

Unexpected wildfire emission impacts air quality worldwide

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Credit: University of Colorado at Boulder

In lab studies of wildfire, nitrous acid seems like a minor actor, often underrepresented in atmospheric models. But in the real-world atmosphere, during wildfires, the chemical plays a leading role—spiking to levels significantly higher than scientists expected, driving increased ozone pollution and harming air quality, according to a new study led by the University of Colorado Boulder and the Belgian Institute for Space Aeronomy.

"We found [nitrous acid](#) levels in wildfire plumes worldwide are two to four times higher than expected," said Rainer Volkamer, CIRES Fellow, professor of chemistry at CU Boulder and co-lead author on the *Nature*

Geoscience study. "The chemical can ultimately drive the formation of lung- and crop-damaging [ozone pollution](#) downwind of fires."

Nitrous [acid](#) in wildfire smoke is accelerating the formation of an oxidant, the hydroxyl radical or OH. Unexpectedly, nitrous acid was responsible for around 60 percent of OH production in the smoke plumes worldwide, the team estimated—it is by far the main precursor of OH in fresh fire plumes. The hydroxyl radical, then, can degrade [greenhouse gases](#), and it can also accelerate the chemical production of ozone pollution—by as much as 7 parts per billion in some places. That's enough to push ozone levels over regulated levels (eg, 70 ppb in the United States).

"Fire size and burn conditions in the real world show higher nitrous acid than can currently be explained based on laboratory data, and this added nitrous acid drives faster chemistry to form ozone, oxidants and modifies aerosols in wildfire smoke," Volkamer said.

Nitrous acid, while abundant after wildfire, degrades quickly in sunlight, and is thus exceedingly difficult to study globally. So the CU Boulder team worked with European colleagues to combine two sets of data: 1) [global measurements](#) from a satellite instrument TROPOMI observed nitrous acid in wildfire plumes around the world, and 2) custom instruments flown on aircraft during a 2018 [wildfire](#) study in the Pacific Northwest during the BB-FLUX campaign. Remarkably, the team was able to compare near-simultaneous measurements made within minutes by the satellite looking down on a plume, and the aircraft-based instrument looking up into the same plume from below.

"Kudos to the pilots and the entire team for dealing actively with this fundamental sampling challenge," Volkamer said. "Simultaneous measurements conducted at different temporal and spatial scales helped us to understand and use what are the first global measurements of

nitrous acid by our Belgium colleagues." With the new comparison in hand, Volkamer and his colleagues—including Nicolas Theys, the study's lead author from BIRA—could then scrutinize satellite data from a large number of wildfires in all major ecosystems across the planet to assess nitrous acid emissions.

The chemical is consistently higher than expected everywhere, but levels differ depending on the landscape. "Nitrous acid emissions relative to other gases involved in ozone formation varied by ecosystem, with the lowest in savannas and grasslands and highest in extratropical evergreen forests," said Kyle Zarzana, chemistry postdoctoral scientist at CU Boulder who led instrument deployment for the aircraft measurements, and coauthor on the new paper.

"Wildfire smoke contains many trace gases and aerosols that adversely affect visibility and [public health](#) over large distances, as we are recently witnessing from fires raging in the Western United States that affect air quality on the East Coast," said Volkamer. "Our findings reveal a chemically very active ingredient of this smoke, and help us to better keep track as photochemistry rapidly modifies emissions downwind."

More information: Theys, N., Volkamer, R., Müller, J. et al. Global nitrous acid emissions and levels of regional oxidants enhanced by wildfires. *Nat. Geosci.* (2020). doi.org/10.1038/s41561-020-0637-7 , www.nature.com/articles/s41561-020-0637-7

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