Geophysical Research Abstracts
Vol. 16, EGU2014-7322, 2014
EGU General Assembly 2014

Onset of new particle formation in boundary layer

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At this moment, the mechanisms of atmospheric new particle formation (NPF), and the vapors participating in this process are not truly understood. Especially, in which part of the atmosphere the NPF takes place, is still an open question. To detect directly the very first steps of NPF in the atmosphere, we measured these chemical and physical processes within the Planetary Boundary Layer (PBL). We used airborne Zeppelin and Cessna measurements, and ground based in-situ measurements. Using Zeppelin, we focused on the time of the development of the PBL (altitudes up to 1 km) from sunrise until noon to measure vertical profiles of aerosol particles and chemical compounds. This is also the time when NPF typically occurs at ground level.

On summer 2012, Zeppelin was measuring nucleation occurring in the polluted Po Valley area, Northern Italy, especially over the San Pietro Capofiume field site. A year later, Zeppelin had a spring campaign in boreal forest area, close to Hyytiälä field site in Southern Finland. During both campaigns, we aimed on measuring the vertical and the horizontal extension for NPF events using an instrumented Zeppelin. The vertical profile measurements represent the particle and gas concentrations in the lower parts of the atmosphere: the residual layer, the nocturnal boundary layer, and the PBL. At the same time, the ground based measurements records present conditions in the surface layer. The key instruments to measure the onset of NPF were an Atmospheric Pressure interface Time-Of-Flight mass spectrometer (APi-TOF), a Particle Size Magnifier (PSM), and a Neutral cluster and Air Ion Spectrometer (NAIS). These instruments are able to measure particles at the size range $\sim$1-2 nm where atmospheric nucleation and cluster activation takes place.

The onset of NPF was usually observed onboard Zeppelin when it was measuring inside the rising mixed layer which is connected to the surface layer by effective vertical mixing. The newly formed, subsequently growing, particles were observed to be homogeneously distributed inside the mixed layer. These measurements are part of the PEGASOS project which aims to quantify the magnitude of regional to global feedbacks between the atmospheric chemistry and physics, and thus quantify the changing climate.