Arctic Aerosols:Behavior,Radiative Forcing,and Linkage with Global Warming

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[Abstract]

Key Words: Global Warming, Environmental Change, Arctic, Aerosol, Black Carbon, Cloud, Ice-Core, Climate-Model, Assessment Report

In this project, black carbon (BC) particles, one of the Short-Lived Climate Forcers (SLCFs), have been intensively studied in the Arctic. We used COSMOS, a high-accuracy instrument developed in Japan, to measure BC concentrations in the atmosphere at four Arctic or high-latitude sites. At these sites, BC measurements have also been made using other BC instruments by other groups. We made detailed comparisons between COSMOS and these other measurements and developed a method to convert their values to COSMOS-scaled BC mass concentrations. We then constructed a unified dataset to study spatial and temporal variation of BC in the Arctic. In addition to these ground-based measurements, we also analyzed vertical profile of BC obtained during PAMARCMiP2018 aircraft experiment to study a year-to-year variation of BC in the Arctic. We also measured BC mass concentration in precipitation (rain and snow) and estimated wet deposition flux. We validated and refined our global models (CAM-ATRAS, Nagoya University, and MRI-ESM2.0, Meteorological Research Institute, Japan) by comparing them to various observations. Using these models, we reveal that the source contribution of each region, such as Asia, to the BC mass concentrations and radiative effects in the Arctic differs significantly. Effective radiation forcing of BC at the top of atmosphere was found to be the second highest after CO2.

In addition to BC, we studied other aerosols and their possible impacts on radiation and clouds in the Arctic. We developed a technique (Complex Amplitude Sensing, CAS, technique) that can simultaneously quantify the chemical species (complex refractive index) and particle size of solid aerosols, which are considered important as ice nucleating particles (INP). Various standard solid particles (mineral dust, biological particles, etc.) were examined and we confirmed that these particles can be successfully measured. We also sampled atmospheric aerosols and cloud residuals at Ny-Alesund in the Arctic and analyzed them using various techniques, such as electron microscopes. We successfully reveal a seasonal variation in INP concentration, differences in chemical composition between aerosols and cloud-residuals, and functional groups of organic aerosols.

Finally, by analyzing an ice core from Greenland, we obtained BC and mineral dust data with high accuracy and high time resolution covering the last 350 years. Chemical composition of

mineral dust varied on a multidecadal scale over the past hundred years. Various emission inventories were examined by comparing numerical model calculations with these ice core data.

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