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Assessment of aerosol-cloud-precipitation interactions employing parameterizations of various complexities

P. Stier (1), R. West (1), J. H. Seinfeld (2), U. Lohmann (3), and J. Quaas (4)

(1) Atmospheric, Oceanic and Planetary Physics, Department of Physics, University of Oxford, United Kingdom (philip.stier@atm.ox.ac.uk), (2) Environmental Science and Engineering & Chemical Engineering, California Institute of Technology, Pasadena, USA, (3) Institute for Atmospheric and Climate Science, Swiss Federal Institute of Technology, Zurich, Switzerland, (4) Emmy Noether Junior Research Group Cloud-Climate Feedbacks, Max Planck Institute of Meteorology, Hamburg, Germany

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 abundance with impacts on the hydrological cycle. In particular the indirect aerosol effects on clouds and precipitation are subject to large uncertainties.

State of the art global aerosol-cloud climate models allow estimates of aerosol-cloud interactions. However, limitations in the underlying cloud and aerosol microphysics and in particular the requirement to reduce their complexity for the implementation in global climate models introduce significant uncertainties. Previous comparisons of conceptually different approaches were often of limited explanatory power due to the usage of varying models and setups.

In this study we investigate uncertainties in estimates of indirect aerosol effects through studies with the ECHAM5-HAM aerosol-climate model. We employ parameterizations of the aerosol-cloud interactions of various complexities in an identical model setup to quantify the contribution of the process parameterization to the uncertainty in the simulated aerosol-cloud interactions. The consideration of the direct and semi-direct effects as well as the indirect cloud albedo and lifetime effects allows for a comprehensive investigation of the aerosol effects on precipitation.

A detailed evaluation of the results with satellite observations of aerosol and cloud parameters will provide observational constraints on the simulated aerosol-cloud-precipitation interactions in the different model setups. Our results help to understand and quantify uncertainties in estimates of aerosol-cloud interactions and yield valuable information about the necessary level of detail of the process representation in global climate models.