

Wildfires: Smoke and cloud interactions unexpectedly result in cooling

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Summary: For years, scientists determined that smoke, overall, diminishes clouds' cooling effect by absorbing light that the clouds beneath the aerosols would otherwise reflect. This new study does not dispute that phenomenon. However, more dominantly, the new study found that smoke and cloud layers are closer to each other than previously thought. This makes the clouds more reflective of light and, thus, accelerates the clouds' cooling effect.

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This is a view from the window of a data collection flight conducted by NASA's P-3 Orion research aircraft over the Atlantic Ocean during August 2017. A layer of smoke is visible over patchy clouds.

Credit: NASA/Kirk Knobelspriesse

University of Wyoming researchers led a study that discovered that biomass smoke originating from South Africa that drifts over the southeast Atlantic Ocean significantly enhances the brightness of low-level clouds there -- creating a reflective process that actually helps cool the Earth and counteract the greenhouse effect.

"If you change the particles, you are changing the composition of the cloud," says Xiaohong Liu, a UW professor in the Department of Atmospheric Science and the Wyoming Excellence Chair in Climate Science. "For our study, we found the smoke comes down and can mix within the clouds. The changed clouds are more reflective of sunlight. Brighter clouds counteract the greenhouse effect. It creates cooling."

Liu is the corresponding author of a paper, titled "Biomass Smoke from Southern Africa Can Significantly Enhance the Brightness of Stratocumulus over the Southeastern Atlantic Ocean," that was published March 5 (today) in the *Proceedings of the National Academy of Sciences* (PNAS).

Zheng Lu, a UW research associate in Liu's research group, was the paper's lead author. The two used the National Center for Atmospheric Research (NCAR)-Wyoming Supercomputing Center in Cheyenne to conduct high-resolution computational modeling of the smoke and its effects on the clouds.

Other contributors to the paper were from the University of Maryland-Baltimore County (UMBC); the University of Science and Technology of China; the NASA Goddard Space Flight Center; and the University of Michigan.

For years, scientists determined that smoke, overall, diminishes the clouds' cooling effect by absorbing light that the clouds beneath the aerosols would otherwise reflect. This new study does not dispute that phenomenon. However, more dominantly, the new study found that smoke and cloud layers are closer to each other than previously thought. This makes the clouds more reflective of light and, thus, accelerates the clouds' cooling effect. This is due to the tiny aerosol particles from the smoke that serve as the nuclei for the formation of cloud droplets.

"The purpose of this paper is to look at these competing processes. Which one is more important?" asks Zhibo Zhang, a co-author of the paper and an associate professor in the Department of Physics at UMBC.

Running the advanced computer models, Liu explains that carbon dioxide (CO₂) -- from human activities since the Industrial Revolution -- provides a greenhouse effect of 1.66 watts per square meter that is uniformly distributed over the globe. Fire smoke produces a much larger cooling effect: 7 watts per square meter over the southeast Atlantic during the fire season of each year.

"Our group is the first to quantify this brightening effect," Liu says. "This (smoke aerosols in clouds) reflects more solar radiation to space, which results in less solar radiation reaching the Earth's surface. This creates a cooling effect."

Each year, biomass-burning aerosols from South Africa emit into the atmosphere during the fire season, which runs from July through October. Many are wildfires, while other fires are set intentionally to clear farmland. These fires create so much smoke that they are observable on satellite images from space, Liu says, pointing to prominent red patches on his computer screen.

The aerosols transport westward over the southeast Atlantic Ocean and interact with underlying stratocumulus cloud decks, which are located approximately 1 kilometer above sea level surface, Liu explains.

Previous studies have shown that such aerosols greatly agitate the top of atmosphere radiation balance by scattering and absorbing solar radiation, and alter cloud properties by changing the stability of the lower troposphere.

Liu says this new study, using state-of-the-art computer modeling and satellite observations, found that the aerosols mixed into the clouds act as cloud condensation nuclei and increase the brightness of stratocumulus clouds. This results in substantial cooling of the Earth.

The research team would ultimately like to refine global climate models by improving how such models account for clouds and interacting with aerosols emitted from a variety of sources, including power plants, automobiles, deserts and oceans. Over time, they plan to quantify the magnitude of the cooling effect of aerosols on the Earth's climate system, which may have masked the greenhouse effect of CO₂. However, the extent of this masking is unknown.

"It's like a puzzle," Liu says.

Story Source:

Materials provided by **University of Wyoming**. Note: Content may be edited for style and length.

Journal Reference:

1. Zheng Lu, Xiaohong Liu, Zhibo Zhang, Chun Zhao, Kerry Meyer, Chamara Rajapakshe, Chenglai Wu, Zhifeng Yang, Joyce E. Penner. **Biomass smoke from southern Africa can significantly enhance the brightness of stratocumulus over the southeastern Atlantic Ocean.** *Proceedings of the National Academy of Sciences*, 2018; 201713703 DOI: [10.1073/pnas.1713703115](https://doi.org/10.1073/pnas.1713703115)