

Project title: Aerosol-climate modelling with ICON-HAM for CleanCloud

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Project overview

Aerosol forcing and aerosol cloud interaction represent still the largest uncertainty in past, present and future radiative forcing according to the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report (AR6)). Improving knowledge on aerosol forcing and aerosol-cloud interactions is crucial to reduce uncertainties in short- and long-term climate projections. The EU-funded Horizon Europe project CleanCloud (Clouds and climate transitioning to post-fossil aerosol regime, <https://projects.au.dk/cleancloud>) aims to quantify and understand regional and temporal effects of aerosol and aerosol-cloud-related processes, and how they will evolve in the transition to atmospheric conditions when fossil emissions will have been stopped, the so-called post-fossil regime. Reductions of anthropogenic pollutants in the atmosphere will not mean a return to the preindustrial state, instead, due to climate feedbacks and changes in land use, a new aerosol regime is expected to develop. Within CleanCloud, uncertainties in climate models through a better representation of aerosol and aerosol cloud processes should be achieved, leading to better short and long-term climate projections. The planned simulations that are part of the CleanCloud project, aims to use AMIP-style simulations with the ICON-HAM model to characterize the distribution of natural aerosol types, such as mineral dust, marine aerosols (including primary organics) and smoke from biomass burning, as well as their radiative effects. As anthropogenic emissions decrease and air quality improves, the role of these natural aerosols in assessments of the effects of aerosol mixtures will become increasingly important. Additionally, as the emissions of these aerosol types depend on climate conditions, their atmospheric distribution and thus their effects are likely to change in a post-fossil environment. Simulations will include anthropogenic emissions for different time periods with different anthropogenic aerosol emission patterns. They will include pre-industrial conditions, present day conditions with India and East Asia as strongest emitters of anthropogenic aerosol and the 1980s when anthropogenic aerosol loads in Europe were at their maximum. Model simulations will be performed using the icosahedral non-hydrostatic global atmosphere model ICON (Giorgetta et al., 2018) coupled with the Hamburg Aerosol Module (HAM v2.3) (Zhang et al., 2012; Tegen et al., 2019, Salzmann et al., 2022) to simulate the life cycle and climate effects of aerosols from natural (dust, sea salt) and anthropogenic (sulfates, black carbon) sources. The simulations will focus on the variability and changes in the natural aerosols, in particular with respect to their interaction with radiation and clouds. The magnitude of feedbacks of aerosol forcing on emission and aerosol loads of the aerosol species will be tested by simulations in which the aerosol is transported but does not interact with radiation.