Warming of Earth proceeding at unprecedented pace

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Temperature records from ice cores and sediments analyzed by NASA show that the current rate of global warming is increasing and is more rapid than at any point in the past millennium. This trend makes it "very unlikely" that the average global temperature will stay within 2 degrees Celsius above the 19th century average.

One of the main reasons global warming is accelerating is that the whole system suffers from positive feedback—for example, as warming occurs, Arctic ice melts, causing more sunlight and heat to be absorbed by the Arctic ocean, since water is less reflective than ice, meaning more warming, ad infinitum.

Another potential positive feedback mechanism is the melting of permafrost (ground frozen throughout the year) in places like Siberia, where it is estimated that a global temperature rise of 1.5 degrees Celsius could release 1 trillion tons of carbon dioxide and methane into the atmosphere over a span of years, something which takes industrial activity decades to do.

Gavin Schmidt, director of NASA's Goddard Institute for Space Studies and one of its leading climate scientists, commented, "In the last 30 years we've really moved into exceptional territory. It's unprecedented in 1,000 years. There's no period that has the trend seen in the 20th century in terms of the inclination" (of temperatures).

One can also compare the last few decades of global warming to the most recent years. When the first indications of global warming were detected in 1977, it was predicted that average global temperatures would rise 2 degrees Celsius per century. In the past five years, the rate of global warming has been about five times that amount.

These rates are also much higher than what has occurred in Earth's past when the planet has moved out of ice ages. During those periods, average temperatures typically rose 4-7 degrees Celsius over a span of 5,000 years. The past century's rise in global temperatures has been 10 times faster than the most recent exit from an ice age. Current data suggests that the coming century's rate of warming will be at least 20 times this rate.

Such estimates are in line with the latest month-by-month temperature data from both NASA and the National Oceanic and Atmospheric Administration. The thousands of worldwide meteorological stations, ship- and buoy-based instruments and Antarctic research stations all show that July 2016 was the hottest month ever in the 136 years of modern temperature recordings. It is also the tenth consecutive month of monthly high-temperature records (i.e., the hottest January ever, followed by the hottest February, etc.), the first of which was October 2015. If this trend continues, which it likely will, 2016 will be the hottest year yet recorded.

Some of these measurements are the effect of an abnormally long "El Niño," a periodic warming of the Pacific Ocean that has taken place for at least 100,000 years. However, climate models of the most recent El Niño, which ended in May, show that even without the increase of temperatures caused, 2015 and 2016 would still be among the hottest years ever recorded.

Other metrics are available to provide insight into what Earth will look like if global temperatures continue current trends. Research done by the National Science Foundation from 2012 looked at the late Pliocene epoch, 2.7 million to 3.2 million years ago, the last time the carbon dioxide levels and global temperatures were as high as they will soon be. It was an attempt to understand the sensitivity of Earth's

glaciers to even small changes in global temperatures.

The research found that over the course of that period, sea levels were raised by 12 to 21 meters as a result of melted land ice from areas such as Antarctica. That is, Earth's natural state with carbon dioxide at modern levels is one with sea levels possibly 21 meters higher than they are now and we are living through the process of the ecosystem approaching that state.

A primary difference, however, is the rate of change of temperatures between the two periods. The Pilocene epoch was one that lasted half a million years. The current era of increasing global temperatures and carbon dioxide levels has lasted half a century, raising the probability of a much quicker, more major shift in the world's ecosystem.

Most of these potential shifts are potentially catastrophic: oceanic acidification leading to the mass death of coral and plankton, the basis of the Earth's food chain; the total collapse of the tropical rainforests; an ice sheet the size of Greenland or Antarctica falling into the ocean, causing a near instantaneous rise in worldwide sea levels of at least five meters and flooding one third of the world's population.

Coral reefs are already suffering the longest global die-off on record, which has so far lasted 28 months and is not expected to end until at least 2017. It is estimated that at least 16 percent of the world's reefs will die as a result.

Short-term effects of climate change have already been felt. Droughts in 1982 and 1997 were more intense than they would have been without climate change. Dry, hot weather in 1998, 2005 and 2007 almost set fire to the Amazon rainforests on a massive scale. This year, global warming has contributed to record flooding in South America, flooding and fatal landslides in Ethiopia, wildfires in Canada, droughts in Africa, Thailand and Venezuela, and a general increase in the intensity and destructiveness of this year's Pacific tropical cyclones and Atlantic hurricanes. These are only a handful of the challenges to human well-being and even survival that have occurred in the past several years, attributable to global warming.