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Biomass burning organic aerosol modulation of droplet number in the Southern Atlantic

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Aerosols both scatter and absorb radiation, causing significant yet variable climate impacts and lending a large source of uncertainty to climate predictions. Cloud condensation nuclei (CCN) measurements help to illuminate how aerosols affect cloud formation and properties such as cloud droplet number. Biomass burning organic aerosol (BBOA) can drastically elevate CCN concentrations, but the response in cloud droplet number may be suppressed or even reversed due to low supersaturations that develop from strong competition for water vapor, as seen in Bougiatioti et al (2016) over the mediterranean. Constraining droplet response to BBOA is a key factor to understanding aerosol-cloud interactions. The southeastern Atlantic (SEA) cloud deck off the west coast of central Africa provides a unique opportunity to study these cloud-BBOA interactions for marine stratocumulus. During winter in the southern hemisphere, a large, optically thick BBOA plume overlies the SEA cloud deck. The NASA ObseRvations of Aerosols above Clouds and their intEractionS (ORACLES) study focuses on increasing the understanding of how these BBOA affect the SEA cloud deck. Measurements of CCN concentration, aerosol size distribution and composition, updraft velocities, and cloud droplet number in and around the SEA cloud deck and associated BBOA plume were taken aboard the NASA P-3 aircraft during the first two years of the ORACLES campaign in September 2016 and August 2017. Here we evaluate the predicted and observed droplet number sensitivity to the aerosol fluctuations and quantify, using the data, the drivers of droplet number variability (vertical velocity or aerosol properties) as a function of biomass burning plume characteristics. Over the course of the campaign, different levels of BBOA influence in the marine boundary layer (MBL) were observed, allowing for comparison of cloud droplet number, hygroscopicity parameter (κ), and maximum in-cloud supersaturation over a range of "clean" and "dirty" conditions. Droplet number sensitivity to aerosol concentration, κ, and vertical updraft velocities are also evaluated. Generally, an increase in BBOA led to increased droplet number along with decreased κ and maximum in-cloud supersaturation (leading to an increase in competition for water vapor). Elevated pollution in the MBL elevates CCN concentrations and extends the range of the marine stratucumulous deck further westward. This work seeks to contribute to an increased understanding of how CCN and aerosol properties affect the radiative and hydrological properties and impact of the cloud.