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Comparing the relationships between aerosol optical depth and cloud properties in observations and global models

Edward Gryspeerdt and Johannes Quaas
Universität Leipzig, Institute for Meteorology, Leipzig, Germany (edward.gryspeerdt@uni-leipzig.de)

Aerosols impact the climate both directly, through their interaction with radiation and indirectly, via their ability to act as cloud condensation nuclei (CCN), modifying cloud properties. The influence of aerosols on cloud properties is highly uncertain. Many relationships between aerosol optical depth (AOD) and cloud properties have been observed using satellite data, but previous work has shown that some of these relationships are the product of the strong AOD-cloud fraction (CF) relationship. The confounding influence of local meteorology obscures the magnitude of any aerosol impact on CF, and so also the impact of aerosol on other cloud properties. For example, both AOD and CF are strongly influenced by relative humidity, which can generate a correlation between them. Previous studies have used reanalysis data to account for confounding meteorological variables. This requires knowledge of the relevant meteorological variables and is limited by the accuracy of the reanalysis data.

Recent work has shown that by using the cloud droplet number concentration (CDNC) to mediate the AOD-CF relationship, the impact of relative humidity can be significantly reduced. This method removes the limitations imposed by the finite accuracy of reanalysis data. In this work we investigate the impact of the CDNC mediation on the AOD-CF relationship and on the relationship between AOD and other cloud properties in global atmospheric models. By comparing pre-industrial and present day runs, we investigate the success of the CDNC mediated AOD-CF relationship to predict the change in CF from the pre-industrial to the present day using only observations of the present day relationships between clouds and aerosol properties. This helps to determine whether the satellite-derived relationship provides a constraint on the aerosol indirect forcing due to changes in CF.