Cloud condensation nuclei (CCN) activation in urban and continental background regions

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Clouds are of crucial importance for the raditative balance of the earth-atmosphere system and global climate. Relatively thin clouds (e.g. stratus clouds) are most susceptible to changes of their microphysical parameters caused by anthropogenic aerosols and therefore play the largest role in anthropogenic climate change issues. Cloud droplets are formed by condensation of super-saturated water vapour on cloud condensation nuclei, which form a sub-fraction of the atmospheric aerosol. CCN have to be water-soluble or at least wettable, and have sizes typically above ca. 40 nm. Although the physical processes of CCN activation are well understood, modelling efforts of cloud droplet formation in the complex atmospheric aerosols have still not achieved closure. Organic carbonaceous material poses the largest problem, as only a small fraction (ca. 10%) can be attributed to individual substances. The mixing state of organic and inorganic material within individual particles on the one hand and the mixing state of the aerosol (external mixtures of water insoluble and soluble particles) poses the largest problem. Estimated number concentrations of CCN can still deviate by large factors from measured concentrations.

In this presentation, CCN concentrations and CCN parameters are given for both atmospheric aerosols and for laboratory generated aerosols prepared from filter samples of the atmospheric aerosol. The CCN concentrations were measured with the University of Vienna Cloud Condensation Nuclei Counter (CCNC) developed over the past 20 years. CCN can be measured in the super-saturation range typical for stratus clouds (0.2–1%). First measurements were conducted in the regional background aerosol (Mt. Sonnblick, 3106 m a.m.s.l. and Mt. Rax, 1680 m a.m.s.l). CCN concentrations there were found to be in the range of both clean maritime background ($<100/cm^3$) and polluted urban aerosols ($>1000/cm^3$). In a ca. one year long study, the activation behaviour of the urban aerosol of Vienna was investigated in detail. CCN were found to have neither seasonal nor weekly variations, although the total aerosol concentration exhibited the typical weekly pattern. Activation ratios (i.e. CCN/total particle concentrations) were very low indicating that only a small fraction of the urban aerosol can act as CCN. In the laboratory measurements, we found that the water soluble fraction of the aerosol in the size range below 100 nm (where most CCN are expected) exhibits quite a different activation pattern with much higher activation ratios. Despite large seasonal differences in the content of water soluble organic carbon, no seasonal differences in activation were found. The laboratory generated particles were however less easily activable than particles consisting of typical inorganic salts found in atmospheric aerosols. Calculations of the expected activation behaviour from the chemical composition showed deviations from the measured behaviour. The question of modelling CCN activation will probably still remain open for some time to come.

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