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Advancing our understanding of how aerosols affect climate and human health

Photo courtesy of U.S. Global Change Research Program.

It's no secret that the emissions leaving a car tailpipe or factory smokestack affect climate and air quality. Even trees release chemicals that influence the atmosphere. But until now, scientists have struggled to know where these organic molecules go and what happens to them once they leave their source, leading to prediction models for climate and air quality that are incomplete or less than accurate.

Now for the first time, a major collaborative effort of more than 60 scientists and led by Jose-Luis Jimenez, associate professor of chemistry and fellow with the University of Colorado and NOAA's Cooperative Institute for Research in Environmental Sciences, finds the common ground in the jumble of organic material floating through the skies. Together, they present a workable solution that will improve the speed and accuracy of prediction models used to understand how these aerosols affect climate and human health. The scientists' work was supported in part by the NOAA Climate Program Office's Atmospheric Composition & Climate Program.

"We're providing a key piece of machinery that is needed to make accurate predictions of air quality and climate and that is also relatively simple and practical to use," said Jimenez, lead-author of the study that appears in the Dec. 11, 2009, issue of *Science*.

Organic compounds coat airborne particles like a lacquer of spray paint and make up as much as 90 percent of all fine particle mass aloft in the atmosphere. These particles influence cloud formation and therefore rainfall. They also affect human health and can lead to illnesses like asthma, heart disease and lung cancer. But so far only about 10-30 percent of the thousands of individual compounds have been identified, and past research has focused on following specific molecules with the idea that these compounds remain relatively static in nature once they enter the atmosphere. Recent discoveries show that the life cycle of these compounds is much more complex, with organic molecules reacting many times over in many different ways. Attempts by atmospheric scientists to track this life cycle often leave researchers with a sea of divergent paths to follow.

To find some order in this chaos, Jimenez and his colleagues began looking at organic particles with a more holistic mindset. Through a series of field observations and lab experiments from all over the world, they found that organic matter ultimately tends to evolve towards a similar end, regardless of the source or where they occur in the atmosphere. "What surprised us is how similar the organic matter looked as we went from the heart of Mexico City to an island in Japan to a forest in Finland or a mountain in the Swiss Alps", said Jimenez.

"The atmosphere acts like Dan Aykroyd's Bass-O-Matic, making similar looking goop almost no matter what you start with," said Neil Donahue, a study co-author with Carnegie Mellon University.

This particle soup can be boiled down into a few measurable characteristics, such as the Oxygen to Carbon ratio, which are key variables for predicting climate and air quality.

"Using a novel aerosol mass spectrometer, we found that the atmosphere blurs the differences between aerosols emitted by different sources relatively quickly. This is potentially a very important simplification, which is key to improving air quality and climate models," said Manjula Canagaratna, a co-author from Aerodyne Research in Billerica, Mass.

Of importance in this study was the creation of a chemical "map" by Donahue. This map provides some of the first clear visualization of how these organic aerosols change once they become a part of the particle soup.

The map tracks two key properties - volatility (the tendency to evaporate) and the Oxygen to Carbon ratio - that evolve as organics make their way through the atmosphere. This ratio is important because it is an indicator of how much the organic matter is gaining oxygen and building up on particles floating in the air influencing air quality and climate. "And as a bonus, this roadmap has the promise to let people predict the ability of the organics to participate in cloud formation," Donahue said.

With the incorporation of these findings into future climate and air-quality modeling and policy assessments, asthma sufferers may soon be able to breathe a bit easier, or at least know where to go when the sky is starting to look a little under the weather.

"These results allow us to do a better job in predicting future climate and air quality," Jimenez said. "And we need good predictions in order to be able to do the right thing."

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