Continuous flow analysis of iron oxide in a Greenland ice core using a modified single-particle soot photometer

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Dark colored aerosols such as black carbon (BC) and iron oxide (FeO_x) absorb solar radiation and reduce snow albedo, thereby influence Earth's radiation budget and hence climate (Moteki et al., 2017). To understand their effects on climate using numerical models, observational data are needed to constrain their sources, emission inventories, transport, and deposition processes. Long-term data are useful, but are still sparse, especially in the Arctic, an important region on Earth where climate and environment have been changing drastically. Arctic ice cores can provide long-term records of these aerosols. BC records have been reported from several Arctic ice cores. We have previously reported temporal variability in BC over the past 350 years obtained from an ice core drilled at the SIGMA-D site, Northwest Greenland, (Matoba et al., 2015) using a Continuous Flow Analysis (CFA) system. However, there has been no long-term record of FeO_x in the Arctic. Here we present the first ice-core record of FeO_x obtained from the SIGMA-D core.

We analyzed the SIGMA-D core for the depths between 6 and 113 m using a CFA system developed at NIPR. The NIPR CFA system allowed high resolution analysis of FeO_x together with stable isotopes of water, BC, microparticles, electric conductivity, and six elements (Na, K, Mg, Ca, Fe, and Al) for the past 350 years. The top 6 m of the core was cut at ca 5cm intervals, melted, and analyzed for the same chemical species as those analyzed with the CFA system. For FeO_x analysis, we used a modified single-particle soot photometer (SP2, Droplet Measurement Technologies) recently developed at University of Tokyo (Yoshida et al., 2016). A modified SP2 detects laser-induced incandescence in two wavelength bands. The signal ratio (colar ratio) of the two bands is an indicator of the blackbody temperature of incandescent particles; thus, we can use it to separate FeO_x from BC. However, there is usually an overlap in the signal, which leads to ambiguity in separation of FeO_x and BC. Before we calculated FeO_x concentrations, we evaluated the ambiguity using two different separation curves in scatterplots of the peak incandescence signal in the two wavelength bands and the color ratio of the aerosol particles. The two separation curves gave significant difference in number concentrations of FeO_x; one gave only 30 % of the other. On the other hand, the difference in mass concentrations was only 10%. Therefore, we use only mass concentrations to discuss temporal changes in FeO_x concentrations.

Mass concentrations of FeO_x were elevated during mid-17th century, the first half of 18th century, the first half of 19th century, and the first half of the 20th century. This temporal trend is different from that of BC concentrations. The elevated concentrations observed during the first half of the 19th century were also observed for elements originated from mineral dust, which suggests that a major source of FeO_x is natural mineral dust. During the first half of 20th century, BC concentrations were elevated due to influx of anthropogenic BC. Part of FeO_x during this period could have been originated from anthropogenic sources.

References

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