EGU22-4896
https://doi.org/10.5194/egusphere-egu22-4896
EGU General Assembly 2022

Addressing the difficulties in quantifying the Twomey effect for marine warm clouds from multi-sensor satellite observations and reanalysis

Hailing Jia[1], Johannes Quaas[1], Edward Gryspeerdt[2], Christoph Böhm[3], and Odran Sourdeval[4]
[1]Universität Leipzig, Leipzig Institute for Meteorology, Leipzig, Germany (hailing.jia@uni-leipzig.de)
[2]Space and Atmospheric Physics Group, Imperial College London, UK
[3]Institute for Geophysics and Meteorology, University of Cologne, Cologne, Germany
[4]Laboratoire d'Optique Atmosphérique, Université de Lille, CNRS, Lille, France

Aerosol–cloud interaction is the most uncertain component of the overall anthropogenic forcing of the climate, in which the Twomey effect plays a fundamental role. Satellite-based estimates of the Twomey effect are especially challenging, mainly due to the difficulty in disentangling aerosol effects on cloud droplet number concentration (N_d) from possible confounders. By combining multiple satellite observations and reanalysis, this study investigates the impacts of a) updraft, b) precipitation, c) retrieval errors, as well as (d) vertical co-location between aerosol and cloud, on the assessment of N_d-toaerosol sensitivity (S) in the context of marine warm (liquid) clouds. Our analysis suggests that S increases remarkably with both cloud base height and cloud geometric thickness (proxies for vertical velocity at cloud base), consistent with stronger aerosol-cloud interactions at larger updraft velocity. In turn, introducing the confounding effect of aerosol–precipitation interaction can artificially amplify S by an estimated 21 %, highlighting the necessity of removing precipitating clouds from analyses on the Twomey effect. It is noted that the retrieval biases in aerosol and cloud appear to underestimate S, in which cloud fraction acts as a key modulator, making it practically difficult to balance the accuracies of aerosol–cloud retrievals at aggregate scales (e.g., 1° × 1° grid). Moreover, we show that using column-integrated sulfate mass concentration (SO4C) to approximate sulfate concentration at cloud base (SO4B) can result in a degradation of correlation with N_d, along with a nearly twofold enhancement of S, mostly attributed to the inability of SO4C to capture the full spatio-temporal variability of SO4B. These findings point to several potential ways forward to account for the major influential factors practically by means of satellite observations and reanalysis, aiming at an optimal observational estimate of global radiative forcing due to the Twomey effect.