Abstract

Aerosols play a major role in the Earth's climate system by influencing light propagation in the atmosphere. Unlike well-mixed greenhouse gases, that induce warming of the Earth's climate system, aerosols indicate its cooling in the first approximation. In turn, particle mixture containing absorbing aerosols may induce radiative warming when they exist over bright surfaces. Complicated mechanisms underlying aerosol interactions with components of the Earth's climate system lead to the propagation of high uncertainties in estimating radiative forcing. Studying underlying systematic error levels in radiative forcing is crucial in environments sensitive to climate change (e.g. in the polar regions). Therefore aerosols are a subject to many studies in the field of atmospheric research.

This doctoral dissertation aims to characterise aerosol optical, micro-physical and radiative properties governing the European Arctic region in spring focusing mainly on their long-term variability (in a temporal and vertical sense) and statistical relationships. Research conducted here was based on data from 4 field experiments carried out in the European Arctic, namely Ny-Alesund (78.9° N, 11.9° E), Svalbard in spring 2014 - 2017. Field campaigns provided a unique set of ground-based data as well as profiles of aerosol optical and microphysical properties. Analyses were complemented by similar in-situ surface measurements obtained from monitoring stations in the High Arctic as well as data-sets provided from the reanalysis of global transport models. Further to this, a theoretical study concerning the impact of aerosol optical and microphysical properties on local radiative balance is being investigated using radiative transfer simulations.

Analyses performed in this dissertation revealed weak vertical variability in aerosol optical and microphysical properties (absorption coefficient and total particle number concentration) within the Arctic boundary layer and above it. This likely indicates a lack of strong local aerosol sources and relates to the fact that most aerosol in the Arctic is long-range transported, preferentially in the free troposphere, from mid-latitudes. In the last decade, main trajectories of air advection into the Arctic as well as the efficiency of far aerosol sources seem to undergo noticeable changes,

likely as a result of modifications in atmospheric circulation patterns, economical transformations as well as climate change. Presented conclusions are in line with performed analysis on temporal variability in aerosol extensive properties, that have shown a statistically-significant negative trend in aerosol optical depth in spring, i.e. $-0.02 \pm 0.01\ 10yr^{-1}$ and a positive one in summer of $0.02 \pm 0.01\ 10yr^{-1}$.

Research concerning theoretical studies on the impact of aerosol on radiative transfer in the Arctic atmospheric column has indicated that aerosol mixture present during iAREA campaigns on average had a cooling effect on the local radiative balance of the atmosphere. Radiative forcing calculated at the top of the atmosphere was negative, reaching -1.5 ± 1.3 W m^{-2} over surfaces covered with snow, whereas its value over the ocean surface was as high as -8.9 ± 4.8 W m^{-2}. Aerosol having primarily cooling radiative effect even over bright surfaces relates to the high efficiency of ageing processes, active during particle long-range transport, which causes a significant decline in aerosol light-absorption ability.