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In-situ single particle composition analysis of free tropospheric ice nuclei and ice residues in mixed-phase clouds during INUIT-JFJ 2013

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In the framework of the DFG (deutsche Forschungsgemeinschaft)-funded research unit INUIT (Ice Nuclei research UnIT) a field campaign at the High Alpine Research Station Jungfraujoch (JFJ, Swiss Alps, Sphinx Laboratory, 3580 m asl; 7°59'2"E, 46°32'53"N) took place in January/February 2013 (INUIT-JFJ 2013). The goal of the measurements was to investigate the chemical composition of ice particle residues (IPR) in ambient air as well as the background aerosol particles. Previous investigations conducted at the JFJ showed that particles consisting of mineral components dominate the ice particle residue number (Kamphus et al., 2008) but also particles consisting of black carbon were found to be enriched in IPR (Mertes et al., 2007; Cozic et al., 2008). Cziczo et al. find out that lead as well is a good ice nucleus and was measured in IPR at previous measurements at the JFJ. During INUIT-JFJ 2013, the IPR were sampled out of mixed-phase clouds by an Ice-CVI (Ice Counterflow Virtual Impactor, Mertes et al., 2007) and an ISI (Ice Selective Inlet, Kupiszewski et al., 2013) and analyzed by the single particle mass spectrometer ALABAMA (Aircraft-based Laser Ablation Aerosol Mass Spectrometer; Brands et al., 2011). Additionally, the ALABAMA was connected to a total aerosol-inlet to investigate the chemical composition of background aerosol particles.
During 217 hours of background aerosol measurements we analyzed more than 27000 aerosol particles, which consisted mainly of pure organic components or organics mixed with ammonium, metals or mineral components. During six cloud events with approximately 63 h measurement time we detected 162 IPR sampled by the Ice-CVI. The main part of these IPR were also composed of organic material mixed with other chemical compounds. Additionally, we found particles which consisted of mineral components (approximately 23 %). Sampling mixed-phase cloud through the ISI we measured during four cloud events 34 ice residues in approximately 30 h measurement time. The main part of the chemical compounds of these IPR were also organic material mixed with metals or with mineral compounds. We also found a smaller part of particles which consisted of pure mineral components (about 48 %). Lead was also found in the IPR measured behind Ice-CVI (∼14 %) as well as in the background aerosol (∼0.04 %). Black carbon particles were only found in the background aerosol.
Because of the topography of the JFJ, air masses can reach the station only from the northwestern or southeastern direction (Hammer et al., 2013). Back trajectory calculations show that during our measurements the air masses were dominated mainly by long-distance transport from North America over Great Britain and France. This may explain the lower abundance of mineral dust in the ice residues compared to the previous studies.

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