Researchers Improve Predictions of Cloud Formation For Better Global Climate Modeling

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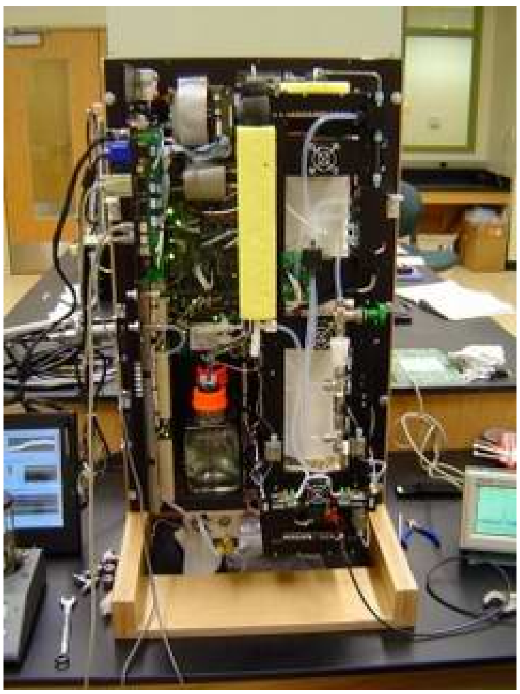

Atmospheric scientists have developed simple, physics-based equations that address some of the limitations of current methods for representing cloud formation in global climate models – important because of increased aerosol pollution that gives clouds more cooling power and affects precipitation.

The National Science Foundation (NSF)-funded researchers, led by scientists at the Georgia Institute of Technology, also have developed a new instrument for measuring the conditions and time needed for a particle to become a cloud droplet. This will help scientists determine how various types of emissions affect cloud formation.

Image: A new type of cloud condensation nuclei (CCN) counter was developed by Georgia Tech Assistant Professor Athanasios Nenes and Gregory Roberts at the Scripps Institution of Oceanography. The instrument measures how many cloud droplets form and how long they take to form. Credit: Image Courtesy of Athanasios Nenes

Georgia Tech scientist Athanasios Nenes will present a lecture on the work at the American Geophysical Union's fall meeting in San Francisco on Dec. 17. The session is titled "Tropospheric Aerosol Processes: The Physical and Chemical Aging of Aerosol Particles and Their Impacts."

Clouds play a critical role in climate, Nenes explained. Low, thick clouds cool the earth by reflecting solar radiation whereas high, thin clouds have warming properties by trapping infrared radiation emitted by the earth.

Scientists have learned that human activities influence cloud formation. Airborne particles released by smokestacks, charcoal grills and car exhaust restrict the growth of cloud droplets, causing condensing water to spread out among a larger number of smaller droplets. Known as the "indirect aerosol effect," it gives clouds more surface area and reflectivity, which translates into greater cooling power. The clouds may also have less chance of forming rain, which allows cloud to remain longer for cooling.

"Of all the components of climate change, the aerosol indirect effect has the greatest potential cooling effect, yet quantitative estimates are highly uncertain," said Nenes. "We need to get more rigorous and accurate representation of how particles modify cloud properties. Until the aerosol indirect effect is well understood, society is incapable of assessing its impact on future climate."

Current computer climate models can't accurately predict cloud formation, which, in turn, hinders their ability to forecast climate change from human activities. "Because of their coarse resolution, computer models produce values on large spatial scales (hundreds of kilometers) and can only represent large cloud systems," Nenes said.

Aerosol particles, however, are extremely small and measured in micrometers. This means predictive models must address processes taking place on a very broad range of scale. "Equations that describe cloud formation simply cannot be implemented in climate models," Nenes said. "We don't have enough computing power -- and probably won't for another 50 years. Yet somehow we still need to describe cloud formation accurately if we want to understand how humans are affecting climate."

To address the lack of computer power and shortcomings of existing parameterization, Nenes and his research team have developed simple, physics-based equations that link aerosol particles and cloud droplets. Then these equations can be scaled up to a global level, providing accurate predictions thousands of times faster than more detailed models.

This modeling method has proven successful in two field tests. Data was collected from aircraft flying through from cumulus clouds off the coast of Key West, Fla., in 2002, and from stratocumulus clouds near Monterey, Calif., in 2003. Compared with this real-world data, predictions from Nenes' model were accurate within 10 to 20 percent.

“We never expected to capture the physics to that degree,” Nenes explained. “We were hoping for a 50 percent accuracy rate.”

Another challenge in predicting climate change is to understand how aerosols’ chemistry affects cloud formation. Each particle has a different potential for forming a cloud droplet, which depends on its composition, location and how long it has been in the atmosphere. Until now, people have measured and averaged properties over long periods of time. “Yet particles are mixing and changing quickly,” Nenes said. “If you don’t factor in the chemical aging of the aerosol, you can easily have a large error when predicting cloud droplet number.”

Working with Gregory Roberts at the Scripps Institution of Oceanography, Nenes developed a new type of cloud condensation nuclei (CCN) counter. This instrument exposes different aerosol particles to supersaturation, which enables researchers to determine: 1) how many droplets form and 2) how long they take to form.

Providing fast, reliable measurements, the CCN counter can be used on the ground or in an aircraft. “It gives us a much needed link for determining how different types of emissions will affect clouds formation,” Nenes explained.

Nenes and Roberts have patented the CCN instrument, and a paper describing the technology will be published in an upcoming issue of the journal Aerosol Science and Technology.

The new modeling method and CCN instrument have far-reaching applications for predicting climate change and precipitation patterns, the scientists believe.

The indirect aerosol effect is counteracting greenhouse warming now, but will stop at some point, Nenes explained. “One of our goals is to figure out how long we'll have this cooling effect so we can respond to changes."

Source: NSF

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