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Cloud fraction and satellite-derived aerosol-cloud relationships

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Atmospheric aerosols can impact cloud properties through their ability to act as cloud condensation nuclei, although the magnitude of the aerosol impact on cloud properties is uncertain. While many previous studies of satellite data have shown strong correlations between aerosol optical depth (AOD) and cloud properties, it is unclear to what extent these correlations are due to an influence of aerosols on cloud properties. Meteorological covariation, where cloud and aerosol properties vary together due to the influence of a meteorological factor, has been shown to generate strong correlations between aerosol and cloud properties. For example, the AOD-cloud fraction (CF) correlation is strongly influenced by meteorological covariation, with the AOD and the CF both increasing in humid environments. This obscures the magnitude of any aerosol influence on CF and can influence correlations between AOD and other cloud properties due to the strong correlation of many cloud properties with CF.

To reduce the impact of meteorological covariation, many previous studies have used re-analysis data to account for the controlling meteorological variables. This method requires knowledge of the possible meteorological covariations involved and is limited by the accuracy of the re-analysis data.

In this work, we account for meteorological covariations in the AOD-CF correlation by deconstructing it into separate components that are less influenced by meteorological covariations. These pieces can then be recombined to provide an estimate of the strength of the AOD-CF correlation with a reduced impact of meteorological covariations. By separating different processes in a hypothesised aerosol effect on CF, we remove the need to explicitly account for all possible meteorological covariations capable of influencing the AOD-CF correlation. This also removes limitations imposed by the finite accuracy of reanalysis data. Although this work cannot completely remove the impact of meteorological covariations, they are significantly reduced, helping to further constrain the possible impacts of aerosol on CF and other cloud properties.