Name of research institute or organization:

Laboratory of Atmospheric Chemistry, Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland

Title of project:

Ice residual characterization during the Cloud and Aerosol Characterization Experiment (CLACE)

Part of this programme:

GAW+

Project leader and team:

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Project description:

Aerosols influence the atmospheric energy budget directly through aerosol radiation interactions (ARI) and indirectly through aerosol cloud interactions (ACI). Direct radiative effects include the scattering and absorption of solar radiation and the subsequent influence on planetary albedo and the climate system. Indirect effects involve the influence of the aerosol on cloud properties, cloud lifetime and cloud cover through acting as cloud condensation nuclei (CCN) and ice nuclei (IN). Anthropogenic changes of the atmospheric aerosol loadings are expected to cause an overall negative climate forcing partially offsetting the positive forcing by greenhouse gases. However, the aerosol effects are still poorly quantified due to the inhomogeneity of global aerosol loadings and chemical composition as well as the complexity of involved interactions and feedbacks.

High uncertainties in future climate predictions arise from insufficient knowledge of the interaction of clouds with visible (solar) and infrared (terrestrial) radiation. The optical properties and lifetime of clouds are strongly influenced by the ability of atmospheric aerosol particles to act as cloud condensation nuclei (CCN) or ice nuclei (IN). Previous research has found that the cloud radiative properties strongly depend on the cloud ice mass fraction, which is influenced by the abundance of IN. Increased IN concentrations are also thought to enhance precipitation, thus causing a decrease in cloud lifetime and cloud cover, resulting in a warming of the atmosphere. Central questions in this context are:

- Which aerosol particles act as IN in our atmosphere?
- By which detailed mechanisms do atmospheric aerosols contribute to the formation of ice?

Ice residual characterization with the Ice-CVI

To approach these questions, a wealth of data was accumulated during the Cloud and Aerosol Characterization Experiment's (CLACE) 2013 and 2014 instalments. Here, we want to highlight results from the Ice-CVI, an inlet system that uses a series of components to remove snow crystal aggregates, liquid droplets and interstitial (not activated) particles from the sample, leaving only small ice crystals with aerodynamic diameters between 5 and 20 µm. These particles are dried such that only the ice residuals (IR) remain which can then be characterized by a multitude of instruments. By comparing the characteristics of IR to the features of the total aerosol, one can then infer which aerosol traits favour or suppress heterogeneous ice formation.

As one would expect, the ice activated fraction increases with particle size. This finding is well in line with previous observations. More surprisingly, however, the data indicate that most active ice nuclei are smaller than 1 µm in diameter. A significant number of IR is even smaller than 500 nm which challenges the classical DeMott parameterisation that determines the number of ice nuclei based on the concentration of particles larger than 500 nm diameter. Furthermore, observations from CLACE 2013 indicate that the ice-activated fraction of black carbon (BC) containing particles is smaller than the fraction of BC-free particles of the same size (Figure 1). BC in particles thus does not favour heterogeneous ice formation and, ultimately, precipitation.

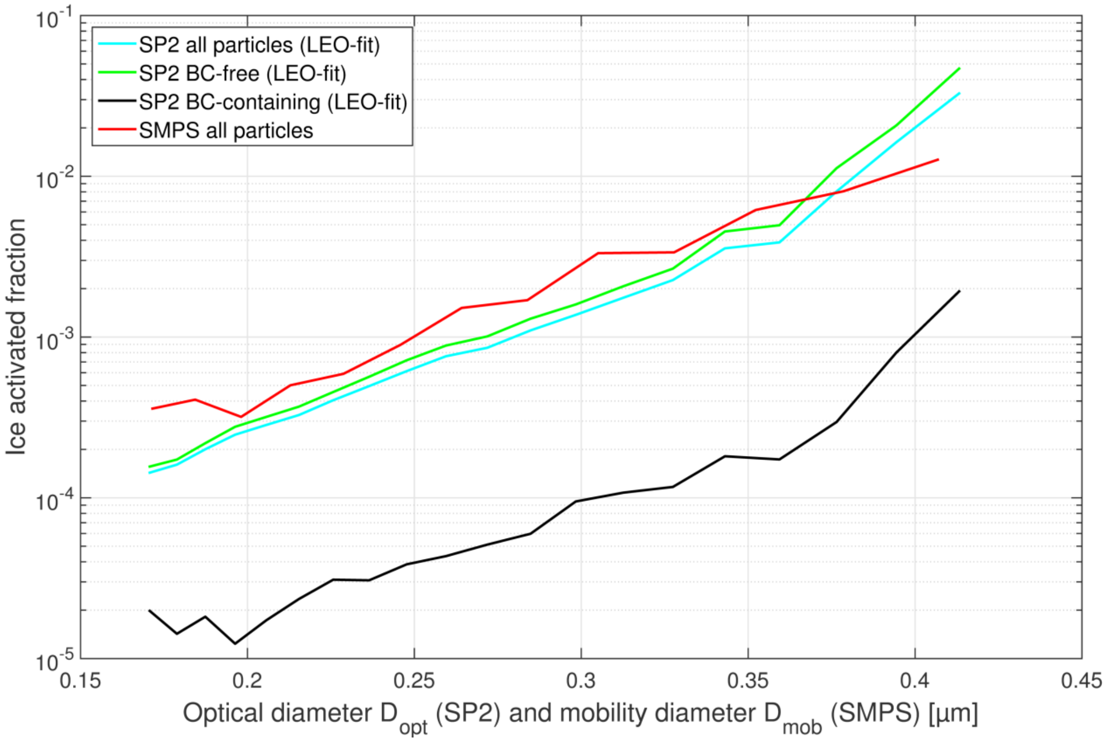

Figure 1. Ice-activated fraction for particles with and without black carbon.

Key words:

Atmospheric aerosol particles, aerosol climatic effects, radiative forcing, ice residual particles, heterogeneous ice nucleation

Internet data bases:

http://www.psi.ch/lac
http://www.psi.ch/lac/gaw-monitoring-nrt-data
http://sites.google.com/site/jfjnrt/
http://www.meteoschweiz.admin.ch/web/en/meteoswiss/international_affairs/GAW.html
http://ebas.nilu.no/
http://www.actris.net/

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Scientific publications and public outreach 2015:

Refereed journal articles and their internet access

Boose et al., Three-year ice nucleating particle climatology in the free troposphere during winter, 2015. *submitted*

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Theses

Kupiszewski, P., Design and application of a novel ice selective inlet and physical and chemical characterization of ice residuals in mixed-phase clouds, PhD Thesis, ETH Zürich, 2015.

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