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Chemical composition, mixing state, size and morphology of Ice nucleating particles at the Jungfraujoch research station, Switzerland

Martin Ebert (1), Annette Worringen (1), Konrad Kandler (1), Stephan Weinbruch (1), Ludwig Schenk (2), Stephan Mertes (2), Susan Schmidt (3), Johannes Schneider (3), Fabian Frank (4), Björn Nilius (4), Anja Danielczok (4), and Heinz Bingemer (4)

(1) Technical University Darmstadt, Applied Geosciences, Environmental Mineralogy, Darmstadt, Germany (mebert@geo.tu-darmstadt.de, ++49/ 6151 164021), (2) Leibniz-Institute for Tropospheric Research, Leipzig, (3) Max Planck Institute for Chemistry, Mainz, (4) 4) Frankfurt Institute for Atmospheric and Environmental Sciences Goethe-University Frankfurt am Main

An intense field campaign from the Ice Nuclei Research Unit (INUIT) was performed in January and February of 2013 at the High-Alpine Research Station Jungfraujoch (3580 m a.s.l., Switzerland). Main goal was the assessment of microphysical and chemical properties of free-tropospheric ice-nucelating 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 Scherer Institute) followed by a pumped counter-stream virtual impactor. The separated ice-nucleating particles were then collected with a nozzle-type impactor.
With the 'FRankfurt Ice nuclei Deposition freezinG Experiment' (FRIDGE), aerosol particles are sampled on a silicon wafer, which is than 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) 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 impactor sampling.
All samples were analyzed in a high-resolution scanning electron microscope. By this method, for each particle its size, morphology, mixing-state and chemical composition is obtained. In total approximately 1700 ice nucleating particles were analyzed.
Based on their chemical composition, the particles were classified into seven groups: silicates, metal oxides, Ca-rich particles, (aged) sea-salt, soot, sulphates and carbonaceous matter. Sea-salt is considered as artifact and is not regarded as ice nuclei here.
The most frequent ice nucleating particles/ice residuals at the Jungfraujoch station are silicates > carbonaceous particles > metal oxides. 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).
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.

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