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Physical and chemical properties of ice residuals during the 2013 and 2014 CLACE campaigns

Piotr Kupiszewski (1), Ernest Weingartner (1,2), Paul Vochezer (3), Emanuel Hammer (1), Martin Gysel (1), Raphael Färber (1), Claudia Fuchs (1), Martin Schnaiter (3), Urs Baltensperger (1), Susan Schmidt (4), Johannes Schneider (4), Alessandro Bigi (5), Emre Toprak (3), Claudia Linke (3), and Thomas Klimach (4)

(1) Laboratory of Atmospheric Chemistry, Paul Scherrer Institute, Villigen, Switzerland (piotr.kupiszewski@psi.ch), (2) School of Engineering, Institute of Aerosol and Sensor Technology, University of Applied Sciences Northwestern Switzerland, Windisch, Switzerland, (3) Institute for Meteorology and Climate Research, Karlsruhe Institute of Technology, Karlsruhe, Germany, (4) Particle Chemistry Department, Max Planck Institute for Chemistry, Mainz, Germany, (5) Department of Engineering "Enzo Ferrari", University of Modena and Reggio Emilia, Modena, Italy

The shortcomings in our understanding and, thus, representation of aerosol-cloud interactions are one of the major sources of uncertainty in climate model projections. Among the poorly understood processes is mixed-phase cloud formation via heterogeneous nucleation, and the subsequent spatial and temporal evolution of such clouds. Cloud glaciation augments precipitation formation, resulting in decreased cloud cover and lifetime, and affects cloud radiative properties. Meanwhile, the physical and chemical properties of atmospherically relevant ice nuclei (IN), the sub-population of aerosol particles which enable heterogeneous nucleation, are not well known. Extraction of ice residuals (IR) in mixed-phase clouds is a difficult task, requiring separation of the few small, freshly formed ice crystals (the IR within such crystals can be deemed representative of the original IN) not only from interstitial particles, but also from the numerous supercooled droplets which have aerodynamic diameters similar to those of the ice crystals.

In order to address the difficulties with ice crystal sampling and IR extraction in mixed-phase clouds, the new Ice Selective Inlet (ISI) has been designed and deployed at the Jungfraujoch field site. Small ice crystals are selectively sampled via the inlet with simultaneous counting, sizing and imaging of hydrometeors contained in the cloud by a set of optical particle spectrometers, namely Welas optical particle counters (OPC) and a Particle Phase Discriminator (PPD). The heart of the ISI is a droplet evaporation unit with ice-covered inner walls, resulting in removal of droplets using the Wegener-Bergeron-Findeisen process, while transmitting a relatively high fraction of small ice crystals.

The ISI was deployed in the winters of 2013 and 2014 at the high alpine Jungfraujoch site (3580 m.a.s.l) during the intensive CLACE field campaigns. The measurements focused on analysis of the physical and chemical characteristics of IR and the microphysical properties of mixed-phase clouds. A host of aerosol instrumentation was deployed downstream of the ISI, including a Grimm OPC and a scanning mobility particle sizer (SMPS) for number size distribution measurements, as well as a single particle mass spectrometer (ALABAMA; 2013 only), single particle soot photometers (SP2) and a Wideband Integrated Bioaerosol Sensor (WIBS-4) for analysis of the chemical composition, with particular focus on the content of black carbon (BC) and biological particles in IR. Corresponding instrumentation sampled through a total aerosol inlet. By comparing observations from the ISI with those from the total inlet the characteristics of ice residuals relative to the total aerosol could be established. First results from these analyses will be presented.