Name of research institute or organization:

Laboratory of Atmospheric Chemistry, Paul Scherrer Institute

Title of project:

Study of new particle formation in the free troposphere (NUCLACE-2014)

Project leader and team:

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Project description:

The aim of this project is to study the nucleation process in the free troposphere. It is well known that atmospheric aerosols can affect the climate directly by absorbing or scattering light and also indirectly through their ability to act as cloud condensation nuclei (CCN).

A recent study (Merikanto et al., 2009) calculates that up to half of the CCN is formed by a gas to particle conversion mechanism (nucleation). Unfortunately only little information about the nucleation process is available for the free troposphere. The questions that we would like to answer are:
What is the sulphuric acid concentration while nucleation is taking place?
Are there other species than sulphuric acid and water participating in the nucleation process?
What is the chemical composition of the growing clusters?
What is the role of the ions in the nucleation process?

To address these questions several state-of-the-art instruments for nucleation measurements were deployed during the years 2013 and 2014 (see Table 1).

Table 1. Instrumentation that has been in use during NUCLACE 2013 and 2014. D = particle or cluster diameter.

Device	**Measured property**
2 atmospheric pressure interface time-of-flight mass spectrometers (APi-TOF)	Chemical composition of the positive and negative ions (D < 2nm)
2 Chemical ionization-APi-TOF	Sulphuric acid concentration and chemical composition of neutral clusters (D < 2nm)
Neutral and air ion spectrometer (NAIS)	Particle and ion size distribution from D = 0.4 to 40 nm
Nano scanning mobility particle sizer (SMPS)	Particle size distribution from D = 4 to 100 nm
Condensation particle counter (CPC)	Particle number concentration (D >3.2 nm)
Particle size magnifier (PSM)	Particle number concentration (D >1 nm) and growth rate between D = 1 and 2.3 nm

As a first step, we performed a characterization of charged molecules and clusters of both polarities (alternately) at the Jungfraujoch based on 9 months data of continuous measurement. For the anion, we found a dominant composition of acidic ions, mainly sulphate and nitrate, but also organic acids like malonate and some halogenated ions. On the other hand, the cation composition consisted mainly of amines.

The long-term measurements allowed comparing different atmospheric conditions: free troposphere vs boundary layer influence, vertical air mass transport, wind direction and speed, seasonal variation and cloud coverage influence.

We found that vertical transport has an important influence on the ion composition at the Jungfraujoch. This implies that vertical transport at some point of the air mass trajectory may contribute species that later will participate in nucleation processes in the free troposphere.

During the full period of measurements, we detected 75 events of nucleation and/or particle growth. Most of the nucleation events showed a significant boundary layer influence. The average event frequency was around 20% which confirms a previous study by Boulon et al. (2010). Figure 1 shows an example of a nucleation event during the long-term measurement campaign. The top panel shows the global radiation, the middle panel the size distribution as seen by the Nano-SMPS and the bottom panel shows the particle number concentration of aerosols with a diameter D > 3.2 nm as seen by the CPC.

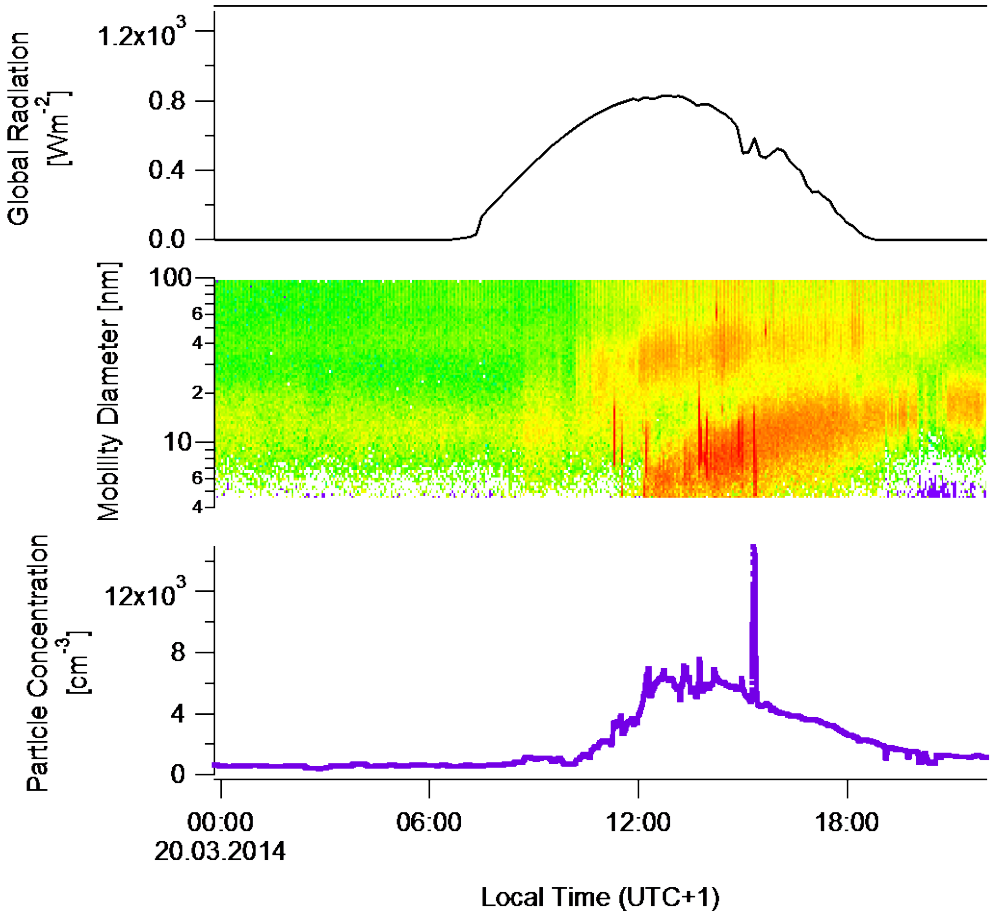

Figure 1. Typical nucleation event with subsequent growth during the long-term measurement campaign 2013/2014. New particles are formed, in addition the preexisting particles further grow to bigger sizes.

References:

Merikanto, J. et al., Impact of nucleation on global CCN, Atmospheric Chemistry and Physics, **21**, 9, 8601-8616, doi: 10.5194/acp-9-8601-2009, 2009.

Boulon, J., et al., New particle formation and ultrafine charged aerosol climatology at a high altitude site in the Alps (Jungfraujoch, 3580 m asl, Switzerland), Atmospheric Chemistry and Physics, **19**, 10, 9333-9349, doi: 10.5194/acp-10-9333-2010, 2010.

Key words:

Nucleation, mass spectrometer, particle size distribution, sulphuric acid, organic molecules, free troposphere

Collaborating partners/networks:

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Joachim Curtius, University of Frankfurt
CLOUD-TRAIN (http://cloud.web.cern.ch/)
Global Atmosphere Watch (http://www.wmo.int/pages/prog/arep/gaw/gaw_home_en.html)

Scientific publications and public outreach 2014:

Conference papers

Frege, C., F. Bianchi, J. Tröstl, H. Junninen, U. Molteni, M. Gysel, M. Sipilä, M. Kulmala, J. Dommen and U. Baltensperger, Characterization of atmospheric ions in the free troposphere at the high Alpine station Jungfraujoch (Switzerland), International Aerosol Conference, Busan, Korea, August 28 - September 2, 2014.

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