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Climate Change Is Accelerating, Bringing World 'Dangerously Close' to Irreversible Change

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More devastating fires in California. Persistent drought in the Southwest. Record flooding in Europe and Africa. A heat wave, of all things, in Greenland.

Climate change and its effects are accelerating, with climate related disasters piling up, season after season.

"Things are getting worse," said Petteri Taalas, Secretary General of the World Meteorological Organization, which on Tuesday issued its annual state of the global climate report, concluding a decade of what it called exceptional global heat. "It's more urgent than ever to proceed with mitigation."

But reducing greenhouse gas emissions to fight climate change will require drastic measures, Dr. Taalas said. "The only solution is to get rid of fossil fuels in power production, industry and transportation," he said.

Seas are warming and rising faster, putting more cities at risk of tidal flooding or worse. Glaciers are melting at a pace many researchers did not expect for decades. The amount of Arctic sea ice has declined so rapidly that the region may see ice-free summers by the 2030s.

Even the ground itself is warming faster. Permanently frozen ground, or permafrost, is thawing more rapidly, threatening the release of large amounts of long-stored carbon that could in turn make warming even worse, in what scientists call a climate feedback loop.

In a recent commentary in the journal Nature, scientists from the Potsdam Institute for Climate Impact Research in Germany and other institutions warned that the acceleration of ice loss and other effects of climate change have brought the world "dangerously close" to abrupt and irreversible changes, or tipping points. Among these, the researchers said, were the collapse of at least part of the West Antarctic ice sheet — which itself could eventually raise sea levels by four feet or more — or the loss of the Amazon rainforest.

"In our view, the consideration of tipping points helps to define that we are in a climate emergency," they wrote.

The societal toll is accelerating, too, United Nations Secretary General António Guterres said in Madrid before the opening this week of the U.N.’s annual climate conference. “Climate-related natural disasters are becoming more frequent, more deadly, more destructive, with growing human and financial costs,” he said.

Flooding in Mogadishu, Somalia, in October. Feisal Omar/Reuters

Burnt farms in Piseux, northwest France, in July during a heat wave. Agence France-Presse — Getty Images

For individual extreme weather events or other disasters it can be difficult to fully separate the effects of global warming from those of natural climate variability and other factors. Warming can make wildfires worse, for example — it makes vegetation drier and more combustible — but forest management practices, as well as decisions about where to build, also affect the degree of devastation.

Yet a growing number of studies have shown the influence of global warming in many disasters. Heat waves in Europe in June and July, extreme rainfall in Texas during Tropical Storm Imelda in September, the drought that precipitated the "Day Zero" water crisis in Cape Town in 2018 are among many events shown to have been made more likely, more intense, or both, by climate change.

Effects like loss of sea ice, more severe heat waves and changes in rainfall patterns were long predicted by scientists and described in reports like those of the Intergovernmental Panel on Climate Change and, in the United States, the National Climate Assessments produced by federal researchers.

"So much of what we're seeing is exactly consistent with what's expected from climate change," said Philip B. Duffy, a physicist and president of the Woods Hole Research Center, which studies the environment.

At the root of the changes is the basic process of global warming. As carbon dioxide and other greenhouse gases build up in the atmosphere, they trap more of the heat that radiates from Earth's surface as it absorbs sunlight.

The W.M.O.'s state of the global climate report, released at the Madrid talks, said that this decade will almost certainly be the warmest decade on record. And the second half of the decade was much warmer than the first, with global temperatures averaged over the second half about 0.2 degree Celsius (about 0.4 degree Fahrenheit) higher.

"All the time we're breaking records in temperatures," Dr. Taalas said.

The records extend to the oceans as well, which absorb about 90 percent of the excess heat retained by Earth as a result of increased greenhouse gases. Average ocean temperatures so far this year exceed those of 2018, which were records, the report said.

Since the rise of industry in the second half of the 19th century, when widespread emissions of greenhouse gases began, the world has warmed by about 1.1 degrees Celsius.

But how fast temperatures will continue to increase, and how much worse things may get, depends in large part on whether the world reins in greenhouse gas emissions, and by how much. After flattening between 2014 and 2016, annual emissions from burning fossil fuels for energy have risen again.

Filling water buckets from a government water pump in the drought-ravaged Lamhata village in Uttar Pradesh, India, earlier this year. Bryan Denton for The New York Times

Bathing in a fountain in St. Petersburg, Russia, during unseasonably hot temperatures in July. Dmitri Lovetsky/Associated Press

The 2015 Paris agreement called for countries to pursue efforts to limit warming this century to 2 degrees Celsius (3.6 degrees Fahrenheit) above preindustrial levels, with an even stricter target of 1.5 degrees Celsius. But the United States under President Trump is leaving the agreement, and a United Nations report last month suggested that even if countries meet their pledges to cut emissions, and many are far off track, warming would be more than twice the 1.5-degree target.

Acceleration of some elements of climate change has been expected, and has now been detected thanks to improvements in measurements. Sea level readings, for example, are now far more extensive, frequent and precise thanks to satellite sensors in use for the last quarter-century. In the past, scientists had to rely on tide gauges.

Using satellite data, a 2018 study found that global sea level rise is now about 4.5 millimeters a year, or a little less than one-fifth of an inch. The rate is increasing by about a 10th of a millimeter a year.

“We knew the rate of sea level rise was increasing, but we had difficulty detecting that,” said Steven Nerem, a University of Colorado researcher and lead author of the study.

The study estimated that the acceleration would result in sea level rise by the end of this century of 65 centimeters, or about 25 inches, which is more than double the rise if the rate had remained constant.

Sea level rise results from a combination of melting glaciers and ice sheets, and the thermal expansion of seawater as ocean temperatures rise. As with most of the projected effects of climate change, there is a high level of uncertainty about future sea levels.

“No one is terribly sure about what will happen by 2100,” Dr. Nerem said. “If the ice sheets really start to go, things could change dramatically.”

Greenland and Antarctica hold enough ice to raise seas by about 220 feet if it all melted. Complete melting would take many centuries, but melting is speeding up on the Greenland sheet, which currently contributes about two-thirds of a millimeter to sea level rise annually, and on much of the West Antarctic sheet.

“This is a consequence of the warming temperatures of climate change,” said Marco Tedesco, a climate scientist at the Lamont-Doherty Earth Observatory at Columbia University.

“Overall we do not expect Greenland to slow down,” he said. “And we definitely expect an acceleration in mass loss of the West Antarctic ice sheet.” While the West Antarctic sheet currently contributes a small amount to sea level rise, eventually it could contribute as much as Greenland, he said.

Melting permafrost threatening a home in Kivalina, Alaska, a coastal village 83 miles above the Arctic Circle. Joe Raedle/Getty Images

Rivulets of meltwater cleaving the Greenland ice sheet near Ilulissat in August. Sean Gallup/Getty Images

Amid the long term increase in ice-sheet melting there have been some exceptional periods, including this summer in Greenland, when heat from Europe spread north, resulting in temperatures as much as 15 degrees Fahrenheit above normal. Overall this year, Greenland had a net ice loss of about 350 billion tons, about 20 percent more than the average in recent years and enough to add one millimeter to sea levels by itself.

A recent analysis by Dr. Tedesco and a colleague showed that a rare combination of atmospheric conditions, related to instability of the polar jet stream that encircles Earth at high northern latitudes, led to this summer’s melting. Some scientists have suggested that this jet stream instability, or wobbling, is a result of climate change, although the idea is not completely accepted.

Warming in the Far North affects more than ice. Louise Farquharson, a geologist and researcher at the University of Alaska-Fairbanks, studies the effect of climate change on permafrost. In the Arctic, ground can be permanently frozen from near the surface to several thousand feet deep.

“We see warming across the board, and generally the rate of warming is increasing,” Dr. Farquharson said. “But the impact varies significantly.”

Her recent research found rapid thawing of permafrost high in the Canadian Arctic, where there is little surface vegetation to insulate the frozen ground. By 2016 the permafrost had already thawed at depths not expected until 2090 under a model of “moderate” global warming.

While the permafrost at her study sites contains little organic matter, much of the Arctic’s permafrost contains large amounts of dead vegetation built up over hundreds or thousands of years. This makes it a huge storehouse of carbon: By some estimates, Arctic permafrost contains about twice as much carbon as is currently in the atmosphere.

When it thaws, the organic matter begins to decompose, and the carbon enters the atmosphere as methane or carbon dioxide, adding to warming.

A floating iceberg in Disko Bay in Ilulissat, Greenland, in August. Sean Gallup/Getty Images

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