

Research Highlight

Determining cloud condensation nuclei (CCN) concentrations, and their spatial and temporal variations, is a key challenge in quantifying aerosol indirect effects. Although some in situ measurements of CCN concentration have been made at a few locations around the world, extensive measurements are not currently feasible because of the high cost and complex nature of the operation. Thus, many attempts have been made to estimate CCN concentrations from more easily measurable and readily available quantities such as aerosol optical depth (AOD).

A deep insight is gained on the relationship between CCN concentration and aerosol optical quantities for some distinct aerosol types using an extensive set of observational data collected at multiple Atmospheric Radiation Measurement (ARM) Climate Research Facility sites around the world, including the Southern Great Plains (rural continental aerosols), the Azores (sea-salt aerosols, local pollution from airport traffic, and long-range transport from Europe), the Black Forest in Germany (agricultural and forested regions with an abundance of biogenic aerosols), the Ganges Valley in India (anthropogenic pollution), and Niamey in Niger (dust aerosols). To reduce the uncertainty in CCN concentration estimations, the influence of relative humidity (RH), aerosol hygroscopicity, and aerosol single scattering albedo (SSA) on the relationship between CCN concentration and aerosol optical measurements was also investigated.

In general, the correlation between AOD and CCN concentration decreases as the wavelength at which AOD is measured increases. So, use of AOD values measured at the shortest wavelengths is recommended. Moreover, it is better to use the aerosol index (AI) derived from AOD measurements at two wavelengths than AOD at a single wavelength because the relationship between AI and CCN is systematically better than the CCN–AOD relationship. The best predictors of CCN are in situ aerosol scattering/extinction coefficients ($\#sp$) and AI measured simultaneously with CCN. If RH exceeds 75 percent, the relationship where AOD is used as a proxy for CCN becomes invalid, whereas a tight $\#sp$ –CCN relationship exists for dry particles. Aerosol hygroscopicity has a weak impact on the $\#sp$ –CCN relationship. Particles with low SSA are generally associated with higher CCN concentrations, suggesting that SSA affects the relationship between CCN concentration and aerosol optical quantities. As such, SSA can be used as a constraint to reduce uncertainties in the relationship. A parameterization of CCN concentration as a function of AOD at 500 nm, $\#sp$, and the Angstrom exponent, valid for rural continental regions, is given.

This study reveals the potentials and limitations of using aerosol optical property measurements to infer CCN concentration with a focus on the impact of ambient RH, aerosol hygroscopic response, and SSA.

Aerosol composition and aerosol size distribution information, together with aerosol optical parameters and meteorological parameters for each aerosol type and region, promises to further help develop more detailed parameterizations of CCN concentrations.

Reference(s)

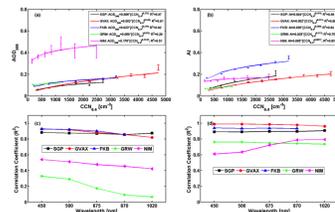
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Contributors

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Working Group(s)

Cloud-Aerosol-Precipitation Interactions



Relationship between AOD at 500 nm and CCN0.4; (b) Relationship between AI and CCN0.4; (c) Their correlation coefficients; and (d) same as (c) but for AI in lieu of AOD.