



The role of natural plant emissions and sulphuric acid on atmospheric nanoparticle formation

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Currently, the controlling mechanism of tropospheric nanoparticle formation is still an open question. Field and laboratory measurements have clearly indicated a strong correlation between observed sulphuric acid – a product of SO₂ oxidation – and nanoparticle concentrations and formation rates. On the other hand, observed seasonality and comparisons with plant-emitted volatile organic compound (VOC) emission strengths show that aerosol formation is also correlated with biogenic organic oxidation. Laboratory studies with real plant emissions have shown a clear dependence of aerosol formation on the VOC emission strength and also the chemical mixture, thereby ruling out the possibility that aerosol formation would be completely independent of organic compounds. Because it is possible that atmospheric particle formation is caused by several different processes, each of which dominate in different precursor domains, reconciling the sulphuric acid and VOC-dependent explanations for aerosol formation is key to understanding the production of aerosol number in the lower atmosphere.

We investigated the formation of nanosized condensation nuclei (nano-CN) from sulphuric acid and plant emissions in the Jülich Plant atmosphere Chamber setup (JPAC). The extensive measurement setup consisted of several condensation nuclei counters (CPCs) including a pulse-height CPC and a Particle Size Magnifier for detection of sub-3 nm CN. Particle size distributions were monitored using an SMPS. Sulphuric acid levels were measured using chemical ionization mass spectrometry, while VOC concentrations were monitored with proton transfer reaction mass spectrometers and a gas chromatograph – mass spectrometer. We also deployed an Atmospheric Pressure Interface TOF spectrometer (API-TOF) to monitor the concentrations and distribution of charged clusters and molecules in the chamber.

We performed a series of experiments using boreal forest tree emissions at levels commonly found in the boreal boundary layer. The sulphuric acid concentration in the chamber was varied by changing the intensity of hydroxyl radical production and addition of SO₂ to the chamber; sulphuric acid levels were on par with atmospheric observations. The reaction chamber was flushed with ozone to achieve a steady-state concentration of 60 ppb when no OH was produced. During the experiment series we varied the emissions of BVOC, the OH production intensity, the O₃ concentration and performed experiments with addition of specific organics, e.g. isoprene.

We found that while the variation of the VOC concentration had a strong impact on the gas phase chemistry and also the hydroxyl radical and sulphuric acid levels, the changes in particle formation rates were not explainable by sulphuric acid concentration variations alone, but the particle formation process is directly influenced by the organic compounds.