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Global performance of the prognostic cloud droplet nucleation scheme and the effective aerosol hygroscopicity parameter in the EMAC model

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Clouds play an important role in the climate system and are still the major uncertainty in general circulation models. Cloud properties are affected by atmospheric aerosol particles, which serve as cloud condensation nuclei(CCN), and so influence the climate by modifying the structure and dynamics of clouds. However, global models encounter challenges to account for these interactions between aerosol, cloud and climate due to the difficulty in parameterizing clouds. To reduce uncertainty in climate predictions there is a need to improve the large-scale cloud schemes and coupling within aerosol models.
In this study we present the global performance of a new two-moment cloud scheme with a more advanced treatment of cloud microphysics combined with a comprehensive treatment of aerosol activation. It is compared with the former version of the cloud module within the EMAC (ECHAM5 MESSy Atmospheric Chemistry) model system. The new scheme prognostically determines the cloud droplet number concentration and mass from a prognostic aerosol model (GMXe, ISORROPIA) implemented in the EMAC model. This approach offers a more realistic treatment of the interactions between cloud, aerosols and chemistry as it explicitly calculates the aerosol activation and so prognostically derives the number of CCN and later on cloud droplet numbers.
In addition, we test the importance of the effective hygroscopicity parameter kappa (which represents the relationship between particle compositions and CCN activity) for aerosol activation in the EMAC model. This work presents the aerosol - cloud interaction with sensitivity simulations for aerosol parameterizations, chemical compositions and hygroscopicity. Furthermore, we evaluate the performance of this scheme using: (i) ECMWF reanalysis data, (ii) MODIS satellite data, and (iii) related other studies that focus on indirect and semi-indirect aerosol effect on clouds.