Pristine environments offer a window to our cloudy past

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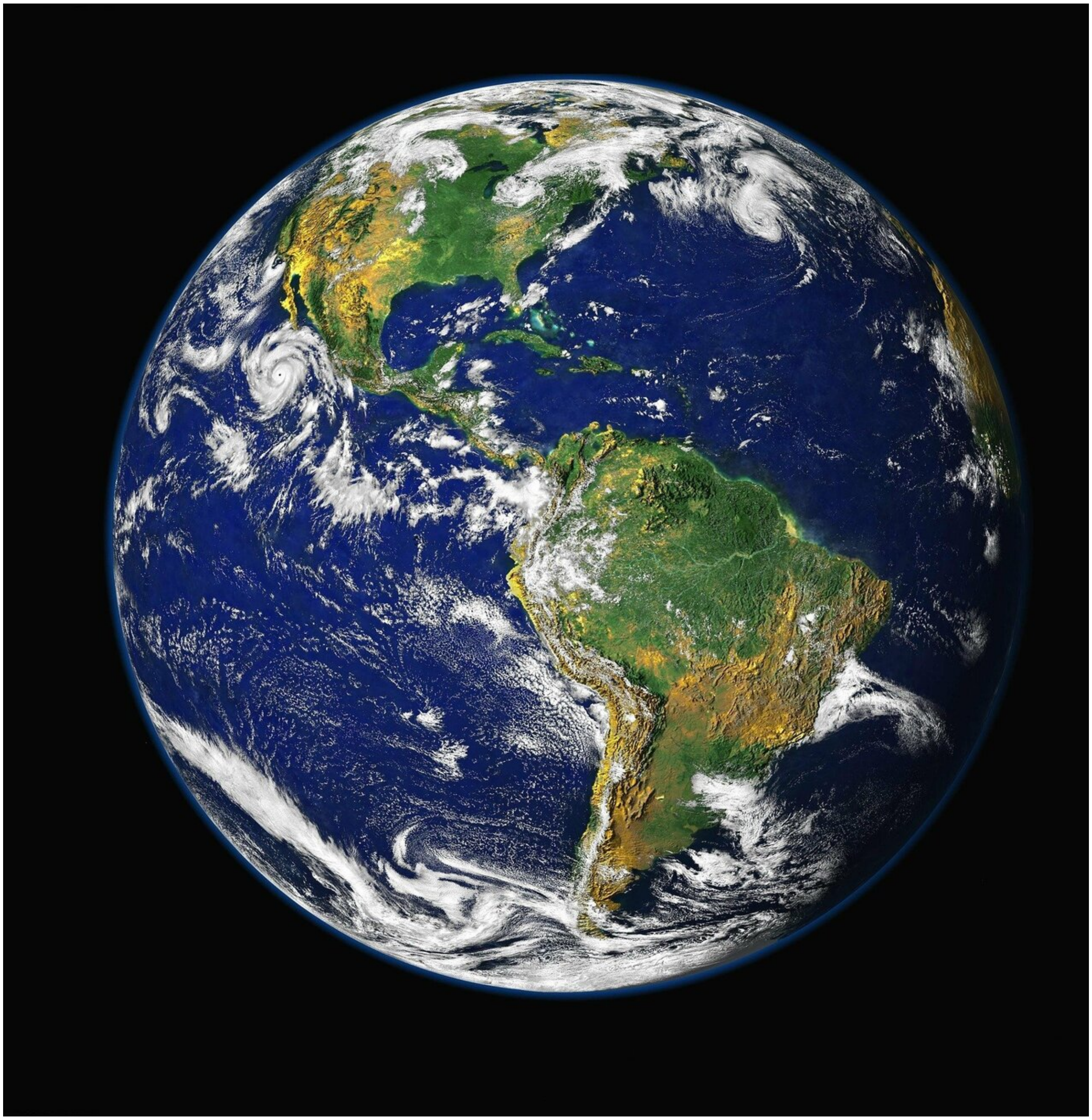

The study highlights a fundamental shift in the nature of crust formation 3.75 billion years ago, which facilitated the formation of Earth's unique, stable continental crust. Credit: CC0 Public Domain

A new study uses satellite data over the Southern Hemisphere to understand global cloud composition during the industrial revolution. This research tackles one of the largest uncertainties in today's climate models—the long-term effect of tiny atmospheric particles on climate change.

Climate models currently include the global warming effect of greenhouse gases as well as the cooling effects of atmospheric aerosols. The tiny particles that make up these aerosols are produced by human-made sources such as emissions from cars and industry, as well as natural sources such as phytoplankton and sea spray.

They can directly influence the flow of sunlight and heat within the Earth's atmosphere as well as interact with clouds. One of the ways that they do this is by bolstering clouds' ability to reflect sunlight back into space by increasing their droplet concentration. This in turn cools the planet. The amount of sunlight that is reflected to space is referred to Earth's albedo.

However, there has been extremely limited understanding of how aerosol concentration has changed between early-industrial times and the present day. This lack of information restricts the ability of climate models to accurately estimate the long-term effects of aerosols on global temperatures -and how much of an effect they could have in the future.

Now, an international study led by the Universities of Leeds and

Washington has recognized that remote, pristine parts of the Southern Hemisphere provide a window into what the early-industrial atmosphere looked like.

The team used satellite measurements of cloud droplet concentration in the atmosphere over the Northern Hemisphere—heavily polluted with today's industrial aerosols—and over the relatively pristine Southern Ocean.

They used these measurements to quantify the possible changes due to industrial aerosols in Earth's albedo since 1850.

The results, published today in the journal *PNAS*, suggest that early-industrial aerosol concentrations and cloud droplet numbers were much higher than is currently estimated by many global climate models. This could mean that human-generated atmospheric aerosols are not having as strong a cooling effect as some climate models estimate. The study suggests that the effect is likely to be more moderate.

Co-lead author, Daniel McCoy, Research Fellow in the School of Earth and Environment at Leeds, said: "Limitations in our ability to measure aerosols in the early-industrial atmosphere have made it hard to reduce uncertainties in how much warming there will be in the 21st century.

"Ice cores provide carbon dioxide concentrations from millennia in the past, but aerosols don't hang around in the same way. One way that we can try to look back in time is to examine a part of the atmosphere that we haven't polluted yet.

"These remote areas allow us a glimpse into our past and this helps us understand the climate record and improve our predictions of what will happen in the future."

Co-lead author, Isabel McCoy, from the Atmospheric Sciences Department at Washington, said: "One of the biggest surprises for us was how high the concentration of cloud droplets is in Southern Ocean clouds. The way that the cloud droplet concentration increases in summertime tells us that ocean biology is playing an important role in setting cloud brightness in unpolluted oceans now and in the past.

"We see high cloud droplet concentrations in satellite and aircraft observations, but not in climate models. This suggests that there are gaps in the model representation of aerosol-cloud interactions and aerosol production mechanisms in pristine environments.

"As we continue to observe pristine environments through satellite, aircraft, and ground platforms, we can improve the representation of the complex mechanisms controlling cloud brightness in climate models and increase the accuracy of our climate projections."

Co-author Leighton Regayre, a Research Fellow also from the School of Earth and Environment at Leeds, said: "The science supporting our climate models is improving all the time. These models are tackling some of the most pressing and complex environmental questions of the modern era and climate scientists have always been up front about the fact that uncertainties exist.

"We are only going to reach the answers we need to combat global warming by regularly interrogating the science. Our team used millions of variants of a model to explore all the potential uncertainties, the equivalent of having a clinical trial with millions of participants.

"We hope our findings, along with studies on the detailed process of aerosol production and aerosol-cloud interactions in pristine environments that our work has motivated, will help guide the development of the next generation of climate models."

The paper "The hemispheric contrast in cloud microphysical properties constrains aerosol forcing" is published in *PNAS*, 27 July 2020.

More information: Isabel L. McCoy el al., "The hemispheric contrast in cloud microphysical properties constrains aerosol forcing," *PNAS* (2020). www.pnas.org/cgi/doi/10.1073/pnas.1922502117

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