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# *CLOUD DROPLET NUCLEATION AND THE AEROSOL FIRST INDIRECT EFFECT*

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## ABSTRACT

Cloud droplet nucleation, which is the growth of aerosols into cloud droplet-sized particles, is the process that underlies the implementation of the first aerosol indirect effect. The nucleation process depends upon many factors including the size and chemical composition of the aerosols and the updraft velocity of the cloud, both of which contribute to the level of supersaturation and, therefore, to the amount of cloud condensation nuclei that become cloud droplets. Here we determine how the nucleation process impacts the implementation of the first aerosol indirect effect in actual clouds. We perform an experiment in which adiabatic realizations of the cloud droplet nucleation process are performed in a cloud chamber operated in close proximity to cloud base and we apply these realizations to the conditions that actually exist in the cloud above. This procedure demonstrates the limitations imposed by the nucleation process upon the manifestation of the first aerosol indirect effect in nature. Instruments are deployed along the California Coast at Pt. Reyes National Seashore, a site where we expect to find a wide variety of aerosol conditions ranging from extremely polluted to reasonably pollution free, and where the cloud base is in close proximity to the surface so that the aerosol measurements are representative of those that exist in-cloud. Included in the instrument package is a Cloud Condensation Nuclei (CCN) Activation Counter that measures the number of CCN that grow to become cloud droplets at a range of supersaturations (cloud droplet activation curve hereafter). The liquid water path and optical thickness in the narrow column of cloud are used to determine the mean effective radius of the cloud particles that exist above the cloud chamber. Adiabatic measurements from the surface cloud chamber are combined with radar-measured updraft velocity to determine how many cloud droplets will be nucleated in rising, adiabatic parcels within the column. Given the adiabatic number density of cloud droplets from surface measurements and reassurance that this number is consistent with aircraft measurements, we remotely sense the aerosol first indirect effect as it occurs naturally in these coastal clouds. We demonstrate that the nucleation process does not occur uniformly and that the efficacy of the process to facilitate the first indirect effect is related to liquid water path.