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How does natural variability in clouds and circulation affect the anthropogenic aerosol radiative forcing?

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Clouds and circulation are thought to be key uncertainties in our understanding of the Earth climate system. Comprehensive Earth system models further suggest that anthropogenic aerosol radiative forcing is uncertain limiting our ability to quantify the total radiative forcing and climate sensitivity. In this presentation we see how clouds and anthropogenic aerosol radiative forcing are linked. In particular, we investigate the role of natural atmospheric variability, global patterns of aerosol radiative effects, and magnitudes of aerosol-cloud interaction in controlling the anthropogenic aerosol radiative forcing (Fiedler et al., in press). To do so, we conduct ensemble simulations with the atmosphere-only configuration of the Earth system model MPI-ESM1.2 and calculate the effective shortwave radiative forcing of anthropogenic aerosol at the top of the atmosphere. The radiative effects are induced by anthropogenic aerosol optical properties and an associated Twomey effect that are constrained by observations and prescribed with the new parameterisation MACv2-SP (Stevens et al., 2017). In a first step, we prescribe the global patterns of aerosol radiative effects from the mid-1970s and today. Our results highlight that such a substantial pattern difference has a negligible impact on the global mean forcing, when the natural variability of the atmosphere is considered. The simulated clouds herein efficiently mask the clear-sky contributions to the forcing and reduce the detectability of significant anthropogenic aerosol radiative effects in all-sky conditions. As second step, we strengthen the forcing magnitude through increasing the effect of aerosol-cloud interaction by prescribing enhanced Twomey effects. In that case, the different spatial pattern of aerosol radiative effects from the 1970s and today causes a moderate change (15%) in the anthropogenic aerosol radiative forcing in our model. The findings let us speculate that models with strong aerosol-cloud interactions show stronger forcing changes with anthropogenic aerosol patterns. Moreover, differences in anthropogenic aerosol forcing might arise alone due to macroscopic differences in simulated clouds, even when we prescribe the same aerosol radiative effects. Testing whether the anthropogenic aerosol radiative forcing is model-dependent under prescribed aerosol is currently ongoing work using MACv2-SP in comprehensive aerosol-climate models in the framework of the EU-funded project BACCHUS. In the future, more CMIP6 models will use MACv2-SP for prescribing aerosol effects for participating in the Radiative Forcing Model Intercomparison Project (Pincus et al., 2016).

References:

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