Carbon emissions to impact climate beyond the day after tomorrow

August 5 2013

Future warming from fossil fuel burning could be more intense and longer-lasting than previously thought. This prediction emerges from a new study by Richard Zeebe at the University of Hawai'i who includes insights from episodes of climate change in the geologic past to inform projections of man-made future climate change. The study is published in the *Proceedings of the National Academy of Sciences*.

Humans keep adding large amounts of greenhouse gases to the atmosphere, among them carbon dioxide (CO2), the most important man-made greenhouse gas. Over the past 250 years, human activities such as fossil fuel burning have raised the atmospheric CO2 concentration by more than 40% over its preindustrial level of 280 ppm (parts per million). In May 2013, the CO2 concentration in Earth's atmosphere surpassed a milestone of 400 ppm for the first time in human history, a level that many scientists consider dangerous territory in terms of its impact on Earth's climate.

A global cooling calamity as depicted in the movie 'The Day After Tomorrow,' though, is very unlikely to be the result of climate change. The globe is likely to become warmer in the near future, and probably a lot warmer in the distant future. Now Zeebe, Professor of Oceanography in the School of Ocean and Earth Science and Technology at the University of Hawai'i at M?noa, has examined mankind's long-term legacy of fossil fuel burning.

The study suggests that amplified and prolonged warming due to

unabated fossil fuel burning raises the probability that large ice sheets such as the Greenland ice sheet will melt, leading to significant sea level rise.

"When we talk about climate sensitivity, we're referring to how much the planet's global surface temperature rises for a given amount of CO2 in the atmosphere," Zeebe said. A standard value for present-day climate sensitivity is about 3°C per doubling of atmospheric CO2. But according to Zeebe, climate sensitivity could change over time. Zeebe uses past climate episodes as analogs for the future, which suggest that so-called slow climate 'feedbacks' can boost climate sensitivity and amplify warming.

An example of a feedback is the familiar audio feedback experienced when a microphone interacts with a speaker. If the audio output from the speaker is received again by the microphone, the initial audio signal is strongly amplified in a positive feedback loop.

A variety of feedbacks also operate in Earth's climate system. For example, a positive feedback loop exists between temperature, snow cover, and absorption of sunlight. When snow melts in response to warming, more sunlight can be absorbed at Earth's surface because most surfaces have a lower reflectivity than snow. In turn, the additional absorption of sunlight leads to further warming, which leads to more snow melt, and so forth.

Previous studies have usually only included fast climate feedbacks (snow cover, clouds, etc.). Using information from pre-historic climate archives, Zeebe calculated how slow climate feedbacks (land ice, vegetation, etc.) and climate sensitivity may evolve over time. Armed with these tools, Zeebe was able to make new predictions about long-term future climate change.

"The calculations showed that man-made climate change could be more severe and take even longer than we thought before" says Zeebe. Although we will not see immediate effects by tomorrow—some of the slow processes will only respond over centuries to millennia—the consequences for long-term ice melt and sea level rise could be substantial. "Politicians may think in four-year terms but we as scientists can and should think in much longer terms. We need to put the impact that humans have on this planet into a historic and geologic context."

"By continuing to put these huge amounts of carbon dioxide in the atmosphere, we're gambling with climate and the outcome is still uncertain," Zeebe said. "The legacy of our fossil fuel burning today is a hangover that could last for tens of thousands of years, if not hundreds of thousands of years to come."

More information: www.pnas.org/cgi/doi/10.1073/pnas.1222843110

Provided by University of Hawaii at Manoa