Rising air pollution worsens drought, flooding, study shows

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This graphic created by a University of Maryland-led team of researchers, illustrates their new finding that increases in air pollution and other particulate matter in the atmosphere can strongly affect cloud development in ways that reduce precipitation in dry regions or seasons, while increasing rain, snowfall and the intensity of severe storms in wet regions or seasons. Credit: University of Maryland

Increases in air pollution and other particulate matter in the atmosphere can strongly affect cloud development in ways that reduce precipitation in dry regions or seasons, while increasing rain, snowfall and the intensity of severe storms in wet regions or seasons, says a new study by a University of Maryland-led team of researchers.

The research provides the first clear evidence of how aerosols -- soot, dust and other small particles in the atmosphere -- can affect weather and climate; and the findings have important economic and water resource implications for regions across the United States and around the world, say the researchers and other scientists.

"Using a 10-year dataset of extensive atmosphere measurements from the U.S. Southern Great Plains research facility in Oklahoma [run by the Department of Energy's Atmospheric Radiation Measurement program] -- we have uncovered, for the first time, the long-term, net impact of aerosols on cloud height and thickness, and the resultant changes in precipitation frequency and intensity," says Zhanqing Li, a professor of atmospheric and oceanic science at Maryland and lead author of the study.

The scientists obtained additional support for these findings with matching results obtained using a cloud-resolving computer model. The study by Li and co-authors Feng Niu and Yanni Ding, also of the University of Maryland; Jiwen Fan of Pacific Northwest National Laboratory; Yangang Liu of Brookhaven National Laboratory, Upton, NY; and Daniel Rosenfeld of The Hebrew University of Jerusalem, is published in the Nov. 13 in *Nature Geoscience*.

"These new findings of long-term impacts, which we made using regional ground measurements, also are consistent with different findings we obtained from an analysis of NASA's global satellite products and have just published in a separate study. Together, they attest to the needs of tackling both climate and environmental changes that matter so much to our daily life," says Maryland's Li, who is also affiliated with Beijing Normal University."

"Our findings have significant policy implications for sustainable development and water resources, especially for those developing regions susceptible to extreme events such as drought and flood. Increases in manufacturing, building of power plants and other industrial developments are often accompanied with increases in pollution whose adverse impacts on weather and climate, as revealed in this study, can undercut economic gains," he stresses.

Tony Busalacchi, chair of the Joint Scientific Committee, World Climate Research Program notes the significance of the new findings. "Understanding interactions across clouds, aerosols, and precipitation is one of the grand challenges for climate research in the decade ahead, as identified in a recent major world climate conference. Findings of this study represent a significant advance in our understanding of such processes with significant implications for both climate science and sustainable development," says Busalacchi, who also is professor and director of the University of Maryland Earth System Science Interdisciplinary Center.

"We have known for a long time that aerosols impact both the heating and phase changes [condensing, freezing] of clouds and can either inhibit or intensify clouds and precipitation," says Russell Dickerson, a professor of atmospheric and oceanic science at Maryland. "What we have not been able to determine, until now, is the net effect. This study by Li and his colleagues shows that fine particulate matter, mostly from air pollution, impedes gentle rains while exacerbating severe storms. It adds urgency to the need to control sulfur, nitrogen, and hydrocarbon emissions."

According to climate scientist Steve Ghan of the Pacific Northwest National Laboratory, "This work confirms what previous cloud modeling studies had suggested, that although clouds are influenced by many factors, increasing aerosols enhance the variability of precipitation, suppressing it when precipitation is light and intensifying it when it is strong. This complex influence is completely missing from climate models, casting doubt on their ability to simulate the response of precipitation to changes in aerosol pollution."

Aerosol Science

Aerosols are tiny solid particles or liquid particles suspended in air. They include soot, dust and sulfate particles, and are what we commonly think of when we talk about air pollution. Aerosols come, for example, from the combustion of fossil fuels, industrial and agricultural processes, and the accidental or deliberate burning of fields and forests. They can be hazardous to both human health and the environment.

Aerosol particles also affect the Earth's surface temperature by either reflecting light back into space, thus reducing solar radiation at Earth's surface, or absorbing solar radiation, thus heating the atmosphere. This variable cooling and heating is, in part, how aerosols modify atmospheric stability that dictates atmospheric vertical motion and cloud formation. Aerosols also affect cloud microphysics because the serve as nuclei around which water droplets or ice particles form. Both processes can affect cloud properties and rainfall. Different processes may work in harmony or offset each other, leading to a complex yet inconclusive interpretation of their long-term net effect.

Greenhouse gases and aerosol particles are two major agents dictating climate change. The mechanisms of climate warming impacts of increased greenhouse gases are clear (they prevent solar energy that has been absorbed by the earth's surface from being radiated as heat back into space), but the climate effects of increased aerosols are much less certain. Until now, studies of the long-term effects of aerosols on climate change have been largely lacking and inconclusive because their mechanisms are much more sophisticated, variable, and tangled with meteorology.

"This study demonstrates the importance and value of keeping a long record of continuous and comprehensive measurements such as the highly instrumented (ARM) sites run by the Department of Energy's Office of Science, including the Southern Great Plains site, to identify and quantify important roles of aerosols in climate processes," says Stephen E. Schwartz, a scientist at Brookhaven National Laboratory. "While the mechanisms for some of these effects remain uncertain, the well-defined relationships discovered here clearly demonstrate the significance of the effects. Developing this understanding to represent the controlling processes in models remains a future challenge, but this study clearly points in important directions."

Provided by University of Maryland

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