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Finding linkages between ocean ecosystems and natural marine aerosols in the minimally polluted North Atlantic atmosphere

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The emission of sea spray aerosol (SSA) and dimethylsulfide (DMS) from the ocean results in marine boundary layer aerosol particles that can impact Earth's radiation balance by directly scattering solar radiation and by acting as cloud condensation nuclei (CCN), thereby altering cloud properties. The surface ocean is projected to warm by 1.3 to 2.8°C globally over the 21st century. Impacts of this warming on plankton blooms, ocean ecosystems, and ocean-to-atmosphere fluxes of aerosols and their precursor gases are highly uncertain. A fundamental understanding of linkages between surface ocean ecosystems and ocean-derived aerosols is required to address this uncertainty. One approach for improved understandings of these linkages is simultaneous measurements of relevant surface ocean and aerosol properties in an ocean region with seasonally varying plankton blooms and a minimally polluted overlying atmosphere. The western North Atlantic hosts the largest annual phytoplankton bloom in the global ocean with a large spatial and seasonal variability in plankton biomass and composition. Periods of low aerosol number concentrations associated with unpolluted air masses allow for the detection of linkages between ocean ecosystems and ocean-derived aerosol.

Five experiments were conducted in the western North Atlantic between 2014 and 2018 with the objective of finding links between the bloom and marine aerosols. These experiments include the second Western Atlantic Climate Study (WACS-2) and four North Atlantic Aerosol and Marine Ecosystem Study (NAAMES) cruises. This series of cruises was the first time the western North Atlantic bloom was systematically sampled during every season with extensive ocean and atmosphere measurements able to assess how changes in the state of the bloom might impact ocean-derived aerosol properties. Measurements of unheated and heated number size distributions, cloud condensation nuclei (CCN) concentrations, and aerosol composition were used to identify primary and secondary aerosol components that could be related to the state of the bloom. Only periods of clean marine air, as defined by radon, particle number concentration, aerosol light absorption coefficient, and back trajectories, were included in the analysis.

CCN concentrations at 0.1% supersaturation were best correlated (r^2 = 0.73) with accumulation mode nss $SO_4^=$. Sea spray aerosol (SSA) was only correlated with CCN during November when bloom accumulation had not yet occurred and dimethylsulfide (DMS) concentrations were at a minimum. The fraction of CCN attributable to SSA was less than 20% during March, May/June, and September, indicating the limited contribution of SSA to the CCN population of the western North Atlantic atmosphere. The strongest link between the plankton bloom and aerosol and cloud properties appears to be due to biogenic non-seasalt $SO_4^=$.