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A reduced complexity aerosol model for km-scale climate models

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Despite their small size, aerosols strongly influence Earth's climate. Aerosols scatter and absorb radiation referred to as aerosol-radiation interactions but also modify the properties of clouds, as cloud droplets form on aerosol particles, referred to as aerosol-cloud interactions. Kilometer-scale simulations allow us to examine long-standing questions related to these interactions. Such simulations resolve atmospheric motions on scales of a few kilometers and represent important atmospheric processes like convective updrafts that were parameterized previously. Regional simulations revealed significant effects of aerosols on convective clouds and provided insights into the underlying processes and drivers.

To examine these interactions with the climate model ICON, we developed the simple aerosol model HAMlite based on and fully traceable to the complex aerosol model HAM. HAMlite represents aerosols as an ensemble of log-normal modes. To reduce the computational and physical complexity, aerosol microphysics are discarded and aerosol sizes and compositions are prescribed. The selection of modes is flexible and can include the Aitken, accumulation, and coarse modes. The calculation of aerosol properties and thermodynamics remains fully consistent with HAM. HAMlite is linked to the atmospheric processes of ICON. Aerosols are transported as tracers in the dynamical core and coupled to the radiation, turbulence, and cloud microphysics schemes.

We present first results from global simulations with ICON-HAMlite. The atmosphere is governed by non-hydrostatic conservation equations, the land is represented with the dynamic vegetation model JSBACH, and the sea surface temperature and sea ice are prescribed with the AMIP database. The horizontal resolution is about 5 km and time period is about 40 days. First, we evaluate the global distributions of the different aerosol modes. And second, we investigate how aerosols influence the diurnal cycle and deep convection in the tropics. In contrast to regional simulations, global simulations include the large-scale circulation and in particular the budgetary constraints on precipitation due to the conservation of water and energy.