Nucleation at high altitude: from the Alps to the Everest Base Camp

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Atmospheric aerosols can affect the climate directly by absorbing or scattering incoming radiation and also indirectly by acting as cloud condensation nuclei (CCN). A recent study estimates that the major fraction of CCN comes from gas to particle conversion (nucleation) (Merikanto et al., 2009).

During the last decade, several nucleation studies have been published based on field observations, however most of them in the planetary boundary layer (PBL). Therefore, our knowledge is mainly limited to PBL conditions, and only little information is available about the free tropospheric case. Therefore, the aim of this set of studies is to understand what species contribute to new particle formation (NPF) at high altitude with a focus on the formation of the first nucleating clusters.

In order to monitor and characterize NPF processes, a number of state-of-the-art instruments were deployed first at the Swiss high alpine research station Jungfraujoch (3580 m asl) (Bianchi et al., 2016) and then at the Himalayan Nepal Climate Observatory Pyramid (NCO-P) site on the southern slope of the Himalayas, not far from Everest base camp (5079 m asl). Previous studies have already showed that at both of these locations NPF takes place frequently (Venzac et al., 2008; Boulon et al., 2010). However, no chemical information of the vapours was retrieved.

At the Nepal Climate Observatory Pyramid, we deployed an atmospheric pressure interface time-of-flight mass spectrometer (APi-TOF, Junninen et al., 2010), a particle size magnifier (PSM) and a neutral cluster and air ion spectrometer (NAIS). The APi-TOF measured the chemical composition of either the positive or negative ions during many the nucleation events and when equipped with a chemical ionization source (CI-APi-TOF, Jokinen et al., 2012) it provided information on the chemical composition of the neutral species.

Figure 1 shows the first APi-TOF mass spectrum running in negative mode recorded above 5000 m asl during such a nucleation event. The main ions that have been identified so far are all deprotonated acids: sulfuric acid, nitric acid, malonic acid, methanesulfonic acid and iodic acid. Larger ions are formed by different combinations of these acids (i.e. $H_2SO_4 \circ HSO_4^-$, $CH_3SO_3H \circ HSO_4^-$, etc.).

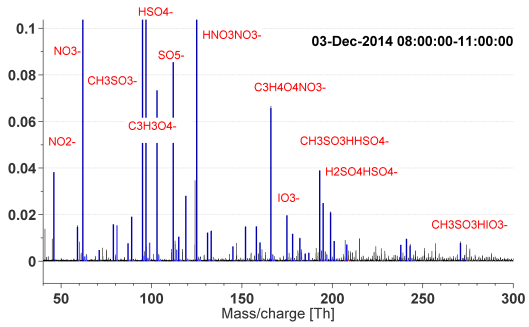

Figure 1. Raw mass spectrum of negative ions recorded during a nucleation event at NCO-P, Nepal, 5079 m asl.

We will present a detailed analysis of the particle evolution during NPF and also the chemical composition of the small clusters measured with these advanced mass spectrometers.

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