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Researchers find wildfire smoke is more cooling on climate than computer models assume

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The University of Wyoming Mobile Lab measures biomass burning smoke in Wyoming from a couple of years ago. This is an example of the type of field measurement that was used to compare with computer models. Credit: Rachel Edie

A study of biomass burning aerosols led by University of Wyoming researchers revealed that smoke from wildfires has more of a cooling effect on the atmosphere than computer models assume.

"The study addresses the impact of wildfires on global climate, and we extensively used the NCAR-Wyoming supercomputer (Cheyenne)," says Shane Murphy, a UW associate professor of atmospheric science. "Also, the paper used observations from UW and other teams around the world to compare to the climate model results. The main conclusion of the work is that wildfire smoke is more cooling than current models assume."

Murphy was a contributing author of a paper, titled "Biomass Burning Aerosols in Most Climate Models Are Too Absorbing," that was published Jan. 12 (today) in *Nature Communications*, an open-access journal that publishes high-quality research from all areas of the natural sciences. Papers published by the journal represent important advances of significance to specialists within each field.

Hunter Brown, who graduated from UW in fall 2020 with a Ph.D. in atmospheric science, was the paper's lead author. Other contributors to the paper included researchers from Texas A&M University; North Carolina A&T State University; the University of Georgia; the Finnish Meteorological Institute; the Center for International Climate and Environmental Science, and Norwegian Meteorological Institute, both in Oslo, Norway; the University of Reading in the United Kingdom; North-West University in South Africa; the University of Science and Technology of China in Hefei, China; and Pacific Northwest National Laboratory in Richland, Wash.

The composition, size and mixing state of biomass burning aerosols determine the optical properties of smoke plumes in the atmosphere which, in turn, are a major factor in dictating how these aerosols perturb the energy balance in the atmosphere.

"We found that many of the most advanced climate models simulate biomass burning aerosols or smoke that is darker, or more light absorbing, than what we see in observations," says Brown, of Juneau, Alaska. "This has implications for the climate predictions made by these models."

The National Science Foundation/National Center for Atmospheric Research (NSF/NCAR) C-130 aircraft measures biomass burning smoke during the WE-CAN (Western Wildfire Experiment for Cloud Chemistry, Aerosol Absorption and Nitrogen) field campaign in 2018. Credit: Shane Murphy

Observations and models used in the study covered a wide temporal range. Africa, South America and Southeastern Asia, in addition to boreal fire regions, were chosen because these are the largest contributors to biomass burning smoke emissions in the world, Brown says.

The National Center for Atmospheric Research (NCAR)-Wyoming Supercomputing Center (NWSC) in Cheyenne was used for all of the data processing and the model sensitivity simulations, Brown says. Some of the other model data used for comparison in this study were generated elsewhere.

"When we compare global observations of wildfire smoke to simulated wildfire smoke from a collection of climate models, the vast majority of the models have smoke that is more light absorbing than the observations," Brown explains. "This means that more energy from the sun is going toward warming the atmosphere in these models, as opposed to what we see in these field campaigns and laboratory studies, which report less absorbing smoke that has more of a cooling effect by scattering light away from the Earth and back to space."

How absorbing these aerosols are in the atmosphere depends on the type of fuel that is burning, as well as the climate of the fire region. Generally, hot, dry grassland fires in Africa and Australia tend to have much darker smoke, which is more absorbing, while cooler, wetter boreal forest fires in North America and Northern Asia tend to have much brighter smoke, which is less absorbing.

After researchers made aerosol improvements to the model, African wildfire smoke still tended to be more absorbing than observations. This might be explained by simplifications in how aerosols evolve over time in the model, or it may be due to a lack of observations from this part of the world biasing the results toward the boreal fire regime, Brown explains.

"We were able to trace the disagreement between the model and observations to how the models represented the individual smoke particles, or aerosols, in the model," Brown says. "This came down to how the model characterized their makeup, their size and the mixtures of different types of biomass burning aerosol. When we changed these variables in one of the models, we saw considerable improvement in the simulated smoke."

This comparison of computer models and global observations is valuable for model development groups and may help reduce uncertainty in biomass burning aerosol climate impacts in models, Brown says.

More information: Hunter Brown et al, Biomass burning aerosols in most climate models are too absorbing, *Nature Communications* (2021). DOI: 10.1038/s41467-020-20482-9

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