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Observational constraints on model-based assessments of indirect aerosol radiative effects - and model constraints on observations

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Atmospheric aerosols play an important role in the global climate system through modifications of the global radiation budget: directly, by scattering and absorption of radiation, and indirectly, by the modification of cloud properties and cloud abundance, which in turn may impact the hydrological cycle. In particular the indirect aerosol effects on clouds and precipitation are subject to large uncertainties.

In the absence of direct observations of indirect aerosol effects with global coverage, global aerosol–cloud climate models have been used to provide quantitative estimates of aerosol–cloud interactions. However, limitations in the underlying cloud and aerosol microphysics, in particular the requirement to reduce their complexity for the implementation in global climate models, introduce significant uncertainties.

In this study we investigate the robustness of observational constraints from remote sensing on model-simulated aerosol radiative effects employing the ECHAM-HAM and HadGEM-UKCA aerosol–climate models. A particular focus will be on comparing of the implications of different satellite retrievals for the MODIS instrument on indirect aerosol effects over regional scales. To minimise sampling issues we output model fields at the satellite overpass time and use the ISCCP and COSP satellite simulators online in the models. Reversely, we also employ the (self-consistent) models to provide further insights into satellite-retrieved aerosol and cloud relationships, such as correlations of cloud condensation nuclei to aerosol optical depth, sensitivities of cloud droplet numbers to aerosol optical depth, and the susceptibility of precipitation to droplet number perturbations.

Our results help to provide understanding and quantification of uncertainties in observational and model-derived estimates of aerosol–cloud interactions.