How long will it take temperatures to stop rising, or return to 'normal,' if we stop emitting greenhouse gases?

Temperatures will likely stop rising in a few years or decades—but it could take centuries for them to fall to the levels humans enjoyed before we started burning fossil fuels.

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The scientific consensus is clear that, to stop further climate change, humanity must stop adding greenhouse gases like carbon dioxide (CO_2) and methane to the atmosphere. A trickier question is how quickly the planet would stop warming, and potentially return to the more stable temperatures of the recent past, if we do succeed in cutting greenhouse gas emissions to zero. (AA note: "to zero" is MUCH more difficult than to "net zero" in which we keep emitting some CO2 but equal to what the earth can absorb, so there is a net zero increase in the atmosphere.)

The good news is that the reversal could begin quite quickly, says Andrei Sokolov, a climate modeler working at the MIT Joint Program on the Science and Policy of Global Change. And in time, the Earth would cool back to "normal." But it would be an awfully long time.

In 2020, Sokolov was part of a team that studied a variety of scenarios in which CO_2 emissions stop entirely in the near future.[1] In most of the models used in their simulations, average global temperature stops rising after a couple of decades, but stays above the historical average for many centuries. A few models showed continued warming for decades or even centuries after the end of CO_2 emissions, but they were in the minority.

The bad news is that, while ending our greenhouse gas emissions could swiftly stop climate change from getting any worse, it takes far longer to reverse the warming we've already caused. For example, Sokolov cites one plan the study modeled called "Sky2050," which was meant to keep the planet from warming by more than 1.5 degrees Celsius.[2] Under this scenario, humans cease all climate pollution in 2030, and the average global temperature decreases right away. Yet temperatures fall so slowly that the Earth cools by only half a degree Celsius by the end of the 21st century, and is still half a degree above "normal" in the year 2300.

The temperature falls at such a slow pace because we are dependent on natural processes to remove CO_2 from the atmosphere and cool the Earth. The ocean is the most crucial piece here, as it takes in a huge amount of CO_2 from the atmosphere (and has absorbed 90 percent of the heat from recent decades' warming).[3] Some of that carbon is mixed from the shallow ocean into

the deep ocean, where it eventually turns into rock, locked out of the atmosphere for millions of years. ”But carbon mixing into the deep ocean is a very slow process,” Sokolov says.

It’s also a complicated one. Sokolov says many centuries may be needed for the Earth to return to normal, especially if “normal” is the climate of the 18th century, before humans started burning fossil fuels on an industrial scale. But to know exactly how long—whether a return to normal would happen in the year 2300 or the year 3000—requires use of a sophisticated type of climate model called an Earth System Model (ESM), which simulates biological activity in oceans, forests and other ecosystems. These models are so computationally demanding that most of today’s long-term climate simulations use only “simplified” ESMs.

Running a simulation with a sophisticated ESM that models a thousand years of climate change would require an enormous amount of computing power. But that’s the way to really answer this question, Sokolov says.

“You really need to model with the real ocean—and it will take forever to run it for a few thousand years.”