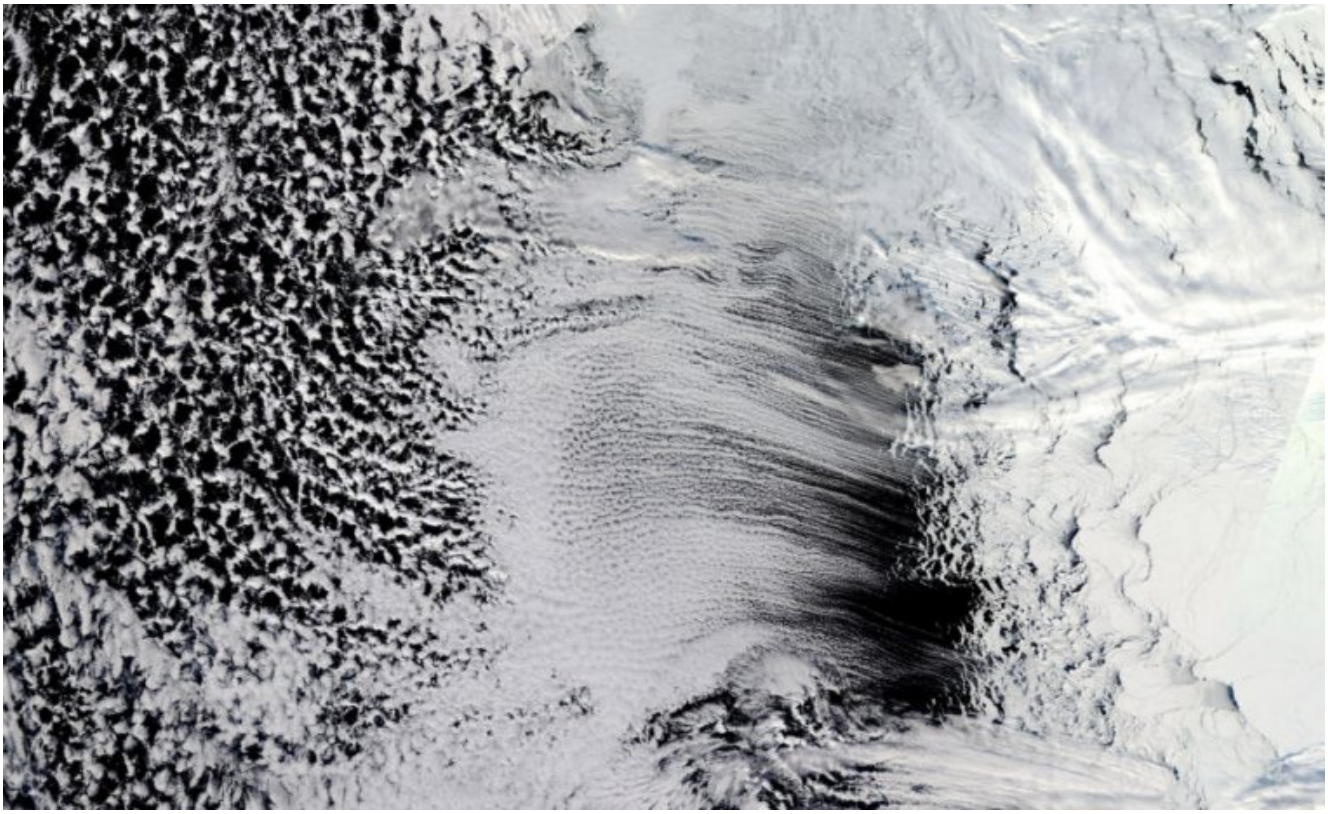
Using pristine Southern Ocean air to estimate pre-industrial pollution



Enlarge / Long lines called “cloud streets” forming off the edge of Antarctic sea ice.

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One of the lesser-known scientific complications that makes assessing human-caused climate change a hassle is that it isn’t all about greenhouse gases. Emissions of aerosols—tiny atmospheric particles from a variety of sources that scatter sunlight back to space, for example—have acted to offset a portion of the human-caused warming. And unlike long-lived greenhouse gases, aerosols wash out of the atmosphere quite

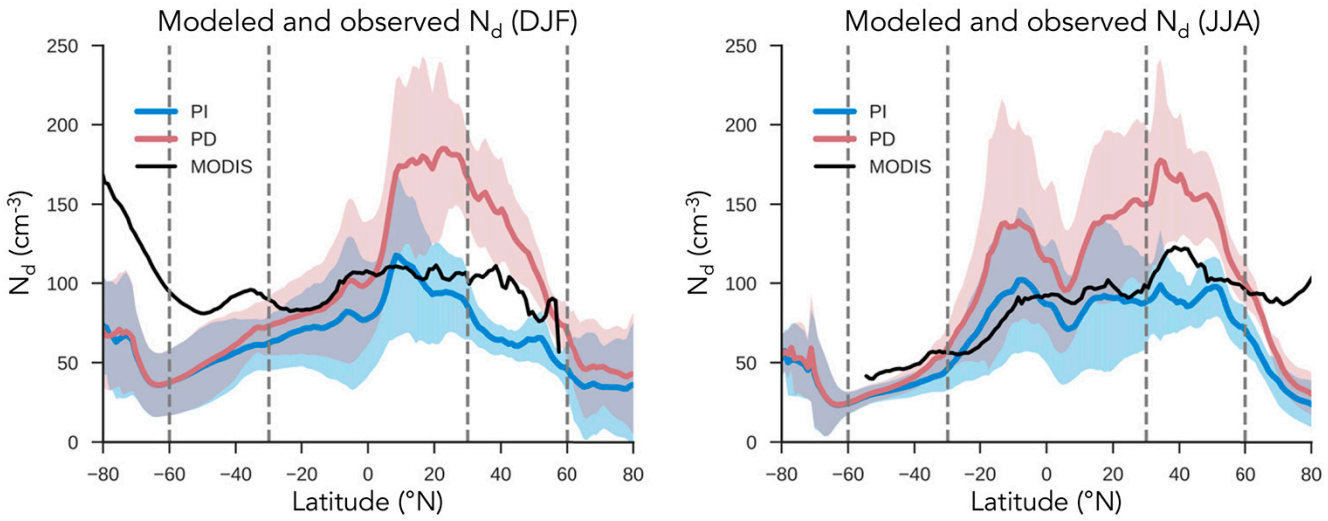
quickly and leave no historical record. That makes reconstructing aerosol levels going back before the Industrial Revolution a challenge.

To improve and cross-check estimates of past aerosol levels, researchers have gotten creative. A new study led by Isabel McCoy at the University of Washington uses the fact that the skies around Antarctica are close to free from human-caused aerosol pollution to set a new pre-industrial baseline.

Aerosols have a cooling influence through both direct (scattering sunlight) and indirect (modifying clouds) effects. In this case, the researchers are looking at the latter by using satellite cloud data. Specifically, they calculate the number of cloud droplets per cubic centimeter based on measurements of droplet size and cloud thickness. Because aerosols can act as condensation nuclei around which droplets form, they tend to lead to higher levels of smaller droplets.

While aerosol pollution from coal-burning and other combustion activities tends to be present throughout the Northern Hemisphere, Antarctica's atmospheric isolation keeps those aerosols at bay. Using the Antarctic as an indicator of pre-industrial aerosol levels, the researchers apply the satellite data to a number of climate models. First, they compare how well the models match modern cloud-droplet concentrations around the world, and then they calculate the impact of aerosol pollution over time.

There are a couple regions where the modern model simulations don't match the satellite data very well. The models generally overestimate droplet concentrations in the midlatitude Northern Hemisphere, and they underestimate summertime droplet concentrations in the Antarctic. While the models show only a modest increase in summer, the satellite data revealed that Antarctic droplet concentrations actually get as high as the polluted Northern Hemisphere—an eyebrow-raising result.



Present-day (red) and pre-industrial (blue) model simulations of cloud-droplet concentration compared to the satellite data (black). Winter season on the left, summer on the right.

How could that be in this “pristine” environment, you ask? It’s probably not a camouflaged coal power plant or any other human source of aerosols. Aerosols do occur naturally, and one prominent source is the phytoplankton and bacteria in the ocean. They produce dimethyl sulfide—one of the sources of seawater’s distinct smell as well as a compound that leads to the formation of tiny sulfur-bearing aerosols.

Huge phytoplankton blooms occur around Antarctica when the sea ice shrinks in summer and life takes advantage of the nutrient-rich waters. And that produces a lot of aerosols for cloud droplets to form around.

What’s most interesting about this is what it implies about our estimates of the cooling influence of aerosol pollution. If models are essentially overestimating the effect of human-caused aerosols on clouds and underestimating the effect of natural aerosols, then the calculated effect of human aerosol pollution will be too large. When the researchers calculate the strength of this aerosol-cloud effect since 1850, they get a reduction of 0.6 to 1.2 watts of energy in Earth’s climate system per square meter. (That offsets a portion of the energy added by greenhouse gases.)

The impact of aerosols has been studied using multiple lines

of evidence beyond just the models, and the newly calculated value supports the current best estimate derived using the full body of evidence, although it’s a slightly tighter range. So the study’s takeaways relate more to the climate models, which the researchers say could use this information to work on improving the models’ cloud-aerosol connection. But it’s also a fascinating example of accessing the past by studying a location on Earth where the Industrial Revolution hasn’t—in one very specific way, at least—had much of an effect.

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