McNeill is particularly interested in how aerosols, small particles or droplets of liquid suspended in the atmosphere, affect global climate. Because they are so small (typically 2 to 10,000 nm), gravity has little effect on aerosol particles and they can remain airborne for several days in the lower atmosphere, longer in the stratosphere. Aerosols such as the sulfur compounds and ash emitted by Mt. Pinatubo pushed down global average temperatures for two to three years after it erupted in 1991. Other aerosols can absorb incoming solar radiation or long-wave radiation reflected from Earth’s surface, resulting in a warming effect on climate. The range of direct and indirect, compounding and conflicting effects makes aerosols one of the biggest unsolved problems facing climate scientists.

Aerosols also can have a wide range of chemical compositions, which reflects their diverse origins. McNeill and her team have recently focused on understanding the sources and properties of light-absorbing organic material, or “brown carbon,” in atmospheric aerosols. Brown carbon is often a by-product of the burning of biomass, but its exact formation mechanism is poorly understood. It turns out that, rather than just being emitted directly from a source such as a brush fire, brown carbon can form through complex reactions in airborne atmospheric particles.

Understanding Brown Carbon

As an undergraduate at the California Institute of Technology, Faye McNeill gravitated to studying the chemistry of the atmosphere for a very personal reason. “The air pollution there was bad,” said McNeill, assistant professor of chemical engineering, of the air in Southern California. “I have asthma, so I’m always a little more aware of atmospheric composition just because of the way I feel.”

Brown carbon also interacts very differently with the atmosphere and environment than its inorganic cousin black carbon, and its role in atmospheric chemistry and climate are just beginning to be understood. For one thing, black carbon tends to absorb radiation across the visible spectrum, but brown carbon preferentially absorbs shorter wavelengths of light and thus can influence the formation of ground-level ozone—the “bad” kind that leads to McNeill’s asthma attacks.

To fill in our understanding of these important atmospheric compounds, McNeill is examining the basic chemistry and physics behind the cloud-forming and light-absorbing characteristics of organic aerosols in the lab. She also works with other groups to integrate their piece of the climate puzzle into the big picture, including climate modelers who write the massive, computer-based simulations that attempt to predict how individual parts of the environment interact to govern Earth’s climate.

“A big part of what we do is communicate the results of our work to modelers,” said McNeill. “The fundamental information we get in the lab will eventually find its way into better climate models.” And that is something that can help us all breathe a little easier.