New approach to emissions makes climate and air quality models more accurate, major study finds

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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 models for predicting climate and air quality that are incomplete or less than accurate.

A major collaborative effort of more than 60 scientists led by Jose-Luis Jimenez, an associate professor of chemistry at the University of Colorado at Boulder, has discovered common ground in the jumble of organic material floating through the skies. The finding presents a workable solution that will improve the speed and accuracy of prediction models used to understand how these aerosols affect climate and human health, said Jimenez, also a fellow of the Cooperative Institute for Research in Environmental Sciences, or CIRES.

"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 issue of *Science*. CIRES is a joint institute of CU and the National Oceanic and Atmospheric Administration.

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 subsequent rainfall. They also affect human health and can lead to illnesses like asthma, heart disease and lung cancer.

But so far only about 10 to 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 vast array 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 conducted all over the world, they found that organic matter ultimately tends to evolve toward a similar end, regardless of the source or where the matter occurs 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.

The study found that 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," said Manjula Canagaratna, a co-author from Aerodyne Research in Boston. "This is potentially a very important simplification, which is key to improving air quality and climate models."

Of importance in the study was the creation of a chemical "map" by Donahue. The 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, or 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, a process that influences air quality and climate. "And as a bonus, this road map has the promise to let people predict the ability of the organics to participate in cloud formation," Donahue said.

"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."

Source: University of Colorado at Boulder (news : web)