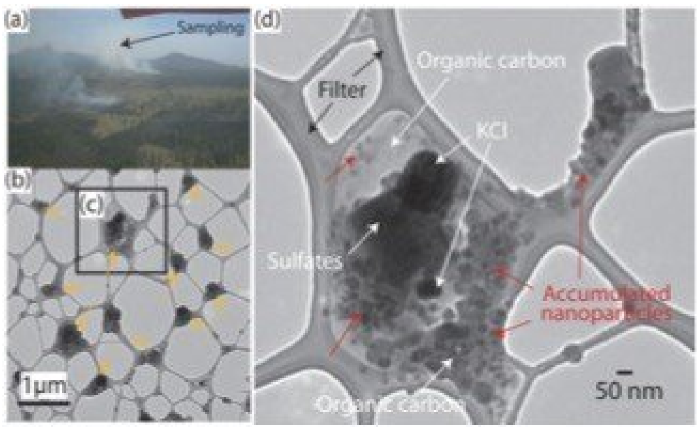
Researcher investigates reflectivity of atmospheric aerosols

December 15 2017, by George Watson



Nanoparticles from biomass burning. (A) Photograph of a region of biomass burning, taken on March 17, 2006, near Mexico City. Gases emitted from the fires cooled rapidly and condensed or accumulated as nanoparticles. (B) Low-magnification TEM image of biomass-burning particles collected from an airplane and deposited on a substrate of lacey carbon (fibers). The orange arrows indicate particles with sizes in the accumulation mode. The sampler was designed to collect particles larger than 50 nm in aerodynamic diameter, and therefore most nanoparticles were not collected on the filter. The area in box C is enlarged in D. (D) Nanoparticles trapped within a larger organic particle and therefore observable (red arrows). Other aerosol particles are indicated by white arrows. The compositions were determined using energy dispersive X-ray spectrometry. Credit: Texas Tech University

Jon Thompson seeks to discover how the composition and morphology of particles affects their ability to absorb or reflect light, thus warming or cooling the climate.

The focus on the underlying causes of climate change is mostly centered on carbon dioxide (CO_2), which can live in the atmosphere for more than 100 years. Reducing the amount of carbon dioxide has been the goal of many who work to reduce climate change.

But carbon dioxide is not the only factor that has led to a changing climate. Particulates, more commonly known as atmospheric aerosols, exist in the atmosphere at number concentrations of several thousand per cubic centimeter of air and either can warm or cool the atmosphere. Aerosols that absorb sunlight strongly will warm the atmosphere, while those that reflect sunlight back into space will cool the earth. The specific ratio of light reflected to light absorbed is crucial to determining the net effect. This ratio is described by aerosol albedo.

But what are the factors that determine the exact quantity of light absorbed or reflected by aerosol? This is the question Texas Tech University researcher Jon Thompson has been attempting to solve since his days as a doctoral student.

"At the time it was known aerosols probably had an impact on the climate, but researchers wanted better quantitative constraints on those effects," said Thompson, an associate professor in the Department of Chemistry & Biochemistry. "The overarching science question is, what is the climate impact of the atmospheric aerosols? Does the presence of aerosols increase or decrease the reflectively of the planet, and what is the net effect on temperature?"

To do that, researchers have examined not only the different types of aerosols that exist in the atmosphere but also their combination with other chemicals, particularly black carbon, and how that affects reflectivity.

What is an aerosol?

Mention aerosol to the average person and they have visions of hair spray or other household emissions from a pressurized can being dispersed in a mist. But that is not the type of aerosol Thompson and his fellow researchers have examined over the years.

"I actually get that a lot and it's one of the misconceptions, people oftentimes think I do research on deodorants or something like that," Thompson said.

An aerosol is defined as a mixture of fine solid particles or liquid droplets in air or another gas. There are several sources of aerosols that exist in the atmosphere but they essentially fall into two categories – natural or manmade, also known as anthropogenic.

A natural aerosol source most common to West Texas is wind-blown dust, which occurs in areas with high winds and low humidity. But wind-blown dust can travel several thousand miles from its source. It is not uncommon to find desert sand particles originating from the Sahara desert in Florida or even East Texas. Another natural aerosol source is sea salt aerosol, which is the spray created by breaking waves in the ocean. A third source of natural aerosol results from volcanic eruptions that release sulfur dioxide (SO2) which can react in the atmosphere to create sulfate aerosol.

Sulfate aerosol is a secondary aerosol, which are aerosols formed from a chemical reaction in the atmosphere rather than being directly emitted. But many secondary aerosols have anthropogenic sources, such as burning coal or fuels that contain sulfur, ammonia produced from agriculture, or unburned fossil fuels.

"Once the precursor gases begin reacting, they have a tendency to incorporate oxygen atoms in the reaction products, and that makes the resulting materials less volatile," Thompson said. "As a result, the reaction products start condensing onto other particles thus increasing the mass of the secondary aerosol. That is the process we see in many large population centers, like Los Angeles and Bejing, China." "The deposition of additional material can dramatically alter the optical properties of the particles, so studying the process and resulting changes is crucial to understanding the aerosol's climate effect."

Measuring aerosol optical properties

Thompson began examining the question of aerosol optics as part of a group that adapted the Cavity Ring-Down Spectroscopy (CRDS) method to measuring aerosols while working on his dissertation. CRDS is a process where light from a pulsed laser bounces back and forth between highly reflective mirrors to create a long path – usually several kilometers – to measure optical loss.

Thompson and his colleagues integrated CDRS into with Integrating Sphere Nepholometry (ISN), which was originally developed by researchers at the University of Nevada-Reno. ISN uses lasers and a spherical chamber to measure of how much light is scattered by aerosols.

By combining the two techniques, Thompson and his colleagues determined they could simultaneously measure how much light is scattered by aerosols and how much is absorbed with the same sample, and doing so in a naturally occurring atmosphere prevented the aerosol particles from accumulating on a filter, which can alter results. Further instrument advances have allowed measurement of the mass concentration of black carbon or soot in conjunction with the optical measurements.

This is what is known as measuring the aerosol's albedo.

"If the albedo is equal to one, the aerosol particles are perfectly reflective and not absorbing light at all," Thompson said. "If the albedo is equal to zero, which does not ever occur, they are perfectly absorbent. Nonetheless, we can measure that ratio, and that is extremely important in determining whether or not the aerosol in the atmosphere will lead to warming or cooling the climate."

Black carbon

One of the major unknown factors in whether aerosols will absorb or reflect light is their interaction with black carbon, which is formed from the incomplete combustion from diesel or gasoline engines.

Mixing black carbon with a secondary material like organics or sulfates actually increases the absorption ability of the mixed particles, but how much depends on where the black carbon is located, whether it's in the center of the particle or attached to the side.

Humidity also plays a big factor in composition of the particles. Black carbon itself is not very adsorbent of water, but when mixed with sulfate or nitrate, it will become more hygroscopic and pick up water from the atmosphere, which allows the particle to grow.

"We want to study the organization of the particle and know how the materials mix and where the black carbon is located within the particle," Thompson said. "Does it dissolve? Does it immerse to the center of the droplet? Is it at the surface? How does that affect the light-absorbing properties of the material? We believe these details have not all been worked out, yet they have profound consequences on the amount of light that is absorbed."

Thompson has previously made optical measurements both in a lab here in Lubbock – and in Houston, where the climate is much more humid along the Gulf Coast. The results from those experiments showed promise that, with further research, the secrets to aerosol particle organization with black carbon can be unlocked and their light-absorbent propensities can be determined.

Thompson and his colleagues are hoping to secure further funding to continue this research on a larger scale.

"All these things need to be worked out to better understand how black carbon influences the climate system," Thompson said. "Those are the types of things we'd like to work on with the devices we've developed."

Provided by Texas Tech University

Citation: Researcher investigates reflectivity of atmospheric aerosols (2017, December 15) retrieved 28 April 2024 from https://phys.org/news/2017-12-atmospheric-aerosols.html