Formation and chemical properties of nano-sized particles in the lower free troposphere

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Introduction

It is well known that atmospheric aerosols influence the Earth's climate directly by light scattering and indirectly by changing cloud properties. Atmospheric aerosols are either emitted directly to the atmosphere (primary sources such as sea spray, windblown dust, soot) or formed by gas-to-particle conversion (secondary sources such as nucleation). A recent study by Merikanto et al. (2009) indicates that up to 45% of **c**loud **c**ondensation **n**uclei (CCN) are formed by nucleation. Many nucleation events have been observed in the planetary boundary layer (e.g. Riipinen et al., 2007). However, only a few measurements have been carried out in the free troposphere (FT) (e.g. Weingartner et al., 1999; Boulon et al., 2010); hence our knowledge of aerosol nucleation in the FT is limited.

In January and February 2013 the **Nu**cleation, **Cl**oud and **A**erosol **C**haracterization **E**xperiment (NUCLACE) was conducted at the high alpine research station Jungfraujoch (JFJ) located in the lower FT at 3580 m asl. in the Swiss Alps. The goal was to characterize the properties of newly nucleated aerosol particles (i.e. their size, charge, nucleation and growth rates) and to understand their detailed formation mechanisms by measuring the prevailing precursor gas concentrations with state-of-the-art instrumentation.

Methods

For this purpose a nano scanning mobility particle sizer (nanoSMPS) and a condensation particle counter (CPC) were installed in the cupola of the Sphinx building on the JFJ. The nanoSMPS measured the number size distributions of particles with diameters D between 5 and 90 nm. The sampling was performed through the wall with a specific inlet (length = 40 cm, aerosol sampling flow 1 l/min, sampling line make up flow 8 l/min). The size spectra were corrected for CPC efficiency and diffusion losses in the sampling line. To avoid freezing of the inlet by supercooled cloud droplets a heating system was employed. An electrostatic precipitator was added to the sampling line to periodically remove all charged aerosols up to 120 nm. With this setup the total and neutral particle size distributions were measured with a time resolution of 200 s and the size dependent charged fraction was calculated.

In addition, two chemical ionization atmospheric pressure interface time of flight mass spectrometer (CI-APi-TOF, Jokinen et al 2012) were employed to measure neutral clusters in the gas phase, and two atmospheric pressure interface time of flight mass spectrometers (APi-TOF, Junninen 2010) measured the composition of charged clusters (positive and negative).

First Results

A number of nucleation events were observed. Nucleation mostly occurred at very low ambient temperatures (around -30°C) and was often related to the disappearance of clouds that were present at the station. Figure 1 shows such a typical nucleation event, where the particles grew to D = ~20 nm. This event shortly occurred after the clouds vanished around 12:00. Future data analysis will also include the measured precursor gas concentrations.

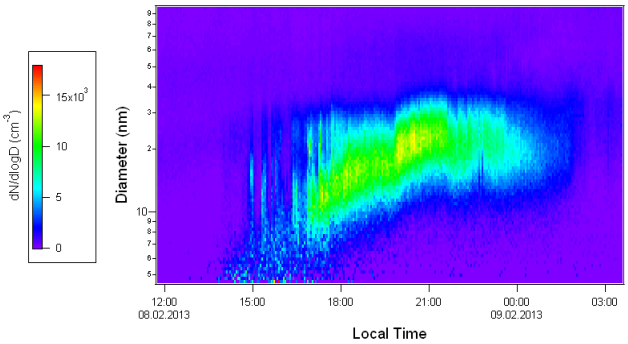

Figure 1. Evolution of particle number size distributions during a nucleation event in the free troposphere.

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