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Measurements of cloud droplet number concentrations (CDNC) and cloud condensation nuclei (CCN) at Puy-de-Dôme, France

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Aerosol particle potential to act as a cloud droplet can be measured using Cloud Condensation Nuclei (CCN) chamber. However, the conditions inside a CCN chamber differ from those in the atmosphere, where the amount of water is limited and a wide range of supersaturations can be attained. To better understand the process of aerosol-cloud activation and the conditions prevailing inside a cloud, the CCN measurements can be combined with measurements of cloud droplets truly activating within a cloud.

This was done during 4-week summer (June–July 2011) and winter (January–February 2012) campaigns at the Puy-de-Dôme (PdD) station in central France. Due to its high elevation (1 465 m a.s.l.), the PdD station is frequently inside a cloud. Our measurements during the campaigns covered particle chemical, hygroscopic, volatile and CCN properties. The size-resolved CCN numbers were measured at two supersaturations: 0.24 % and 0.51 %. Additionally, during cloud episodes, particle size distributions were measured through interstitial (cut-off diameter 5 μm) and whole air inlet every 15-min in turns. By comparing the two size distributions, the cloud droplet numbers and size distributions were deduced.

CCN number concentration at PdD, as measured in 0.24 % supersaturation, ranged from 50 up to 3000 cm-3. The highest concentrations were seen in continental, in contrast to marine, air masses. The average calculated aerosol hygroscopicity parameter kappa, κ, was 0.29 $\pm$ 0.13 in summer and 0.43 $\pm$ 0.19 in winter, and its value was seen to decrease with decreasing particle size. The obtained κ values are in line with the proposed global continental κ of 0.27 $\pm$ 0.21. The high κ values in winter were for the large part explained by the very aged organics, which was analysed based on organic m/z 44 ratio. Interestingly, during winter, the smallest κ values and the highest organic fractions were measured in marine air masses. A good CCN closure was obtained with aerosol chemistry on both seasons.

Finally, in-cloud droplet numbers were compared with total and interstitial aerosol numbers. In-cloud droplet number concentration increased with total particle number, and the calculated in-cloud supersaturation correspondingly decreased. This suggests that an aerosol particle number can be a factor limiting the maximum obtainable supersaturation within a cloud.