

In-cloud observations highlighting the importance of aerosol chemical composition on CCN activation

O. Väisänen¹, P. Miettinen¹, A. Ylirirniö¹, S. Romakkaniemi² and A. Virtanen¹

¹Department of Applied Physics, University of Eastern Finland, FI-70210 Kuopio, Finland

²Finnish Meteorological Institute, FI-70210 Kuopio, Finland

Keywords: aerosol cloud interaction, physical and chemical properties

Presenting author email: olli.vaisanen@uef.fi

In order to gain knowledge about the processes governing atmospheric aerosols and their connection to cloud condensation nuclei (CCN) activation, we carried out an intensive measurement campaign at the Puijo SMEAR IV station (e.g. Leskinen *et al.*, 2009) in Kuopio, Finland, during the autumn 2014. Besides the stationary measurement instruments, the station was equipped with a high resolution time-of-flight aerosol mass spectrometer (Aerodyne HR-ToF-AMS), hygroscopic tandem differential mobility analyzer (HTDMA), cloud condensation nuclei counter (DMT-CCN 100) and proton transfer reaction time-of-flight mass spectrometer (Ionicon PTR-ToF 8000). In this abstract, we present the preliminary results concerning the conducted HTDMA measurements.

The HTDMA was operated to measure the hygroscopic growth factors (GF) at 90 % relative humidity using the dry diameters of 80, 120 and 150 nm. The instrument was attached to the custom-made twin inlet system (Portin *et al.*, 2014) in order to measure the total aerosol (TOT) and interstitial particles (INT) separately. During a cloud event, the total air inlet samples all the particles and cloud droplets using a cut-off diameter of 40 μm . Meanwhile, the interstitial sample flow contains only the non-activated particles.

Figure 1 shows the average growth factors and their probability density functions (GF-PDF) averaged over the observed cloud events. Since the 80 nm particles do not usually activate into cloud droplets, the measured GF-PDFs are almost identical for both sample lines. However, the 120 nm and 150 nm particles are already showing considerable differences between different populations, with activated particles appearing more hygroscopic than the interstitial ones. In addition, the fraction of more hygroscopic particles increases with particle size causing an increasing trend for overall hygroscopicity.

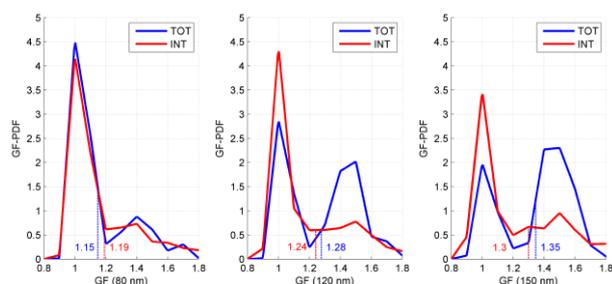


Figure 1. Average GFs and GF-PDFs during cloud events for dry diameters of 80, 120 and 150 nm.

By using the non-normalized GF distributions, we calculated the average activation efficiencies of low and high hygroscopicity particles separately (Table 1). The limiting value between different categories was set to 1.20 representing the most common midpoint between the two GF modes (Figure 1). The results underline the strong dependence of activation efficiency on particle size. Increasing the particle size from 80 to 150 nm elevates the overall activation efficiency ($AF_{0.8 \leq GF \leq 1.8}$) from 25 % up to 59 %. These values are broadly in line with the respective efficiencies of 7 % and 60 % calculated from DMPS measurements.

Table 1. Average activation efficiencies (\pm one standard deviation) within different GF ranges.

$D_{p,dry}$	$AF_{0.8 \leq GF \leq 1.8}$	$AF_{0.8 \leq GF \leq 1.2}$	$AF_{1.2 \leq GF \leq 1.8}$
80 nm	25 ± 13 %	23 ± 15 %	25 ± 21 %
120 nm	50 ± 7 %	12 ± 11 %	74 ± 5 %
150 nm	59 ± 10 %	7 ± 12 %	79 ± 6 %

Similarly to $AF_{0.8 \leq GF \leq 1.8}$, the activation efficiency of more hygroscopic particles increases with size. However, a quick comparison between the values indicates, that the increment in $AF_{0.8 \leq GF \leq 1.8}$ is most likely resulting from the joint effect of particle size (Kelvin effect) and varying chemical composition. With hygroscopicity-dependent efficiencies varying from just few percent up to almost 90 %, the results also highlight the importance of chemical composition on potential cloud condensation nuclei spectra.

This work was supported by Academy of Finland Centre of Excellence (decision no. 272041).

Leskinen, A. et al. (2009). *Boreal. Env. Res.*, **14**, 576–590.

Portin, H. et al. (2014). *Atmos. Chem. Phys.*, **14**, 6020–6034.