Climate Shift

Ocean Explorer

Module 7

Bayworld Centre for Research & Education

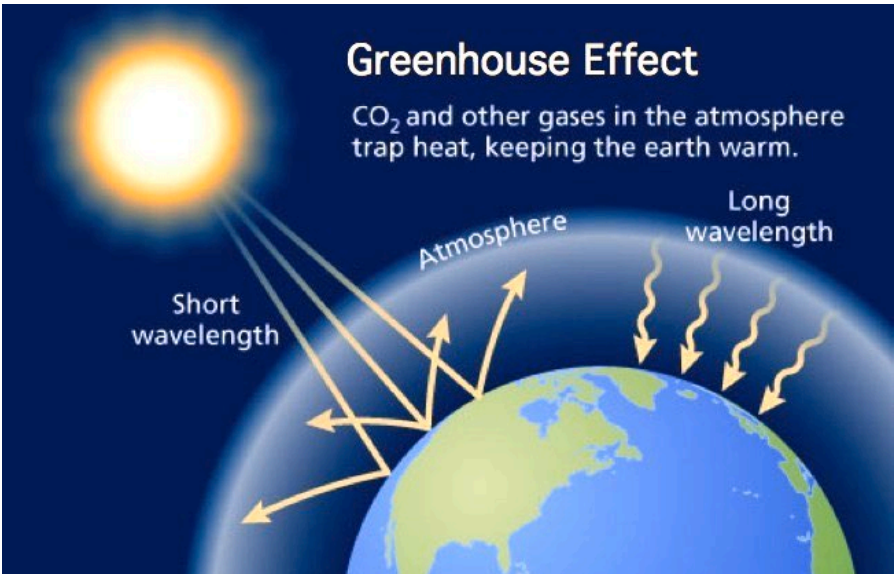
BCRE

Overview

1 - The greenhouse effect

The "greenhouse effect" is not the same as global warming. "Global warming" refers to the increase in global average temperature due to excessive amounts of greenhouse gases. The greenhouse effect describes a critical function of our atmosphere: to keep the earth warm enough to sustain life.

The greenhouse effect is similar to the process that goes on in a real greenhouse. The glass of a greenhouse allows the sun's radiation in, which warms the ground inside, which in turn warms the air above the ground by long-wave (heat) radiation. The glass then acts like a barrier to keep the warm air inside from mixing with the cooler air outside the greenhouse.

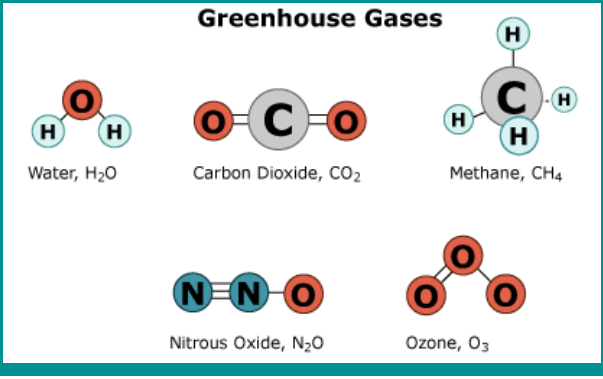


The greenhouse gases in the atmosphere allow the sun's short wavelength radiation in, and because of the chemical properties of the gases, they do not interact with sunlight. But they do absorb the long-wave radiation from the earth and emit it back into the atmosphere, different from a greenhouse which does not allow the long-wave radiation to escape through the glass. The increase in trapped energy leads to higher temperatures at the earth's surface.

Greenhouse gases are gases that absorb energy emitted from the earth and radiate it back into the atmosphere. If there are too many greenhouse gases, the earth could become too warm. If greenhouse gases dramatically decrease, the earth may be too cool for human activities, such as farming, planting, and harvesting, to occur.

Greenhouse gases are :

- Water vapor (H_2O)
- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous oxyde (N_2O)
- Ozone (O_3)
- Chlorofluorocarbons (CFCs)
- Hydrofluorocarbons (HFCs)



2 - Human impact and the enhanced greenhouse effect

Earth's atmosphere is made up of 78% nitrogen and 21% oxygen. Only about 1% is made up of natural greenhouse gases, but this comparatively small amount of gas makes a big difference. The Industrial Revolution brought new industrial processes, an increase in the burning of fossil fuels, more extensive agriculture, and a rapid increase in the world's population. This rapid increase in human activity led to the (still ongoing) emission of significant amounts of greenhouse gases into the atmosphere. We know this because of measurements made over the past 50 years and the

analysis of air bubbles trapped in ancient ice, which show that levels of carbon dioxide, methane, nitrous oxide and halocarbons are increasing.

The disruption to Earth's climate equilibrium caused by the increased concentrations of greenhouse gases has led to an increase in the global average surface temperatures. This process is called the enhanced greenhouse effect.

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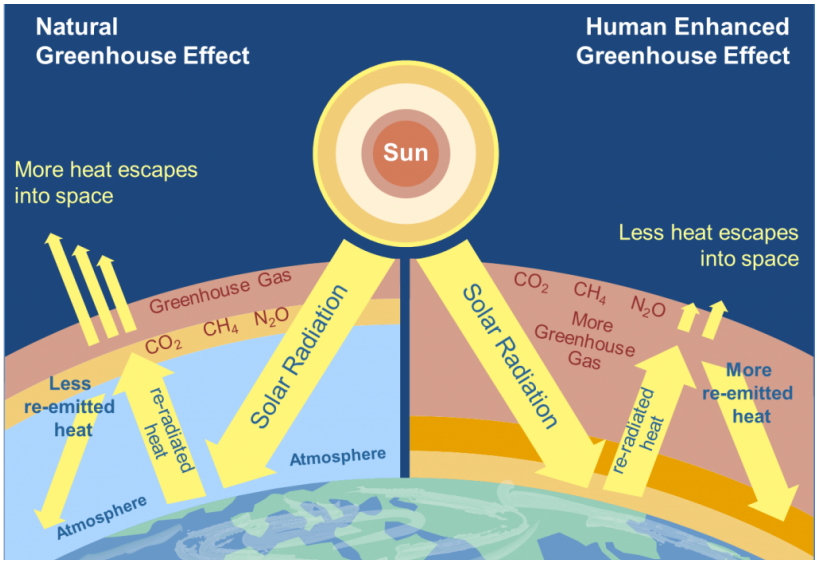
Ancient Ice & Air bubbles

Ice sheets have one special property : ice core records allow us to generate continuous reconstructions of past climate, going back at least 800,000 years ! By looking at past concentrations of greenhouse gasses in layers in ice cores, we can calculate how modern amounts of CO_2 and methane compare to those of the past, and model past temperatures.



While scientists agree that the levels of greenhouse gases and average global temperatures are rising, there is less certainty about what the future consequences will be. To help understand this, scientists use mathematical models. These models take account of many processes that together determine the behaviour of the atmosphere (e.g. temperature, humidity, wind speed and atmospheric pressure).

When talking about climate change, footprint is a metaphor for the total impact that something has. And carbon is a shorthand for all the different greenhouse gases that contribue to global warming.

The term **carbon footprint**, therefore, is a shorthand to describe the best estimate that we can get of the full climate change impact of something. That something could be anything – an activity, an item, a lifestyle, a company, a country or even the whole world.

Calculating the carbon footprint of one object is no easy task : the true carbon footprint of driving a car for example includes not only the emissions that come out of the exhaust pipe, but also all the emissions that take place when oil is extracted, shipped, refined into fuel and transported to the petrol station, not to mention the substantial emissions caused by producing and maintaining the car.

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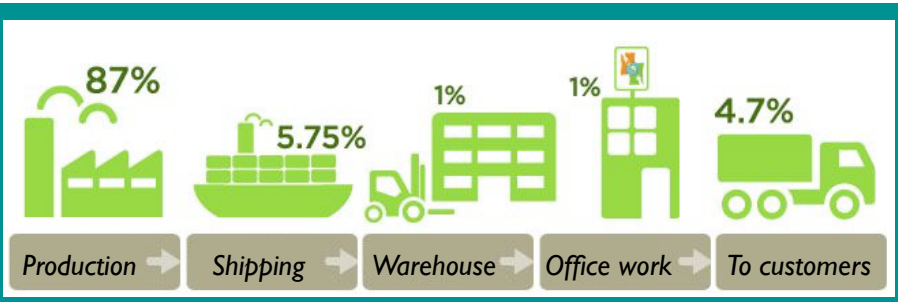
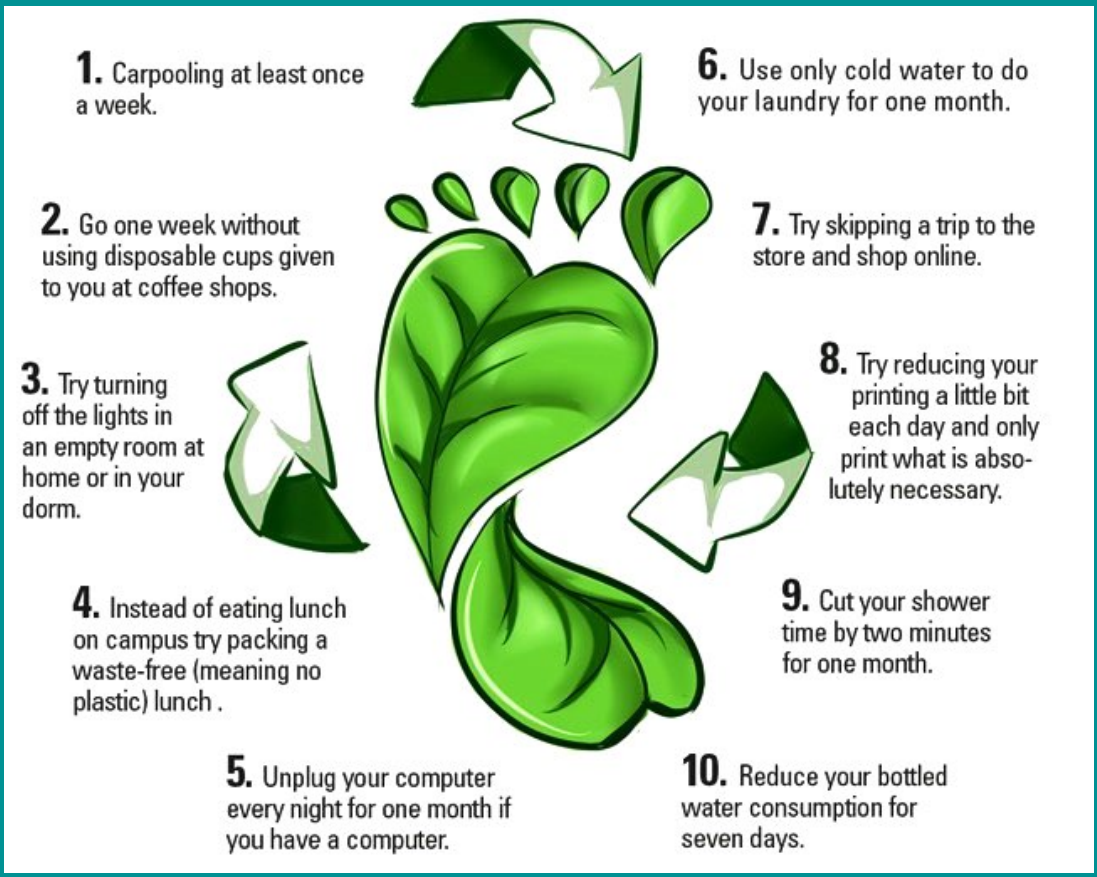
Calculate your carbon footprint

The most common abuse of the phrase carbon footprint is to miss out some or even most of the emissions caused, whatever activity or item is being discussed. For example, many online carbon calculator websites will tell you that your carbon footprint is a certain size based purely on your home energy and personal travel habits, while ignoring all of the goods and services you purchase !



A quick drawing of the carbon footprint of a product shipped to South Africa.
All of this is part of the carbon footprint of only one product !

Because we all contribute to the enhanced greenhouse effect on Earth, we need to change some of our habits and begin to think about what we can do to help reduce our carbon footprint. Here are 10 ideas for you to try at home !



4 - Ozone depletion

The ozone layer is a belt of the naturally occurring gas ozone. It sits 15 to 30 km above Earth in the region called the stratosphere, and serves as a shield from the harmful ultraviolet B (UVB) radiation emitted by the sun.

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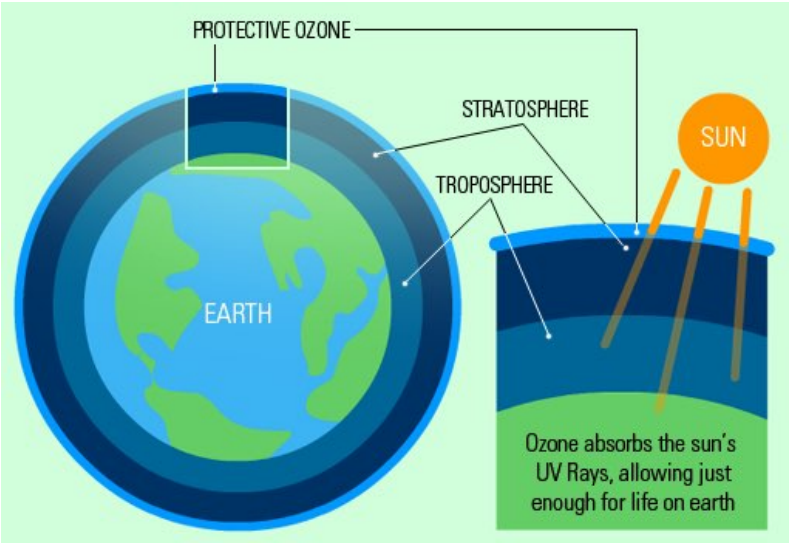
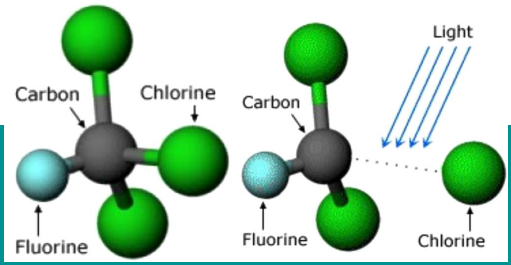
UVBs are one of the most harmful sun rays, as they can cause skin cancer and cataracts. These rays also perturb the life cycle of many animals and if too intense might lead to the disappearance of species.

Today, the ozone layer is deteriorating due to the release of pollution containing the chemicals chlorine and bromine. Such deterioration allows large amounts of ultraviolet B rays to reach Earth.



How is the Ozone layer destroyed ?

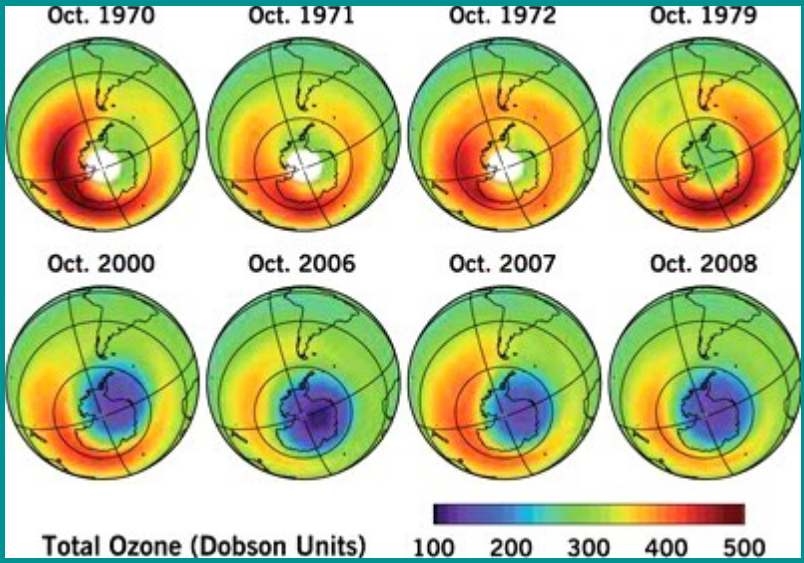
Chlorofluorocarbons (CFCs), chemicals found mainly in spray aerosols heavily used by industrialised nations for much of the past 50 years, are the primary culprits in ozone layer breakdown. When CFCs reach the upper atmosphere, they are exposed to ultraviolet rays, which causes them to break down into substances that include chlorine. The chlorine reacts with the oxygen atoms in ozone and rips apart the ozone molecule. One atome of chlorine can destroy up to 100 000 molecules of Ozone !



The CFC molecules react with light once in the stratosphere and breaks into chlorine.

The "hole" in the Ozone layer

The ozone layer above the Antarctic has been particularly impacted by pollution since the mid-1980s. This region's low temperatures speed up the conversion of CFCs to chlorine. In the southern spring and summer, when the sun shines for long periods of the day, chlorine reacts with ultraviolet rays, destroying ozone on a massive scale, up to 65%. This is what some people erroneously refer to as the "ozone hole." In other regions, the ozone layer has deteriorated by about 20%.



Ozone layer recovery

No one knows for certain how much more ozone depletion will occur. It takes years for CFCs and other ozone-depleting compounds to reach the stratosphere. Many of them can persist in the stratosphere for centuries : some have life spans of 25 to 400 years ! Almost all of the CFCs and halons ever released are still in the atmosphere and will continue to destroy ozone for many years to come.

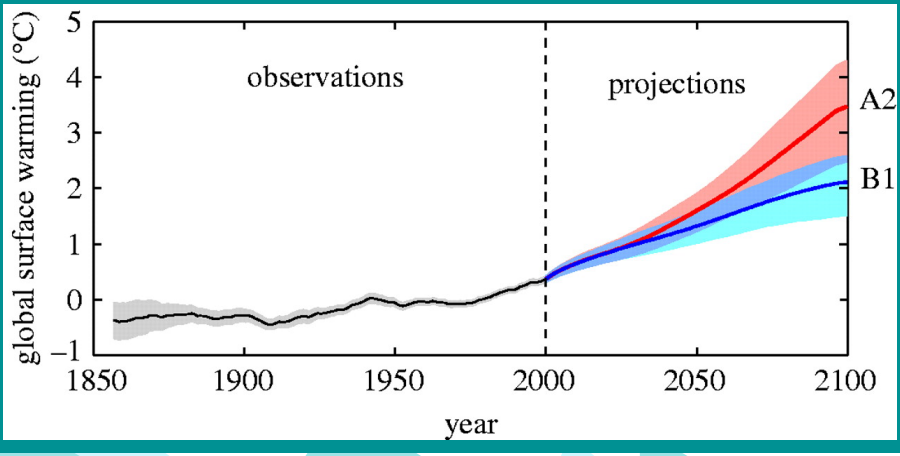
Scientists estimate it will take another 50 years for chlorine levels to return to their natural levels.

Future climate changes cannot be simply extrapolated from past climate. Non-linear processes must be taken into account, along with a range of plausible future greenhouse gas and aerosol concentration pathways. The best tools for projecting climate change are global climate models (GCMs).

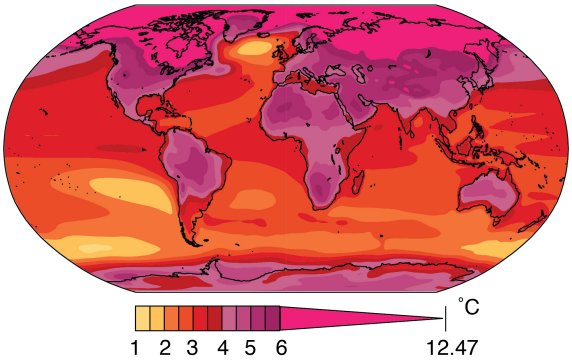
These models are mathematical representations of the climate system run on powerful computers. They represent large-scale synoptic features of the atmosphere, such as the progression of high and low pressure systems, and large scale oceanic currents.
Although these models work quite well in describing a general trend, their predictions for a specific region are not as accurate. As with any tool, it is important to understand its strengths and limitations in order to use it properly.

A model will give predictions or projections depending on the parameters that were entered into it at first (actual temperature, population levels, amounts of greenhouse gases emitted per year…). The observations are very important to calibrate the model.

Here, two scenarios were run, A1 and B1, with different parameters. The results are then totally different.

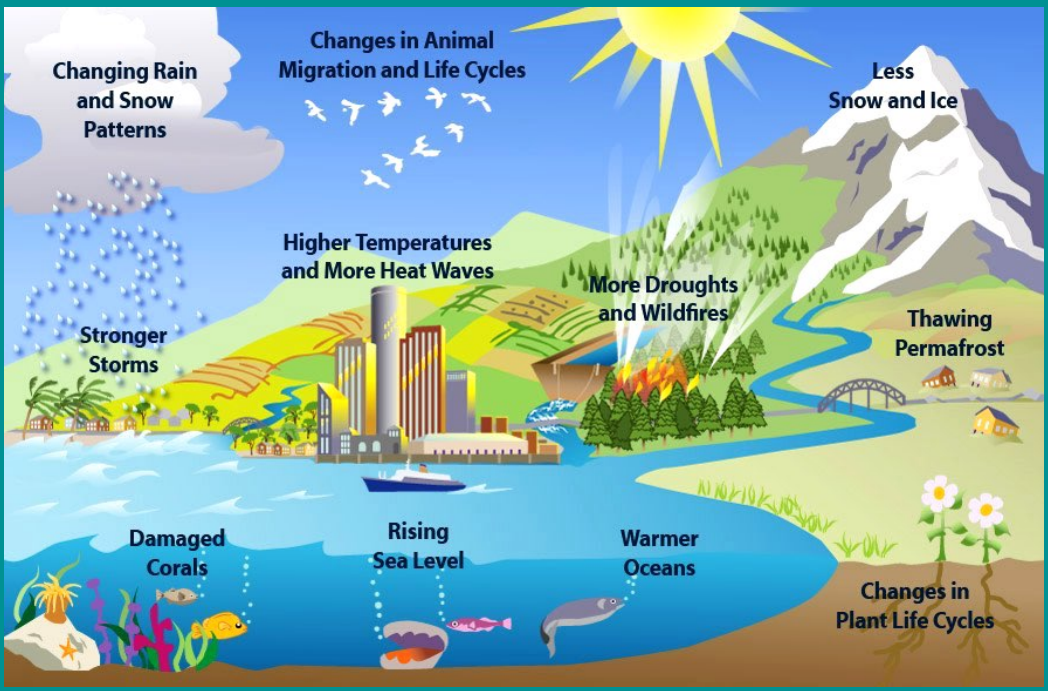


Changes in annual temperatures (year 2100)



Concerning the climate on Earth, every model depicts a warmer future. Some are very extreme, others only up the temperatures by a few degrees. However, keep in mind that even a single degree more on the Earth's general temperature level is enough to create profond changes, such as sea levels rising and desert locations moving.

What will happen if the global warming continues ?



Question

What will cause each of the 4 scenarios below ? Link the parameters given to each result.

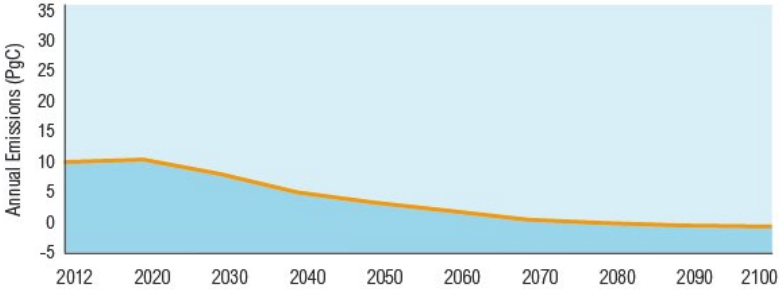
Parameters

- No reduction of the greenhouse gas emissions at all
- Reduction of the greenhouse gas emissions
- Reduction of use of manufactured goods
- Increase of use of manufactured goods
- Development of renewable energies
- Use of petrol and non-renewable energies
- Reduction of waste per person per annum
- Increase of waste per person per annum
- Population growth
- Stable population
- Deforestation continues
- Deforestation reduced / stopped

Some predictions tell us that it might already be too late to change our habits and save most of the biodiversity on Earth.
Whatever we do, life will go on and Earth will survive, but if we unleash catastrophes because of global warming, humans might not be part of the future.

LOW EMISSIONS PATHWAY

Carbon dioxide emissions peak by 2020 and then drop 66 percent below 2010 levels by 2050. While the world will still experience some climate impacts under this pathway, they grow exponentially worse under higher emissions scenarios.



Global temperature increases by up to 2°C.[1]

About 24% more of the projected global population will face reduced renewable groundwater resources by the 2080s compared to the 1980s.

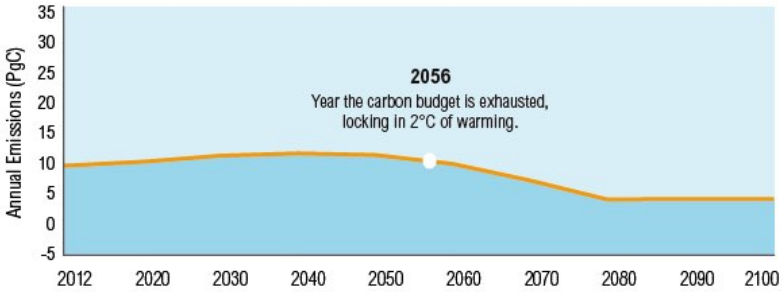
In the 2080s, about 4 times as many people are expected to be annually exposed to the amount of water associated with a 100-year flood compared to the 1980s.

Roughly one-third of the world's coral reefs, which provide habitat and resources to more than 500 million people, will experience long-term degradation over the next few decades.

Australasia provides more than 40% of global dairy products. With 1°C of warming by 2030, dairy production will likely decline throughout Australia.

MEDIUM EMISSIONS PATHWAY

Carbon dioxide emissions peak by 2040, but still rise 19 percent above 2010 levels by 2050.



Global temperature increases by up to 2.9°C.

About 26% more of the projected global population will face reduced renewable groundwater resources by the 2080s compared to the 1980s.

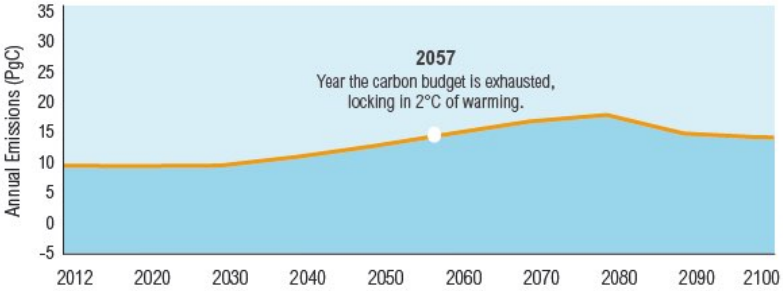
In the 2080s, about 6 times as many people are expected to be annually exposed to the amount of water associated with a 100-year flood compared to the 1980s.

Roughly two-thirds of the world's coral reefs will experience long-term degradation over the next few decades.

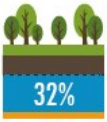
Climate change impacts like heat stress are expected to negatively impact workers and decrease global productivity by 20 percent by 2100.

HIGH EMISSIONS PATHWAY

Carbon dioxide emissions peak by 2080, but still rise 34 percent above 2010 levels by 2050.



Global temperature increases by up to 3.7°C.



About 32% more of the projected global population will face reduced renewable groundwater resources by the 2080s compared to the 1980s.

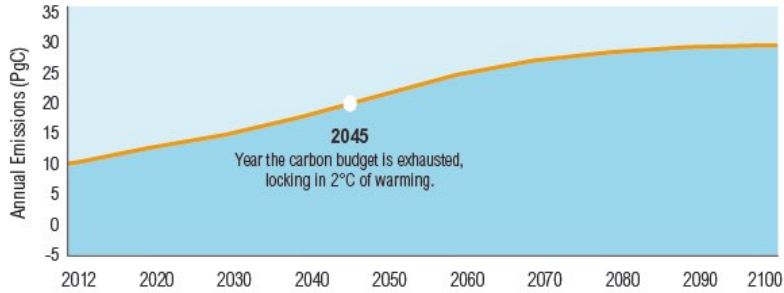
In the 2080s, about 7 times as many people are expected to be annually exposed to the amount of water associated with a 100-year flood compared to the 1980s.

Ranges of many of the world's plant and animal species will decrease by more than 50 percent by the 2080s with 3.5°C of warming.

With temperature increases of 3-4°C, agricultural production and global food security could see negative impacts so large-scale they cannot be adapted to.

HIGHEST EMISSIONS SCENARIO

Annual carbon dioxide emissions continue to rise through 2100, rising 108 percent above 2010 levels by 2050.



Global temperature increases by up to 4.8°C.

About 38% more of the projected global population will face reduced renewable groundwater resources by the 2080s compared to the 1980s.

In the 2080s, about 12 times as many people are expected to be annually exposed to the amount of water associated with a 100-year flood compared to the 1980s.

More than 4°C of temperature rise will likely bring decreased agricultural production, loss of critical ecosystem functions, and extinction of many animal and plant species.

Soybean yields in the Amazon would drop 44 percent by 2050. With higher amounts of warming, coffee farming could be virtually impossible in Southeastern Brazil in 2100.