Man-made pollutants significantly influence how tree emissions form aerosol particles

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Sally Ng

The southeastern United States is a natural laboratory for scientists studying how chemicals emitted by human activities and trees interact with each other and affect air quality and climate. A new study has found that certain emissions from cars and coal-fired power plants promote processes that transform naturally occurring emissions from trees into organic aerosols. Organic aerosols make up a substantial

fraction of ambient particulate matter (PM) that can affect climate, air quality and human health.

Combining laboratory studies and ambient measurements from multiple sites in and around Atlanta, Georgia, and rural Alabama, scientists found that sulfur dioxide and nitrogen oxides directly and substantially mediate the formation of aerosols from the volatile organic compounds produced by trees.

"This finding is good news for pollution control. If we are able to further reduce sulfur dioxide and nitrogen oxide emissions, we will not only decrease sulfate aerosols but also organic aerosols, thus lowering the total aerosol burden in the southeast United States," said Nga Lee (Sally) Ng, co-author of the study and assistant professor in Georgia Tech's School of Chemical and Biomolecular Engineering and School of Earth and Atmospheric Sciences. Other Georgia Tech co-authors include professors Rodney Weber and Athanasios Nenes, Georgia Power Scholar and Cullen Peck Faculty Fellow.

The study was sponsored by the National Science Foundation (NSF), the Environmental Protection Agency (EPA), and the National Oceanic and Atmospheric Administration (NOAA). The study was published December 22 in the journal *Proceedings of the National Academy of Sciences*.

Scientists have known for years that human-made pollutants can interact with vegetation-emitted organic compounds, turning them into airborne particles. Those particles may affect air quality, human health and climate. However, to what extent and how exactly human-made pollutants affect aerosol formation from vegetation in the ambient environments are poorly understood.

Anthropogenic sulfate, produced mainly by coal-fired power plants, and

nitrogen oxides, produced mainly by vehicle emissions, control 43 to 70 percent of the total measured organic aerosol load in the southeastern United States during summer months, the study found.

According to the study, the formation of aerosols from certain tree emissions is directly controlled by the abundance of sulfate, instead of particle water or particle acidity as suggested by prior studies. This is surprising, but it appears that in the southeastern U.S. the particles have sufficient water and acidity to preclude them from being the controlling factors in aerosol formation. The study further shows that the nighttime aerosol chemistry is more important than previously thought.

"Aerosol chemistry does not stop at night," Ng said. After sunset, the nitrogen oxide compounds and ozone can react with the emissions from trees to produce organic aerosols.

The findings may help improve air quality and climate simulations in regions where anthropogenic-biogenic interactions contribute substantially to aerosol formation, Ng said.

To unravel the complexity of what drives particle formation, researchers collected data in ambient field studies using advanced aerosol mass spectrometry techniques, in combination with particle into liquid sampler, and cloud condensation nuclei counter, which quantified the aerosol chemical composition and its ability to uptake liquid water. The data collected, combined with a state-of the art thermodynamic model ISORROPIA, revealed the contribution of organic species and sulfate to the acidity and water uptake. A comprehensive multivariate linear regression analysis showed that sulfate alone, not its associated water uptake or acidity, was responsible for the organic aerosol levels measured. This study also used the Georgia Tech Environmental Chamber Facility to investigate aerosol formation and chemical composition under nighttime conditions in a well-controlled laboratory

setting, which was supported by an EPA Early Career Award Ng received.

The study is an outcome of one of the largest U.S. atmospheric chemistry field projects in decades – the Southeast Atmosphere Study (SAS), which took place in Alabama's Talladega National Forest in 2013. The initiative brought together dozens of national and international institutions. The research teams used instrumentation onboard aircraft and ground sites to learn more about the region's atmospheric chemistry. Data was also collected from four sites around the Atlanta area over two years, as part of the U.S. Environmental Protection Agency (EPA) Clean Air Research Center at Georgia.

"To study this type of chemistry and understand how man-made pollutants interact with natural emissions, the southeast United States is the best place in the country," Ng said.

"We have seen evidence for this possible effect in prior studies a number of years ago. Results from this study provides a coherent understanding of this interaction and allow us to put together a comprehensive picture," Weber added.

More information: Lu Xu, et al. "Effects of anthropogenic emissions on aerosol formation from isoprene and monoterpenes in the southeastern United States." (*PNAS*, December 2014) DOI: 10.1073/pnas.1417609112

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