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Recent Findings Related to Giant Cloud Condensation Nuclei in the Marine Boundary Layer and Impacts on Clouds and Precipitation

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This presentation reports on findings from multiple airborne field campaigns off the California coast to understand the sources, nature, and impacts of giant cloud condensation nuclei (GCCN). Aside from sea spray emissions, measurements have revealed that ocean-going ships can be a source of GCCN due to wake and stack emissions off the California coast. Observed particle number concentrations behind 10 ships exceeded those in "control" areas, exhibiting number concentration enhancement ratios (ERs) for minimum threshold diameters of $\sim$2, $\sim$10, and $\sim$20 μm as high as 2.7, 5.5, and 7.5, respectively. The data provide insights into how ER is related to a variety of factors (downwind distance, altitude, ship characteristics such as gross tonnage, length, and beam).

The data also provide insight into the extent to which a size distribution parameter and a cloud water chemical measurement can capture the effect of sea salt on marine stratocumulus cloud properties. The two GCCN proxy variables, near-surface particle number concentration for diameter > 5 μm and cloud water chloride concentration, are significantly correlated with each other, and both exhibit expected relationships with other parameters that typically coincide with sea salt emissions. Factors influencing the relationship between these two GCCN proxy measurements will be discussed. When comparing twelve pairs of high and low chloride cloud cases (at fixed liquid water path and cloud drop number concentration), the average drop spectra for high chloride cases exhibit enhanced drop number at diameters exceeding 20 μm, especially above 30 μm. In addition, high chloride cases coincide with enhanced mean columnar R and negative values of precipitation susceptibility. The difference in drop effective radius (re) between high and low chloride conditions decreases with height in cloud, suggesting that some GCCN-produced rain drops precipitate before reaching cloud tops. The sign of cloud responses (i.e. re, R) to perturbations in giant sea salt particle concentration, as evaluated from MERRA-2 reanalysis data, is consistent with the aircraft data.