Biological activity alters the ability of sea spray to seed clouds

April 22 2013

Ocean biology alters the chemical composition of sea spray in ways that influence their ability to form clouds over the ocean. That's the conclusion of a team of scientists using a new approach to study tiny atmospheric particles called aerosols that can influence climate by absorbing or reflecting sunlight and seeding clouds.

"After many decades of attempting to understand how the ocean impacts the atmosphere and clouds above it, it became clear a new approach was needed to investigate the complex ocean-atmosphere system—so moving the chemical complexity of the ocean to the laboratory represented a major advance that will enable many new studies to be performed," said Kimberly Prather, Distinguished Chair in Atmospheric Chemistry at the University of California, San Diego and director of the Center for Aerosol Impacts on Climate and the Environment, who led the team of more than 30 scientists involved in this project. They report their findings in the early, online edition of the *Proceedings of the National Academy of Sciences* the week of April 22.

Tiny air bubbles form in the ocean when waves break and then rise to the surface and burst, releasing gases and aerosols into the atmosphere. This study demonstrates how sea spray aerosols come in a wide variety of sizes and shapes with chemical complexity ranging from simple salts to complex biological mixtures to bacterial cells.

For decades, scientists have been studying how their chemical make-up affects their ability to take up water, seed clouds, and react in the atmosphere. It is has been difficult to isolate and study marine aerosols in the real world, however, because aerosols from other sources overwhelm field measurements.

"Once the ocean-atmosphere system was isolated, we can systematically probe how changes in the seawater due to biological activity affect the composition and climate properties of the sea spray aerosol," said Prather, a professor in the Department of Chemistry and Biochemistry who holds a joint appointment at Scripps Institution of Oceanography.

In their studies, seawater is pumped directly from the Pacific Ocean into a specially modified enclosed wave flume in the Hydraulics Laboratory at Scripps Oceanography. By stringently filtering the air within the wave chamber, the team eliminated contamination from other sources allowing them to probe sea spray aerosol directly for the first time after it was produced by breaking waves.

Over five days, the team systematically altered biological communities within the flume by adding various combinations of cultures of marine bacteria and microscopic marine algae, or phytoplankton. Then, as a hydraulic paddle sent waves breaking over an artificial shoal, instruments positioned along the 33 meter long flume measured the chemistry of the seawater, air, and aerosols.

As the seawater changed and bacteria levels increased, the resulting aerosols showed a major change in composition leading to a reduction in their ability to form clouds. In particular, a day after new cultures were added, bacteria levels rose fivefold and cloud-seeding potential fell by about a third. These changes were happening even as the concentration of phytoplankton fell, along with levels of chlorophyll-a, the pigment essential to photosynthesis. This is an important finding because current estimates of biological activity in surface waters of the ocean rely on instruments aboard satellites that measure the color of the sea surface, which changes along with levels of chlorophyll-a.

The findings demonstrate the value of the Center's novel approach for sorting through the interdependent factors governing the effects of the ocean and sea spray on climate.

More information: Bringing the ocean into the laboratory to probe the chemical complexity of sea spray aerosol, Kimberly A. Prather, et al. *PNAS*. 2013.

Provided by University of California - San Diego