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European climate during the last decades - Atmospheric response to constant and transient aerosol forcing

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As summarized in the 5th Assessment Report of the IPCC, the effects of aerosols on the Earth's energy budget are one of the largest uncertainties in a changing climate. Despite a better understanding of aerosol processes since the previous report, still, it remains unclear to which degree of complexity these processes need to be represented within a climate model to consider their effects in a sufficient manner.
Within the regional climate modelling community it is common practice to use timely constant aerosol climatologies to simulate the direct effect of aerosols on radiative processes. Apart from a low spatial resolution, these climatologies do not capture the increase of European aerosol concentrations until the 1980th and the subsequent decrease due to political regulations concerning air quality.
In this study the aim is to investigate the general atmospheric response to aerosol forcing. It is also a main focus to explore whether a decrease in anthropogenic aerosol load in Europe during the last decades enhances the greenhouse gas induced near surface warming. Therefore different fixed aerosol distributions and the transient MAC-v2 aerosol climatology provided by the MPI-M were used to perform long-term simulations with the Regional Climate Model COSMO-CLM covering the 60 years period 1950 – 2010.
The results indicate a near surface cooling which is strongly linked to Aerosol Optical Depth, and a broad mid-troposphere warming for all simulations in comparison to the control simulation without aerosols. A decrease in precipitation is mainly caused by stabilization of stratification and by less evapotranspiration resulting from surface cooling. We also detected weak impacts on circulation patterns especially during high-pressure situations. Altogether the largest impact of direct and semi-direct aerosol effects was found in summer season.
Decadal temperature trends and their connection to tropospheric aerosol load are still under investigation.