

Research Highlight

Atmospheric aerosols affect climate by scattering and absorbing sunlight and by modifying the properties of clouds. However, there are gaps in our understanding of chemical processes involving these airborne particulates, and these gaps contribute significantly to uncertainties in predicting future climate change. Developing more-accurate global climate models requires a more complete understanding of the aerosol lifecycle, from initial particle formation to loss through incorporation into precipitating clouds or dry deposition.

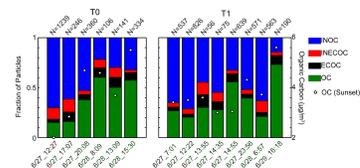
In research published in the journal *Atmospheric Chemistry and Physics*, a team of scientists from Lawrence Berkeley National Laboratory (Berkeley Lab), University of the Pacific, and Pacific Northwest National Laboratory report on a comprehensive analysis of carbon-containing particles collected from an air mass as it drifted from the urban Sacramento, CA environment to a largely forested region to the east in the Sierra Nevada foothills. Their observations were carried out as part of the Carbonaceous Aerosols and Radiative Effects Study (CARES), supported by the U.S. Department of Energy Atmospheric System Research (ASR) program.

The CARES researchers collected samples of atmospheric aerosol particles at 20 minute intervals over a month. This project focused on a two-day period, June 27-28, 2010. The team deployed time-resolved aerosol collectors (TRACs) at Sacramento and foothills sites, which collect particles by inertial impaction onto substrates. Later, using an array of sophisticated laboratory techniques, including scanning electron microscopy, X-ray microanalysis, and synchrotron X-ray microscopy at Berkeley Lab's Advanced Light Source, the chemical composition and morphology of individual particles were evaluated, tracking the differences that occurred as the plume "aged" during the two-day period. What emerged is a unique case study of how aerosol particles changed in concentration and chemistry as they interacted with anthropogenic volatile organic hydrocarbons (VOCs) from the urban area and subsequently with biogenic VOCs above the foothills.

The results show that the mass of organic carbon on individual particles increased through condensation of secondary organic aerosols. Initially, the plume was characterized by a higher concentration of particles. The sources of these particles in the Sacramento region were transportation and oil refineries from the Bay Area to the west; cooking, biomass burning; windblown dust; sea salt; secondary organics, and dust probably from long range transport from Asia. Scanning Electron Microscopy identified a curious class of biological particles in the Sacramento samples: particles commonly found around the world known as brochosomes, which come from the outer coats of grasshoppers. Biogenic VOCs came from agricultural fields surrounding Sacramento and from forests in the Sierra foothills. The concentration of particles decreased from 30,000 particles cm⁻³ in Sacramento to 10,000 cm⁻³ in the foothills, but the masses of individual particles increased as they accrued thick organic coatings, consistent with the high photochemical activity and pollution build-up during the study period.

The study concluded that, as the plume "aged" during its two-day transfer from the Sacramento to the foothills region:

- The carbon content of particles increased roughly fivefold from that of the "fresh," or newly condensed particles.
- Sodium- and potassium-containing particles, which are less likely to react chemically with organics, were less abundant.
- The number and percentage of particles without any inorganic content increased, indicating that organic mass was increased by condensation and coagulation of small, organic dominant nucleating particles.



Fractions of STXM-derived particle types for different sites (T0 and T1), dates, and local times. White dots show organic carbon mass concentration determined by the Sunset OCEC analyzer. Legend indicates mixtures of the following chemical components: OC-organic carbon, EC-elemental carbon, IN-inorganic carbon. Hence, INOC denote particles containing both inorganic carbon and organic carbon.

- Organic carbon content on extremely small particles (0.2–2 μm) increased as a function of plume age, most likely a direct result of organic compound condensation on particle surfaces.

The CARES findings were compared with a similar study (MILAGRO) conducted previously in Mexico City, where fresh organic particles were shown to have three times as much carbon by mass. The similarities and differences among these two rich datasets provide a reference for comparison of process models. Together these studies provide the most detailed observations available on the aging of organic aerosols. Such measurements are essential for developing the improved process-level understanding of aerosol formation and aging, as well as their impacts on radiative and cloud-nucleating properties, which can lead to more accurate climate-prediction models.

Reference(s)

Moffet RC, TC Rödel, ST Kelly, XY Yu, GT Carroll, J Fast, RA Zaveri, A Laskin, and MK Gilles. 2013. "Spectro-microscopic measurements of carbonaceous aerosol aging in Central California." *Atmospheric Chemistry and Physics*, 13, doi:10.5194/acpd-13-9179-2013.

Contributors

Mary Gilles, *Lawrence Berkeley National Laboratory*; Ryan Moffet, *University of the Pacific*

Working Group(s)

Aerosol Life Cycle