Clean air, thinner clouds? A century-old pollution puzzle

May 6 2026, by Sayan Tribedi

Sailboat "ship tracks" in a cloud—fine particles from ship exhaust seed extra droplets, making a bright streak of cloud over the Pacific (NASA MODIS)

Pre-industrial pollution from coal smoke and wood-burning in regions like the southeastern U.S. and UK may have made the air murkier than previously thought. This historical haze could significantly alter our understanding of how clouds formed and reflected sunlight in the past.

Tiny particles in the air can have big climate effects. Each tiny dust or soot grain can seed a water droplet, so more particles mean more, smaller droplets and a brighter, whiter cloud. NASA satellites often see this in action: long, bright "ship tracks" form behind ocean vessels, where soot from exhaust seeds extra clouds. This real-world example of the Twomey effect shows how pollution boosts cloud reflectivity.

The vast majority of climate models have assumed that the skies over 19th-century Earth were pristine, meaning that anthropogenic aerosols were much lower than those observed today. However, if the skies back then were dirtier than we think, the net impact on the clouds changes sign.

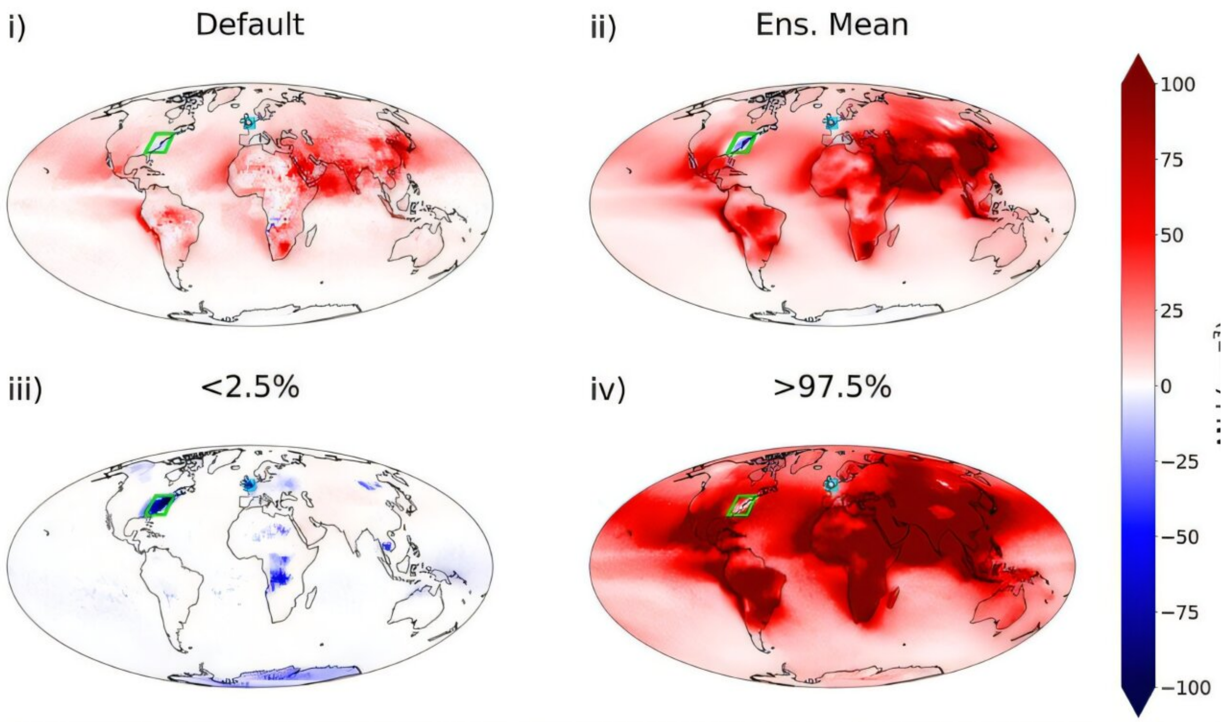
For this reason, scientists carried out multiple computer simulations of the climate from the years 1850 to 2050, including various physical aspects and different degrees of 19th-century emissions from biomass burning and industry. They got the expected results in most places, but there was an unexpected result in two spots.

The paper is published in the journal *Geophysical Research Letters*.

A cloud experiment in time

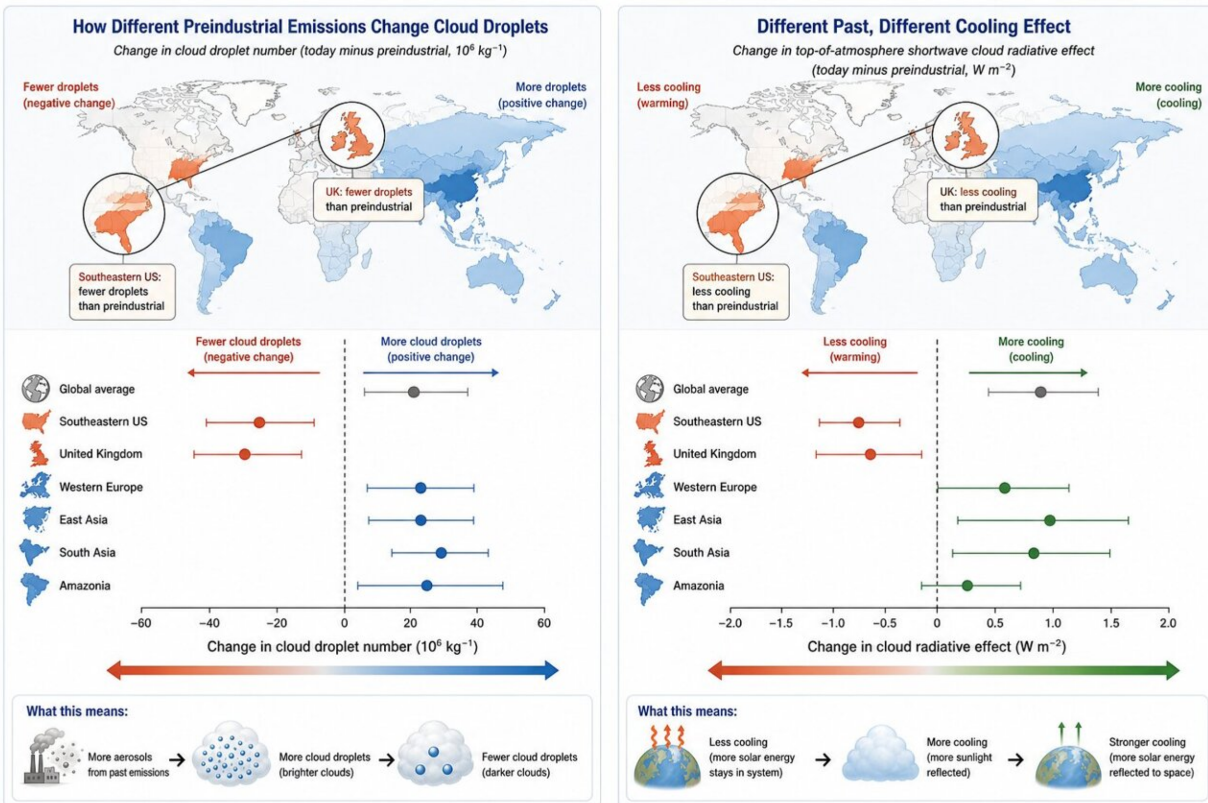
Using the E3SMv3 Earth-system model, the team "replayed" history from 1850 to today under different aerosol scenarios. In most of the world, cranking up 19th-century soot led to larger jumps in today's cloud droplets. But not everywhere. In the southeastern U.S. and in the British Isles, the simulations actually produced fewer cloud droplets in modern skies than in 1850. Why?

The culprit was old pollution: these regions had especially heavy 19thcentury burning (wood, peat, coal) around towns and farms, so the 1800s atmosphere was already murky.



Map showing where cloud droplet numbers increased (green) or decreased (blue) since pre-industrial times. Credit: *Geophysical Research Letters* (2026). DOI: 10.1029/2025gl121443

As the authors explain, "We find that the input data sets describing PI combustion in the model are the key source of these negative signals." In other words, the assumed preindustrial soot levels drive the result. Changing those assumptions can literally flip the outcome. The team adds, "We can change cloud density by changing these input data sets, indicating a need for better estimates for PI aerosol emissions."



Graphs illustrating how different levels of past pollution change cloud droplet numbers and Earth's energy balance. Credit: generated by AI for illustrative purpose

This is a critical point. Several studies indicate that even a simple re-evaluation of preindustrial fire soot will result in reducing the estimated impact on cloud cooling by more than one-third.

Indeed, one study showed that assuming greater fire emissions during the 1800s could reduce the estimated cloud albedo forcing by 91% and lead to ancient fires being regarded as the "single largest source of uncertainty" in estimating historical aerosol forcing.

In essence, estimates of historical aerosol forcing are already considered among the greatest sources of uncertainty when predicting future warming.

Implications for the climate picture

How does this affect our knowledge of climate? With the realization that the skies of old were foggy compared to our previous estimates, our estimation of the impact of pollutants on cloud coverage (and hence global cooling) might be wrong. This is important in knowing the amount of warming that could have been hidden by clouds.

The importance of getting aerosol-cloud interactions right cannot be overemphasized; even a little change in cloud cover could result in major changes in temperatures.

This is certainly no theory at all. A better understanding of how aerosols interact with cloud formation can greatly help improve predictions on climate change, as well as policy decisions. This means that the prediction of warming in certain regions might not have been very accurate because of the lower cooling effect brought about by the cloud formation.

Some places might even be an exception to the rule, where pollution levels increase the water droplets. This must be considered when developing policies to control air pollution.

A complex clear sky

The authors also point out that their results are those from just one model, and that the exact extent of 19th-century emissions is still largely unknown. Different models could produce different reactions to greenhouse gases, and the true picture of what happened during the 1800s can only be pieced together through indirect evidence (such as historical documents and ice cores).

Nevertheless, the notion that the air before the industrial revolution was "pristine" may need to be revised. More research needs to be done, both in modeling and history.

More information: Hunter Y. Brown et al, Sensitivity of Anthropogenic Cloud Droplet Number Change to Preindustrial Emission Inventories and Physics Parameterizations, *Geophysical Research Letters* (2026). DOI: 10.1029/2025gl121443