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Retrieving cloud condensation nuclei concentrations from spaceborne lidar measurements

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Aerosols interact with atmospheric radiation either directly through scattering and absorption or indirectly by acting as cloud condensation nuclei (CCN) and ice nucleating particles (INP), thereby altering cloud properties. The latter aerosol-cloud interaction (ACI) effects are still poorly understood and believed to be one of the key uncertainties in climate models. In the present scenario, the observations of CCN are still sparse as in-situ measurements are expensive and often restricted to specific locations and limited time periods. An alternative is to turn to satellite observations for ACI studies. The Cloud Aerosol Lidar with Orthogonal Polarisation (CALIOP) is a spaceborne lidar aboard the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite. It provides high-resolution vertical profiles of aerosol related parameters such as the aerosol extinction coefficient, backscatter coefficient, aerosol subtypes, and depolarization ratio. In order to estimate the CCN concentrations, we use these parameters along with the normalised lognormal bimodal volume size distributions and complex refractive indices of different aerosol subtypes given in the CALISPO aerosol model.

The normalised size distribution, the refractive index and the relative humidity are first used to compute the extinction coefficient using the MOPSMAP package. For this, all the aerosol types are treated as spherical particles except the dust which is treated as spheroid. The size distribution is then modified until the estimated extinction agrees with that measured by the CALIPSO. The modified size distribution is integrated to compute the number concentration of aerosols that form the favourable CCN reservoir. To estimate the uncertainty in the retrieval algorithm, we performed the sensitivity analysis by varying the initial normalised volume size distribution by up to +/- 50 % for each mode (fine and coarse). The results are presented as case studies with some preliminary validation against in-situ measurements. The purpose of this work is to obtain a global 3D CCN climatology for use in ACI studies and improving the performance of the global climate models.