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Evaluation of aerosol indirect radiative effects on climate in the EMAC model

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Anthropogenic aerosol particles directly and indirectly influence cloud properties and the Earth's radiative energy budget. Several studies have estimated the effects on climate using global circulation models (GCMs), indicating large differences between different models and large uncertainty ranges. These are mostly attributed to different cloud microphysical process parameterizations and uncertainties in the representation of aerosols. Without detailed cloud microphysical processes, using empirical relations between aerosol number or mass and cloud droplet number potentially even large discrepancies may arise.
In the present study, a mechanistic aerosol activation scheme, based on double moment cloud microphysics, is used to compute aerosol indirect radiative and cloud effects in the EMAC model. Aerosol activation is linked to the cloud droplet nucleation processes in warm clouds, accounting for the number, size, and chemical composition of particles under ambient meteorological conditions. This approach uses a combination of empirical and semi-empirical parameters to represent aerosol water uptake and hygroscopic growth into cloud droplets. To evaluate the performance of our approach satellite datasets are used; for example, total cloud fraction from MODIS data and cloud radiative forcing at the top of atmosphere from CERES EBAF data.