First field study finds soot particles absorb significantly less sunlight than predicted by models

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Viewed as a potential target in the global effort to reduce climate change, atmospheric black carbon particles absorb significantly less sunlight than scientists predicted, raising new questions about the impact of black carbon on atmospheric warming, an international team of researchers, including climate chemists from Boston College, report today in the latest edition of the journal *Science*.

Mathematical models and laboratory experiments used to study airborne soot particles led to projections that the absorption-boosting chemicals that coat black carbon could yield an increase in absorption by as much as a factor of two. But field studies in smoggy California cities found black carbon absorption enhancements of just 6 percent, suggesting that climate models may be overestimating warming by black carbon, the researchers report.

The surprising results highlight the early challenges in a nascent sector of climate science and could have implications for regulatory efforts to reduce the production of black carbon, or soot, by curbing the burning of fossil fuels. Still, scientists agree that black carbon in the atmosphere has a significant effect on global and regional climate, with earlier studies ranking the warming effects of black carbon particles second only to carbon dioxide gas.

"The team's field measurements in California showed the enhancement

of absorption was very small – approximately six percent instead of by a factor of two," said Boston College Professor of Chemistry Paul Davidovits, an authority on airborne particles, known as aerosols. "In one respect, it shows that nature is much more complicated than our initial laboratory experiments and modeling indicated. Now we will try to unravel and understand that complexity."

The historic role of black carbon soot in climate change has been well documented by scientists, most notably in the study of ice samples taken from deep within glaciers. For the past several years, Davidovits has collaborated with Aerodyne Research Inc., and colleagues from universities and government labs in the U.S., Canada and Finland. Their research has focused on the chemical and optical properties of sub-micron airborne particles of black carbon produced by commercial and industrial activity.

Unlike carbon dioxide and other greenhouse gasses, which can survive in the atmosphere for decades and centuries, black carbon has a relatively short life span of approximately one to two weeks. Black carbon is part of a group of pollution sources known as Short-Lived Climate Forcers (SLCFs), including methane gas and ozone, which are produced on earth.

During their lifetime, black carbon particles are coated with airborne chemicals, which sophisticated laboratory tests have shown can act like lenses capable of increasing the ability of the particles to absorb sunlight and heat the atmosphere. That has raised a critical question as to whether targeting black carbon emissions in an effort to reduce climate change could yield relatively quick results on a regional or global level.

Led by principal investigators Christopher D. Cappa, a professor of engineering at the University of California, Davis, and Timothy B. Onasch, principal scientist at Aerodyne and an associate research

professor of chemistry at Boston College, the team analyzed air samples near the California cities of Los Angeles, San Francisco and Sacramento.

Researchers tested air samples using a combination of real-time techniques, including aerosol mass spectrometry and photoacoustic spectroscopy. These techniques are capable of making measurements to determine the chemical, physical and optical properties of the black carbon particles, said Onasch, whose Billerica, MA-based company has developed the aerosol mass spectrometer instruments.

Onasch said the recent findings set the stage for further studies around the world under different atmospheric conditions in order to better understand how chemical coatings from a range of emission sources affect the absorptive properties of black carbon.

"When you put a soot particle into the atmosphere, we known it contains an elemental carbon component and we know what it's absorption will be based on mass and size," said Onasch. "But black carbon particles in the air are constantly changing. They collect inorganic and organic materials, they grow, change shapes, and change composition. These changes affect the absorption or warming capability of the black carbon. So the question remains: to what extent exactly?"

The recent findings only add to the challenge of understanding complex chemical activity in the atmosphere, said Davidovits, whose research is supported by the National Science Foundation's Atmospheric Chemistry division and the U.S. Department of Energy's Atmospheric System Research program.

"These findings do require us to reduce our projections about the amount of heating soot produces, at least under some experimental conditions. But the findings don't point to soot as being a harmless climate forcer," said Davidovits. "Soot remains an important climate

heating agent, as well as a health problem that has been well documented."

More information: "Radiative Absorption Enhancements Due to the Mixing State of Atmospheric Black Carbon," by C.D. Cappa, *Science*, 2012.

Provided by Boston College