Georgia Institute of Technology
Research News

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REPORT ASSESSING IMPACT OF SOOT ON GLOBAL WARMING COULD SHIFT BURDEN TO DEVELOPING NATIONS & CREATE NEW CLIMATE MODEL DOUBT

A new study on the role that atmospheric soot particles may play in global warming suggests a new near-term control strategy, introduces a new element of uncertainty in climate models and shifts more responsibility for curbing pollution to developing nations such as China and India.

Published in the September 27 issue of the journal *Science*, the report -- by researchers from NASA's Goddard Institute for Space Studies -- suggests that by absorbing sunlight and altering weather patterns, light absorbing carbon-based particles could have nearly as much impact on global warming as carbon dioxide: a greenhouse gas that has long been considered the primary culprit in global warming. The soot particles are produced by diesel engines, cooking fires and other sources.

In a perspectives article published with the NASA Goddard paper, atmospheric researchers at the Georgia Institute of Technology describe some of the policy implications of the new findings. Among them:

• Because black carbon particles have relatively short atmospheric lifetimes, successful control efforts could curb their effects in a matter of months or years. Carbon dioxide remains in the atmosphere for hundreds of years, meaning control efforts couldn't impact global warming for generations.

Typical hazy day near Lin An, China as black carbon emanates from a small brick factory.

• Soot emissions come primarily from developing nations such as India and China. If these emissions do in fact play a large role in global warming, that could shift pressure for environmental control to those nations. Industrialized nations in North America and Europe are responsible for the bulk of carbon dioxide emissions.

•Efforts to control soot may also bring immediate improvements in human health since the small particles thought to be most active in

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affecting climate are the same PM 2.5 particles that cause respiratory distress when trapped deep in the lungs.

•Little is known about the worldwide impact of soot emissions or even how to properly measure them. Significant new research will be needed before the role of black carbon emissions can be reliably assessed.

"The study reported this week in *Science* really raises some important policy issues regarding soot," said Michael Bergin, an assistant professor in Georgia Tech's School of Earth and Atmospheric Sciences and co-author of the perspectives article. "In the past, researchers have felt that soot didn't really have a significant warming effect. But as we've learned more about the amount of black carbon emitted by countries like China and India, it appears now that soot could have important climatic effects, and that these effects may be almost as much as those of carbon dioxide."

In their perspectives article, Bergin and Professor William Chameides, also in Georgia Tech's School of Earth and Atmospheric Sciences, point out the differences between black carbon soot and greenhouse gases such as carbon dioxide and methane. For instance, soot particles are removed from the atmosphere on time scales of weeks to months, while carbon dioxide lingers for hundreds of years. That could point toward a better near-term control strategy.

"This could be 'low-hanging fruit' in trying to deal with the anthropogenic (human-caused) effects on the climate," Bergin noted. "From a policy standpoint, the payoff for controlling soot could be on the scale of years rather than centuries."

Black carbon creates its warming effect through an entirely different mechanism than greenhouse gases, which act as an insulating blanket to keep heat within the earth's atmosphere. Black carbon absorbs light from the sun, converting that to heat. The effect varies, depending upon what is beneath the carbon particles.

If a light-colored surface lies below the carbon particles, the heating effect is increased as incoming photons heat the particles on their way toward the surface, then heat them again as they reflect off the land or clouds. The particles are also involved in cloud formation which impacts precipitation patterns. Those weather changes, seen in regions of China and India with large soot emissions, may in turn affect the global climate.

"There are a lot of possible atmospheric effects from soot," Bergin said. "We really don't yet understand all the feedback cycles involved."

In fact, researchers are just beginning to learn about black carbon soot -- and even to agree on what it is. Formed by the incomplete combustion from diesel engines, cooking fires and coal burning, black carbon can take different forms. Depending on the specifics of the combustion process, soot can take many different forms from spherical particles to chain agglomerates.

"The nature of the particles and how they absorb light could be different," Bergin explained. "So one gram of soot from one part of the world could be different from a gram of soot from another part of the world. We are really at the beginning of trying to understand the influences of soot on climate. Right now, there is a great deal of uncertainty in any estimate of the climatological impact of soot."

A key uncertainty is the amount of soot going into the atmosphere. Localized studies in China and India, where crops wastes are burned for heating and cooking, show very high levels. In developed nations, elevated soot levels are found in urban areas -- which have often been excluded from climate studies to avoid confusing global climate change with the local "urban heat island" effect.

Because nations such as China and India produce so much black carbon, a new focus on this pollutant could shift control responsibility to the developing nations. Controlling soot emissions would include developing more efficient combustion techniques, both for biomass burning and diesel engines, Bergin added.

The *Science* report calls into question the accuracy of global climate change models, which have not considered the effects of black carbon.

"This creates some opportunities for climate modelers to revise their approaches and to add a potentially important anthropogenic climate forcing agent to their models," said Bergin. "We now have an opportunity to include more of the important anthropogenic effects. It could be that there are other feedback cycles in the global climate system that we don't understand."

Controlling soot could have an impact broader than global climate change. The tiny particles that appear to be most active in absorbing

radiation are of the size implicated in causing human health effects because they can lodge deeply in the lungs.

"These health impacts could make it politically much easier for policy-makers to enact the kinds of controls needed," said Bergin. "The control strategy could provide a double-whammy by increasing the health of both human beings and the environment."

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