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Controlling factors of aerosol size distribution over East Asia

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Aerosol is known for its direct and indirect effects on climate, with both effects having a larger uncertainty than other radiative forcing elements, such as carbon dioxide. Investigating ambient aerosol size distributions is an important factor in estimating radiative forcing effects, as aerosol size is a major contributing factor to both the aerosol direct and indirect effects.

Ambient aerosol size and spatial distributions are controlled by various processes; e.g. new particle formation, coagulation, transportation, and wet deposition. For this reason, in situ measurements and analyses based on such processes are essential. However, results from measurements with high time resolution and low detection limits (e.g. of aerosol diameter) are rare. In this research, we introduce measurements of the aerosol size distribution over East Asia using the ultra high sensitivity aerosol spectrometer (UHSAS), and have tried to analyze the results based on wet removal processes.

The UHSAS is an optical particle counter. With its 2 types of photon diode and its efficiency in collecting scattering light, the UHSAS can obtain measurements of aerosol diameter in a wide range (about 70 to 1500 nm). We improved the hardware and software of the UHSAS specifically for use in aircraft measurements, to improve time resolution data and the instrumental precision of measurements of aerosol number concentration and size distribution (assuming spherical particles with refractive index 1.52). In addition, we have installed a robust mass-flow controlling system to deal with the significant changes in pressure associated with aircraft measurements. Scattering light signals obtained from photon diodes are saved to an external storage medium, which aids us in distinguishing signal from noise. We also present results showing the successful estimation of the optics inside UHSAS, in order to obtain highly precise diameter information using known standard particles.

The aerosol radiative forcing in East Asia (A-Force 2013W) aircraft campaign was conducted from late February to early March. We obtained air samples in real time from a forward facing inlet outside of the aircraft, Air was sampled by a variety of instruments including the UHSAS in real-time from a forward facing inlet outside of the aircraft. Data from the UHSAS showed good consistency with other instruments. During the campaign, the mean size distribution shifted to smaller diameters with increasing altitude. The transport efficiency (TE) of BC, which describes the degree of the wet removal of BC (calculated from the carbon monoxide mixing ratio and BC mass concentration), also decreased with increasing altitude (i.e. strong wet removal tendency for higher altitude). As the TE became smaller, the mean size distribution also shifted to smaller diameters, independent of altitude. This shows that the TE is the dominant factor controlling the aerosol size distribution, rather than absolute altitude. When the TE is smaller, the size distribution shifted to smaller diameters; this is the first observation of the size-dependent wet removal of general aerosols based on Köhler theory. This dynamic state of aerosol size distribution observed by the UHSAS surely contributes to quantitative understanding of aerosol direct and indirect effects on climate.

Keywords: aerosol, size distribution, wet removal process, black carbon, transport efficiency, UHSAS