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Small particles big effect? - Investigating ice nucleation abilities of soot particles

Fabian Mahrt (1), Robert O. David (1), Ulrike Lohmann (1), Chris Stopford (2), Zhijun Wu (3), and Zamin A. Kanji (1)

(1) Institute for Atmospheric and Climate Science, ETH, Zurich, Switzerland (fabian.mahrt@env.ethz.ch), (2) Centre for Atmospheric and Instrumentation Research, University of Hertfordshire, Hatfield, Hertfordshire United Kingdom, (3) Peking University, Beijing, China

Atmospheric soot particles are primary particles produced by incomplete combustion of biomass and/or fossil fuels. Thus soot mainly originates from anthropogenic emissions, stemming from combustion related processes in transport vehicles, industrial and residential uses. Such soot particles are generally complex mixtures of black carbon (BC) and organic matter (OM) (Bond et al., 2013; Petzold et al., 2013), depending on the sources and the interaction of the primary particles with other atmospheric matter and/or gases
BC absorbs solar radiation having a warming effect on global climate. It can also act as a heterogeneous ice nucleating particle (INP) and thus impact cloud-radiation interactions, potentially cooling the climate (Lohmann, 2002). Previous studies, however, have shown conflicting results concerning the ice nucleation ability of soot, limiting the ability to predict its effects on Earth's radiation budget.
Here we present a laboratory study where we systematically investigate the ice nucleation behavior of different soot particles. Commercial soot samples are used, including an amorphous, industrial carbon frequently used in coatings and coloring (FW 200, Orion Engineered Carbons) and a fullerene soot (572497 ALDRICH), e.g. used as catalyst. In addition, we use soot generated from a propane flame Combustion Aerosol Standard Generator (miniCAST, JING AG), as a proxy for atmospheric soot particles. The ice nucleation ability of these soot types is tested on size-selected particles for a wide temperature range from 253 K to 218 K, using the Horizontal Ice Nucleation Chamber (HINC), a Continuous Flow Diffusion Chamber (CFDC) (Kanji and Abbatt, 2009). Ice nucleation results from these soot surrogates will be compared to chemically more complex real world samples, collected on filters. Filters will be collected during the 2016/2017 winter haze periods in Beijing, China and represent atmospheric soot particles with sources from both industrial and residential emissions. Collected particles will be re-suspended and aerosolized using an atomizer (TSI, model 3076) and dried by a diffusion drier prior to ice nucleation experiments.
A Particle Phase Discriminator (PPD) coupled to HINC will allow discrimination of size-resolved liquid and ice hydrometeors formed on the atmospheric soot particles injected into the CFDC. This will allow to more precisely quantify the microphysical properties of these particles in cloud processes for the conditions tested. To our knowledge this is the first time such a coupling is done for atmospheric soot particles.
Results show different activation behavior of the soot over the temperature range investigated. While CAST-brown soot needs conditions above water saturation to show any freezing, some of the commercial soot samples show heterogeneous ice nucleation well below water saturation for the cirrus conditions. For the mixed-phase cloud conditions all soot types show droplet activation for high water supersaturation.