Future Effects of Climate Change in the U.S.

By John Benson

January 2025

1. Introduction

I write occasionally about the title subject, but a highly respected body just released (in December) a publication. This is rich in information on the likely pain that our economy is likely to feel as a result of this human-caused modification to the world's environment, it is likely to strongly impact future laws that the federal government is likely to implement.[1]

The Congressional Budget Office provides non-partisan analysis and reporting for the U.S. Congress. This report was prepared at the request of the Chairman of the Senate Budget Committee. In keeping with the Congressional Budget Office's mandate to provide objective, impartial analysis, the report makes no recommendations.

The economic effects of climate change will depend on the extent of its physical effects. Those effects are highly uncertain. The Congressional Budget Office estimates that by 2100, there is a 5 percent chance that average global temperatures will be more than 4 degrees Celsius (4°C) warmer than they were in the latter half of the 19th century and an equal chance that they will have risen by less than 2°C. In the United States, sea levels have a 5 percent chance of rising by about 4 feet or more by 2100 and an equal chance of rising by about 2 feet or less. Damage from natural disasters is also expected to increase.

The uncertainty of climate change's physical effects implies a wide range of possible economic consequences, ranging from benign to catastrophic. In this report, CBO focuses, where possible, on the 5th and 95th percentiles of the distributions of potential outcomes. The report examines the possible economic effects of climate change on gross domestic product (GDP), real estate markets, and other areas that influence the economy and the federal budget.

- ***Effect on GDP.*** *In CBO's estimation, there is a 5 percent chance that GDP will be at least 21 percent lower in 2100 than it would have been if temperatures remained stable after 2024 and an equal chance that GDP will be at least 6 percent higher. In CBO's central estimate, GDP would be 4 percent lower than if temperatures remained unchanged.*
- ***Effects on Real Estate Markets.*** *CBO estimates that with roughly 4 feet of sea-level rise, recurring flooding would cause the loss of residential property currently worth $930 billion—roughly 2 percent of the total value. A rise of about 2 feet would cause losses of $250 billion. Those losses would mostly be borne by property owners, mortgage lenders, insurance companies, and the federal government.*

[1] Caroline Nielsen, Robert Shackleton (formerly of CBO), Chad Shirley, and William Swanson, Congressional Budget Office (CBO), "The Risks of Climate Change to the United States in the 21st Century" December, 2024, https://www.cbo.gov/system/files/2024-12/60845-climate-risk.pdf

- ***Other Consequences.*** *Climate change will raise mortality rates and rates of illness, especially if increases in temperature are large, though adaptations will mitigate those effects. It will also harm ecosystems that provide food, clean air and water, medicines, and other useful products. Some effects of climate change will increase immigration to the United States and raise defense costs. Hotter temperatures and more intense natural disasters will disproportionately affect low-income households, minority communities, and residents of the Southeast.*

The effects of climate change will be more severe if components of the climate system reach certain critical thresholds, sometimes called tipping points. Crossing those thresholds would accelerate greenhouse gas emissions, cause major ice sheets to melt completely, or shift ocean circulation and weather patterns. The temperature changes required to cross those thresholds, the breadth and severity of the effects of crossing them, and the time frames over which those effects would unfold are subject to great uncertainty because they are unprecedented in recorded history

2. Climate Change Through 2100

Human activities—especially fossil fuel use, deforestation, and agriculture—are producing increasing emissions of greenhouse gases and other gases and particulates that affect the climate. Because a large portion of the emitted gases will remain in the atmosphere for centuries, their effects will persist even if emissions decline. According to scientific consensus, the accumulation of greenhouse gases, coupled with widespread changes in land use, is altering climate conditions throughout the world, including in the United States. Since the latter half of the 1800s, average global temperatures have increased by 1.3 degrees Celsius (about 2.3 degrees Fahrenheit).[2]

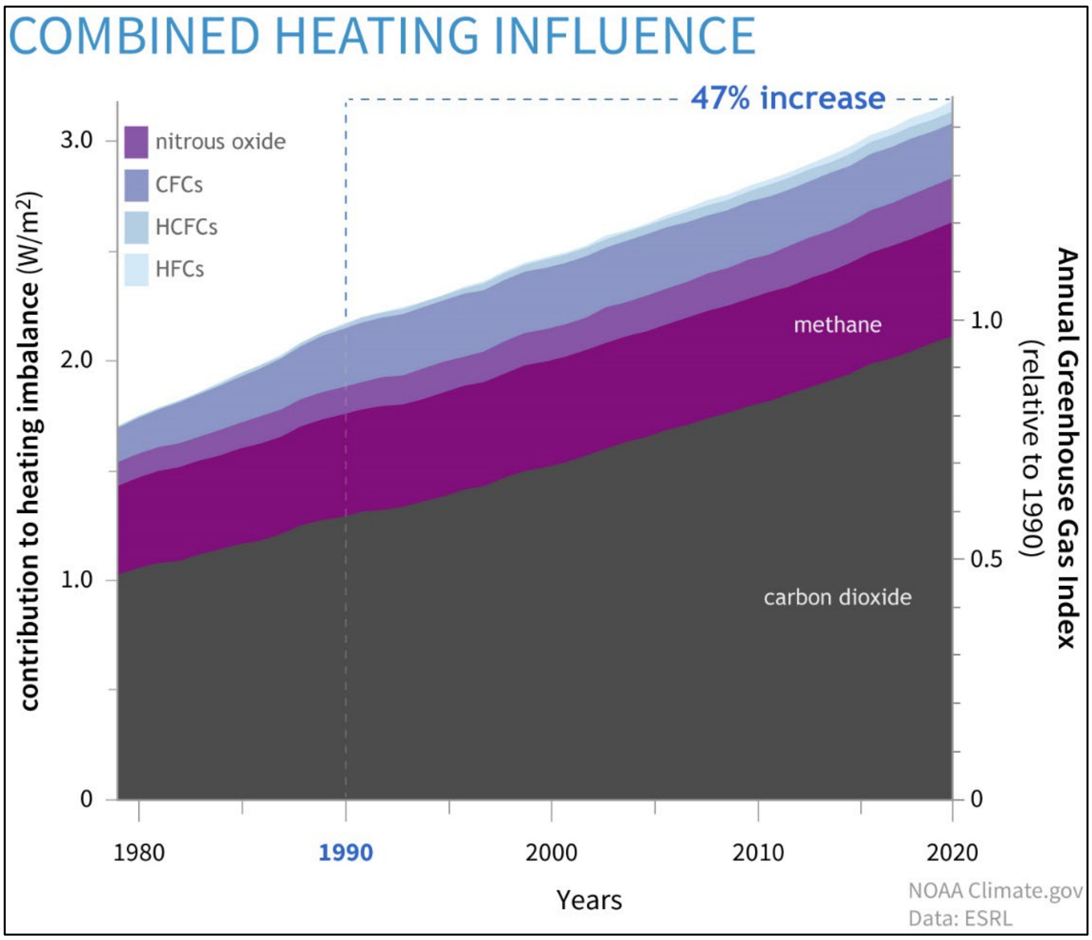
To understand the risks that further climate change would pose to the economy and society, the Congressional Budget Office projected changes in certain key features of the climate through the end of the century. To do so, CBO analyzed projections of future emissions, accounting for the effects of climate policies adopted around the world through 2020, as well as the 2022 reconciliation act. CBO's analysis suggests a wide range of possible outcomes. In particular, there is about a 5 percent chance that by 2100, global warming will exceed 4°C—that is, nearly 3°C more than has already occurred since the 19th century—and a roughly equal chance that warming will be less than 2°C. The central estimate points to about 3°C of warming. Efforts to reduce emissions would lower the range of projected outcomes.

Warming will also lead to changes in precipitation, sea levels, and natural disasters. Many of those changes are reasonably well understood, and their effects can be estimated with confidence. However, because projected levels of warming are unprecedented in recorded history, other possible changes—including changes that could have catastrophic consequences—are poorly understood. The critical thresholds at which such changes would occur, often referred to as tipping points, and the extent of their effects can be projected only with great uncertainty.

[2] (Secondary reference): Copernicus Programme, "Climate Indicators: Temperature" (updated April 22, 2024), https://tinyurl.com/2mkt83ex Estimates of changes in temperature are based on averages across several years to better control for short-term fluctuations. Note that "Secondary References, like this one, in the rest of this paper are references made in the reference 1 document, included to allow deeper research.

2.1. Sources of Climate Change

As energy from the sun is absorbed by the Earth and radiated back into space, greenhouse gases increase the energy held in the lower atmosphere, keeping the Earth's surface warmer than it would otherwise be. Those gases include carbon dioxide (CO_2), methane (CH_4 – major constituent of natural gas), nitrous oxide (N_2O – medical anesthetic and analgesic, aerosol propellant for food, and pollutant), and several human-made gases containing fluorine and chlorine (HCFCs and HFCs – refrigerants, blowing agents, aerosol propellants). See chart below. Other substances in the atmosphere also affect the climate: Soot absorbs incoming energy and tends to warm the lower atmosphere, whereas other aerosols (such as sulfur dioxide from the combustion of coal) tend to exert offsetting cooling effects.[3] *The internal variability of the climate system and other natural factors, such as the amount of sunlight, have had only minor effects on recent warming.*[4]



[3] (Secondary reference): Aerosols from volcanic eruptions and other natural and human made sources can temporarily result in regional or even global cooling. Those fluctuations are not inconsistent with an ongoing long-term warming trend caused by human activities.

[4] Note that the primary author of this paper (John) added some definitions of various greenhouses to this paragraph, and the above figure.

2.1.1. Historical Emissions

Since the onset of industrialization, human activities have yielded substantial emissions of greenhouse gases, including about 2,500 billion metric tons (gigatons, or Gt) of CO_2. Over half of those CO_2 emissions have been absorbed by land, forests, and oceans, which act as carbon sinks, or natural systems that absorb more CO_2 than they release.[5]

The remaining emissions have raised atmospheric concentrations of CO_2 by more than 50 percent, to levels not seen for about 3 million years. CO_2 emissions account for about 80 percent of the warming caused by greenhouse gases. For other gases, the patterns of accumulation differ but are similarly complex.

Most CO_2 emissions have come from fossil fuel consumption and cement production; a smaller portion have resulted from changes in land use, such as deforestation and the clearing of land for agriculture. Roughly half of the emissions from fossil fuels and cement production have occurred in the past 30 years. Over the past decade, global emissions of CO_2 have averaged about 40 Gt per year. The United States has produced 13 percent of those annual emissions. About 26 percent have come from China, the world's largest emitter, and about 6 percent have come from India, which ranks third.

2.1.2. Projections of Future Emissions

To analyze the effects of future climate change, CBO drew on the Intergovernmental Panel on Climate Change's (IPCC's) sixth assessment report (AR6), a collection of three volumes published between 2021 and 2022 that evaluate and summarize scientific research related to climate change for the United Nations.[6]

The report presents the results of thousands of scenarios of future emissions and climate change based on roughly 200 peer-reviewed modeling frameworks.[7] *CBO analyzed 21 scenarios that incorporated the assumption that climate-related policies implemented around the world by the end of 2020 would be maintained indefinitely and no further policies would be adopted.*[8] *CBO also adjusted the projections to account for the effects of the 2022 reconciliation act,*[9] *which provided incentives for the development and use of technologies with lower emissions. (That treatment is consistent with the agency's approach in producing its budgetary and economic projections, which reflect the assumption that current U.S. laws will remain unchanged.)*

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[5] (Secondary reference): On land, vegetation absorbs CO_2 through photosynthesis. In the ocean, physical and chemical processes dissolve CO_2 at the surface of the water, where further chemical reactions convert the dissolved CO_2 into forms of carbon that can remain in the ocean for longer periods. Other greenhouse gases are also absorbed by the land and the ocean but to a much lesser extent. See Josep G. Canadell and others, "Global Carbon and Other Biogeochemical Cycles and Feedbacks," in Valérie Masson-Delmotte and others, eds., Climate Change 2021: The Physical Science Basis, Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge University Press, 2021), pp. 673–816, https://doi.org/10.1017/9781009157896

[6] See Intergovernmental Panel on Climate Change, "Sixth Assessment Report" (accessed October 7, 2024), www.ipcc.ch/assessment-report/ar6

[7] (Secondary reference) The results of those scenarios are available at International Institute for Applied Systems Analysis, "AR6 Scenario Explorer and Database Hosted by IIASA" (2022), https://data.ece.iiasa.ac.at/ar6

[8] (Secondary reference) Although many countries have signaled an intention or even made a commitment to achieve net zero greenhouse gas or CO_2 emissions by midcentury, few have enacted policies to do so. The set of climate scenarios that CBO analyzed does not incorporate those intentions or commitments.

[9] See https://www.axios.com/2022/08/16/biden-reconciliation-inflation-reduction-act

The scenarios based on implemented policies yield a range of projections of CO_2 emissions over the rest of the century. That range reflects uncertainty about societal factors (such as population growth) as well as physical factors (such as the capacity of sinks to absorb carbon). In all of the projections involving implemented policies, concentrations of CO_2 in the atmosphere continue to rise through the end of the century, even if emissions start to decline in the coming decades.

Projections of emissions are also subject to uncertainty about future developments that emissions scenarios do not capture. Those developments include policy changes, technological advances, and events such as natural disasters, pandemics, financial crises, or wars. Any of those developments would cause emissions and levels of warming to be higher or lower than projected

2.2. Projected Changes in Climate

The atmospheric accumulation of greenhouse gases and other emissions has initiated an irregular and gradual warming of the Earth's surface and various related changes in precipitation, sea levels, and other aspects of the climate. Tropical and temperate climate zones are expanding, and in North America, growing seasons are lengthening by about one to two days per decade.[10]

2.2.1. Temperature

The average temperature across the globe is currently about 15°C (59°F)—1.3°C (2.3°F) higher than it is estimated to have been in the latter half of the 19th century. Roughly half of that increase has occurred since the mid-1980s.

Rising concentrations of greenhouse gases and changes in land use have caused temperatures to rise. Some of the warming effect from greenhouse gases—most likely about one-quarter—has been offset by the cooling effects of aerosols in the atmosphere. The climate scenarios described above yield a range of projections of further increases in temperatures over the rest of the century.

Accounting for the effects of climate policies adopted internationally through 2020 and, in the United States, the 2022 reconciliation act, CBO's central estimate is that by 2100, the average global temperature is likely to be about 3°C warmer than it was during the 1850-1900 period. That difference would amount to an increase of 1.6°C relative to today.

Many uncertain factors could cause increases in temperatures to be larger or smaller than that estimate, including physical processes (such as those associated with emissions, sinks, and aerosols) and future societal changes (such as those involving population levels, economic growth, and land use).

2.2.2. Precipitation

As a result of climate change, average rainfall over land is increasing at an accelerating rate. In most regions, episodes of heavy rain are becoming more frequent and intense. Within the United States, precipitation is projected to increase in most parts of the country. However, in the Southwest and some parts of Texas, precipitation is projected to decline modestly.

[10] (Secondary reference) Environmental Protection Agency, "Climate Change Indicators: Length of Growing Season" (updated June 27, 2024), https://tinyurl.com/4ffcycap

2.2.3. Sea Levels

The ocean surface has warmed nearly as much as the atmosphere. As deeper waters gradually warm and expand and as glaciers and ice sheets melt, sea levels are rising at an accelerating pace. Because those processes respond relatively slowly to a warming atmosphere, projected increases in sea levels are fairly consistent across scenarios until later in the century. Even if global temperatures stabilize by 2100, expanding oceans and melting ice will continue to raise sea levels for centuries.

Author's comment: Note that the last sentence in the above paragraph is consistent with any other authoritative source that I've seen lately. Also, this is basically a no-brainer for the reasons explained in this paragraph.

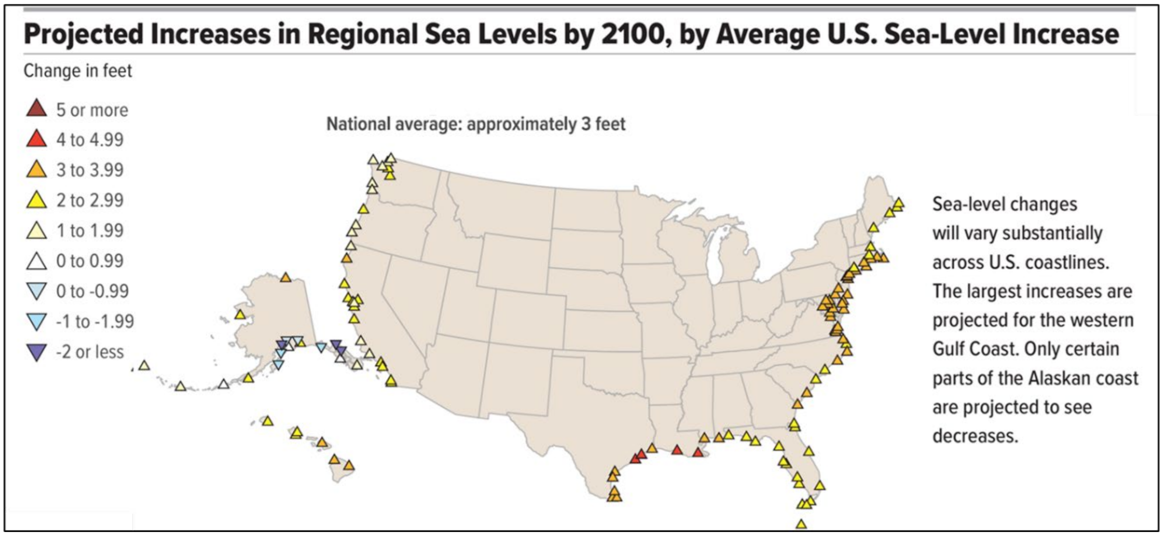
The extent to which sea levels will ultimately rise in response to any amount of warming is highly uncertain, however. Some of that uncertainty reflects a range of potential outcomes due to processes that are well understood, such as the gradual expansion of warming oceans and the melting of glaciers. For example, by 2100, given the central estimate of about 3°C of warming, there is a 5 percent chance that well-understood processes will raise average global sea levels about 3 feet or more above their 2005 levels and an equal chance that the rise will be about 1 foot or less.[11] *The central estimate is an increase of 2 feet. About one more degree of warming would increase those amounts by about 4 inches; one less degree of warming would lower them by a similar amount.*

Even higher sea levels could result from processes that are poorly understood. Those processes include how warming ocean waters will affect the melting of the bases of ice sheets that lie below sea level. With sufficient warming, such processes could cause global sea-level rise to reach 5 feet or more by 2100—but the likelihood that they will produce that much melting is currently unknown.

By 2100, average sea levels are projected to rise roughly 8 inches more on the coasts of the contiguous United States than around the globe. With warming of 3°C, that means a 5 percent chance that average U.S. Sea-levels will rise by about 4 feet or more, another 5 percent chance that they will rise by about 2 feet or less, and a central estimate of approximately 3 feet of sea-level rise. But changes in sea levels will vary substantially across U.S. coastlines. Sea levels are expected to rise most along the western Gulf Coast—by roughly 3.5 feet to 5.0 feet, depending on the exact location, given an average increase of about 3 feet nationwide.

The Pacific Northwest is expected to see the smallest increase in the contiguous United States, with sea levels rising by 1.0 feet to 2.5 feet in the same scenario. See the figure below for other U.S. locations.

[11] (Secondary reference) William V. Sweet and others, Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines, Technical Report NOS 01 (National Oceanic and Atmospheric Administration, February 2022), https://tinyurl.com/cmsv48xr



2.2.4. Natural Disasters

Researchers expect that higher sea levels, more intense storm surges, and heavier rainfall will make floods more frequent and extreme. By 2050, flood damage is projected to increase by one-quarter to one-third solely as a result of climate change.[12]

Climate change will also create hotter, drier conditions in some parts of the United States that are vulnerable to wildfires. The amount of land burned by wildfires has doubled over the past 30 years.[13] *Increases in temperatures dry out vegetation, making fires more likely to start and spread. Higher temperatures will probably also induce more ignitions by prompting more lightning strikes. However, predicting future wildfire risk is difficult because people play an important role in both starting and stopping fires. Unlike flood models, models that attempt to predict increases in wildfires due to climate change have not performed well.*[14]

2.3. Uncertainty and Tipping Points

Many processes in the climate system are sufficiently well understood that associated risks can be confidently projected with clearly defined probability ranges. For other processes, however, the scientific community has not reached a consensus on the underlying mechanisms, or the data needed to make predictions are incomplete, inconsistent, or unreliable—in large part because projected levels of warming have no precedent in recorded history. In such cases, projections involve uncertainties that cannot be well quantified, and as a result, they are reported with low confidence and wide ranges of possible outcomes.

[12] (Secondary reference) Congressional Budget Office, Flood Damage and Federally Backed Mortgages in a Changing Climate (November 2023), www.cbo.gov/publication/59379 ; and Oliver E. J. Wing and others, "Inequitable Patterns of U.S. Flood Risk in the Anthropocene," Nature Climate Change, vol. 12, no. 2 (February 2022), pp. 156–162, https://doi.org/10.1038/s41558-021-01265-6

[13] (Secondary reference) Congressional Budget Office, Wildfires (June 2022), www.cbo.gov/publication/57970

[14] For a discussion of wildfire modeling by insurers, see Congressional Budget Office, Climate Change, Disaster Risk, and Homeowner's Insurance (August 2024), www.cbo.gov/publication/59918

Warming within the range projected through the rest of the century might push one or more components of the climate system past critical thresholds—sometimes called tipping points—that would lead those components to shift to a very different state. (To conceptualize such a change in state, consider how warming ice remains solid until it reaches the threshold of melting, after which it becomes water.) However, those critical thresholds cannot yet be identified with confidence.

Research suggests that three types of climate processes would have especially large impacts if they reached such critical thresholds:

- *Greenhouse gas and temperature feedbacks would cause the release of substantially more greenhouse gases, thereby increasing the amount and rate of warming.*
- *Changes to ocean circulation and weather patterns would shift regional temperatures and precipitation.*
- *The melting of ice sheets would dramatically change the amount and rate of sea-level rise.*

Some of those components of the climate system could reach critical thresholds by the end of the century, many of the effects would unfold over a longer time frame. Some of those effects would occur over the course of decades; others would unfold over centuries or even millennia. And some changes would be irreversible for hundreds or thousands of years, even if climate conditions returned to their present state sooner. Furthermore, crossing one critical threshold would probably change the likelihood of crossing others.

There is some chance that one or more thresholds have already been crossed, and that chance will generally increase with more warming (see Figure on the next page). But those critical thresholds are uncertain, and estimates of the size and likelihood of their effects will be revised as scientific understanding improves.

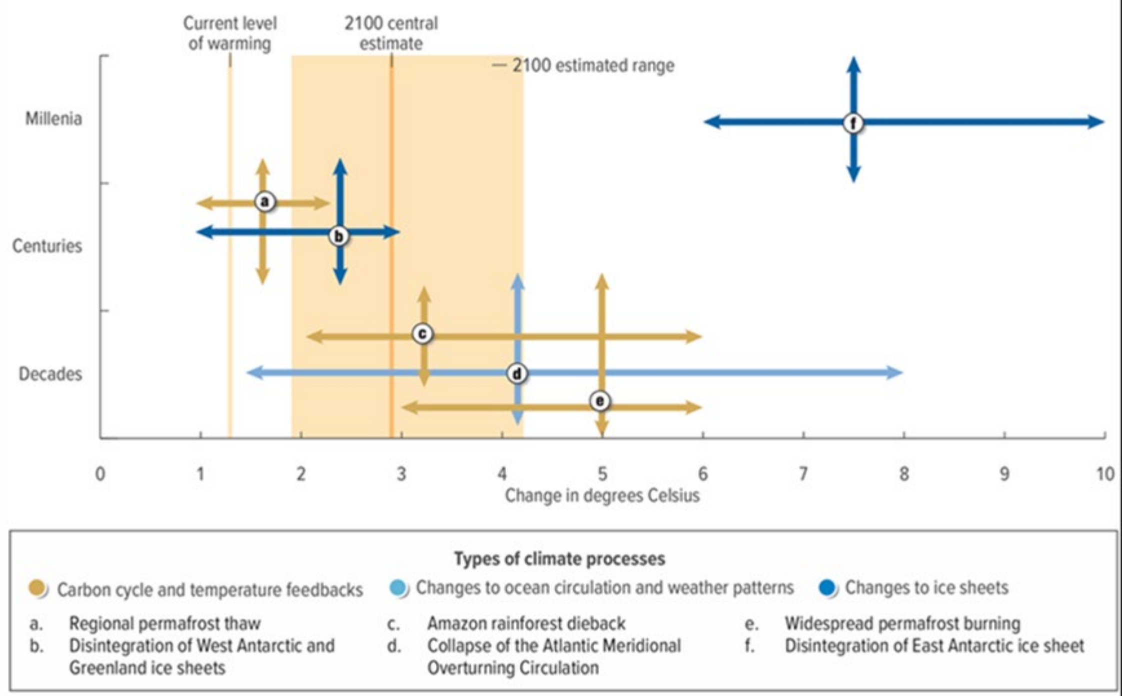
2.3.1. Greenhouse Gas and Temperature Feedbacks

Some of the Earth's natural features, such as permafrost and the Amazon rainforest, respond to warming by releasing additional amounts of greenhouse gases. Those additional greenhouse gases, in turn, increase the amount and pace of warming.

Permafrost—a mix of perennially frozen Earth's surface to nearly a mile deep. Organic matter in permafrost holds nearly twice as much carbon as the atmosphere does. Much of that carbon is in the form of methane, which traps heat more powerfully than CO_2. As permafrost thaws, its organic matter decomposes and releases both CO_2 and methane into the atmosphere.

Permafrost has already begun to thaw gradually and to release greenhouse gases. As global temperatures continue to rise, that process will persist, causing modest increases in warming.

Ranges of Temperature Thresholds and Time Frames for Major Changes in Climate Processes



Data source: Congressional Budget Office, using data from Timothy M. Lenton and others, *Global Tipping Points: Report 2023* (University of Exeter, 2023), https://report-2023.global-tipping-points.org; Seaver Wang and others, "Mechanisms and Impacts of Earth System Tipping Elements," *Reviews of Geophysics*, vol. 61, no. 1 (March 2023), article e2021RG000757, https://doi.org/10.1029/2021RG000757; and David I. Armstrong McKay and others, "Exceeding 1.5°C Global Warming Could Trigger Multiple Climate Tipping Points," *Science*, vol. 377, no. 6611 (September 9, 2022), article eabn7950, https://doi.org/10.1126/science.abn7950. See www.cbo.gov/publication/60845#data.

Once warming reaches a critical threshold—somewhere between 1.0°C and 2.3°C—pockets of permafrost in many regions will thaw more abruptly. Over the course of a few centuries, such regional thawing would increase emissions by 50 percent more than gradual thawing alone

With even more warming, more extensive areas of permafrost would thaw, and some of the organic matter in that permafrost would dry out and become susceptible to f ire. The heat generated by such burning could become self-sustaining, leading to the collapse of large regions of permafrost. Widespread burning of permafrost would release hundreds of gigatons of CO_2 over several decades or centuries, yielding roughly 0.2°C to 0.4°C of additional warming. For such widespread burning to occur, global temperatures would probably have to rise by 3°C to 6°C.

Some permafrost lies underwater in shallow ocean sediments. In that permafrost are methane hydrates—mixtures of ice and methane. If exposed to enough warming, methane hydrates would be an extremely large source of emissions. However, researchers believe that only a small portion of the methane in those deposits will be released over the coming century.[15]

The Amazon Rainforest. *Warming is projected to make the Amazon rainforest drier and more vulnerable to drought, wildfires, and other threats. Parts of the rainforest are sustained throughout its annual dry season by rainfall that is retained from its wet season. Warming is projected to disrupt that water cycle by reducing rainfall during the wet season and lengthening the dry season. Sufficient warming would lead to a self-sustaining process whereby much of the remaining forest dies and is replaced by drier savannah, which stores far less carbon. The retreat of the rainforest, referred to as dieback, would add on net up to 200 Gt of* CO_2 *to the atmosphere—the equivalent of about five years' worth of current global* CO_2 *emissions from fossil fuel combustion and cement production. That process would probably occur over the course of several decades to a couple of centuries.*

However, the amount of warming needed to initiate that process is highly uncertain. In the absence of further deforestation, dieback would likely be initiated somewhere in the range of 2°C to 6°C of warming. The extent to which any given amount of deforestation would lower that threshold is unknown.

According to recent research, patterns of rainfall in the Amazon region will also be affected by changes in the Atlantic Meridional Overturning Circulation (AMOC), which is discussed further below. The potential for such interactions among components of the climate system highlights the complexity of projecting the effects of warming on all of them together.

2.4. Changes to Ocean Circulation and Weather Patterns

Several components of the global ocean circulation system have powerful effects on regional temperatures and patterns of precipitation. The most important is the Atlantic Meridional Overturning Circulation (AMOC), which includes the Gulf Stream. The AMOC carries warm water from the South Atlantic and the tropics to the North Atlantic. When it reaches high latitudes, the water evaporates and cools, becoming saltier and therefore denser, and sinks into the deep ocean. That downwelling helps drive a system of circulation that flows through the deep Atlantic and ultimately into the Indian and Pacific Oceans, playing a central role in maintaining ocean circulation patterns and climates around the world. If climate conditions slow or disrupt that downwelling (such as by changing the temperature or salinity of the water in the North Atlantic), the AMOC would slow down or even collapse—that is, stop—completely.

[15] (Secondary Refere3nce) Josep G. Canadell and others, "Global Carbon and Other Biogeochemical Cycles and Feedbacks," in Valérie Masson Delmotte and others, eds., Climate Change 2021: The Physical Science Basis, Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge University Press, 2021), pp. 673–816, https://doi.org/10.1017/9781009157896

The AMOC collapsed repeatedly in the distant past. In the most recent instance, about 13,000 years ago, warming surface waters and melting ice contributed to a collapse of the AMOC as the Earth was emerging from the last ice age. That collapse led to a southward shift in the tropical rain belt, weaker African and Asian monsoons in the Northern Hemisphere, stronger monsoons in the Southern Hemisphere, and cooler and drier conditions in Europe. Once the system collapses, it takes centuries to start circulating again

The AMOC has weakened in recent decades and is expected to weaken further. However, it is unclear how much of that weakening is due to natural variability and how much is due to recent warming. As a result, future trends in the AMOC are highly uncertain. Collapse of the AMOC could be caused by as little as 1.4°C or as much as 8°C of warming. It is therefore possible that nearly enough warming has already occurred to cause an eventual collapse of the AMOC, although the Intergovernmental Panel on Climate Change has stated that a collapse is unlikely to occur in this century.

2.5. Changes to Ice Sheets

A third group of potentially large impacts involves ice sheets—continent-sized bodies of ice covering land in Greenland and Antarctica. Ice sheets are responding to recent warming by melting at an accelerating rate. So far, only a small portion of the ice in the sheets (a fraction of a percent) has melted. It is uncertain how much mass the ice sheets will lose or how rapidly they will lose it in response to any increase in global temperatures. The most important uncertainties involve the effects of warming ocean waters on the bases of ice sheets below sea level. As discussed above, given the potential for rapid ice sheet loss due to uncertain processes, there is a risk that global sea-level rise will reach 5 feet or more by 2100.[16]

With sufficient warming, each ice sheet will reach a critical threshold that causes its complete, irreversible disintegration. Far larger increases in sea levels would follow. If the ice sheets disintegrated completely in Greenland and the western part of Antarctica, sea levels would rise by roughly 30 feet over centuries to millennia.

That disintegration could be initiated by as little as 1°C to 3°C of warming.[17] *In the very large eastern part of the Antarctic ice sheet, portions with bases below sea level could begin to melt with 2°C to 6°C of warming. The critical threshold for complete disintegration lies between 6°C and 10°C of warming—well outside the range of projections for the next century. The total loss of all ice sheets would raise sea levels by roughly 200 feet, but the full effect would take thousands or tens of thousands of years to realize.*

[16] (Secondary Reference) William V. Sweet and others, Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines, Technical Report NOS 01 (National Oceanic and Atmospheric Administration, February 2022), https://tinyurl.com/cmsv48xr

[17] (Secondary Reference) Timothy M. Lenton and others, eds., Global Tipping Points: Report 2023 (University of Exeter, 2023), https://report-2023.global-tipping-points.org

However, like projections of the amount and pace of ice loss, projections of the amount of warming needed to trigger the ice sheets' disintegration are highly uncertain. Because researchers cannot yet fully characterize and quantify the underlying processes, the Intergovernmental Panel on Climate Change has expressed a low degree of confidence about those projections

Final author's comment: I'm approaching my preferred maximum length for this paper. In spite of making some small deletions of content, I've only covered one section of the total of four from Reference 1. However, I believe the above will give readers a strong idea of the potential effects that may result from climate change in this century. Also, feel free to go through the link in Reference 1, and read this whole report. A middle-ground for readers would be to use the above secondary references' links to further research areas of interest.