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Immersion freezing induced by different kinds of coal fly ash: Comparing particle generation methods and measurement techniques

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To date, a lot of effort has been put into the identification and characterization of atmospheric ice nucleating particles (INPs), which may influence both weather and climate. The majority of studies focuses on INPs from natural origin such as biological particles or mineral dust particles (Hoose and Möhler 2012, Murray et al. 2012). Combustion ashes, being possible sources of anthropogenic INPs, have rarely been investigated in the past.
Ash particles may be emitted into the atmosphere either by the action of wind from ash deposits on the ground (bottom ash), or during the combustion process (fly ash). Two recent studies (Umo et al., 2015; Grawe et al., 2016) identified fly ash from coal combustion as the most efficient of the investigated samples (including also bottom ashes from wood and coal combustion). These results motivate the here presented study in which we investigated the immersion freezing behavior of four coal fly ash samples taken from the filters of different coal-fired power plants in Germany.
A combination of two instruments was used to capture the temperature range from 0 °C to the homogeneous freezing limit at around -38 °C. Firstly, the new Leipzig Ice Nucleation Array (LINA) was used, where droplets from an ash-water suspension are pipetted onto a cooled plate. Secondly, we used the Leipzig Aerosol Cloud Interaction Simulator (LACIS; Hartmann et al., 2011), a laminar flow tube in which every droplet contains a single size-segregated ash particle. Here, it was possible to study the effect of different kinds of particle generation, i.e. atomization of an ash-water suspension, and aerosolization of dry ash material. The composition of the ash particles was investigated by means of single particle aerosol mass spectrometry and particles were sampled on filters for environmental scanning electron microscope analysis.
Our measurements show that all four fly ash samples feature a similar immersion freezing behavior (ice fractions vary by a factor of 5 at most) when particles are generated via dry dispersion. Furthermore, we found that the ice nucleation ability of all samples is lowered significantly when changing from dry to wet particle generation. The aim of the study is to identify possible reasons for these observations.

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