African smoke is fertilizing Amazon rainforest and oceans, study finds

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A new study led by researchers at the University of Miami's (UM) Rosenstiel School of Marine and Atmospheric Science found that smoke from fires in Africa may be the most important source of a key nutrient—phosphorus—that acts as a fertilizer in the Amazon rainforest, Tropical Atlantic and Southern oceans.

Nutrients found in atmospheric particles, called aerosols, are transported by winds and deposited to the ocean and on land where they stimulate the productivity of marine phytoplankton and terrestrial plants leading to the sequestration of atmospheric carbon dioxide.

"It had been assumed that Saharan dust was the main fertilizer to the Amazon Basin and Tropical Atlantic Ocean by supplying phosphorus to both of these ecosystems," said the study's senior author Cassandra Gaston, an assistant professor in the Department of Atmospheric Sciences at the UM Rosenstiel School. "Our findings reveal that biomass burning emissions transported from Africa are potentially a more important source of phosphorus to these ecosystems than dust."

To conduct the study, the researchers analyzed aerosols collected on filters from a hilltop in French Guiana, at the northern edge of the Amazon Basin, for mass concentrations of windborne dust and their total and soluble phosphorus content. They then tracked the smoke moving through the atmosphere using satellite remote sensing tools to understand the long-range transport of smoke from Africa during time periods when elevated levels of soluble phosphorus were detected. They were then able to estimate the amount of phosphorus deposited to the Amazon Basin and the global oceans from African biomass burning aerosols using a transport model.

The analysis concluded that the smoke from widespread biomass burning in Africa, mostly the result of land clearing, brush fires and industrial combustion emissions, is potentially a more important source of phosphorus to the Amazon rainforest and Tropic Atlantic and Southern oceans than dust from the Sahara Desert.

"To our surprise, we discovered that phosphorus associated with smoke from southern Africa can be blown all the way to the Amazon and, potentially, out over the Southern Ocean where it can impact primary productivity and the drawdown of carbon dioxide in both ecosystems," said UM Rosenstiel School graduate student Anne Barkley, lead author of the study.

"Aerosols play a major role in Earth's climate, however, there is a lot that we don't understand regarding how they affect radiation, clouds, and biogeochemical cycles, which impedes our ability to accurately predict future increases in global temperature," said Gaston. "These new findings have implications for how this process might look in the future as combustion and fire emissions in Africa and dust transport patterns and amounts change with a changing climate and an increasing human population."

This study builds on more than 50 years of ground-

breaking aerosol research in the Caribbean and Latin America by UM Rosenstiel School Professor Emeritus Joe Prospero that is being continued by Gaston. In addition, it represents an interdisciplinary collaboration across the UM Rosenstiel School in which Professor Paquita Zuidema Department of Atmospheric Sciences published extensive measurements of biomass burning to corroborate the seasonality of smoke transport, Associate Professor Ali Pourmand and Assistant Professor Amanda Oehlert, Department of Marine Geosciences analyzed samples in the Neptune Mass Spectrometer, Assistant Professor Kim Popendorf, Department of Ocean Sciences, aided in the measurement of soluble phosphorus in aerosols, and Pat Blackwelder, Assistant Director of the University of Miami College of Arts and Sciences Department of Chemistry Center for Advanced Microscopy, provided her expertise with scanning electron microscopy to image the filter samples on a micrometer scale.

More information: African biomass burning is a substantial source of phosphorus deposition to the Amazon, *PNAS*(2019). DOI: 10.1073/pnas.1906091116

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