Name of research institute or organization:

Institut für Angewandte Geowissenschaften, Technische Universität Darmstadt

Title of project:

Single-particle composition of ice nuclei and ice residuals: comparison of different measurement techniques – part of the Ice Nuclei Research Unit (INUIT)

Project leader and team:

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Project description:

A large field campaign from the Ice Nuclei Research Unit (INUIT) was performed in January and February of 2013 at the High Alpine Research Station Jungfraujoch for the assessment of microphysical and chemical properties of free-tropospheric ice-nucleating particles. The ice-nucleating particles were discriminated from the total aerosol with the 'Fast ice nucleation chamber' (FINCH; University Frankfurt) and the 'Ice-selective inlet' (ISI; Paul Scherrer Institute) followed by a pumped counter-stream virtual impactor. The separated ice-nucleating particles were then collected with a nozzle-type impactor on pure boron and transmission electron microscopy (TEM) grids. With the 'Frankfurt ice nuclei deposition freezing experiment' (FRIDGE; University Frankfurt), aerosol particles are sampled on a silicon wafer, which then is exposed to ice-activating conditions in a static diffusion chamber. The locations of the growing ice crystals are recorded for later analysis. Finally, with the ice counter-stream virtual impactor (ICE-CVI; Tropos Leipzig) atmospheric ice crystals are separated from the total aerosol and their water content is evaporated to retain the ice residual particles, which are then collected also by nozzle-type impactors on boron and TEM grids.

All the collected samples were analyzed in a high-resolution scanning electron microscope at the Institute for Applied Geosciences in Darmstadt. By this method, for each particle its size, shape/morphology and chemical (elemental) composition is obtained. A total of 16 FINCH, 20 FRIDGE, 20 ICE-CVI and 4 ISI samples were successfully collected, of which about half – containing approximately 1700 ice nucleating particles – could be analyzed in 2013. According to their chemical signature, the particles were classified into seven groups (silicates, metal oxides, Ca-rich particles, (aged) sea-salt, soot, sulphates and carbonaceous matter). Though this is under discussion, the soluble salts are considered as artifacts and are not regarded as ice nuclei here, as of current knowledge there is no mechanism producing ice effectively from these particles; however, soluble salts are reported in ice residuals also from other groups at other locations.

The most frequent ice nucleating particles/ice residuals at the Jungfraujoch station are silicates > carbonaceous particles > metal oxides (Fig. 1). Calcium-rich particles and soot play a minor role. Similar results are obtained by quasi-parallel measurements with an online single particle laser ablation mass spectrometer (ALABAMA; Max Planck Institute Mainz). All the tested techniques for measuring ice nucleating particles perform similar from a chemical point of view within the range of their uncertainties and low counting statistics due to the low particle concentrations in free-tropospheric air. Thus, for the first time most of the existing ice nucleation measurement techniques could be compared side by side under real-world atmospheric conditions. Further evaluation of the data is now expected to result in a decrease of the uncertainties by addressing and correcting technique-immanent problems.

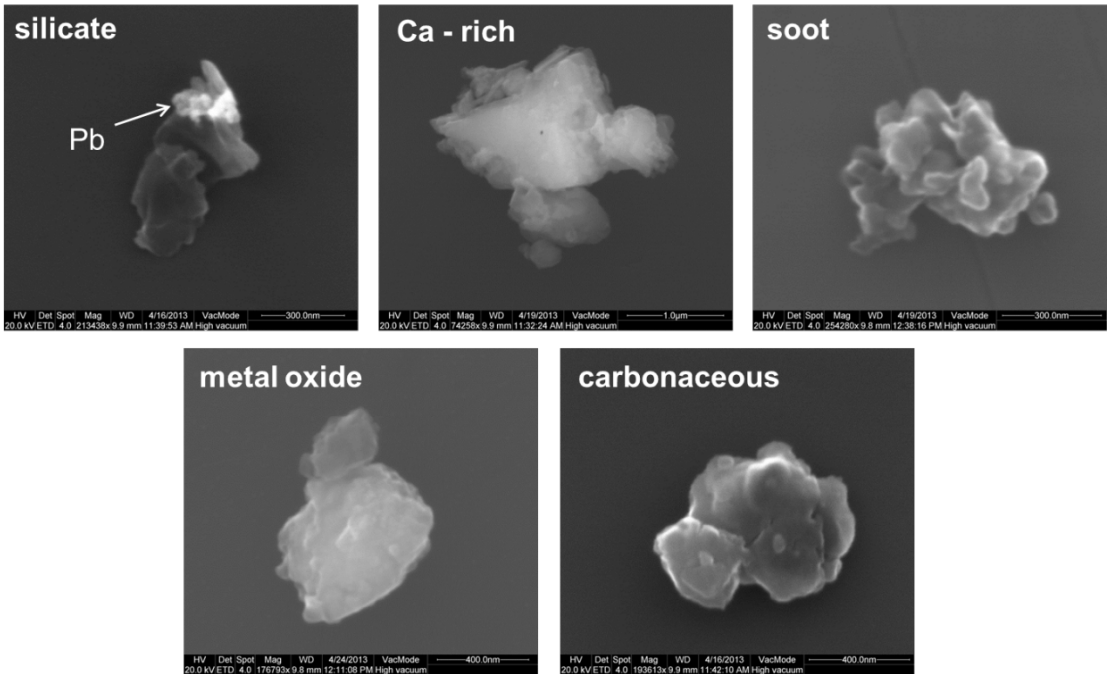

Figure 1. Examples for the major compositional groups of ice-nucleating particles/ice residuals at the Jungfraujoch station during January/February 2013.

Key words:

Atmospheric aerosol, ice nuclei, scanning electron microscopy, chemical composition

Collaborating partners/networks:

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Institute for Tropospheric Research, Leipzig, Germany
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