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Urban heat island and aerosol-cloud interactions in the Rhine-Main area

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The excessive warming of impervious surfaces and additional release of anthropogenic heat promotes urban heat island (UHI) formation. Human activities lead to an increase of emissions of air pollutants which in turn influences the chemical composition of urban air. Anthropogenic aerosols either produced locally or transported from remote areas are linked to the modulation of the regional hydrological cycle.
This study investigates the combined effects of the thermodynamic nature of the urban boundary layer and aerosol loading on rainfall and cloud cover in the Rhine-Main urban area. After the Ruhr and the Berlin metropolitan area, the Rhine-Main area is the third largest urban agglomeration in Germany, with a total population exceeding 5.8 million. Being a highly industrialized region, urban emissions play an important role for regional air quality here.
For analyzing the link between UHI and aerosol transport and chemistry in and around clouds, we use the global chemistry climate model EMAC and its regional nested version MECO(n), which are based on the ECHAM (global) and the COSMO (regional) models. Regional nesting into a global chemical transport model allows for both the representation of synoptic meteorology and regional thermodynamic properties of the urban boundary layer.
Our model results show, that urban originated aerosols can act as cloud condensation nuclei, triggering cloud formation and remote precipitation events. The sign and magnitude of precipitation and cloud cover varies significantly for different aerosol concentrations and emission scenarios and is dependent upon regional meteorological patterns.
In the framework of current discussions on air pollution regulations in German cities we design dedicated case studies where we artificially increase or decrease local pollution levels and analyze the expected effects on meteorology, locally and remote. Observations from local measurement stations and satellite data is used to evaluate our model results.