

## Research Highlight

Like people, particles in the atmosphere can gain weight, and it is not easy to predict how much and how quickly they do. The culprit is newly formed carbon-containing compounds in the atmosphere, also referred to as secondary organic aerosols (SOAs), which pile on pre-existing particles, resulting in a gain in mass. It is even harder to predict how the gain is distributed among all the different-sized particles in the atmosphere and how they change particles' climate-relevant properties in the atmosphere.

To address the size-dependent weight gain problem, a team of scientists, led by Dr. Rahul Zaveri of Pacific Northwest National Laboratory (PNNL), designed a new modeling framework recently described in *Atmospheric Chemistry and Physics*. The framework is a significant advancement over the previous modeling paradigm that focused only on the total mass.

"Predicting the total organic aerosol mass is not enough. The next-generation climate models must also be able to reliably predict the particle size distribution, an aspect absolutely crucial in determining their climate-relevant properties," said Zaveri.

The new modeling framework designed by the PNNL and Caltech team dynamically partitions SOAs according to the size of pre-existing particles and takes into account diffusion and chemical reactions within their particle phase. The framework uses a combination of two mathematical approaches: first, an analytical quasi-steady-state treatment for the diffusion-reaction process within the particle phase for fast-reacting organic gases; and second, a two-film theory approach for slow- and non-reacting gases. The framework can be applied in both regional and global atmospheric models, although it currently awaits specification of the various gas- and particle-phase chemistries and the related physicochemical properties that are important for SOAs to form. In this study, the new framework was implemented in PNNL's Model for Simulating Aerosol Interactions and Chemistry (MOSAIC), a box model, to investigate the competitive growth dynamics of the different size particles under various hypothetical conditions.

Their results showed that the timescale of gas-to-particle conversion of organic gases and the resulting evolution of the particle size distribution depend on the complex interplay between organic gas volatility, particle-phase diffusivity, and particle-phase reactivity, each of which can vary over several orders of magnitude.

Clouds have major clout over the atmospheric warming and cooling balance of the Earth. Atmospheric particles that influence clouds—whether encouraging them to grow, precipitate, or dry out and disappear—are important to understand increasing pressures of climate change. SOAs are formed through complex physical and chemical interactions between gases and pre-existing atmospheric particles, and the process greatly depends on the size and physical state (i.e., solid, semisolid, or liquid) of the pre-existing particles. These carbon-containing particles are among the most abundant aerosol particle components in the atmosphere, yet the least understood. These particles can significantly affect cloud formation and the climate. Therefore, accurately predicting how these particles form and grow will help scientists and policy makers understand and predict future global climate change.

## Reference(s)

Zaveri RA, RC Easter, JE Shilling, and JH Seinfeld. 2014. "Modeling kinetic partitioning of secondary organic aerosol and size distribution dynamics: Representing effects of volatility, phase state, and particle-phase reaction." *Atmospheric Chemistry and Physics*, 14, doi:10.5194/acp-14-5153-2014.

## Contributors



Modeling not only the total mass but also the size distribution of carbon-containing particles in the atmosphere will help scientists understand how they behave and contribute to atmospheric conditions that are important to climate, such as cloud formation.

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**Working Group(s)**  
Aerosol Life Cycle

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