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Interpreting statistical relationships between cloud and aerosol quantities from satellite data using sensitivity studies with a general circulation model

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In several recent studies, it has been found that satellite retrievals of cloud cover, liquid water path, droplet number concentration, and top height are statistically significantly positively correlated with aerosol optical depth. In the scientific discussion, aerosol indirect effects on clouds, meteorological co-incidence, and retrieval errors have been proposed as a reason for these relationships. GCM simulations are useful to disentangle these reasons (e.g., Lohmann et al., Geophys. Res. Lett., 2006).
We use here various versions of the ECHAM5 general circulation model to investigate to which degree the representation of particular cloud-aerosol interactions in the model allows to simulate a similar relationship, and where meteorological co-incidence causes the statistical relationship. The model versions include configurations without any aerosol influence on clouds as a control simulation, a simple description of droplet activation without interaction with precipitation microphysics, an advanced double-moment cloud scheme with different activation parameterizations, and finally including the impact of aerosols on convective clouds.