Human-caused emissions create new cloud-forming particles

December 20 2022, by Paul Gabrielsen

The University of Utah's Storm Peak Laboratory. Credit: Gannet Hallar/University of Utah

Human activity is changing atmospheric chemistry—even in remote places—that could alter how and when clouds form.

That's the conclusion of a new study from University of Utah scientists and colleagues, which finds that at a laboratory on a mountaintop in Colorado, new aerosol particles are forming in the air on average every other day and that those particles, likely formed from gases emitted by nearby power plants, can grow until they're big enough for water to condense around, forming clouds.

The study draws an important scientific link, using newly developed statistical methods, that link aerosol growth to measured cloud condensation nuclei—which are the critical ingredients for accurately modeling the role of aerosols and clouds in climate change.

"Storm Peak Laboratory is a remote site in the Intermountain West," says Gannet Hallar, professor of atmospheric sciences. "Just because we only measure there doesn't mean it's not happening at all other remote sites in the Intermountain West."

The study is published in *Atmospheric Chemistry and Physics*.

How clouds form

Let's begin with the process of cloud formation. To form, clouds need something in the air, such as a speck of dirt or salt, around which to begin condensing water vapor. These somethings, about a tenth of the diameter of spider silk, are particles called "cloud condensation nuclei."

It's known that increased aerosols in the atmosphere lead to more cloud formation, and more reflective clouds. But it's not known whether new aerosol particles, much smaller than cloud condensation nuclei and formed with human-caused emissions, can grow into cloud condensation nuclei. And it's also not known how to incorporate the relationship between aerosols and clouds in climate models. As you might imagine, clouds play a large role in the climate, reflecting solar energy and moving water from one place to another. So being able to realistically model those clouds could help increase the accuracy of the models forecasting changes in our climate.

Every other day

To understand the relationship between the formation of new aerosol particles and cloud condensation nuclei, recent graduate Noah Hirshorn, Hallar and colleagues dove into a 15-year record of aerosol measurements at Storm Peak Laboratory, a University of Utah facility directed by Hallar and located on the Steamboat ski resort in Colorado at an elevation of more than 10,500 ft (3210 m).

"Given the remote, mountaintop location of Storm Peak Lab," the authors write, "clean atmospheric conditions are common at the laboratory."

Upwind of the laboratory, however, are several power plants emitting sulfur dioxide, a gas that changes in the atmosphere to sulfuric acid, which can form into particles and cause new particle formation events.

For nearly 20 years, new particle formation has been measured by people looking at three-dimensional charts showing measurements of aerosol particles over time. Certain patterns in the appearance of bursts of new particles, as well as persistent growth of those particles, formed the criteria for designating new particle formation events.

But Hirshorn, Hallar and other researchers, including U graduates Lauren Zuromski and Christopher Rapp, developed an automatic method, based on statistics, to classify new particle formation events.

The new method improves event detection accuracy and efficiency and agrees well with manual detection methods.

Using this method, the researchers found that new particle formation events occurred at Storm Peak on 50% of days between 2006 and 2021. But comparing the rates of new particle formation with the amounts of particles big enough to serve as cloud condensation nuclei, the authors found that new particle formation events enhanced the numbers of cloud condensation nuclei by a factor of 1.36 in the winter and a factor of 1.54 in the spring.

What does this all mean?

"Every other day we see gases that are condensing into nanoparticles, which are growing large enough to uptake water and become cloud droplets," Hallar says.

"This provides that clear connection from a new particle formation event all the way to cloud condensation nuclei," Hirshorn says. "The biggest direct benefit of that is probably going to be for climate modelers to be able to connect one to the other. It fills in a lot of gaps."

The study was focused on Storm Peak Lab, with the particular atmospheric chemistry created by the upwind power plants. But it's plausible, the researchers say, that similar rates of new particle formation are happening even in remote places throughout the world. Hirshorn says that they're working on applying their statistical method to mountaintop observatories in Europe and South America. And Hallar recently received a $720,000 grant from the U.S. Department of Energy to apply the method to data from the DOE's Atmospheric Radiation Measurement facility.

New particle formation is a process that hits close to home for residents of Utah's Wasatch Front, where the U is located. In winter, temperature inversion events trap emissions from cars, businesses and buildings under a lid of warm air, changing the atmospheric chemistry and degrading air quality.

"About 70% of the aerosol measured during strong inversion events is ammonium nitrate," says Hallar, referring to a 2014 study conducted by the Utah Department of Air Quality and Brigham Young University. "That is formed through this same new particle formation process." U graduate student Gerardo Carrillo-Cardenas is already at work applying statistical methods to better understand Utah's aerosols, how they form, and how they affect air quality.

In future years, Storm Peak's location will make it an ideal place to study how cuts to worldwide greenhouse gas emissions might impact new particle formation, as the powerplants currently emitting sulfur dioxide upwind of the lab will likely be decommissioned within 10 to 15 years.

"In about 20 years we may have an answer to that," Hirshorn says. "My hypothesis is you would see a decreased frequency in new particle formation events. It wouldn't cut out new particle formation entirely, but the frequency would go down."

More information: Noah S. Hirshorn et al, Seasonal significance of new particle formation impacts on cloud condensation nuclei at a mountaintop location, *Atmospheric Chemistry and Physics* (2022). DOI: 10.5194/acp-22-15909-2022

Provided by University of Utah

retrieved 22 June 2024 from https://phys.org/news/2022-12-human-caused-emissions-cloud-forming-particles.html