CLACE 2013: Cloud microphysics and physico-chemical characterization of ice residuals in mixed-phase clouds

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Much of the uncertainty in climate projections is due to an insufficient understanding of aerosol-cloud interactions. In particular, the formation of mixed-phase clouds via heterogeneous nucleation, their temporal and spatial evolution and the physico-chemical characteristics of ice nuclei (IN), the aerosol sub-population facilitating formation of ice crystals, is not well known. Meanwhile, cloud glaciation enhances precipitation formation, decreasing cloud cover and lifetime, and affects cloud radiative properties. Analysis of ice residuals (IR) in mixed-phase clouds is a difficult task: small, freshly formed ice crystals (where the IR contained within can be considered representative of the original IN) must be separated from super-cooled droplets with similar aerodynamic sizes, as well as the orders of magnitude more abundant interstitial particles.

A new Ice Selective Inlet (ISI) has been designed to extract small ice crystals from mixed-phase clouds, simultaneously counting, sizing and imaging the hydrometeors contained in the cloud with the use of Welas optical particle counters (OPC) and a Particle Phase Discriminator (PPD). The core of the ISI is an evaporation unit with ice-covered inner walls, removing droplets using the Wegener-Bergeron-Findeisen process, while transmitting a relatively high fraction of ice crystals (Fig. 1).

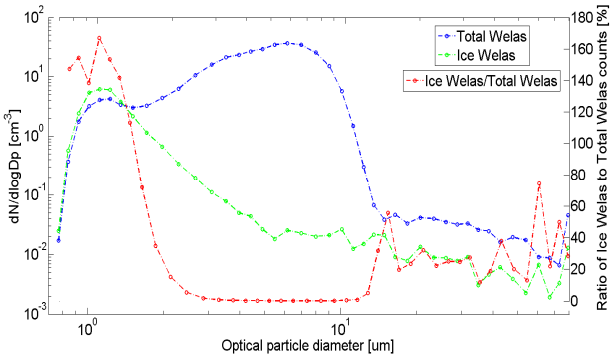

Figure 1. Particle and hydrometeor number size distributions measured by Welas OPCs upstream (blue) and downstream (green) of the droplet evaporation unit during a mixed-phase cloud event.

The ISI was deployed in winter 2013 at the high alpine Jungfraujoch site (3580 m.a.s.l) during the intensive CLACE 2013 field campaign. The measurements obtained shed light on both the microphysics of mixed-phase clouds and the physico-chemical characteristics of IR. Droplet and ice crystal size distributions measured with the optical spectrometers in the ISI are compared with those measured in situ by the Small Ice Detector (SID-3). A number of online instrumentation was deployed downstream of the inlet, including a scanning mobility particle sizer (SMPS) and a Grimm OPC for number size distribution measurements, as well as a single particle mass spectrometer (ALABAMA), single particle soot photometers (SP2) and a Waveband Integrated Bioaerosol Sensor (WIBS-4) for analysis of the chemical composition, with particular focus on the content of black carbon and biological particles in IR. Simultaneously, similar instruments were deployed downstream of a total inlet, which samples the bulk aerosol. A comparison of measurements from the total inlet and the ISI provides information on the characteristics of ice residuals relative to the total aerosol. First results show that the measured IR are generally larger than the bulk aerosol (Fig. 2).

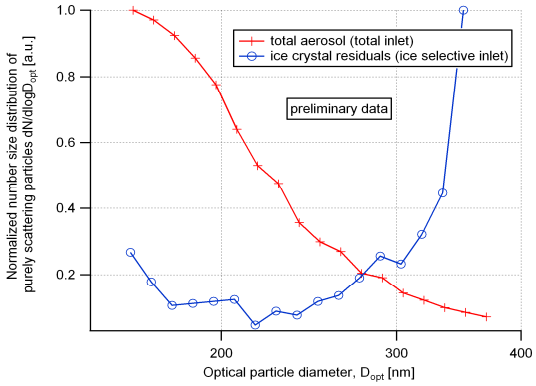

Figure 2. Normalized dry size distributions of the total aerosol (red) and ice residuals (blue)

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