

Heatwaves turn nature against itself: How forests and soils fuel a dangerous air pollution feedback loop

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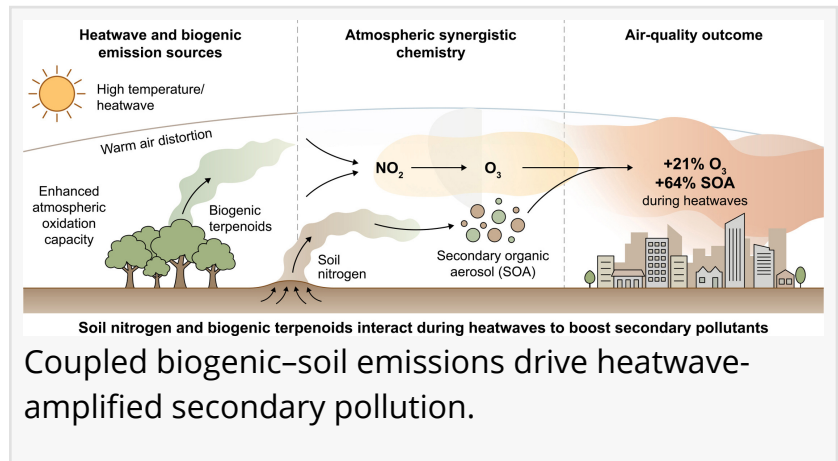
/EINPresswire.com/ -- As global air pollution policies successfully cut human-made emissions, an overlooked natural feedback loop is undermining those hard-won gains. New research reveals that extreme heatwaves trigger a powerful synergy between plant-released chemicals and soil nitrogen emissions—dramatically accelerating the formation of ozone (O₃) and

secondary organic aerosols (SOA). During China's unprecedented 2022 [heatwave](#), this coupled biogenic-soil mechanism drove a 21% regional ozone surge across the Yangtze River Basin and boosted SOA loads by up to 4 micrograms per cubic meter, demonstrating that climate-driven natural emissions can offset decades of anthropogenic pollution control.

Over recent decades, effective air pollution policies have substantially reduced anthropogenic emissions across China, making biogenic sources increasingly important contributors to air quality. These natural emissions—terpenoids released by vegetation and nitrogen oxides from soils—are strongly temperature-sensitive, spiking dramatically during heatwaves. While scientists have separately studied how heatwaves boost biogenic volatile organic compounds (BVOCs) and soil nitrogen emissions, the chemical interactions between these co-elevated biogenic fluxes remained completely unconstrained. Based on these challenges, there is an urgent need to investigate how temperature-driven natural emissions interact with each other and with atmospheric chemistry during extreme weather events.

A multinational research team led by Fudan University, in collaboration with Duke University, the University of California, Irvine, and other institutions, publishes these findings on June 12, 2026, in *Environmental Science and Ecotechnology*. The study integrates ground-based observations, satellite data, and chemical transport modeling to unravel the mechanisms behind secondary pollution amplification during China's record-breaking 2022 summer heatwave.

The researchers found that soaring temperatures during the 2022 heatwave—which pushed the



average summer temperature from 23.0°C to 25.0°C, with maxima reaching 46.4°C—triggered massive surges in both biogenic terpenoid emissions and soil nitric oxide (NO) release across the Yangtze River Basin. Isoprene, the dominant terpenoid species, increased by more than 130% in emission rates compared to the 2020–2021 average, a trend independently confirmed by satellite observations of formaldehyde (HCHO) column densities. Crucially, the study uncovered a previously unknown synergistic mechanism: rising biogenic terpenoids generate reactive peroxy radicals (RO₂) that dramatically enhance atmospheric oxidation capacity. These radicals accelerate the conversion of soil-emitted NO to nitrogen dioxide (NO₂) without consuming O₃—a chemical pathway that bypasses the normal ozone-depleting reaction between NO and O₃. In nitrogen oxide (NO_x)-limited regions where this mechanism is most potent, the team documented a 21% regional ozone increase and a substantial boost in SOA formation, with SOA concentrations rising by up to 4 μg m⁻³. The researchers also found that future warming under the Shared Socioeconomic Pathway 5-8.5 scenario could intensify these effects, with a 5°C temperature increase nearly doubling the impact.

"We were genuinely surprised by how powerful this natural feedback loop turned out to be," the authors said. "For years, we've been patting ourselves on the back for reducing anthropogenic emissions, but what we're seeing here is nature pushing back in a way we hadn't anticipated. The vegetation and the soil are essentially conspiring during heatwaves—the trees pump out these reactive compounds that supercharge the atmosphere's oxidation capacity, which then grabs the nitrogen coming out of the soil and turns it into ozone much faster than we thought possible. If we don't account for this in our pollution control strategies, we could be chasing our tails as the climate continues to warm."

These findings carry profound implications for air quality management in a warming world. As anthropogenic NO_x emissions continue to decline across China and other regions, the geographic extent of NO_x-limited regimes—where this biogenic-soil synergy is most potent—is expanding. This means that the relative importance of natural emissions will only grow, potentially offsetting the air quality gains expected from further emission reductions. The study also cautions that large-scale afforestation, while vital for carbon sequestration, could inadvertently worsen local air quality if not planned with atmospheric chemistry in mind. Forest management strategies must integrate ecological and atmospheric feedbacks to ensure that greening efforts support rather than undermine regional air quality targets. The researchers urge policymakers to incorporate dynamic biogenic emission baselines into future climate adaptation and pollution control frameworks.

References

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