

Climate scientists reach 'unequivocal' consensus on human-made warming in landmark report

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An epochal new report from the world's top climate scientists warns that the planet will warm by 1.5 degrees Celsius in the next two decades

without drastic moves to eliminate greenhouse gas pollution. The finding from the United Nations-backed group throws a key goal of the Paris Agreement into danger as signs of climate change become apparent across every part of the world.

The latest scientific assessment from the UN's Intergovernmental Panel on Climate Change for the first time speaks with certainty about the total responsibility of human activity for rising temperatures. The scientists forecast no end to warming trends until emissions cease.

"It is unequivocal that human influence has warmed the atmosphere, ocean and land," wrote the authors of the IPCC's sixth global science assessment since 1990 and the first released in more than eight years. The crucial warming threshold of 2 degrees Celsius will be "exceeded during the 21st century," the IPCC authors concluded, without deep emissions cuts "in the coming decades."

The assessment released on Monday is the work of more than 200 scientists digesting thousands of studies, and an accompanying summary was approved by delegates from 195 countries. More than any other forecast or record, this report's determinations establish a powerful global consensus—less than three months before the UN's COP26 international [climate](#) talks.

Among the headline findings: The past decade was most likely hotter than any period in the last 125,000 years, when sea levels were as much as 10 meters higher. Combustion and deforestation have also raised carbon dioxide in the atmosphere higher than they've been in 2 million years, according to the report, and agriculture and fossil fuels have contributed to methane and nitrous oxide concentration higher than any point in at least 800,000 years.

The full, 3,949-page assessment was released in conjunction with the

42-page "summary for policymakers." While the latter went through a diplomatic approval process in addition to a scientific one, the former comes directly from scientists. Chapter one of the underlying report includes strong language admonishing Paris signatories, calling their pledges so far under the agreement "insufficient to reduce greenhouse gas emission enough" to keep global warming well below 2 degrees Celsius.

The document is "a code red for humanity," said Antonio Guterres, secretary-general of the United Nations, in prepared remarks tied to the release. "This report must sound a death knell for coal and fossil fuels before they destroy our planet."

Even as the IPCC authors have done away with some of the cautious uncertainty that marked past assessments, the last few months have seen a series of rapid-fire climate disasters that underline the new language. Summertime in the Northern Hemisphere has been marred by severe flooding across Europe and China, as well as alarming drought and the early onset of large wildfires in the Western U.S. and Canada. One of the coldest places on the planet, Siberia, has experienced severe heat and forest fires. Just this past weekend brought disturbing footage of people fleeing sprawling wildfires in Greece.

Nearly all of this can be attributed to human influence. The IPCC found that the combined effects of human activity have already increased the global average temperature by about 1.1 degrees Celsius above the late 19th-century average. The contribution to global warming of natural factors, such as the sun and volcanoes, is estimated to be close to zero. In fact, humans have dumped enough greenhouse gas into the atmosphere to heat the planet by 1.5 degrees Celsius, according to the report, but fine-particle pollution from fossil fuels provides a cooling effect that masks some of the impact.

In its fifth assessment, published in 2013, IPCC's volunteer scientists introduced the idea of a "carbon budget," setting an upper bound on the amount of carbon dioxide that can be added to the atmosphere before it will breach certain temperature thresholds. "Now we have much more confidence in those numbers," said Joeri Rogelj, a lecturer in [climate change](#) and the environment at Imperial College London and one of the report's authors.

Humanity will have about a 50% chance of staying below the 1.5 degrees Celsius threshold called for by the Paris Agreement if carbon dioxide emissions from 2020 onwards remain below 500 billion tons. At the current rate of emissions, that carbon budget would be used up in about 13 years. If the rate doesn't come down, the planet will warm more than 1.5 degrees Celsius.

"Our opportunity to avoid even more catastrophic impacts has an expiration date," said Helen Mountford, vice president of climate and economics at the World Resources Institute. "The report implies that this decade is truly our last chance to take the actions necessary to limit temperature rise to 1.5 degrees Celsius. If we collectively fail to rapidly curb greenhouse gas emissions in the 2020s, that goal will slip out of reach."

The new publication lands in the middle of the ramp-up to COP26, to be held in Glasgow in November. A global deal to pursue faster emission cuts would depend on poor countries securing \$100 billion a year in climate finance from rich countries, something envisioned in previous climate agreements but not yet achieved. National governments would also need to agree to rules governing the trading of emissions permits, to ensure those moving faster toward cuts are rewarded for doing so.

Unlike the IPCC's somewhat anomalous 2018 special report, Global Warming of 1.5 degrees Celsius, the publication released Monday

doesn't explicitly state that net-zero emissions must be achieved by 2050 to meet the goals set out in the Paris Agreement. That's because this group's mandate was to assess new scientific knowledge, not prescribe policy actions. Upcoming IPCC assessments expected next year in February and March will address climate impacts, adaptation and mitigation.

The authors of the new IPCC publication add that, after accounting for global emissions since the 2018 special release, its estimate of the world's remaining carbon budget is "of similar magnitude" to the one in its prior publication, implying that the finding stands. This latest assessment's most ambitious scenario shows emissions falling to net zero around 2050, which is as close as it comes to restating the top-line conclusion of the special report.

All five of the new report's temperature scenarios show the 1.5 degrees Celsius marker passed by 2040, before cooling down below that mark in only one of five scenarios. Achieving that cooling will depend on large-scale removal of carbon dioxide from the air. An independent analysis conducted by the group Climate Action Tracker suggests that current global policies may track either the IPCC's medium or high scenarios, which lead to 2.7 degrees Celsius and 3.6 degrees Celsius of warming by 2100.

New scientific tools enter the mainstream

The climate science profession has seen entire specialties emerge and mature in the years since the IPCC's previous mega-report on science. None of these is more resonant than the ability to analyze [extreme weather events](#) in real-time to determine the role of climate change.

Twenty years ago, researchers couldn't link a specific weather event directly to human-made climate change, meaning that the scientific

likelihood of a specific storm or heat wave being tied to warmer temperatures wasn't knowable. Today, many of these weather attribution studies can be produced within days or weeks of an event.

The deadly heat wave that gripped the western coast of North America in June had detectable evidence of human responsibility. World Weather Attribution, an international research group, needed just days after the heat broke to conclude that the extraordinary temperatures would be "virtually impossible" without climate change.

This ability of scientists to parse the probability that any one disaster is driven by warming temperatures highlights one of the IPCC's core findings: The entire globe is warming, although not uniformly. Regions will still experience natural swings in temperature, particularly in coming years, as it takes time for heating to have a significant effect on the Earth's processes.

Another research breakthrough in the field of climate sensitivity now allows scientists to make even more confident projections about future warming. Drawing from research on ancient climates, as well as advanced satellite technology that monitors clouds and emissions, IPCC authors were able to narrow their temperature projections for the rest of the century, giving humanity a clearer picture of what lies in store if we don't act quickly to curtail emissions.

The Earth's response to a theoretical doubling of preindustrial carbon dioxide levels is now thought to be between 2.5 degrees Celsius to 4 degrees Celsius—a much smaller range than 1.5 degrees Celsius to 4.5 degrees Celsius in previous IPCC reports. "The top end is being reduced, which means that some of these really bad outcomes, where we roll sixes on the climate sensitivity dice, seems a little less plausible than they did," said Zeke Hausfather, director of climate and energy at the Breakthrough Institute, who wasn't an author of the summary.

This development helped the IPCC authors cope with another headache: Some Earth-system models updated for this assessment began showing surprisingly high projections for future warming. But the breakthrough allowing greater confidence in the Earth's potential response to carbon dioxide gave scientists welcome evidence to balance the modeling approach with other research.

The improvements in projections came, in part, from a stronger grasp of so-called "climate feedbacks" such as the way melting ice and greenhouse gases escaping from thawing permafrost compound on each other in previously unpredictable ways. Scientists are now more confident that lowering emissions will mean less chance of activating feedbacks. That also means that the actions humanity takes in the near term to limit emissions will be a determining factor in whether we see these dramatically accelerating effects in the longer term.

The IPCC's new findings rule out the possibility that unrestricted emissions will have only a mild effect on global temperatures, a hope few if any observers were still clinging to. But the updated science, particularly the narrowed range for climate sensitivity, provides powerful evidence of the world's best pathway to safety: swiftly ending the release of carbon dioxide and other greenhouse gases.

What comes next?

There is an endgame, if nations choose to try and reach it. The data continue to show a straightforward relationship between carbon dioxide and temperature. That means that when atmospheric carbon concentrations stop rising, the temperature will, too, soon thereafter.

Scientists have broken ground by projecting what happens when our emissions cease. As the world reduces its use of fossil fuels, for instance, the cooling effect of aerosols will start to decline. Scientists are

confident that one way to counter that decline would be to pursue "strong, rapid and sustained reductions" in methane emissions. Beyond [carbon dioxide](#), methane, and nitrous oxide, there are four other greenhouse gases that also provide opportunities to slow warming.

Even at 1.1 degrees Celsius, climate change is taking lives and destroying property and forcing retreat, migration and conflict. The effects of human activity are continuing to melt glaciers and sea ice. Heating oceans means raising them—at a rate more than 2.5 times faster in this century than the last, according to the IPCC. Some of that harm is now baked in for centuries to come.

"This last year has proven that climate change is no longer a distant threat," said Katharine Hayhoe, chief scientist at the Nature Conservancy, who wasn't involved in the summary. "We can no longer assume that citizens of more affluent and secure countries like Canada, Germany, Japan and the United States will be able to ride out the worst excesses of a rapidly destabilizing climate, even as those in more vulnerable latitudes suffer."

In a press conference Monday morning, IPCC leadership emphasized that the disparate effects of climate change are being felt in every region of the world. The new report also comes with an interactive tool that enables users to apply its underlying datasets to the world map. That could, for example, help India reckon with the impact warming could have on economically crucial rainfall patterns under different emissions scenarios.

"When we put everything together, for almost all of the 44 regions in the world, coastal climate impact drivers were increasing," said Roshanka Ranasinghe, professor of climate change impacts and coastal risk at the University of Twente and one of the authors of the assessment.

The IPCC is inherently conservative. It emphasizes information in which scientists have the most evidence and agreement. At the same time, the new scientific consensus doesn't rule out continued investigation of its lower-confidence findings. The authors indicate that some potentially sweeping changes are not as well understood, such as unlikely but still possible heat extremes or ice-sheet collapse.

Another "low-likelihood high-impact outcome" flagged by IPCC authors is a sudden, dramatic change in ocean circulation. A study released last week in the journal *Nature Climate Change* documented changes in the powerful churn of Atlantic water as potential indicators of "an almost complete loss of stability."

The IPCC itself foresees further weakening of the Atlantic Meridional Overturning Circulation in the decades ahead, with disagreement over the possibility of collapse before 2100. Such an event would weaken monsoons in Africa and Asia, strengthen them in the Southern Hemisphere and dry out Europe.

There are always more questions to ask, and the perpetual churn of research means even the most comprehensive assessment can never be truly complete. "That's just what science is, right?" said Tamsin Edwards, an IPCC author and a reader in climate change at King's College London. "It's constantly evolving and refining and adding new studies, and improving our knowledge. The intensity of the effort that goes into assessing the literature—the 14,000 papers for this report—makes it an authoritative, comprehensive, coherent synthesis in a way that a single paper can never be."

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