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Global warming is being caused by humans, not the sun, and is highly sensitive to carbon, new research shows

New research reinforces human-caused global warming and a climate that's highly sensitive to an increased greenhouse effect

New research suggests that clouds amplify global warming, and the sun plays a minor role. Photograph: Frank Rumpenhorst

Over the past few weeks, several important new papers related to human vs. natural climate change have been published. These papers add clarity to the causes of climate change, and how much global warming we can expect in the future.

First, a paper published in the Journal of Climate by Jara Imbers, Ana Lopez, Chris Huntingford, and Myles Allen examines the recent IPCC statement that expressed with 95 percent confidence that humans are the main cause of the current global warming. One of the main challenges in attributing the causes of global warming lies in the representation of the natural internal variability of the Earth's climate.

The study used two very different representations of natural variability. The first model assumed that the present climate has a short and finite memory, and is mostly determined by the recent past. The second model assumed that the climate's internal variability has long memory and the present climate is influenced by all the previous years.

The authors then incorporated each of these representations of natural variability with a statistical approach to estimate the individual contributions of the various factors (e.g. the sun, volcanoes, greenhouse gases) to the increase in average global surface temperature. In each case, the study found that the greenhouse gas-global warming signal was statistically significant, supporting the robustness of the IPCC statement on human-caused global warming. As lead author Jara Imbers told me,

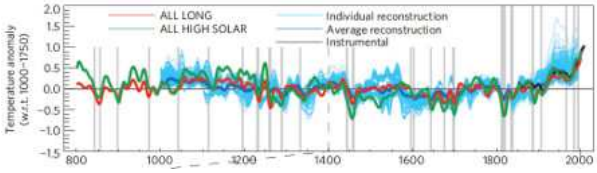
> "...we investigate two extreme cases of the plausible temporal structures of the internal variability, and we find that the anthropogenic signal is robust and significant."

Second, a paper published in Nature Geoscience by Andrew Schurer, Simon Tett, and Gabriele Hegerl investigates the sun's influence on global climate changes over the past 1,000 years. Although we know the sun can't be causing the current global warming

because solar activity has declined slightly over the past 50 years, "it's the sun" nevertheless remains one of the most popular climate contrarian arguments. However, in recent years, research has pointed in the direction of a relatively small solar impact on the Earth's climate changes.

It's important to realize that while the Earth is bombarded by a lot of heat from the sun, the amount of solar energy reaching the planet is relatively stable. According to the best recent estimates, it's only increased by about 0.1 percent over the past 300 years, causing a global energy imbalance less than 10 percent as large as that caused by humans over the same period.

In this study, the authors tested reconstructions that incorporated relatively large and small changes in solar activity, and compared them to northern hemisphere temperature reconstructions over the past millennium. The reconstruction using a stronger solar influence (green) was a worse fit to the temperature data (blue) than the reconstruction with the weaker solar influence (red), especially around the 12th century.



Simulations with all external climate influences including strong (green) and weak (red) solar influences, compared to the ensemble of northern hemisphere surface temperatures over the past 1,000 yeas (blue) and instrumental surface temperature measurements (black). From Schurer et al. (2013).

As in the Imbers paper, this study used a statistical approach to determine the contribution of each factor in the measured temperature changes. The authors conclude,

> "Volcanic and GHG [greenhouse gas] forcings seem to contribute most to pre-twentieth-century climate variability, whereas the contribution by solar forcing is modest, agreeing with the simulations with low solar forcing."

The study finds that the sun is unlikely to have caused more than 0.15°C of the observed approximately 1°C warming over the past 300 years. The authors find a detectable greenhouse gas influence on the climate before the 20th century, and consistent with the IPCC and Imbers, they conclude that humans are the dominant cause of recent global warming.

> "Over the twentieth century, anthropogenic forcings dominate with GHGs the largest forcing, offset by the effect of anthropogenic aerosols and land use changes"

However, the authors note that while the sun has little impact on average hemispheric and global temperatures, it does have a significant influence on regional temperatures, for example in Europe.

Finally, a paper published in Nature by Steven Sherwood, Sandrine Bony, and Jean-Louis Dufresne examines the role that clouds will play in the sensitivity of the global climate to the increased greenhouse effect. To this point, cloud responses to global warming have remained a key uncertainty.

We know that a doubling of the amount of carbon dioxide in the atmosphere will cause a bit more than 1°C global surface warming by itself, and we know that there are several feedbacks that will amplify that warming. The amount of water vapor in the atmosphere – another greenhouse gas – increases as the planet warms, amplifying that warming. This is the single largest feedback, and is increasing as climate scientists expect. We also know that melting ice makes the planet less reflective, causing it to absorb more sunlight, also amplifying global warming. And carbon released from various sources like beneath melting permafrost and from burning peatlands will also increase the greenhouse effect as another positive feedback in a warming world.

However, we know of few significant negative feedbacks that will offset these effects and dampen global warming. The reckless contrarian approach is dependent upon the

climate being relatively insensitive to the increased greenhouse effect, which requires that something offset all of these warming feedbacks. Clouds, whose responses in a warming world have been difficult to pin down, were the contrarians' last and best hope. An increase in cloud cover in response to global warming would reflect more sunlight back out to space, thereby cooling the Earth and offsetting some of those positive warming feedbacks.

The authors of the Nature study examined cloud change simulations in relatively low and high sensitivity climate models. As summarized by Rob Painting, they found that the less sensitive models were incorrectly simulating water vapor being drawn up to higher levels of the atmosphere to form clouds in a warmer world. In reality (based on observations) warming of the lower atmosphere pulls water vapor away from those higher cloud-forming levels of the atmosphere and the amount of cloud formation there actually decreases, resulting in another amplifying global warming feedback. Lead author Steven Sherwood describes the study in the video below.

These results are consistent with Fasullo & Trenberth (2012), who found that only the higher sensitivity climate models correctly simulated drying in key cloud-forming regions of the atmosphere. Likewise, preliminary results by scientists at the California Institute of Technology Jet Propulsion Laboratory presented at the 2013 AGU meeting showed that higher sensitivity models do the best job simulating observed cloud changes. These results are also consistent with Lauer et al. (2010) and Clement et al. (2009), which looked at cloud changes in the Pacific, finding the observations consistent with a positive cloud feedback.

To summarize, the evidence that humans are the dominant cause of the current global warming is overwhelming (which is the reason behind the 97 percent expert consensus), and continues to grow. And while the media has lately tended to focus on the few papers that suggest climate sensitivity is relatively low, there is a growing body of evidence based on cloud observations that it's actually on the high end, above 3°C warming in response to doubled CO_2, which under business as usual would lead to more than 4°C warming by 2100 – a potentially catastrophic scenario.

In short – it's us, it's bad, and if we don't change course, it's a potential catastrophe.

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