Forward step in forecasting global warming

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Arizona State University researchers have made a breakthrough in understanding the effect on climate change of a key component of urban pollution. The discovery could lead to more accurate forecasting of possible global-warming activity, say Peter Crozier and James Anderson.

Crozier is an associate professor in ASU's School of Materials, which is jointly administered by the College of Liberal Arts and Sciences and the Ira A. Fulton School of Engineering. Anderson is a senior research scientist in the engineering school's Department of Mechanical and Aerospace Engineering.

As a result of their studies of aerosols in the atmosphere, they assert that some measures used in atmospheric science are oversimplified and overlook important factors that relate to climatic warming and cooling.

The research findings are detailed in the Aug. 8 issue of *Science* magazine, in the article "Brown Carbon Spheres in East Asian Outflow and Their Optical Properties," co-authored by Crozier, Anderson and Duncan Alexander, a former postdoctoral fellow at ASU in the area of electron microscopy, and the paper's lead author.

So-called brown carbons – a nanoscale atmospheric aerosol species – are largely being ignored in broad-ranging climate computer models, Crozier and Anderson say.

Studies of the greenhouse effect that contribute directly to climate change have focused on carbon dioxide and other greenhouse gases. But there are other components in the atmosphere that can contribute to warming – or cooling – including carbonaceous and sulfate particles from combustion of fossil fuels and biomass, salts from oceans and dust from deserts. Brown carbons from combustion processes are the least understood of these aerosol components.

The parameter typically used to measure degrees of warming is radiative forcing, which is the difference in the incoming energy from sunlight and outgoing energy from heat and reflected sunlight. The variety of gasses and aerosols that compose the atmosphere will, under different conditions, lead to warming (positive radiative forcing) or cooling (negative radiative forcing).

The ASU researchers say the effect of brown carbon is complex because it both cools the Earth's surface and warms the atmosphere.

"Because of the large uncertainty we have in the radiative forcing of aerosols, there is a corresponding large uncertainty in the degree of radiative forcing overall," Crozier says. "This introduces a large uncertainty in the degree of warming predicted by climate change models."

A key to understanding the situation is the light-scattering and light-absorbing properties – called optical properties – of aerosols.

Crozier and Anderson are trying to directly measure the light-absorbing properties of carbonaceous aerosols, which are abundant in the atmosphere.

"If we know the optical properties and distribution of all the aerosols over the entire atmosphere, then we can produce climate change models that provide more accurate prediction," Anderson says.

Most of the techniques used to measure optical properties of aerosols involve shining a laser through columns of air.

"The problem with this approach is that it gives the average properties of all aerosol components, and at only a few wavelengths of light," Anderson says.

He and Crozier have instead used a novel technique based on a specialized type of electron microscope. This technique – monochromated electron energy-loss spectroscopy – can be used to directly determine the optical properties of individual brown carbon nanoparticles over the entire visible light spectrum as well as over the ultraviolet and infrared areas of the spectrum.

"We have used this approach to determine the complete optical properties of individual brown carbon nanoparticles sampled from above the Yellow Sea during a large international climate change experiment," Crozier says.

"This is the first time anyone has determined the complete optical properties of single nanoparticles from the atmosphere," Anderson says.

It's typical for climate modelers to approximate atmospheric carbon aerosols as either non-absorbing or strongly absorbing. "Our measurements show this approximation is too simple," Crozier says. "We show that many of the carbons in our sample have optical properties that are different from those usually assumed in climate models."

Adds Anderson: "When you hear about predictions of future warming or changes in precipitation globally, or in specific regions like the Southwestern United States, the predictions are based on computer model output that is ignoring brown carbon, so they are going to tend to be less accurate."

Source: Arizona State University