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EARTH AND ITS RESOURCES
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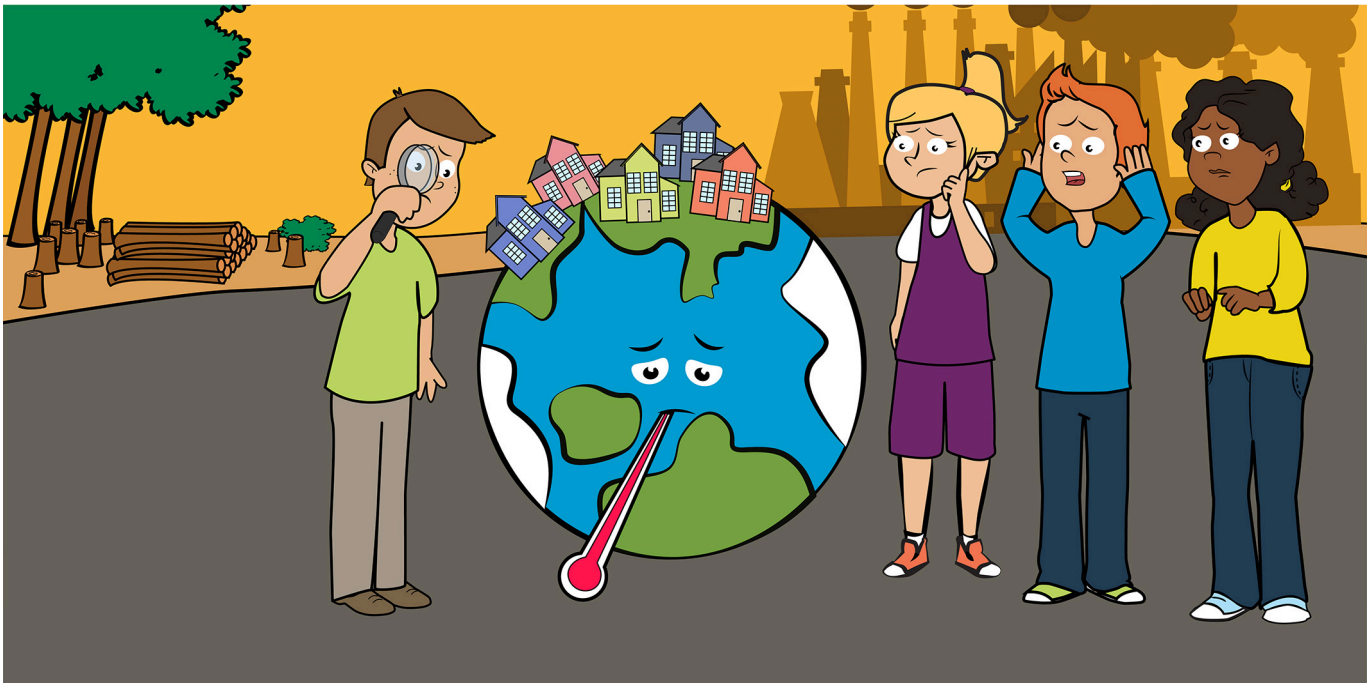

HOW WILL CLIMATE CHANGE AFFECT WHERE YOU LIVE?

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In recent times, scientists have seen large changes in our planet's climate. Although climate change is a global issue, the effects of climate change are not the same around the world. Each continent, country, and area will experience different effects. These effects include different speeds of warming or, in some places, cooling, and changes to rain- and snowfall. Since the climate is global, what happens in other places can also impact the place where you live. In this article, you will learn how various places on Earth have been affected by climate change up to now. We will also show you what kind of climate changes can be expected in the future.

GREENHOUSE GAS

Gases from human activities that end up in the Earth's atmosphere and trap heat from the sun, leading to global warming. Examples are carbon dioxide (CO_2), methane, and water vapor.

WHAT HAS CHANGED IN EARTH'S CLIMATE?

In recent decades, there has been an increase in Earth's air temperature. What caused this increase? The warming temperatures are related to **greenhouse gas emissions**, including the release of

EMISSIONS

The amount of **greenhouse gases** released into the atmosphere.

carbon dioxide (CO_2), into the atmosphere. Greenhouse gas emissions are mainly caused by human activities, such as the burning of fossil fuels to power our cars and to make electricity. Greenhouse gases in the atmosphere are also increasing because of the decrease in Earth's forested areas. We experience this human-made climate change as changes in things like the average air temperature and average rainfall during a certain period.

The average global temperature has increased by 1.2°C since the late 1800s. Figures 1A,B show the global average air temperature for 2018 and 2020, compared with the past period from 1981 to 2010. Despite a separation of only 1 year, there were big differences in the pattern of temperature change. In 2018, the Arctic was warmer, except for a part of Siberia. At the same time, Northern America was colder than before (Figure 1A). However, in 2020, the Arctic was much warmer, mainly over Siberia (Figure 1B). At the same time, some regions of Antarctica were colder than they have been. What does this mean? These data show that the climate naturally changes a little from year to year, and that it is normal for some years to be colder or warmer than others. But when we average the temperature for the whole globe, we see that it has gotten much warmer during the last 40 years (Figure 1C). Although 2018 was colder than the previous years, its annual average temperatures were much warmer compared with temperatures seen in the 1980s. The highest temperatures ever recorded have been seen in the last few years (2016 and 2020).

What are the consequences of global warming? Well, for example, since the late 1970s, the area of Arctic sea ice has decreased around 4% every 10 years [1]. Glaciers are getting thinner and shorter, not only

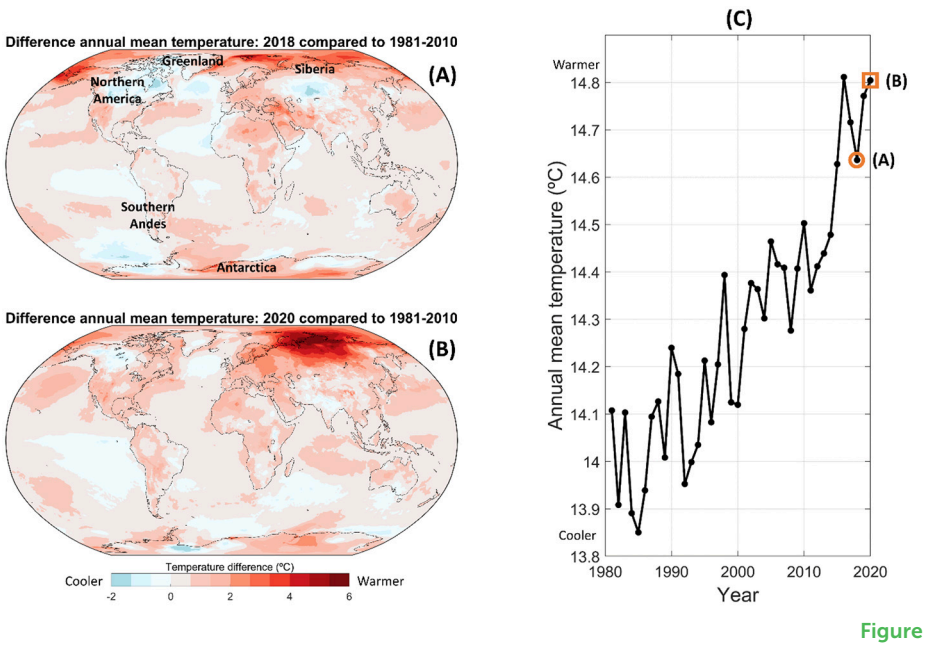

Figure 1

(A) Difference in average air temperature between 2018 and the years 1981–2010. **(B)** Difference in average air temperature between 2020 and the years 1981–2010. Red shows warmer and blue cooler temperatures than in the past years. **(C)** Global average air temperatures from 1981 until 2020. Note that the orange circle and square mark the years 2018 and 2020 that are shown in **(A,B)**.

in polar regions like Antarctica, Greenland, and North America, but also in high mountain regions, such as those in the Southern Andes and in Asia [1]. The ocean is also getting warmer: in recent years, the surface of the ocean has warmed by 0.11°C each decade [1]. This has caused **coral bleaching**, which means that the coral turned white. From 2014 to 2017, coral bleaching affected more than 70% of the world's coral reefs. Severe weather events, such as flooding and storms, have been occurring more often across the planet. The sea level has risen because of the warming ocean and melting glaciers, and this affects coastal areas. Global average sea levels have risen from 1 to 2 mm each year over the twentieth century, and now more than 3 mm each year, and the speed of this sea level rise is increasing [1]. Due to human activity, the amount of CO_2 in the air has increased more than 40% since 1750 [1].

CORAL BLEACHING

When corals lose their source of food, causing them to turn white and more vulnerable to diseases. This can happen due to changes in temperature, light, or nutrients.

HOW DO WE KNOW WHAT WILL HAPPEN IN THE FUTURE?

Scientists use **climate models** to understand what happened to Earth's climate in the past and what is likely to happen in the future. These models are run on computers and use complex formulas that describe the links between the air, ocean, land, and ice-covered regions. Around the world, research centers create models using different scenarios of greenhouse gas emissions (such as the amount of CO_2 that is released into the atmosphere). These models help to explain how human activities may need to change in the future, to reduce greenhouse gas emissions. Climate models also take into account future increases in the world's population and changes in the world's economy (more sustainable development or larger use of fossil fuels, investment in health and education, changes in climate strategies). In the best-case scenario, people will take urgent action to reduce their greenhouse gas emissions and as a result, climate change will slow down. In the worst-case scenario, nothing is done to reduce CO_2 and global warming will continue to get worse.

CLIMATE MODELS

Models run in computers and based in complex formulas to simulate the factors that can affect Earth's climate, such as the links between the air, ocean, land, and ice-covered regions.

HOW WILL FUTURE CLIMATE CHANGE AFFECT VARIOUS LOCATIONS?

In the future, the average temperature across the world is expected to increase. However, some regions might warm more quickly than others. As shown in Figures 2A,B, land regions are likely to warm faster than the oceans. At the same time, the Arctic will warm faster than the tropics. This unequal warming is caused by differences in the type of surface. The land is quicker to warm than the water, which leads to slower warming of the oceans. The Arctic changes faster than the tropical regions due to a process called **Arctic amplification**. Arctic amplification happens because the whiter sea ice reflects more sunlight than the darker ocean, which absorbs most of the sunlight

ARCTIC AMPLIFICATION

Phenomenon known as the faster warming of the Arctic when compared to other regions of the world, during the last decades.

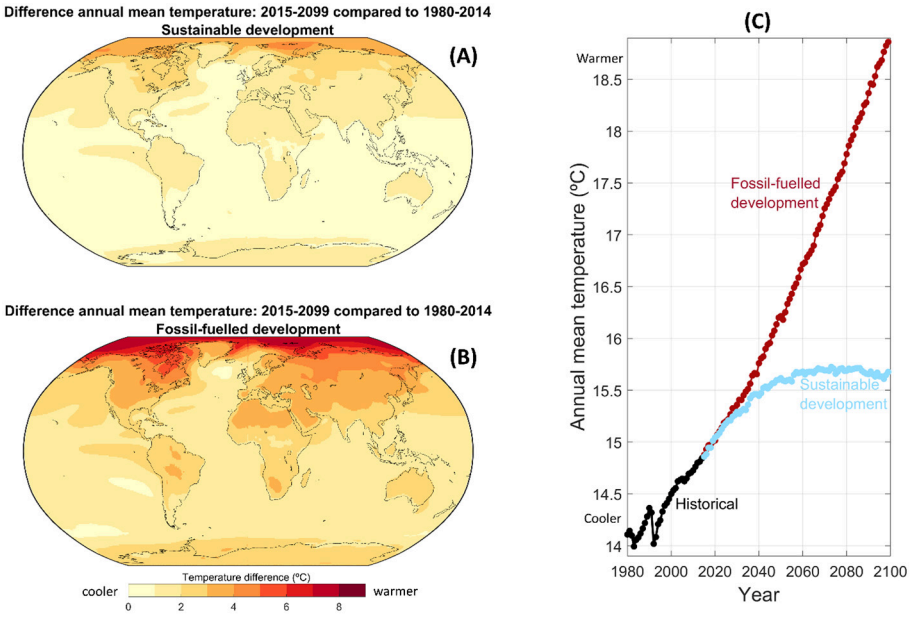

Figure 2

Figure 2

Difference in air temperature between future (2015–2099) and past years (1980–2014). **(A)** In the best-case scenario (sustainable development) where we act to decrease CO_2 emissions, air temperature increase stays below 4°C. **(B)** In the worst-case scenario (fossil-fuelled development), where CO_2 emissions increase, an 8°C warming is expected. Red colors show more warming. **(C)** Temperature record from 1980 until 2099. You can see that in the best-case scenario (blue line) the increase in annual mean temperature stays under 2°C by 2099, while in the worst-case scenario (red line) it can go up to 5°C.

that hits it. Sunlight absorption causes ocean warming and leads to sea ice melting. Melting of sea ice increases the area of the darker ocean, which then absorbs even more sunlight and gets even warmer, melting more sea ice. This process keeps going on.

If nothing is done, it is expected that the global air temperature will increase by 2°C by the year 2050. By the year 2100, a rise of 5°C is expected. However, if we act now to reduce CO_2 emissions, global warming could be <2°C by 2100 (Figure 2C) [2].

Since climate change is not equal around the world, people will experience different impacts depending on where they live [3]. Figure 3 shows how future climate change will affect specific areas. If you live in a coastal region, you might expect more flooding, due to sea level rise. On the other hand, the inland regions are expected to have less rainfall, on average, which will increase drought and bushfires in many regions. In the case of big cities, cars and factories cause pollution, which affects human health. In rural regions, climate change is expected to affect agriculture, which may impact the food supply. Also, we cannot forget the ocean and the **cryosphere**—the frozen part of Earth. These areas play important roles in many of the Earth's systems, since the oceans and cryosphere are responsible for the absorption and distribution of CO_2 and heat. This means that they can also accelerate temperature increase by changing how heat is absorbed and distributed. Global warming will continue to reduce the sea ice, glaciers, and ice sheets in areas including Antarctica. These changes affect not only humans, but also the ecosystems of the animals that live in these cold areas.

CRYOSPHERE

The part of Earth's surface with frozen water (snow and ice, over land, or ocean).

Figure 3

How climate change may affect specific regions in the future.

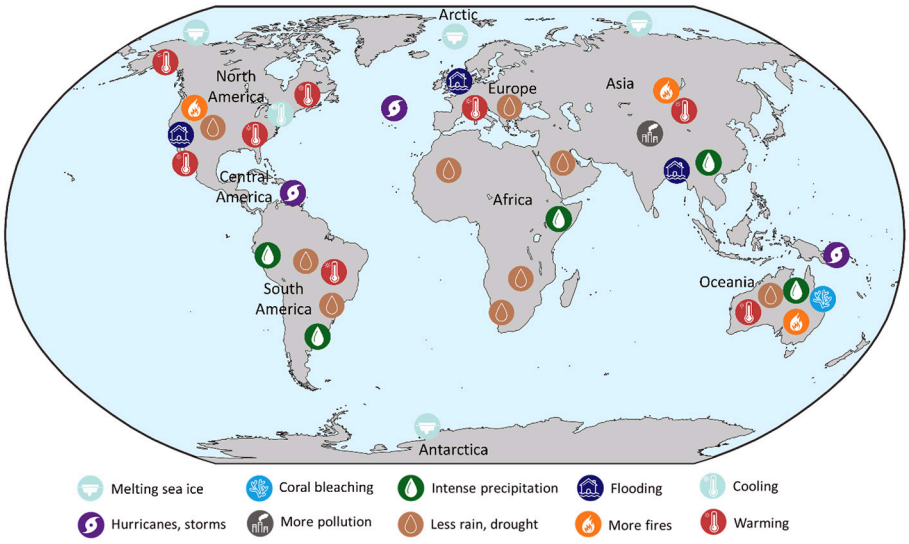

Figure 3

Focusing on specific regions, more wildfires are expected in North America, mainly over the West Coast (for example, in California). At the same time, more flooding is expected in coastal regions. In Central America, hurricanes are likely to happen more often. In South America, Amazonia might receive less rain, causing drought. This might affect the plant and animal life in this region. Similar changes are expected in Africa, where drought can affect the health of the human population due to effects on food and water supplies. In Oceania, less rainfall is likely, which may cause more forest fires and extremely hot temperatures. In this area, the increased ocean temperature is causing coral bleaching. Coral bleaching is associated with a loss of plant and animal species, some of which only exist in regions like the Great Barrier Reef. In Europe, higher air temperature and less rain are likely, which may cause more frequent extreme hot temperatures and droughts. These changes may affect farming and energy production. In Asia, expected changes vary depending on the region: extremely hot temperatures, droughts, heavy rain events, melting of glaciers, wildfires, and more pollution may happen across this area. Due to the population growth across Asia, a lot of people will be affected. Figure 3 shows how climate change is predicted to affect various regions in the future.

SUMMARY

During the last 40 years global air temperatures have increased by over 1°C, with important impacts being already observed, although they depend on the region where you live. In the future, global warming is expected to continue, with some regions warming faster than others. If we reduce CO_2 emissions, global air temperature increase can be <2°C by 2100, if not, a warming of 5°C is expected by 2100.

How can you help reduce climate change? First, it is important that you keep learning more about how our planet works to understand the climate, and what is causing climate change and its impacts. You can start from changing simple things in your daily routine to minimize global warming, such as walk or bike to school or recycle. With this information you can explain your parents and friends about this subject and try to convince them to change some of their habits that can help to reduce climate change.

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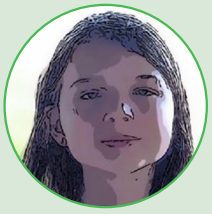

ASPEN, AGE: 9

Hi, my name is Aspen, I live in the U.S. and I like the outdoors and hiking. I am in 4th grade, and my favorite subjects are art, music, math, and Spanish. I love to read, particularly fantasy novels and series. I am very excited to be working with Frontiers for Young Minds!

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I am currently a Ph.D., student at the Department of Physics at the University of Aveiro, Portugal. In my Ph.D., work I study atmospheric rivers (known as rivers in the sky) in the Arctic, and their influence on precipitation in Arctic's present and future climate. Before starting my Ph.D., I completed a master's degree in meteorology and physical oceanography. I am also a member of the Association of Polar Early Career Scientists (APECS) Portugal. *carolinaviceto@ua.pt

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I am a glaciologist focusing on remote sensing of Antarctic sea ice. I work alongside Dr. Wongpan at the Australian Antarctic Program Partnership, a part of the Institute for Marine and Antarctic Studies at the University of Tasmania, Australia. I completed my Ph.D. at the University of Tasmania in 2011 and have since undertaken post-doctoral research fellowships both in Tasmania and at Hokkaido University's Institute of Low Temperature Science, Japan. Climate change continues to surprise me: last time I was in Antarctica, I was unexpectedly rained on (in June)!