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Aerosol as a player in the Arctic Amplification – an aerosol-climate model evaluation study

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Climate warming is much more pronounced in the Arctic than in any other region on Earth – a phenomenon referred to as the “Arctic Amplification”. This is closely related to a variety of specific feedback mechanisms, which relative importance, however, is not yet sufficiently understood. The local changes in the Arctic climate are far-reaching and affect for example the general atmospheric circulation and global energy transport. Aerosol particles from long-range transport and local sources play an important role in the Arctic system by modulating the energy balance (directly by interaction with solar and thermal infrared radiation and indirectly by changing cloud properties and atmospheric dynamics). The main source regions of anthropogenic aerosol are Europe and East Asia, but also local shipping and oil/gas extraction may contribute significantly. In addition, important sources are widespread, mainly natural boreal forest fires. Most of the European aerosol is transported through the lower atmospheric layers in wintertime. The Asian aerosol is transported through higher altitudes. Because of the usually pristine conditions in the Arctic even small absolute changes in aerosol concentration can have large impacts on the Arctic climate.

Using global and Arctic-focused model simulations, we aim at investigating the sources and transport pathways of natural and anthropogenic aerosol to the Arctic region, as well as their impact on radiation and clouds. Here, we present first results from an aerosol-climate model evaluation study. Simulations were performed with the global aerosol-climate model ECHAM6-HAM2, using three different state-of-the-art emission inventories (ACCMIP, ACCMIP + GFAS emissions for wildfires and ECLIPSE). The runs were performed in nudged mode at T63 horizontal resolution (approximately 1.8°) with 47 vertical levels for the 10-year period 2006-2015.

Black carbon (BC) and sulphate (SO4) are of particular interest. BC is highly absorbing in the solar spectrum, an effect that is enhanced by the contrast between the bright snow/ice surfaces and the dark BC. When deposited on snow and ice, BC also accelerates melting and lowers the surface albedo. SO4 however is more scattering and, therefore, cooling.

The model results are compared among each other and evaluated against ground-based in-situ and remote sensing, as well as active satellite observations. The following questions are addressed in the evaluation: 1) Are the sources and transport pathways of aerosol to the Arctic region captured? 2) Is the annual cycle of aerosol conditions reproduced? 3) What are uncertainties related to the emission database?

After thorough evaluation, the model results will provide a state-of-the-art estimate of the aerosol budget and the effective radiative forcing by anthropogenic aerosols in the Arctic region.