in November and December. We are already seeing the effects of this on human activities, with consequences on the tourism industry in mountain areas. In some places, the snow cover is also used as a water source, meaning that the slightest decrease has a direct impact on the local people, who no longer have access to fresh water throughout the summer period.

Reduction in the snow cover on Mount Kilimanjaro between 1993 and 2000 (Source: AFP)

Melting ice is not confined to mountain glaciers. The Greenland icecap and the Arctic pack-ice area have both diminished rapidly over the past 50 years. Even the ice built up over many years in the Arctic pack-ice, which used to be several metres thick, is now less than a metre thick in certain places. Satellite observations show that the pack-ice extent during the summer and winter has decreased significantly. In this particular region of the world, climate change has progressed two to three times faster than the average across the planet.
Scientists estimate that the Greenland icecap is losing 80 cubic kilometres of ice every year and the process appears to be accelerating. Areas where the ice is melting are becoming more and more extensive, while snowfall is no longer sufficient to make up for what has melted during the summer.



Increase in the summer melt area of the Greenland icecap
(Source: © Clifford Grabhorn, 2004, ACIA/Map)

With the temperature increasing at twice the rate of world averages, the Arctic and sub-Arctic ecosystems are seriously being affected. The permafrost (ground that is frozen permanently) has begun to thaw, causing the ground to cave in and landslides to occur, and posing serious problems for human infrastructures (houses, pipelines, etc.).

Hole caused by the permafrost melting

The same type of effect can be seen in mountainous regions. As the layer of permanent ice melts, landslides, rock-falls and even cave-ins can occur.

Our rivers and lakes have also begun to respond to the increase in temperatures. The surface water in some lakes and rivers has risen in temperature, which in turn has caused the water quality to decline with the proliferation of algae. Also linked to the increase in glacier melting and the rise in rainfall, the volume of water in rivers has increased locally in winter for the past few years. Furthermore, the water has been rising higher and earlier during the springtime.

The biosphere

The Earth's climate has varied on a regular basis over millions of years. Plants and animals have either adapted to these changes by evolving, or have disappeared and made way for other species. These transformations and replacements are happening gradually, following the biosphere's own rhythm.
But the climate change we are seeing at the moment is both fast and abrupt for plants and animals alike, some of which are already seeing their lifecycles being altered. The impact of climate change on the biosphere affects plants, animals and ecosystems in a number of ways:
Physiology: a rise in temperatures or carbon dioxide levels has a direct effect on the metabolism of plants and animals.
For example, the Nile crocodile is extremely sensitive to temperature variations during its reproduction period. As a matter of fact, the sex of the crocodile's offspring depends on the temperature in the nest. Any rise in temperature can result in just one sex of crocodile being produced, which could impede on future reproduction of the species.
Phenology: The early arrival of spring and the late end to summer have a direct impact on the life rhythms of many organisms (migration of birds, first shoots, etc.).

The flycatcher has seen its population decimated in Europe on account of rises in temperature (Photograph: Fabrice Croset)

The flycatcher is a migratory bird that comes to Europe to spend a cool summer and lay its eggs. The growth of the young flycatchers depends on the presence of caterpillars. In less than 20 years, the peak time for springtime caterpillar emergence has advanced 16 days, whereas the laying period for the flycatcher is only 10 days earlier. This means that the chicks do not have enough to feed on. Consequently, flycatcher populations have fallen by 90% in 20 years…

The **geographic distribution** of species: the annual temperature rise in temperate climates corresponds to isotherm variations of 300 to 400 km in latitude and 500 metres in altitude.
The polar bear, which lives on the Arctic pack-ice, is losing its habitat as the pack-ice melts. With global warming, the period during which the polar bear's hunting grounds are actually covered with ice has become shorter, forcing it to go longer periods than before without food. Polar bears have reduced in number and are less strong than they used to.
In temperate regions, at low latitudes, scientists are observing the arrival of tropical species in places where they never ventured before. In the mountains, some animals are migrating to higher altitudes to retain the same temperature conditions. However, this system has its limits: once the species has reached the top of the mountain, there is nowhere else to go. This is also the case for populations confined on islands or in highly specific ecosystems.
Adaptation is not possible for all species. Adapting involves physiological changes that will enable the animal to survive within its new environment. The current warming is happening quickly. Hence, only those species with a very rapid rate of growth will be able to produce the minute changes to enable them to survive. However, if they do not succeed in migrating or adapting, some species are doomed to rapid **extinction**.

Marine ecosystems are also feeling the effects of climate change. In addition to the rise in sea levels, some organisms are already suffering from the **increase in water temperatures**, causing harmful secondary effects on humans:

- Coral reefs: the microscopic algae that live with the coral are highly sensitive to temperature variations. If the water is too warm, the algae are driven out and the coral bleaches and dies. Since 1980, many coral sites have already bleached. Living corals are a little like the tropical forest of the seas. They make up complex habitats allowing for a whole retinue of other species to cohabit. They also serve as reproduction sites for many fish that swim from the open waters, as well as natural barriers to the powerful waves that can be wiped up by storms and which the coral reefs break up before the waves reach the coast.
- Krill in polar regions: krill is at the bottom of the ocean food chain. The recent warming of the oceans has reduced the water exchange rate between the surface and the depths of the oceans, thereby restricting the krill's food source. This implies that the amount of krill has diminished rather suddenly which has, in turn, already resulted in penguin populations to decline over certain areas.
- The distribution of various species has also begun to endure the effects of global warming. Typical warm-water species (fish, shellfish, molluscs) have already begun to migrate north, whereas others from the colder regions, such as the Arctic, are decreasing in number, because they cannot migrate further north and find the conditions that suit them. Recent studies have shown that some fish populations are simply absent from fishing areas when the water is too warm.

The human environment

Some effects are already being felt on the human environment. Some have a direct link with global warming, while others are the result of these direct effects.
We have already discussed the impacts due to weather factors and the changes made to oceans, ecosystems and the biosphere. But scientists also agree that there are additional effects associated with climate change in other areas:

For example, temperature rise is having an effect on **farming and forestry management** in the high latitudes of the northern hemisphere. To prevent the loss of certain plant types and to adapt to the new rhythm of seasons, farmers have to sow some crops earlier in the spring. In more northerly regions, parasites from traditionally warmer areas have moved in and are partly destroying the forests.
In the Sahel, the temperature rise and the rainfall decrease are causing the growing period of the crops to decrease. If the seeds don't germinate when they are first sown, the time available for replanting is significantly shortened.

The two points mentioned above both have consequences on the local and regional **economy**. Whether it is the damage caused by floods or the thawing permafrost, reduced fishing catches or greater levels of aridness, higher costs are generated by these situations and result in hard times both for the economy and the wellbeing of the people who depend on it – it is often the poorest people who suffer the most.

The most direct impact on humans concerns their health. The 2003 heat wave in Europe saw an increase in mortality rate (an additional 10,500 deaths in France and 20,000 in Italy). Extreme heat means that the body has to adjust, requiring the heart to work faster. People whose bodies are weakened and frail find it hard to make the adjustment.
We are also seeing an increase in infectious diseases that can be transmitted by insects in some parts of the world. The temperature rise has redrawn the distribution map for many species, now attacking organisms that are unfamiliar with these diseases and unable to fight them.
In recent years, doctors have also seen an increase in allergic reactions to pollen. Hot, sunny weather, with no rainfall, increases the amount of pollen in the air. People who were previously not particularly sensitive have developed allergies as a result of high pollen levels in the air.

NB: The impacts mentioned here are by no means exhaustive, but they are dealt with in the fourth IPCC report and are acknowledged scientifically as being a result of climate change.

THE VARIOUS SCENARIOS OF GLOBAL WARMING

IPCC[3] experts have come up with **various scenarios depicting the way global warming may develop in the future** and the impact it may have on humans and the planet. These models rely on computer-generated models. They take account of future quantities of CO_2 and other greenhouse gases emitted by man, based on future socio-economic conditions[4].
These scenarios cannot be used as forecasts, such as weather forecasts for example. They outline how greenhouse gas emissions might develop between 2000 and 2100, based on certain parameters. The number of possibilities is thus infinite. This is why we can't call them "forecasts" in the strict sense of the word. These models are used to highlight the risks relating to the rise in temperatures so that they can be prevented. There are 6 fairly contrasting scenarios that cover a rise in temperature ranging from 1.1°C to 6.4°C between now and 2100. They can be separated into 4 distinct groups:

A world with a growing economy: scenarios A1

The following scenarios assume that globalisation (links between regions) and world economical growth are maintained. Population increases until mid-century, then decreases. New and efficient technologies will be developed. Differences proceed from the type of energy used.
Scenario A1T, a rise of 2.4°C (1.4°C to 3.8°C): Energy is provided by "clean" fuels (nuclear, renewable energy) and not by fossil fuels.
Scenario A1B, a rise of 2.8°C (1.7°C to 4.4°C): Half the energy is provided by fossil fuels and half by renewable energy. This scenario is the closest to forecasts made by the International Energy Commission.
Scenario A1F1, a rise of 4°C (2.4°C to 6.4°C): Energy is provided by fossil fuels only.

3 The role of the **Intergovernmental Panel on Climate Change** "is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. It does not have a mandate to undertake research work, nor to monitor changes to climate-related variables or other relevant parameters. Its evaluations are based principally on scientific and technical publications whose scientific value is widely recognised." (Source: wikipedia)

4 An equation, called the Kaya Equation (or Kaya Identity) is generally used to determine the various parameters:
- Environmental impact = (Impact / Activity) x (Activity / GDP) x (GDP / Per capita) x Population.
- Units: CO2 = (CO_2 / unit of energy consumed) x (unit of energy consumed / $) x ($ / Per capita) x Population.

A regionally self-sufficient world: scenario A2

Scenario A2, a rise of 3.4°C (2°C to 5.4°C): This scenario provides for a world made up of disparities (heterogeneous). It is orientated towards regional self-sufficiency and the preservation of local identities. Economic development is regional and slow. World population growth is continuous.

The least polluting world: scenario B1

Scenario B1, a rise of 1.8°C (1.1°C to 2.9°C)
This scenario is the least polluting. World population rises until mid-century, then falls. The economy changes rapidly. Solutions are put in place on a worldwide scale to ensure economic, social and environmental viability. No additional initiative is taken to pay attention to the climate.

A locally-oriented world: scenario B2

Scenario B2, a rise of 2.4°C (1.4°C to 3.8°C)
In this scenario, world population continues to rise. The solutions applied to protect the environment and ensure social equity are implemented locally. Technological developments are highly diversified and provide adequate solutions.
[End box]

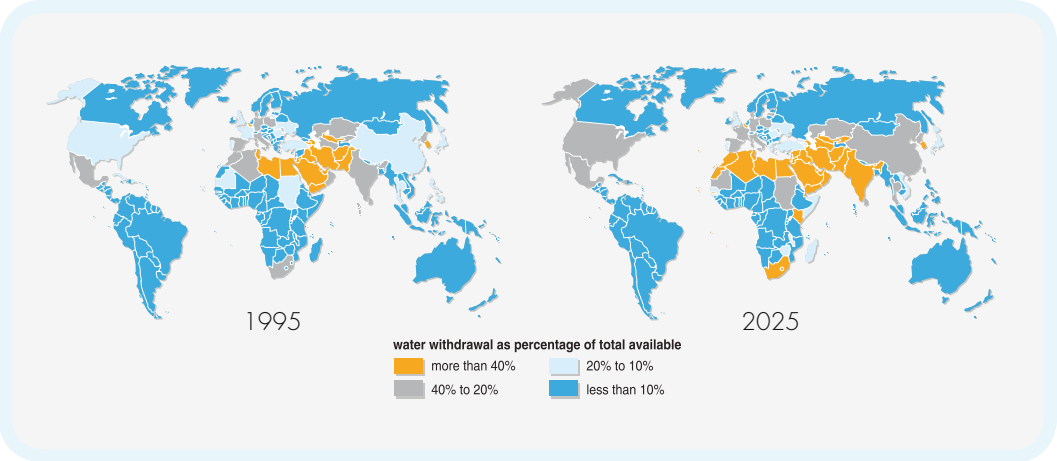
THE FUTURE ON AN OVERHEATING EARTH

Climate change has already begun altering our environment… Scientists from all around the world agree that these changes will become increasingly obvious as time goes by.
Even if we halted all emissions of greenhouse gases today, the atmosphere would take at least a century to eliminate them. The planet would thus continue to heat up a few degrees.
Unfortunately, such a scenario is simply unimaginable. Consequently, IPCC[5] scientists are attempting to determine the respective temperature increase and impacts for the various scenarios mentioned above. They were included in the 4th IPCC report by working group II.
Climate models (general circulation models) are generated by powerful computers. They enable us to examine "atmosphere-ocean" interactions for different variables. These models are not entirely accurate, but they do give us a good idea of what might happen in the future.
A quick look at an overheating Earth…[6]

Current changes to the climate are marked by an overall increase in temperatures throughout the world. Based on current observations, scientists estimate that the average temperature rise for next century could range between 1.5°C to 5°C.

In many regions, the hot and dry summers will be characterised by serious droughts. It therefore seems natural to wonder about the availability of **freshwater** on Earth a century from now.

5 See note 3
6 The predictions presented here are based on the "Summary for decision-makers: Impact, Adaptation and Vulnerability" released by the IPCC's working group II (Fourth IPCC Report, 2007).



Freshwater stress due to the availability of drinking water between now and 2025. (Source: GRID Arendal)

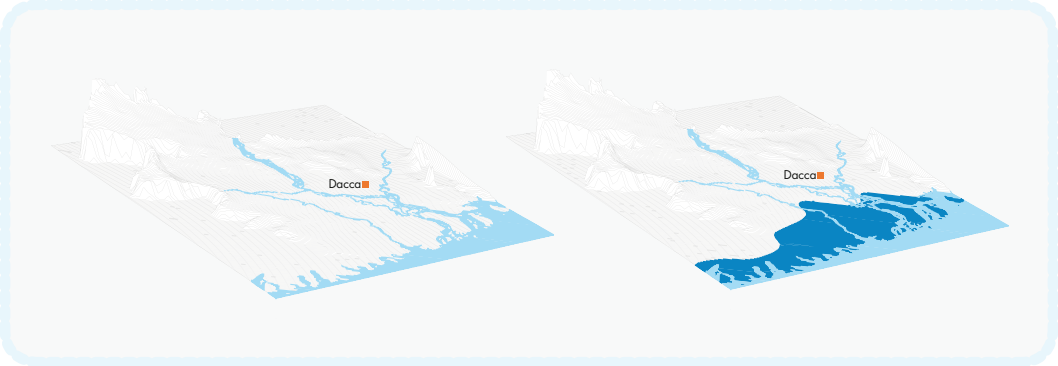
Scientists estimate that between now and 2050, both the average annual flow volume of rivers and the availability of freshwater will increase in regions located below the higher latitudes (northern Europe) and in certain humid tropical areas (equatorial rainforest). Variations in the flow of rivers over the course of the year are linked in part to the precipitation rate. Precipitation swells the rivers directly,, but also and especially as a result of run-off.
These models predict an increase in precipitation and, therefore also, an increased risk for flooding.
The influx of water may also come from water which is released by the melting of the snow cover and glaciers. Projections show a sharp reduction – and in some regions, the total disappearance – of the freshwater stock within a century. Currently, one-sixth of the world's population lives in high-altitude regions. This freshwater shortage could thus dramatically disrupt the daily life in concerned areas.
For dry regions in the mid-latitudes (southern Europe) and low latitudes (Africa), the lack of available freshwater will be felt in many areas. Zones of drought will expand and affect both industrialised and developing countries.
Some countries have already established procedures to adapt to these changes and manage the situation as well as they can. However, it remains clear that, for most of the world's population, access to fresh drinking water will be one of the great challenges of the next century. Specialists estimate that several hundred million people will be affected by major freshwater stress.

As we have already seen, flora, fauna and other living organisms are sensitive to variations in their environment, whether directly or indirectly. The ecological niche is used by scientists as a model for predicting the future of **ecosystems**. This model examines the different variables of the environment enabling a species to maintain and perpetuate itself. By studying the variations in these environmental conditions in light of the various scenarios advanced by the IPCC, it is possible to predict with a certain degree of accuracy which species will be exposed the most.
Using this type of model allows scientists to estimate that, between now and 2050, 30 to 40% of the species studied thus far will die out if the rise in temperature exceeds 1.5°C to 2.5°C. For many other ecosystems, the ability to regenerate in the face of climate change and its associated disruptions (drought, flooding, etc.) will be extremely limited.
If the increase is greater than 1.5°C – 2.5°C (associated with a rise in CO_2), it is the structure and very functions of the ecosystems that are likely to be modified and, thus also, the benefits they provide to humans. For example, if temperatures actually rise to this extent, the majority of coral reefs will likely die, thereby depriving hundreds of thousands of people of fishing areas for whom fish often represent the only easily accessible source of protein.

As the temperatures rise, so will sea levels. The thermal dilatation of the oceans will increase, as will the influx of freshwater generated by the retreat of the icecaps and mountain glaciers. The rise in sea levels estimated by the latest IPCC report will range between 20 and 60 cm by 2100. However, a number of more recent glaciological studies conducted both in Greenland and the Antarctic appear to indicate that a sea level rise

of several metres high is no longer as improbable as has long been believed.
The rise in sea levels will also expose crumbling and unstable coastlines to significant erosion, which can further be worsened by severe storms, and will also incite a greater area of land to being flooded. Some coastal ecosystems (marshland, polders, mangrove, salt marsh, etc.) are likely to be seriously affected by higher sea levels.
With over 50% of the world's population living less than 10 km away from the coast (see the Education File on the oceans), economic and human damage will be significantly worsened. For certain regions having an average altitude just above the current sea level, the consequences will be devastating. According to various simulations, millions of people will be affected each year by flooding which, over time, will cause major population migrations towards areas or countries higher in altitude.
In its most recent report[7], UNEP (United Nations Environment Programme) estimates that a one metre rise in sea level would expose 145 million people to floods, mainly in Asia, causing damage estimated at 950 billion dollars.

7 **Global outlook of snow and ice** (UNEP, 2007)



Potential impact from a 1.5-metre rise in sea level in Bangladesh (Source: GRID Arendal)

A change in the ecosystems will also have an effect on the **food-producing** industry. A rise in temperatures may favour or disadvantage certain types of crops in a particular region. The way farming yields react to changes in the climate is not the same everywhere. They also vary depending on the extent to which temperatures rise.
Mid- and high-latitude regions should see their crop yields increase. However, if the temperature rises over 3°C, yields will start to drop. But we shouldn't neglect the increase in rainfall and floods either, which could have a negative impact on harvests.
Those regions suffering from droughts will see their crop yields drop, even if temperature increases are not significant. The risk of famine in these areas will thus rise.
For fish-farming and commercial fishing, the rise in water temperatures will create a new geographic distribution and cause a drop in production of most fish species. Some of these species may even die out locally or on a wider scale. Both small-scale and industrial fishing will be affected.

The consequences for our **health** have already been felt for a number of years now. Scientists estimate that climate change and its effects will have a growing impact on the health of millions of people. Those who are weakest (the elderly, children, the ill) will be most affected. Less well-developed countries with lacking infrastructure will also be significantly affected. Other aspects, such as education and public prevention may also play a decisive role in the impact that climate change has on health.
As we have already seen, some countries will see their farming yields diminish. From a health point of view, this also means an increase in malnutrition, which also has its own ramifications (difficulties linked to growth and development). Extreme events (floods, heat waves, storms, forest fires) will affect the population by raising both the rates of mortality and of serious injuries. The insalubrious conditions caused by some of these extreme events may increase the incidence of diarrhoeal illnesses in certain regions. The rise in temperature will also modify the geographical distribution of the carriers of certain infectious diseases like malaria, bringing it to regions where it does not exist yet.

The golden triangle of the Arctic

Generally speaking, temperatures have risen twice as fast in the Arctic than in the rest of the world. The extent and thickness of the Arctic sea ice have diminished appreciably in recent years. The projections made by the IPCC experts predict a total lack of ice in summer on the Arctic Ocean by 2100. In fact, according to the latest data, this may even become the case as early as 2040.
In addition to the impact on the world's ocean circulation, ecosystem and native populations, the prospect of an ice-free ocean gives reason to believe that economic activity will increase in this part of the world.
World navigation and maritime transport will change considerably. The Northeast Passage along the northern coastline of Russia is currently only navigable for 30 days a year. In the not-too-distant future, over the course of this century, sailors will be able to use it twice as long as presently, that is for about 60 days a year. The opening up of the Northwest Passage along Canada's territorial waters is also likely to modify the development of world maritime transport.
The bed beneath the Arctic Ocean is rich in natural resources. The USGS (US Geological Survey) believes that 25% of the world's reserves of hydrocarbons currently lie beneath the pack-ice, along with deposits of gold, diamonds, manganese and nickel. It appears that the inexorable thawing of the Arctic pack-ice will open up a whole new Ali Baba's cave of riches to the region's bordering countries.

A little cooler?

As we have already mentioned, even if we halted all greenhouse gas emissions today, the atmosphere would continue to heat up for a number of centuries.
But the current world economy and way of life lead by most people on the planet simply cannot allow the immediate implementation of such a drastic measure. This is why the IPCC's working group III[8] is examining ways to mitigate climate change. This group has been given the assignment of assessing every angle that will enable us to find relevant solutions for reducing the emission of greenhouse gases into the atmosphere, hence also for limiting global warming.

In the IPCC's fourth report (2007), experts put forward a number of measures that would enable us to reduce the rise in temperatures at a moderate cost. Their results are based on a change in lifestyles, in consumer trends and in the methods of management that are chosen. It is, of course, the industries that produce the greatest amount of greenhouse gases that are most affected by these measures.

This is certainly the case for the energy-producing industry. Taken worldwide, energy is mainly generated by either fossil fuel or wood combustion. Electricity, which is the most used form of energy, is principally generated by burning fossil fuels. Everybody consumes electricity – from the private individual to major industries. However, there are sources of energy that do not emit greenhouse gases: hydraulic energy, wind energy, photovoltaic energy, geothermal energy, nuclear energy (see the animations on energy at www.educapoles.org)
Other industries releasing major amounts of CO2 include transport, construction, manufacturing and farming.
The measures proposed by the IPCC could help worldwide temperatures to only rise between

8 see note (3)

2 and 2.4°C, These measures, however, must be taken in the near future and in most countries, particularly in more industrialised nations.
Although the various business sectors can already significantly help meet emission reductions, it is important to stress that such a level is reachable only if consumers also change their habits. This means a change in lifestyle and in current cultural identity and the promotion of measures such as car-pooling, restrictions on the purchase of vehicles with large engines, mitigation of excessive consumption, and so on.

A 60% reduction in greenhouse gases would be needed merely to stabilise their atmospheric concentration. We will have to see who and which sectors put these reductions into effect. The distribution of CO_2 emissions, the main greenhouse gas generated by human activity, clearly illustrates the disproportions that exist between the more industrialised countries and the others. In 2004, 20% of the world's population produced 46% of all greenhouse gases.
This disproportion can also be seen when comparing country emission levels. The Americans emit approximately 20% of the world's greenhouse gases, whereas southern Asia, which has 6 times as many inhabitants, only emits 13%. It would be difficult not to take these differences into account when the time comes to pinpoint the level of reduction that is required by each country, especially if we take account of the "lead" that the northern countries have taken since the beginning of the Industrial Revolution.
In order to stabilise CO_2 levels, the emissions quota divided between the planet's 7 billion human beings would be equivalent to the average emission of a Chinese or South American.

From an economic and social point of view, impacts of climate change will vary significantly from one place to another. Some areas, such as coastal regions, will be affected more than others, especially those close to the current sea level. Communities that are disadvantaged and unable to implement immediate adaptation measures will be those that are affected the most. But overall, the entire planet will have to adjust to the new climate and evolve with it.

While the road ahead may seem long and hard, it is also full of promise: all of the remedies suggested for global warming will also help fix other major environmental problems. In fact, they have the potential to lead us towards a sustainable way of life that is in equilibrium with the rest of the planet. Life on Earth has survived other cataclysms and is not threatened as such. The real issue is that of our future: what type of World and Humanity do we wish to pass on to future generations?

Educational note

Teaching note

The teaching activities suggested in the following pages are designed to establish links between experimental science and human science, following a systemic and cross-disciplinary approach.

The whole issue that is dealt with in this document concerning the "Impacts of climate change on humans" implies a clear understanding of the natural phenomena that rule the climate of our planet, as well as a good knowledge of the human-related causes of global warming.
This approach can only be partial for children aged 10 to 14. Nevertheless, it is important to show pupils the various stages that enable us to produce models and understand climate change. The experimental side of the approach involves making models to explain the complexity of a physical phenomenon. Once that is done, it is easier for children to understand the consequences of a similar phenomenon observed in nature.

Reading and interpreting diagrams, graphs and aerial photographs is no simple task for pupils of that age. The activities suggested in this file enable children to take their first steps with various illustrative tools and to build basic cognitive tools.
For example, when it comes to aerial photographs, it is important to spend time examining the photos to identify the main elements in the picture (coastlines, shape of forests, location of various places, etc.). The children then need to be able to compare the photos (such as two aerial shots of the same place taken several years apart). The aim here is to build up skills associated with representations of space, as well as representations of time and timescales.

The final section of the file emphasises the initiatives that are taken in human sciences. This is one of the main issues involved in teaching sustainable development. The impact of climate change on mankind, as well as the way humans will have to adjust and the answers they can come up with depend essentially on the social skills that people will be able to display in situations of crisis. It is therefore important to carry out as many activities as possible demonstrating some key principles of education about sustainable development (the principle of participation, individual and collective responsibility, precautions, supporting one another). This opens up the scope on values, civic education and governance.

NB: When dealing with the issues of this file, it is also important to make links with various concepts. The authors of this file therefore direct readers towards other International Polar Foundation productions.

Suggested activities

To understand and remember:
- That water exists in various states.
- That water forms clouds and condenses into rain or snow.
- That heat can be stored in differently, depending on the material.
- That the greenhouse effect traps the sun's rays.

To be able to:
- Set up an experiment
- Discover natural phenomena
- Ask questions to oneself and to others
- Make links between the experiments and the outside world

File: "Experiments in Earth Sciences"

- The water cycle: condensation
- The water cycle: creating a cloud
- The water cycle: making it rain
- Storing heat: testing receptacles that store heat
- The greenhouse effect: the greenhouse box

File: "The climate and climate change"

- The climate, weather and daily life
- How the melting of the pack-ice can have an effect on the climate of our region

File: "Polar Science"

- What surface area of the pack-ice has disappeared?

Reading: "Migration of the Ibanes" and dossiers linked to this cartoon.

Teaching/learning sequence:

To understand and remember:
- That global warming induces change at a large scale.
- That climate change has repercussions on the environment
- That climate change has repercussions on living beings and on humans in particular
- That environmental changes have repercussions on humans and living beings.

To be able to:
- Set up an experiment
- Discover natural phenomena
- Ask questions to oneself and to others
- Observe differences
- Make a link between the experiments and natural phenomena

The teaching/learning sequence introduces the impacts of climate change on humans. The thought process proposed here covers various disciplines and attempts to highlight the link between changes to the environment and the social impact they induce.
To do this, we suggest you begin with simple experiments that represent certain physical phenomena of our environment, then add the "global warming" element and have your pupils think about the impact these changes have on nature, followed by their consequences for humans.

Starting point: Immersion in another world (20 minutes)

Ask the children to read pages 3 to 9 and pages 39-40 of "Migration of the Ibanes". Discuss the story with them without delving into second-level reading.

Experiment: The physics of the environment (30 – 45 minutes)

Conduct the following three experiments with the children (described in detail in the attachments) without mentioning climate change, or the physics of the environment:

1. The ice cube and the glass of water
2. Water vapour or not
3. The soil that dries out

Have the children work in pairs and each pair on one experiment. Ask them to record their observations carefully (see pupil sheet in the attachments).
NB: You will find other experiments in the file on "Climate and climate change"

Thinking: Linking experiments to the surrounding environment (15 minutes)

Ask the pupils to use their notes to come up with equivalent natural phenomena. Each pair of children needs to come up with at least one. Write them on the blackboard.

Discussion: Global warming (45 minutes)

For each experiment, write down the differences between parts 1 and 2 on the blackboard. Discuss the role of the hair-dryer or kettle. What effects do they have? What do they represent?
Show the children the graph on rising temperatures (see attachments). Ask them to look at it carefully. Discuss their observations. Bring up the notion of global warming. Discuss with the children what they know about it. Write down what they find out on the blackboard or on a large sheet of paper.

Set-up: Impact of climate change on the environment (45 minutes)

Show the children photographs of different places in the world linked to the experiments. Ask them to link the photos with the various experiments. Ask each pair to come up with a written scenario for this particular region assuming the scenario represents reality. To help them be aware of the main elements in the picture, ask them to reproduce it on a piece of tracing paper by outlining things such as the towns, the coastline, etc.
For some of the photos, there are two images: one before a big rain event, one after. After the pupils have done their scenarios, ask them to take their tracing paper again and to draw in the elements that need to be added, using a different colour.
Important: ask them to try not to take humans into account.

Specialisation: Environmental changes and impacts on humans

(1 x 30 minutes + 1 x 45 minutes)

Select one scenario per experiment and read it out to the class. Ask the children to think about the effects of these changes on the people who live there. Use pictures to promote discussion.
Make the link between global warming, changes to the environment and the consequences for humans and living beings in general.
Reflect with the children about the impact of climate change on their region in the medium term (the future of mountain regions, coasts, etc.).
Then make the children do the puzzle in the figure "Spiral of climate change" (see attachment). Explain any difficult terms first. Discuss the components of this diagram.

Photo-language: Impact of climate change in the Arctic

(60 minutes)

Get the children to discuss a region that is very sensitive to climate change. Print the photo-language images in large format. Ask the children to look at them closely. Suggest they each say a few words in turn about what they see. Define the issue together, along with the implications for the fauna and the native people. Watch the video: "What species are threatened in the Arctic?" (www.educapoles.org) with the children. Visit the "forces of change" website (http://forces.si.edu/arctic/02_00_00.html) and view the eyewitness documentary. Continue the discussion with the children, using any new information taken in by watching the video and exploring the website.

Survey 1: The perception of climate change

(1 x 30 minutes and 2 x 45 minutes)

Discuss their perception of global warming with the children. Ask them to collect signs of climate change from their immediate surroundings.
Make a list of all this information and try to find confirmation of each item. Try and find out whether scientists have proved that this particular phenomenon is caused by climate change. Differentiate between popular beliefs and established facts.
For facts that have been proved, try and think of the problems they might cause for people and whether they can affect the region.

Role-play: Looking for solutions

(20 minutes + 60 minutes)

Ask the pupils to reread the pages from the **"M**igration of the Ibanes**"** cartoon, as well as pages 24-25 and 32 to 36.
Get the pupils to take part in a role-playing session. Ask them to identify the various characters they have met during their reading. Define their role and motivation. Start the role-playing (described in detail in the attachments).
At the end, go through the solutions that were identified with the children, and redefine the issues and impacts.

Survey 2: what should we do and what is being done in my region?

(1 x 30 minutes and 2 x 45 minutes)

Ask the children to examine what is going on in their region. Reiterate the changes that are affecting the area.
Try to find solutions. For problems where the solution appears to be technology-based, ask the children to make a drawing of the solution.
You can also try to find out how the local council, town or country intends to remedy the problem, or how scientists in the area are trying to resolve the problem.

Conclusion

(30 minutes)

Go over the whole of the sequence again with the children. Write the different stages down on the blackboard and what they have learned. The aim is to bring out the value of conducting experiments (understanding a natural phenomenon) and to link them with climate change, to notice the resulting changes to the environment, the impacts on humans and the responses provided by policy and the economy. You can incorporate the various notions dealt with in the sustainable development diagram (see attachments).

The ice cube and water experiment

Equipment:

- Two identical glasses, cylindrical in shape (not conical)
- A cup made out of flexible plastic
- An ice cube
- Water
- Scissors
- A stopwatch
- A hair-dryer

Part 1
Fill a glass up with water to about 1 mm from the top. Take an identical, empty glass, turn it upside down and place it alongside the full glass. The two glasses must be touching.
Using the scissors, make a hole in the bottom of the cup on one side. Place the cup on top of the upside down glass, slightly to one side so that the hole is above the full glass. Place an ice cube in the goblet and start the stopwatch. With the children, check what happens every five minutes until the ice cube has melted completely.
Record the observations as you go in the table below.

Part 2
Do the same experiment again, only this time blow on the ice cube with the hair-dryer on a medium setting.

Time	I draw what I see	I write down what happens
0 minutes		
5 minutes		
10 minutes		
15 minutes		
… minutes		
… minutes		
	End time: …….	

Experiment: water vapour or not

Equipment

- A kettle
- A plain bowl
- A salad bowl made from transparent glass, narrower than the tray
- A tray with a raised rim
- A scale

Part 1
Fill the bowl with hot water from the tap (as hot as possible). Place the bowl on the tray. Cover with the salad bowl. Wait 15 minutes. Make a drawing of what happens.
Remove the salad bowl and plain bowl from the tray. Recover the water in the tray and weight it. Record the amount.

Part 2
Boil some water using the kettle. Pour it into the plain bowl and place the bowl on the tray. Cover with the salad bowl. Wait 15 minutes. Make a drawing of what happens.
Remove the salad bowl and plain bowl from the tray. Recover the water weight it. Record the amount.

I draw what happens:

Quantity of water in the tray after 15 minutes:

Experiment: the soil that dries out

Equipment

- A little soil (the equivalent of two tablespoons)
- 1.5 dl water
- A hair-dryer
- A cake pan
- A stopwatch

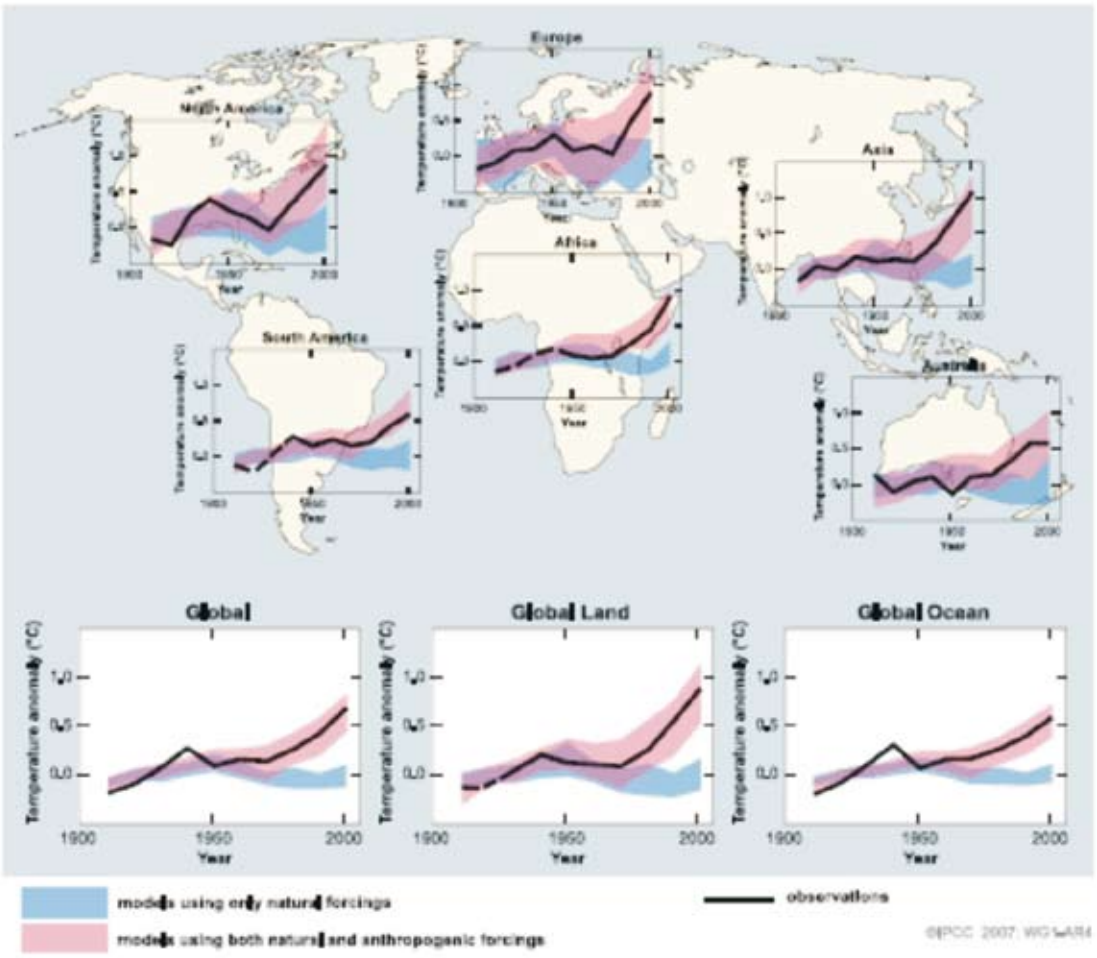
Part 1
Place the earth in the pan. Wet it with water. Start the stopwatch. Observe every 5 minutes until the soil is dry and record your observations. Stop the stopwatch once the soil is dry and record the time shown on the stopwatch.

Part 2
Place the earth in the pan. Wet it with water. Start the stopwatch. Blow on the soil with the hair-dryer. Observe every 5 minutes until the soil is dry and record your observations. Stop the stopwatch once the soil is dry and record the time shown on the stopwatch.

The temperature on the surface of the Earth

The map of the world below shows the temperature anomalies recorded over the past century. Draw a table on the back of your sheet with 10 lines and three columns. On each line, write the name of all the continents as they are shown below. For each continent show the anomaly in 1950 and the anomaly in 2000.
What do you see?
What does it mean?

Figure SPM-4, IPCC 2007, working group 1

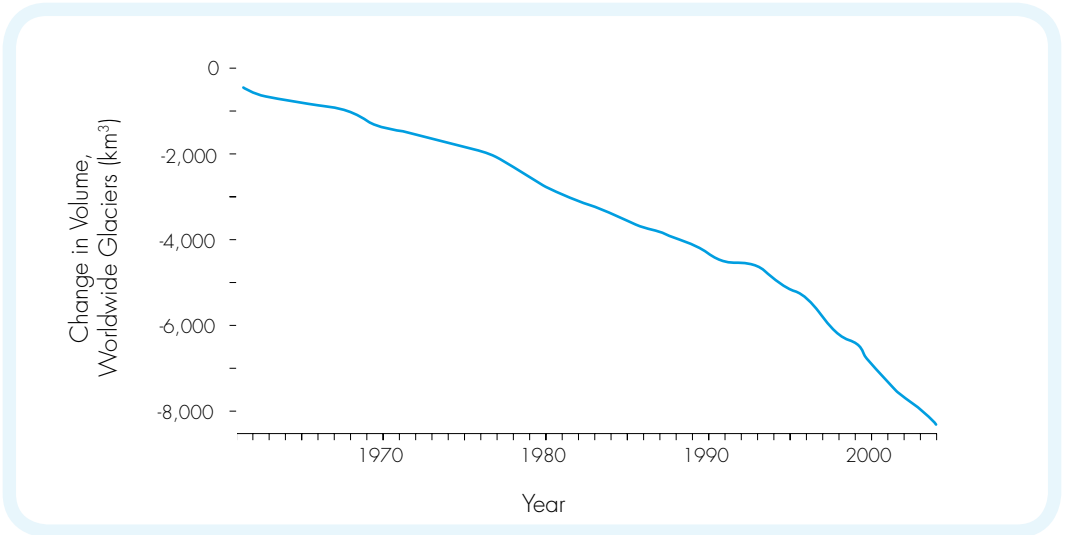


Impact of climate change on the environment/ Environmental changes and impacts on humans

Suggested photos for both activities; other photos on the NASA – Earth observatory website

Glacier in the Antarctic (Source: IPF)

Colony of emperor penguins (Source: IPF)



Athabasca Glacier, Canada (Source: NASA, Earth observatory)

Venise, Italie (Source: NASA, Earth observatory)

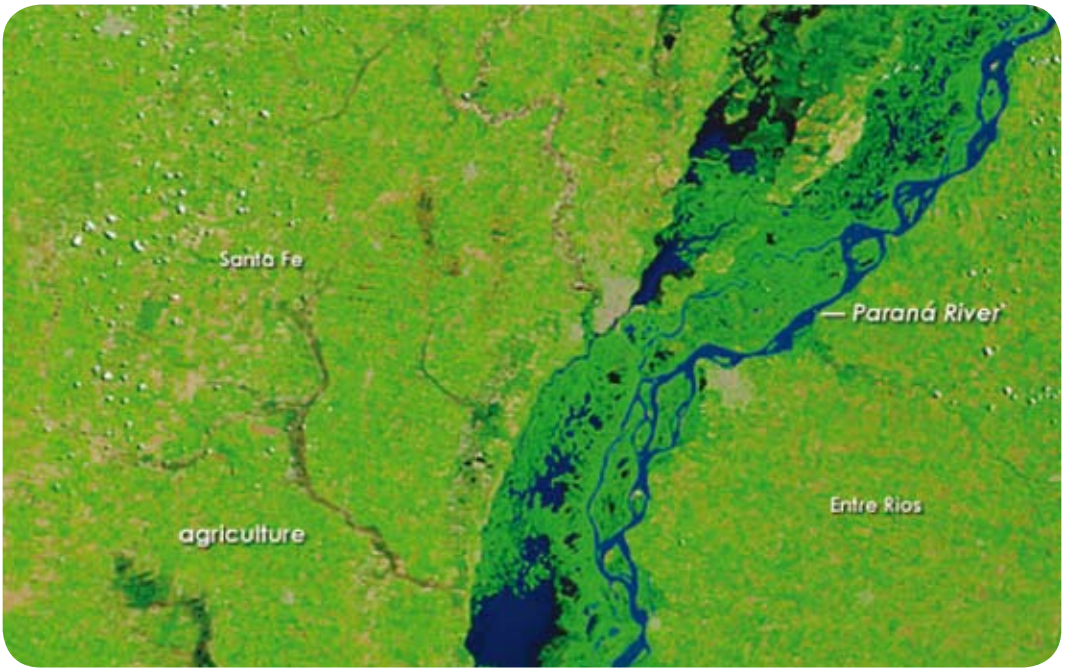
Den Helder, Holland (Source: NASA Earth observatory)

Saemangeum estuary, South Korea (Source: NASA Earth observatory)

Bermuda (Source: NASA Earth Observatory)

De Grey river, Australia. (Source: NASA Earth observatory)

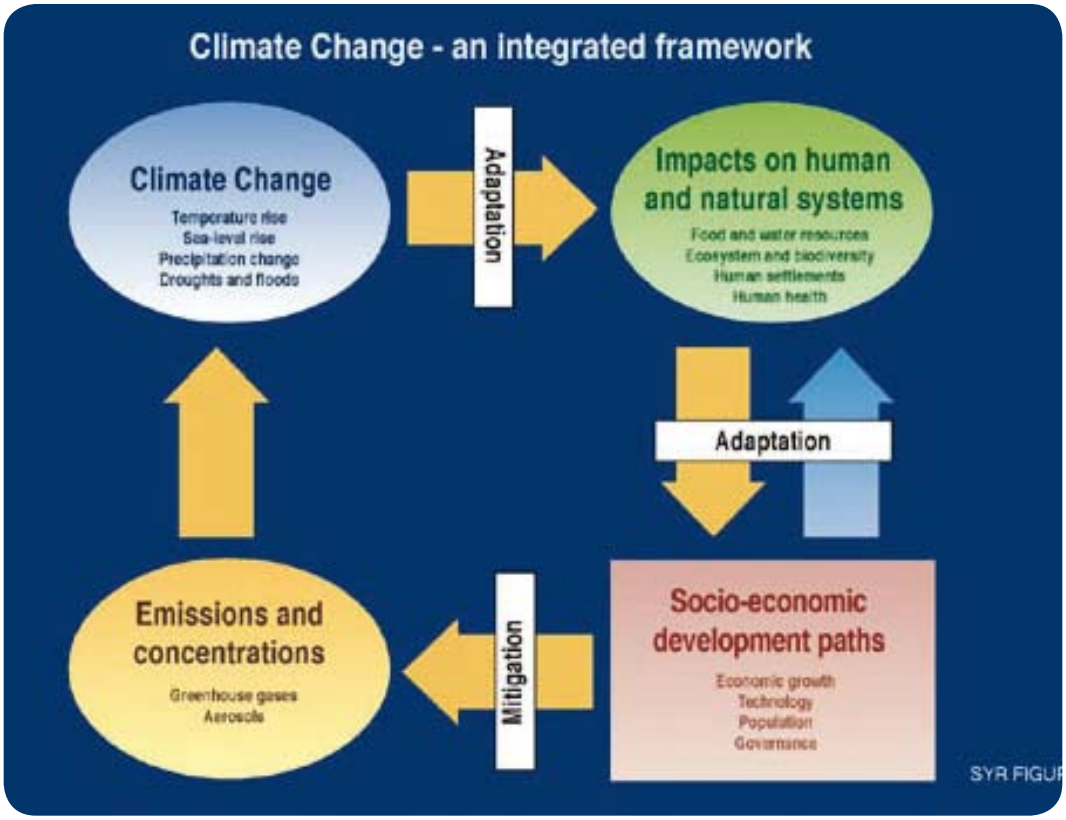
Somalia. (Source: NASA Earth observatory)



Santa Fe, Argentina. (Source: NASA Earth observatory)

The following photos show the three previous photos after heavy rainfall:

The spiral of climate change



A few definitions:

Adaptation:

Adaptation is a change that makes it possible to respond or cope better with the events that are going on.

Attenuation:

Attenuation is a term used in telecommunications to indicate a reduction in the strength of a signal. It is also used in climate change when speaking of a reduction in certain economic aspects or in greenhouse emissions.

Governance: Governance is a method of governing that tries to respond to the interests of the constituents, rather than to the wellbeing of the representative members voted in.

The cycle of climate change

Cut this diagram into pieces and then put it together correctly. Use your dictionary if there are any words you do not understand.

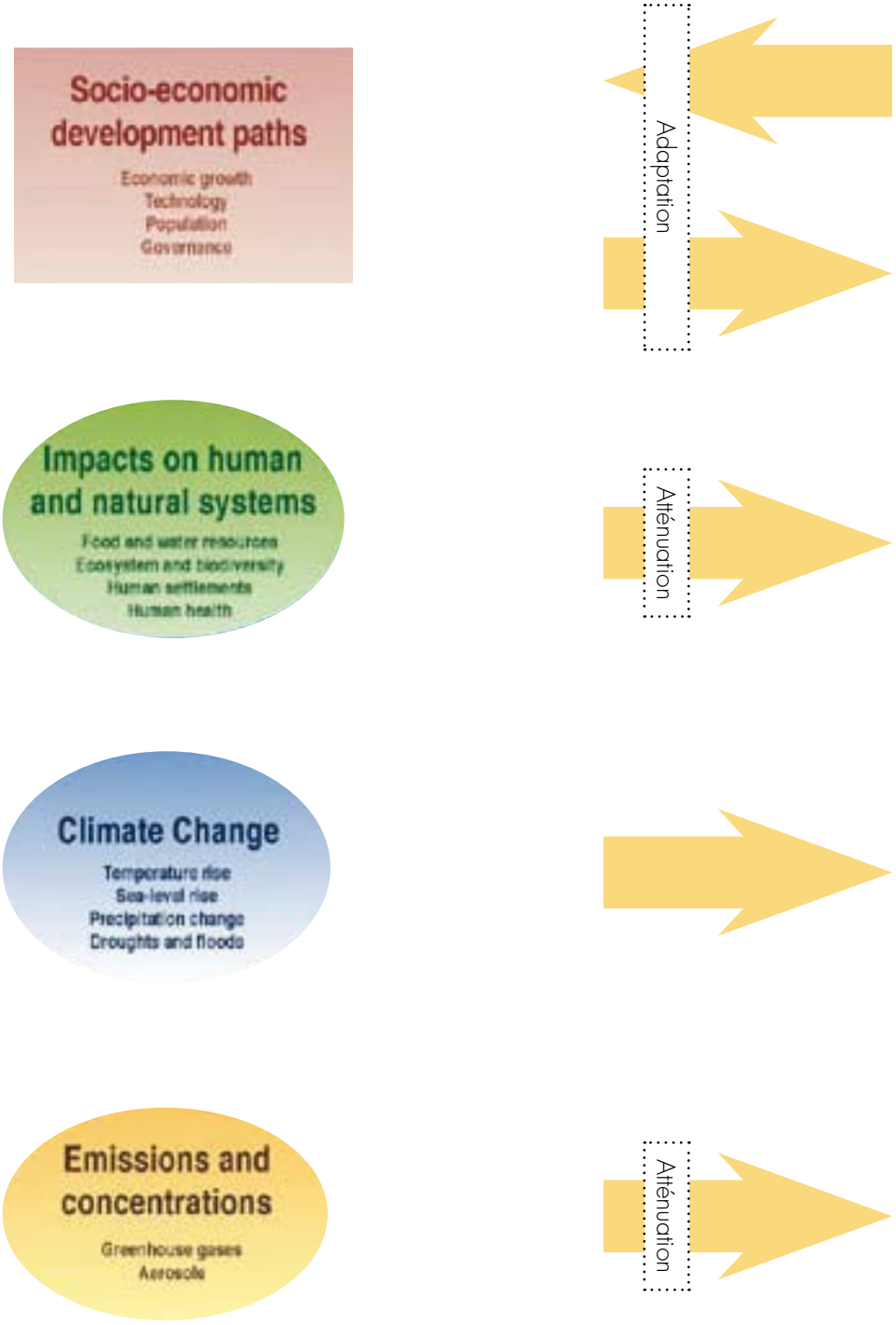


Photo-language: Impacts of global warming in the Arctic

ROLE-PLAYING

Preparation

Each pupil takes a role-playing card (included further in this document). Some of the cards represent characters encountered directly in the cartoon strip. Others, by contrast, appear indirectly.
All of the children with the same card form a group. They read their card and think about the positions they will defend in the role-play. Documentary research is suggested before beginning the actual role-playing game (school library, Internet, CD-ROM, surveys with local people, etc.). This allows the children to find out the opinions and arguments corresponding to the role they will have to play. They should also prepare a brief presentation to make their position and arguments as clear and credible as possible. Finally, each group will summarise its claims on a document (a poster, for example). Each group will explain the position it defends by making a brief presentation based on their document.

Starting point

A starting point is defined by the whole class. For example, it might be that the manager of a furniture factory wants to chop down a new area of the tropical forest in a protected area in order to boost his production.

Set-up

Each group designates one of its members to take part in the debate. A "**timekeeper**" can be selected from the pupils, whose role will be to place a time limit on the exchanges. The length of time for the debate can either be imposed (longer or shorter depending on the participants 'on stage') or depend on the quality of the ideas put forward (arguments that are too redundant might prompt the moderator to decide to end the debate). Consequently, the amount of time given to each speaker can vary depending on the relevance of the arguments put forward by the parties.

The role-playing

A "**playmaker**" is appointed (depending on the age of the pupils, the teacher might take on this role). Under the direction of the playmaker, the various delegates debate the issue by defending the opinions that correspond to their role. The other pupils follow the discussion. When one of them thinks he/she is being poorly represented or that an important argument has been forgotten, he/she can ask the "playmaker" if he/she can intervene. A limit can be set (one or two interjections per group) to avoid there being too many interruptions. The "playmaker" will try and guide the debate towards building common solutions, in line with the principle of joint development.

The "playmaker" ends the discussion if the debate gets stuck, if no new arguments are being put forward, or when it has become possible to consider plausible solutions.

Variant: The teacher throws a die and the number shown determines the number of speakers 'on stage'. The speakers are drawn at random and the groups designate their member who will take part in the debate. The aim of this variant is to make the children aware that the more people there are to defend the various points of view and interests, the more the debate becomes complex.

Each time someone goes 'on stage', a note is made on the blackboard of which characters have faced each other and of which arguments he/she put forward to defend his/her point of view.

Summary

When the role-playing is done, a summary of the arguments will make it possible to analyse the various performances. The arguments are organised according to different topics that may relate to deforestation or climate change in the Arctic.

Some of the risks and changes that might emerge:
Modification of cultural components (a break in knowledge transmission; displacement of populations linked to the creation of protected areas for deforestation or to the thawing of the permafrost for the Arctic; risk of standardising cultural values through the cultural invasion of a foreign society; risk of losing autonomy in local governance); destabilisation of equilibrium and ecosystems, loss of biodiversity, unknown risk associated with genetic manipulation, poor environmental management, risk of invasion by a foreign industry to exploit the local resources; changes to the local economic network.

Conclusion

It is important for the pupils to understand that each one of the various types of behaviour that are inherent to the various roles pursue the same aim: to improve their quality of life. As a result, the aim is for the pupils to get past this initial awareness and to consider ways of "improving the quality of life for each and every one of us" while preserving specific social and cultural distinctions, promoting access to economic resources and preserving the environment.

You are Halaya. You have a good understanding of the problems concerning your region and the creation of natural reserves.

You are Alibert. Coming from the North, you try to find solutions for Tobolo while also being active in your own country.

You are a worker in the saw-mill. Environmental organisations want to close part of the plant; you try to protect your job.

You are the director of the plant and want to increase the export of furniture overseas. By changing a part of the natural reserve, and exploiting new plantations, it will be possible to cut down even more trees in the future.

You are a tourist who likes to discover places off the beaten path. You want to photograph wild animals in their own habitat and are willing to do anything to bring back typical souvenirs and trophies (gleopard teeth)

You are the minister of Tobolo. You are trying to develop your country's economy that has already borrowed large sums from northern countries to build a telecommunications infrastructure and put together an army for protection against neighbouring countries.

You are Gen-Dhi, Halaya's grandfather. Your country has undergone many changes since your childhood: extinction of hundreds of animal and plant species, creation of the reserve, changes in Tobolese lifestyle.

You are an ecologist and part of a non-governmental organisation working towards environmental protection of the region.

You are a gleopard. Several years ago, your territory expanded as far as the eye could see and beyond and your population was high in numbers. Since 80% of the tropical forest, your home, has disappeared, you are now in danger of becoming extinct.

You hunt harinas. During your youth, there were many harinas in the waters of Nora-Bama. For the past few years, the numbers have been diminishing due to climactic changes.

You are Archill, a scientist having spent many years studying the climate. Optimistic by nature, you try to promote all activities aimed at reducing man's impact on the planet.

You are a fisherman hired by a large fishing company. Your boat furrows the ocean collecting enormous quantities of fish. As fish are becoming scarce, new, more effective fishing techniques must be developed.

You are Inu. You studied biology at the University of Torombo and specialised in biodiversity. Your work in Nora-Bama is to determine the influence of global warming on the flora and the fauna.

You are the director of an oil company and want to excavate in Nora-Bama to exploit recently discovered oil.

Nora-Bama is an island belonging to the Reunited States of Eularic. You are the governor of the province and need to consider everyone's interests for the good of the region.

You are the director of a travel agency that organises trips in the world's most remote areas (virgin forests, Polar Regions) and would like to build a hotel in Nora-Bama.

You are an old woman from Nora-Bama. Much has changed since your childhood: the climate has warmed; a village, airport and science station were built; plant and animal species have gone extinct.

You are a harina. You are suffering from the changes to your habitat: warming of the ocean; various pollutants; intensive hunting.