Researchers measure atmosphere's self-cleaning capacity

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An international, NOAA-led research team took a significant step forward in understanding the atmosphere's ability to cleanse itself of air pollutants and some other gases, except carbon dioxide. The issue has been controversial for many years, with some studies suggesting the self-cleaning power of the atmosphere is fragile and sensitive to environmental changes, while others suggest greater stability. And what researchers are finding is that the atmosphere's self-cleaning capacity is rather stable.

New analysis published online today in the journal *Science* shows that global levels of the hydroxyl radical, a critical player in atmospheric chemistry, do not vary much from year to year. Levels of hydroxyl, which help clear the atmosphere of many hazardous air pollutants and some important greenhouse gases — but not carbon dioxide — dip and rise by only a few percent every year; not by up to 25 percent, as was once estimated.

"The new hydroxyl measurements give researchers a broad view of the 'oxidizing' or self-cleaning capacity of the atmosphere," said Stephen Montzka, the study's lead author and a research chemist at the Global Monitoring Division of NOAA's Boulder, Colo., laboratory.

"Now we know that the atmosphere's ability to rid itself of many pollutants is generally well buffered or stable," said Montzka. "This fundamental property of the atmosphere was one we hadn't been able to confirm before."

The new finding adds confidence to projections of future air pollutant loads. The hydroxyl radical, comprised of one oxygen atom and one hydrogen atom, is formed and broken down so quickly in the atmosphere that it has been extremely difficult to measure on global scales.

"In the daytime, hydroxyl's lifetime is about one second and is present at exceedingly low concentrations," said Montzka. "Once created, it doesn't take long to find something to react with."

The radical is central to the chemistry of the atmosphere. It is involved in the formation and breakdown of surface-level ozone, a lung- and crop-damaging pollutant. It also reacts with and destroys the powerful greenhouse gas methane and air pollutants including hydrocarbons, carbon monoxide and sulfur dioxide. However, hydroxyl radicals do not remove carbon dioxide, nitrous oxide or chlorofluorocarbons.

To estimate variability in global hydroxyl levels — and thus the cleansing capacity of the atmosphere — researchers turned to studying longer-lived chemicals that react with hydroxyl.

The industrial chemical methyl chloroform, for example, is destroyed in the atmosphere primarily by hydroxyl radicals. By comparing levels of methyl chloroform emitted into the atmosphere with levels measured in the atmosphere, researchers can estimate the concentration of hydroxyl and how it varies from year to year.

This technique produced estimates of hydroxyl that swung wildly in the 1980s and 1990s. Researchers struggled to understand whether the ups and downs were due to errors in emissions estimates for methyl chloroform, for example, or to real swings in hydroxyl levels. The swings would be of concern: Large fluctuations in hydroxyl radicals would mean the atmosphere's self-cleaning ability was very sensitive to human-caused or natural changes in the atmosphere.

To complicate matters, when scientists tried to measure the concentration of hydroxyl radical levels compared to other gases, such as methane, they were seeing only small variations from year to year. The same small fluctuation was occurring when scientists ran the standard global chemistry models.

An international agreement helped resolve the issue. In response to the Montreal Protocol – the international agreement to phase out chemicals that are destroying the Earth's protective stratospheric ozone layer – production of methyl chloroform all but stopped in the mid 1990s. As a result, emissions of this potent ozone-depleting gas dropped precipitously.

Without the confounding effect of any appreciable methyl chloroform emissions, a more precise picture of hydroxyl variability emerged based on the observed decay of remaining methyl chloroform. The scientists studied hydroxyl radicals both by making measurements of methyl chloroform from NOAA's international cooperative air sampling program and also by modeling results with state-of-the-art models.

The group's findings improve confidence in projecting the future of Earth's atmosphere.

"Say we wanted to know how much we'd need to reduce human-derived emissions of methane to cut its climate influence by half," Montzka said. "That would require an understanding of hydroxyl and its variability. Since the new results suggest that large hydroxyl radical changes are unlikely, such projections become more reliable."

More information: "Small Inter-Annual Variability of Global Atmospheric Hydroxyl," *Science*, January 7, 2011.

Provided by NOAA