New insight on the impacts of Earth's biosphere on air quality

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A new study led by a team of University of Minnesota researchers provides the first global satellite measurements of one of the most important chemicals affecting Earth's atmosphere.

Isoprene is a natural hydrocarbon emitted to the atmosphere in vast quantities—approximately 500 billion kg per year—by plants and trees. Isoprene is chemically reactive, and once in the atmosphere it combines with human-caused pollutants to adversely affect air quality. Isoprene also reacts with the main atmospheric oxidizing agent—called OH radicals—and therefore reduces the capacity of the atmosphere to scrub itself of pollutants and greenhouse gases.

Scientists look to atmospheric models to predict current and future atmospheric composition and air quality, as well as to diagnose the atmosphere's ability to remove greenhouse gases and air pollutants. But isoprene emission rates are highly uncertain due to sparse ground-based measurements, and scientists are also unsure of the extent to which isoprene acts to suppress or sustain the abundance of OH radicals in the atmosphere.

Now, researchers have developed the first-ever global measurements of isoprene from space. Using observations from the Cross-track Infrared Sounder (CrIS) satellite sensor, researchers developed a retrieval method that uses machine learning to determine the atmospheric concentration of isoprene over different parts of the world. They combined these measurements with atmospheric modeling to test current scientific understanding of global isoprene emissions and how isoprene affects atmospheric oxidation. The research will be published on Wednesday, September 9 in the journal *Nature*.

"Isoprene is one of the most important drivers of global atmospheric chemistry," said Dylan Millet, a professor in the U of M's Department of Soil, Water, and Climate. "These satellite measurements provide new understanding of how Earth's biosphere and atmosphere interact."

By combining the CrIS isoprene measurements with other satellite data, for the first time researchers were able to estimate the abundance of OH from space over isoprene source regions. These observations support recent laboratory and theory-based findings: isoprene emissions do lower atmospheric OH, but not nearly as strongly as was originally believed. As a result, the atmosphere maintains a significant ability to scrub itself of pollution even in the presence of natural isoprene emissions. Combining these measurements with other space-based data will open new doors to investigate changes in OH over time.

This research lays a foundation for multi-year studies examining seasonal-to-interannual isoprene changes and their impacts on the global atmosphere. Information from these new satellite measurements can also be used to improve current atmospheric models, with the goal of more accurately predicting air quality in a changing climate.

Researchers revealed that:

- The satellite measurements of isoprene show dramatic model overestimates over Amazonia. These disparities indicate a strong need for better understanding of tropical emissions of isoprene and other reactive chemicals.
- Over southern Africa, the CrIS measurements reveal a major isoprene hotspot that is missing from bottom-up predictions. This points to a need for further investigation of isoprene sources in this understudied region.

"These new satellite measurements reveal that, while our understanding of isoprene chemistry is getting pretty good, we still have a lot to learn about how isoprene emissions vary across Earth's different ecosystems," said Kelley Wells, a researcher in the Department of Soil, Water, and Climate in the U of M's College of Food, Agricultural and Natural Resource Sciences.

More information: Satellite isoprene retrievals constrain emissions and atmospheric oxidation, *Nature* (2020). DOI: 10.1038/s41586-020-2664-3 , www.nature.com/articles/s41586-020-2664-3