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Lidar-Derived Vertically Resolved Cloud Condensation Nuclei Concentrations for Various Aerosol Types and their Applications in Evaluating Aerosol-Cloud Interactions

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Aerosols that activate to become cloud droplets are termed cloud condensation nuclei (CCN), and they provide a direct microphysical link between aerosols and clouds and are a key driver of aerosol-cloud interactions (ACI). The lack of a global understanding of CCN distributions contributes to the high uncertainty in ACI, which remains one of the most uncertain components of anthropogenic climate change. In situ CCN observations are valuable due to their high accuracy but are very sparse, so remote sensing-based approaches have been developed to retrieve CCN concentrations (N_{CCN}) on larger spatiotemporal scales. One common alternative method to represent N_{CCN} uses column-effective proxies such as aerosol optical depth (AOD). However, CCN are usually optically invisible and high AOD does not necessarily correspond to high N_{CCN}. More importantly, this method does not provide information about the vertical distributions of CCN as the levels near cloud base are most relevant for understanding cloud droplet nucleation.

We present an approach to estimate vertically resolved N_{CCN} using relationships between in situ measured N_{CCN} and aerosol backscatter (BSC) coefficients. In situ N_{CCN} is measured by a Droplet Measurement Technologies Continuous Flow Streamwise Temperature Gradient Chamber (CCN-100) and BSC is obtained by the airborne High Spectral Resolution Lidar 2 (HSRL-2). We compare CCN – BSC relationships for the ObseRvations of Aerosols above CLouds and their intEractions (ORACLES) campaign, focused on a biomass burning aerosol (BBA) plume, and the Cloud, Aerosol and Monsoon Processes Philippines Experiment (CAMP^{2}Ex), which features a more heterogeneous mixture of urban polluted aerosol, marine aerosol, and BBA. In comparing observations of BBA in both regions we find a strong dependence of the CCN – BSC relationship on ambient relative humidity (RH). We assess the spatiotemporal variability of N_{CCN} in both regions using autocorrelation analysis and explore how this impacts the performance of our regression equations. We also begin to explore the applicability of our vertically resolved N_{CCN} curtains to analyze potential relationships between cloud micro- and macrophysical properties and near-cloud N_{CCN}.

Keywords: aerosol, clouds, remote sensing, in situ