Team develops new method to gauge atmosphere's ability to clear methane, a potent greenhouse gas

June 3 2019

The “flying laboratory”: Instruments inside the NASA research aircraft used for Glenn Wolfe’s research. Credit: NASA.

New research by UMBC's Glenn Wolfe and collaborators is shaping how scientists understand the fate of methane, a potent greenhouse gas, in Earth's atmosphere.

Of the greenhouse gases, methane has the third greatest overall effect on climate after carbon dioxide and water vapor. And the longer it stays in the atmosphere, the more heat it traps. That's why it's essential for climate models to properly represent how long methane lasts before it's broken down. That happens when a methane molecule reacts with a hydroxyl radical—-an oxygen atom bound to a hydrogen atom, represented as OH—-in a process called oxidation. Hydroxyl radicals also destroy other hazardous air pollutants.

"OH is really the most central oxidizing agent in the lower atmosphere. It controls the lifetime of nearly every reactive gas," explains Wolfe, an assistant research professor at UMBC's Joint Center for Earth Systems Technology. However, "globally, we don't have a way to directly measure OH." More than that, it's well understood that current climate models struggle to accurately simulate OH. With existing methods, scientists can infer OH at a coarse scale, but there is scant information on the where, when, and why of variations in OH.

New research published in *Proceedings of the National Academy of Sciences* and led by Wolfe puts scientists on the path to changing that. Wolfe and colleagues have developed a unique way to infer how global OH concentrations vary over time and in different regions. Better understanding of OH levels can help scientists understand how much of the ups and downs in global methane levels are due to changing emissions, such as from oil and natural gas production or wetlands, versus being caused by changing levels of OH.

A flying laboratory

NASA satellites have been measuring atmospheric formaldehyde concentrations for over 15 years. Wolfe's new research relies on that data, plus new observations collected during NASA's recent Atmospheric Tomography (ATom) mission. ATom has flown four around-the-world circuits, sampling air with the aid of a NASA research aircraft.

This "flying laboratory," as Wolfe describes it, collected data on atmospheric formaldehyde and OH levels that illustrates a remarkably simple relationship between the two gases. This did not surprise the scientists, because formaldehyde is a major byproduct of methane oxidation, but this study provides the first concrete observation of the correlation between formaldehyde and OH. The findings also showed that the formaldehyde concentrations the plane measured are consistent with those measured by the satellites. That will allow Wolfe's team and others to use existing satellite data to infer OH levels throughout most of the atmosphere.

"So the airborne measurements give you a ground truth that that relationship exists," Wolfe says, "and the satellite measurements let you extend that relationship around the whole globe."

Wolfe, however, is the first to acknowledge that the work to improve global models is far from done. The airplane measured OH and formaldehyde levels over the open ocean, where the air chemistry is relatively simple. It would be more complicated over a forest, and even more so over a city.

While the relationship the researchers determined provides a solid baseline, as most of Earth's air does, indeed, float above oceans, more work is needed to see how OH levels differ in more complex environments. Potentially, different data from existing NASA satellites, such as those tracking emissions from urban areas or wildfires, could help.

Wolfe hopes to keep refining this work, which he says is at "the nexus of the chemistry and climate research communities. And they're very interested in getting OH right."

Getting it right

The current study did consider seasonal variations in OH, by analyzing measurements taken in February and August. "The seasonality is one aspect of this study that's important," Wolfe says, "because the latitude where OH is at its maximum moves around." Considering seasonal shifts in OH concentrations, or even multi-year shifts caused by phenomena like El Niño and La Niña, could be one angle to explore when trying to improve global climate models.

Looking further at OH levels on a global scale using satellite data validated by airplane data could also help scientists refine their models. "You can use the spatial variability and the seasonality to understand at the process level what's driving OH, and then ask if the model gets that right or not," Wolfe says. "The idea is to be able to poke at all these features, where we haven't really had any data to do that with before."

This new research is one step in the journey to enhancing our understanding of the global climate, even as it is rapidly changing. More accurately understanding how, for example, cutting methane emissions would affect the climate, and how quickly, could even influence policy decisions.

"It's not perfect. It needs work," Wolfe says. "But the potential is there."

More information: Glenn M. Wolfe et al, Mapping hydroxyl variability throughout the global remote troposphere via synthesis of

airborne and satellite formaldehyde observations, *Proceedings of the National Academy of Sciences* (2019). DOI: 10.1073/pnas.1821661116

Provided by University of Maryland Baltimore County