National Aeronautics and Space Administration
Goddard Institute for Space Studies

Research News

NASA Finds Soot has Impact on Global Climate

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A team of researchers, led by NASA and Columbia University scientists, found airborne, microscopic, black-carbon (soot) particles are even more plentiful around the world, and contribute more to climate change, than was previously assumed by the Intergovernmental Panel of Climate Change (IPCC).

The researchers concluded if these soot particles are not reduced, at least as rapidly as light-colored pollutants, the world could warm more quickly.

The findings appear in the latest issue of the *Proceedings of the National Academy of Sciences*. It is authored by Makiko Sato, James Hansen and others from NASA's Goddard Institute for Space Studies (GISS) and Columbia University, New York; Oleg Dubovik, Brent Holben and Mian Chin of NASA's Goddard Space Flight Center, Greenbelt, Md.; and Tica Novakov, Lawrence Berkeley National Laboratory, Berkeley, Calif.

Sato, Hansen and colleagues used global atmospheric measurements taken by the Aerosol Robotic Network (AERONET). AERONET is a global network of more than 100 sun photometers that measure the amount of sunlight absorbed by aerosols (fine particles in the air) at wavelengths from ultraviolet to infrared. The scientists compared the AERONET data with Chin's global-aerosol computer model and GISS climate model, both of which included sources of soot aerosols consistent with the estimates of the IPCC.

The researchers found the amount of sunlight absorbed by soot was two-to-four times larger than previously assumed. This larger absorption is due in part to the way the tiny carbon particles are incorporated inside other larger particles: absorption is increased by light rays bouncing around inside the larger particle.

According to the researchers, the larger absorption is attributable also to previous underestimates of the amount of soot in the atmosphere. The net result is soot contributes about twice as much to warming the world as had been estimated by the IPCC.

Black carbon or soot is generated from traffic, industrial pollution, outdoor fires and household burning of coal and biomass fuels. Soot is a product of incomplete combustion, especially of diesel fuels, biofuels, coal and outdoor biomass burning. Emissions are large in areas where cooking and heating are done with wood, field residue, cow dung and coal, at a low temperature that does not allow for complete combustion. The resulting soot particles absorb sunlight, just as dark pavement becomes hotter than light pavement.

Both soot and the light-colored tiny particles, most of which are sulfates, pose problems for air quality around the world. Efforts are beginning to reduce the sulfate aerosols to address air quality issues.

"There is a pitfall, however, in reducing sulfate emissions without simultaneously reducing black carbon emissions," Hansen said. Since soot is black, it absorbs heat and causes warming. Sulfate aerosols are white, reflect sunlight, and cause cooling. At present, the warming and cooling effects of the dark and light particles partially balance.

This research continues observations of global climate change. It was funded by NASA's Earth Science Enterprise. The Enterprise is dedicated to understanding the Earth as an integrated system and applying Earth System Science to improve prediction of climate, weather, and natural hazards using the unique vantage point of space.

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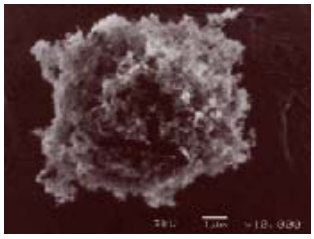
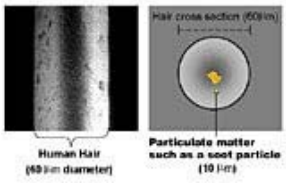
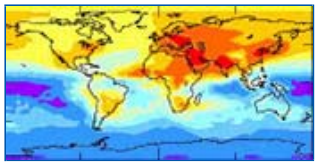


Soot Particle Under a Microscope
Image: D.M. Smith, University of Denver



Size of a Soot Particle
Soot particles are measured in micrometers (μm), and are smaller than the diameter of a human hair.*Image: NASA*



Spotting Airborne Soot
Some climate computer models indicate soot by using colors, such as yellow and orange. Darker colors indicate more soot.*Image: NASA/GISS*

Burning and Soot
Outdoor biomass burning,

Reference
Sato, Mki., J. Hansen, D. Koch, A. Lacis, R. Ruedy, O. Dubovik, B. Holben, M. Chin, and T. Novakov 2003. Global atmospheric black carbon inferred from AERONET.*Proc. Natl. Acad. Sci.* **100**, 6319-6324, doi:10.1073/pnas.0731897100.

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This article was derived from the NASA Goddard Space Flight Center Top Story.

including forest fires and the burning of fields in the tropics, is a large source of soot.*Image: NASA*

Carbon Dioxide from Fossil Fuels
Diesel engines are a major soot source in developed countries, especially trucks and buses.*Image: NASA/GSFC*

Soot Generated from a Smokestack
Image: Energy Information Admin., U.S. Dept. of Energy