

# Frequently Asked Questions

# FAQ

## Frequently Asked Questions

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These Frequently Asked Questions have been extracted from the chapters of the underlying report and are compiled here. When referencing specific FAQs, please reference the corresponding chapter in the report from where the FAQ originated (e.g., FAQ 3.1 is part of Chapter 3).

## FAQ 2.1 | The Earth's Temperature Has Varied Before. How Is the Current Warming Any Different?

*Earth's climate has always changed naturally, but both the global extent and rate of recent warming are unusual. The recent warming has reversed a slow, long-term cooling trend, and research indicates that global surface temperature is higher now than it has been for millennia.*

While climate can be characterized by many variables, temperature is a key indicator of the overall climate state, and global surface temperature is fundamental to characterizing and understanding global climate change, including Earth's energy budget. A rich variety of geological evidence shows that temperature has changed throughout Earth's history. A variety of natural archives from around the planet, such as ocean and lake sediments, glacier ice and tree rings, shows that there were times in the past when the planet was cooler, and times when it was warmer. While our confidence in quantifying large-scale temperature changes generally decreases the farther back in time we look, scientists can still identify at least four major differences between the recent warming and those of the past.

**It's warming almost everywhere.** During decades and centuries of the past 2000 years, some regions warmed more than the global average while, at the same time, other regions cooled. For example, between the 10th and 13th centuries, the North Atlantic region warmed more than many other regions. In contrast, the pattern of recent surface warming is globally more uniform than for other decadal to centennial climate fluctuations over at least the past two millennia.

**It's warming rapidly.** Over the past 2 million years, Earth's climate has fluctuated between relatively warm interglacial periods and cooler glacial periods, when ice sheets grew over vast areas of the northern continents. Intervals of rapid warming coincided with the collapse of major ice sheets, heralding interglacial periods such as the present Holocene Epoch, which began about 12,000 years ago. During the shift from the last glacial period to the current interglacial, the total temperature increase was about 5°C. That change took about 5000 years, with a maximum warming rate of about 1.5°C per thousand years, although the transition was not smooth. In contrast, Earth's surface has warmed approximately 1.1°C since 1850–1900. However, even the best reconstruction of global surface temperature during the last deglacial period is too coarsely resolved for direct comparison with a period as short as the past 150 years. But for the past 2000 years, we have higher-resolution records that show that the rate of global warming during the last 50 years has exceeded the rate of any other 50-year period.

**Recent warming reversed a long-term global cooling trend.** Following the last major glacial period, global surface temperature peaked by around 6500 years ago, then slowly cooled. The long-term cooling trend was punctuated by warmer decades and centuries. These fluctuations were minor compared with the persistent and prominent warming that began in the mid-19th century when the millennial-scale cooling trend was reversed.

**It's been a long time since it's been this warm.** Averaged over the globe, surface temperatures of the past decade were probably warmer than when the long cooling trend began around 6500 years ago. If so, we need to look back to at least the previous interglacial period, around 125,000 years ago, to find evidence for multi-centennial global surface temperatures that were warmer than now.

Previous temperature fluctuations were caused by large-scale natural processes, while the current warming is largely due to human causes (see, for example, FAQ 1.3, FAQ 3.1). But understanding how and why temperatures have changed in the past is critical for understanding the current warming and how human and natural influences will interact to determine what happens in the future. Studying past climate changes also makes it clear that, unlike previous climate changes, the effects of recent warming are occurring on top of stresses that make humans and nature vulnerable to changes in ways that they have never before experienced (for example, see FAQ 11.2, FAQ 12.3).

FAQ 2.1 (continued)

## FAQ 2.1: How is this global warming different to before?

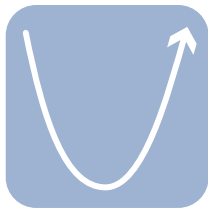
Climate has always changed, but warming like that of recent decades has not been seen for millennia or longer.



It is warming almost everywhere



It is warming rapidly



The warming reversed a long-term cooling



It has been a long time since it has been this warm

FAQ 2.1, Figure 1 | Evidence for the unusualness of recent warming.

## FAQ 2.2 | What Is the Evidence for Climate Change?

*The evidence for climate change rests on more than just increasing surface temperatures. A broad range of indicators collectively leads to the inescapable conclusion that we are witnessing rapid changes to many aspects of our global climate. We are seeing changes in the atmosphere, ocean, cryosphere, and biosphere. Our scientific understanding depicts a coherent picture of a warming world.*

We have long observed our changing climate. From the earliest scientists taking meteorological observations in the 16th and 17th centuries to the present, we have seen a revolution in our ability to observe and diagnose our changing climate. Today we can observe diverse aspects of our climate system from space, from aircraft and weather balloons, using a range of ground-based observing technologies, and using instruments that can measure to great depths in the ocean.

Observed changes in key indicators point to warming over land areas. Global surface temperature over land has increased since the late 19th century, and changes are apparent in a variety of societally relevant temperature extremes. Since the mid-1950s the troposphere (i.e., the lowest few km of the atmosphere) has warmed, and precipitation over land has increased. Near-surface specific humidity (i.e., water vapour) over land has increased since at least the 1970s. Aspects of atmospheric circulation have also evolved since the mid-20th century, including a poleward shift of mid-latitude storm tracks.

Changes in the global ocean point to warming as well. Global average sea surface temperature has increased since the late 19th century. The heat content of the global ocean has increased since the 19th century, with more than 90% of the excess energy accumulated in the climate system being stored in the ocean. This ocean warming has caused ocean waters to expand, which has contributed to the increase in global sea level in the past century. The relative acidity of the ocean has also increased since the early 20th century, caused by the uptake of carbon dioxide from the atmosphere, and oxygen loss is evident in the upper ocean since the 1970s.

Significant changes are also evident over the cryosphere – the portion of the Earth where water is seasonally or continuously frozen as snow or ice. There have been decreases in Arctic sea ice area and thickness and changes in Antarctic sea ice extent since the mid-1970s. Spring snow cover in the Northern Hemisphere has decreased since the late-1970s, along with an observed warming and thawing of permafrost (perennially frozen ground). The Greenland and Antarctic ice sheets are shrinking, as are the vast majority of glaciers worldwide, contributing strongly to the observed sea level rise.

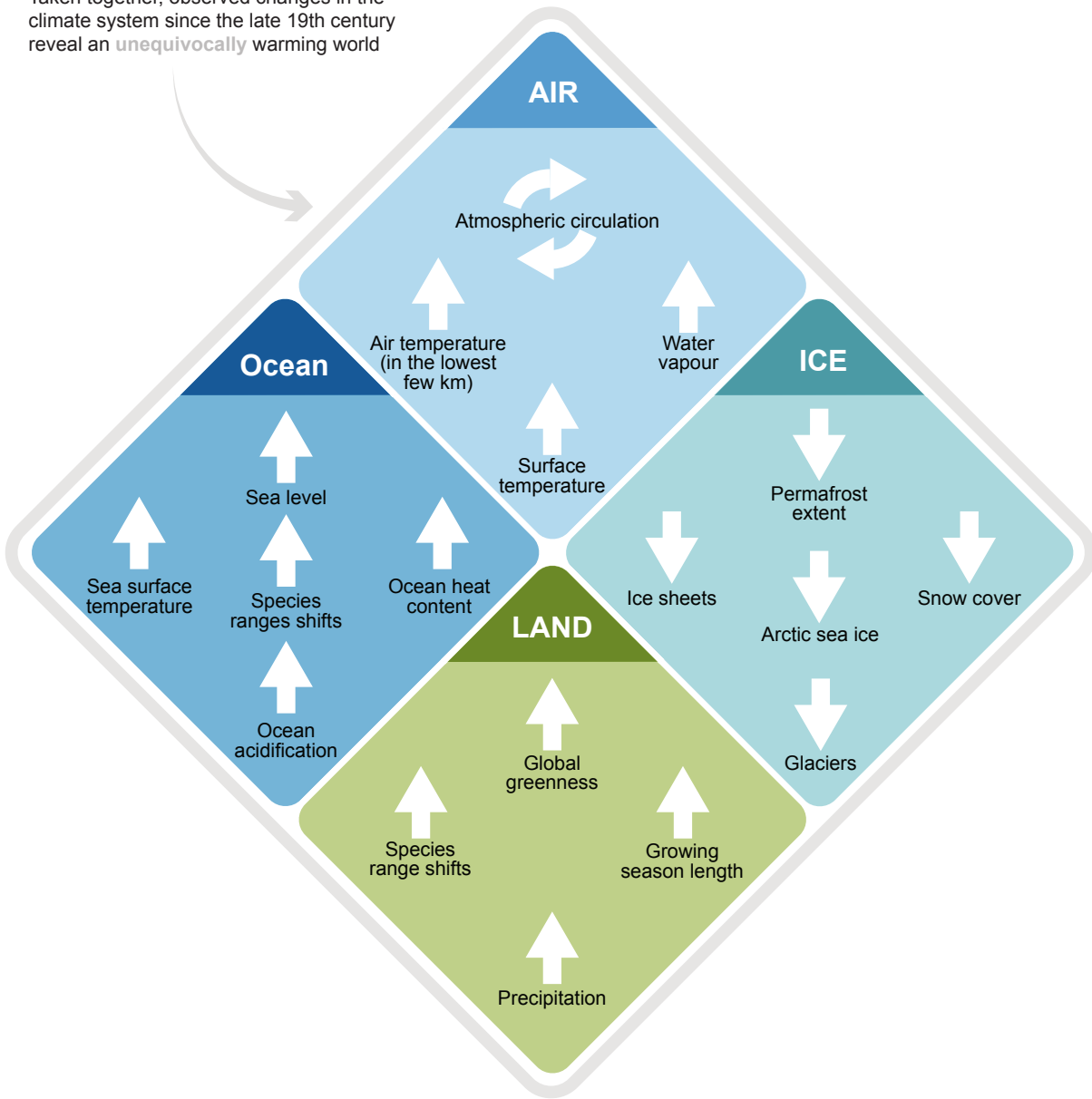
Many aspects of the biosphere are also changing. Over the last century, long-term ecological surveys show that many land species have generally moved poleward and to higher elevations. There have been increases in green leaf area and/or mass (i.e., global greenness) since the early 1980s, and the length of the growing season has increased over much of the extratropical Northern Hemisphere since at least the mid-20th century. There is also strong evidence that various phenological metrics (such as the timing of fish migrations) for many marine species have changed in the last half century.

Change is apparent across many components of the climate system. It has been observed using a very broad range of techniques and analysed independently by numerous groups around the world. The changes are consistent in pointing to a climate system that has undergone rapid warming since the industrial revolution.

FAQ 2.2 (continued)

**FAQ 2.2: What is the evidence for climate change?**

Taken together, observed changes in the climate system since the late 19th century reveal an unequivocally warming world



**FAQ 2.2, Figure 1 | Synthesis of significant changes observed in the climate system over the past several decades.** Upwards, downwards and circling arrows indicate increases, decreases and changes, respectively. Independent analyses of many components of the climate system that would be expected to change in a warming world exhibit trends consistent with warming. Note that this list is not comprehensive.

FAQ