Characterization of Atmospheric Ions at the High Alpine Station Jungfraujoch (Switzerland)

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Understanding the occurrence and composition of ions in the atmosphere is of high interest since ions regulate the electrical properties of the atmospheric medium, participate in ion-catalyzed and ion-molecule reactions and contribute to physico-chemical interactions, including ion-induced nucleation (Schulte and Arnold, 1990). In the last decade, the interest in atmospheric ions increased because of a potential implication of ion-aerosol-cloud interaction on climate (Hirsikko et al., 2011).

High altitude sites, often in the free troposphere, represent an interesting region with low condensational sink and low temperatures, conditions that could favor the process of new particle formation. Although some studies did investigate ions in the free troposphere and their link with nucleation (Boulon et al., 2010; Rose et al., 2015), these ion measurements were only in terms of total concentration but did not resolve the ion chemical composition.

From August 2013 to March 2014 we measured the composition of atmospheric ions and small particles in the lower free troposphere at Jungfraujoch (JFJ, 3580 m asl; 46.55ºN, 7.98ºE) in the Swiss Alps. The instruments employed were an Atmospheric Pressure Interface Time-of-Flight Mass Spectrometer (APi-TOF), for ion characterization in positive and negative mode (alternately), and a TSI condensation particle counter (CPC) 3776 for aerosol concentration with a cut-off of 3 nm for detecting nucleation events. Additional meteorological measurements enabled us to compare different conditions like solar radiation, presence or absence of clouds and wind direction which is linked to air mass origin with the chemical composition of air ions and nucleation events.

The negative ions were dominated by sulfuric acid, nitric acid, malonic acid, SO_5^- and methanesulfonic acid (MSA) (see Figure 1). Sulfuric acid followed clearly the global radiation but showed under certain conditions also enhanced levels during nighttime. Positive ions were dominated by amines. We often observed a remarkably strong correlation between SO_5^- and MSA, which indicates a common source. Halogenated species were measured regularly, especially Br^- and IO_3^-. Back trajectories suggest an origin over the Atlantic and Mediterranean Sea. Two different types of new particle formation events will be discussed.

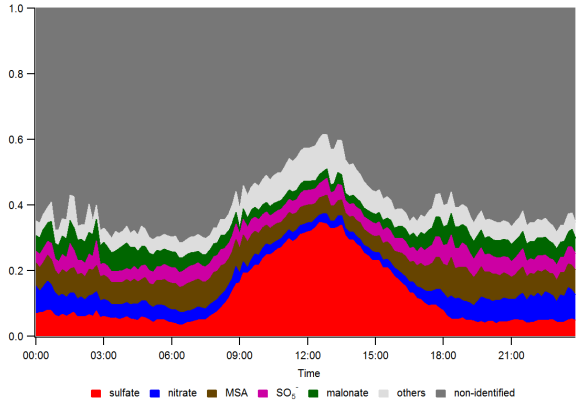

Figure 1. Average diurnal variation of the main ions at JFJ over 15 days of clear sky normalized to the total ion counts.

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