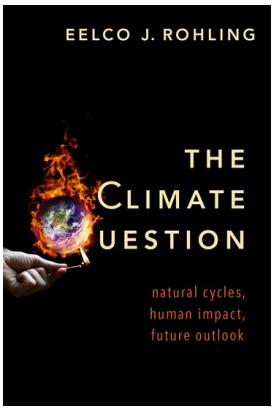
Why urgent action is needed to avoid centuries of global warming



The Climate Question

BY EELCO ROHLING (HTTPS://BLOG.OUP.COM/AUTHORS/EELCO-ROHLING/) JUNE 15TH 2019 9701

In the climate change debate, we often hear the argument that the climate has been changing since time immemorial. This is true, but if modern climate change differs from pre-historic climate cycles, the statement by itself is empty. We need to know how modern climate change compares with that of the past.

Geological observations and computer climate-models have revealed the basic controls and responses involved in past climate variability. This is how we know that climate has always varied. We also know that this happened because of small changes in the forcing of climate that resulted from long-term changes in Earth's orbital position around the Sun, small changes in the actual solar output, and occasional injection of volcanic dust veils into the atmosphere. These small triggers could result in large climate responses because of **feedback processes** (https://www.metoffice.gov.uk/climate-guide/science/science-behind-climate-change/feedbacks).

Earth's climate system includes a plethora of processes that govern the carbon cycle. Their atmospheric expression is familiar to all: changes in the concentration of greenhouse gases, especially carbon dioxide and methane. Climate fluctuations include changes in Earth's reflectivity to incoming solar radiation, through changes in its cover by cloud, snow, ice, and different land surfaces (desert, tundra, forest, etc.). Together, these feedback processes underpinned all known climate variations in a well-understood and quantifiable manner.

And there we have it: in the natural state, greenhouse gas concentration changes were generally part of Earth's intricate climate feedback processes. But we also know of a few past events that *started* with greenhouse gas changes. A key example is the **Paleocene-Eocene Thermal Maximum (https://www.britannica.com/science/Paleocene-Eocene-Thermal-Maximum)** (PETM) which occurred 56 million years ago and was the most dramatic natural event of the past 66 million years. At that time, burps of methane and carbon dioxide, likely triggered by volcanic processes, caused a shock-change in the carbon inventory of Earth's climate system and a rapid global warming event. This well-studied event provides useful information about the likely consequences of humanity's industrial-age emissions.

The PETM saw carbon dioxide concentration in the atmosphere increase to 500 parts per million (ppm) or more. By comparison, humanity's carbon injection into the climate system has so far changed atmospheric carbon dioxide concentrations by 130 to 140 ppm. But the rate of this recent change far exceeds that of the PETM. In recent years, human-caused carbon emissions were 10 times *more rapid* than during the PETM. It is this rapidity that concerns climate researchers.

Humanity's super-rapid carbon dioxide emissions are acidifying the oceans because they do not allow enough time for neutralizing reactions with sea-floor sediments, which requires thousands of years. In other words, the rapidly increasing ocean acidification marks a disequilibrium that is growing out of control. Something very similar happened during the PETM, albeit at a less dramatic rate. Despite that slower growth of the PETM disequilibrium, it took about 200,000 years for the ocean and climate system to recover. That is a strong indication of the sort of timescale Mother Nature will need to clean up our mess.

In addition, humanity's unnaturally rapid greenhouse gas increase is driving such a fast warming response that most biological species cannot evolve or migrate fast enough to keep up. This drives many species to extinction rapidly. In the oceans this push is worsened by acidification. Global extinction rates are now at least 1000 times faster than past natural extinction rates, which include **Earth's five great mass extinctions** (https://www.nationalgeographic.com/science/prehistoric-world/mass-extinction/). In consequence, biologists often speak of the current period as the sixth mass extinction.

Since the industrial revolution, global average surface temperature has gone up by 1.1 to 1.2 °C. But almost no region experiences the global average. Polar regions are warming two to four times more rapidly (and in some places even faster), and tropical regions somewhat slower, than the average. The rapid polar warming causes ice and snow reduction, leading to more warming, sea-level rise, and permafrost melting that will unlock masses of methane held within it.

All of the above changes concern hard observations, not disputable theory. Evidence for the expected consequences can be seen directly as well, in paleoclimate data.

Finally, there is the hidden menace of delayed ocean warming. Oceans absorb massive amounts of heat; so far, they have taken up some 95% of the climate system's industrial-age heat accumulation. Because it takes gargantuan amounts of heat, and thus time, to warm up the oceans, their temperature lags behind the warming of land (land responds very rapidly to climate forcing). As a result, ocean temperature will take centuries to catch up with the amount of climate forcing that has been applied until today. Even if we stopped all greenhouse gas emissions today, considerable global warming would continue over centuries to come. And given that ocean warming causes ice-sheet melting, we should also expect considerable sea-level rise to continue for a very long time.

So how can we humans help Mother Nature clean up the mess of our wild carbon party? Emissions reductions are not enough. We will need to draw greenhouse gases out of the atmosphere (and thus the wider climate and ocean system). Nature alone cannot do this on societally relevant timescales—it would take hundreds of thousands of years. We will need to be inventive and help. And we will need to do so sooner rather than later.

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Jan 17TH JUNE 2019

No mechanism to reduce carbon is known at any scale that is necessary. The best we can do is stop emitting co2, cut our tragic losses and hold on for a few thousand years. And deniers in Congess should be locked up for a very long time. The charge? Criminal negligence.

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