Hygroscopic growth parameterization of aerosol particles based on high humidity measurements in the Po-Valley, Italy

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Keywords: Hygroscopic growth, Hygroscopicity parameter
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The hygroscopic behaviour of atmospheric aerosol particles was determined during the PEGASOS measurement campaign in 2012. The measurements were performed at the regional site in San Pietro Capofiume (SPC) in the PO-Valley, Italy, from June 9 to July 12, 2012. A High Humidity Tandem Differential Mobility Analyzer (HH-TDMA) was used for the hygroscopicity measurements. The HH-TDMA was developed to quantify the hygroscopic growth factor (HGF) and the mixing state of the aerosol particles for relative humidities (RH) ≥ 90 % under highly temperature-stabilized conditions (Hennig, T. et al., 2005). The HH-TDMA was applied to measure the hygroscopic properties at 90, 93 and 95 % RH for the particle size with 75, 100, 200 and 300 nm. Based on the measured HGFs and under use of the single-parameter κ-Köhler model, the hygroscopic growth behaviour was analysed. κ is the so called hygroscopicity parameter and enables the comparison between measurements at different RHs at a certain dry diameter (Liu et al., 2011). According to Petters, M. D. et al. (2007), κ can be estimated by the following equation:

$$\kappa = \left(HGF^3 - 1\right)\left[\frac{1}{S}\exp\left(\frac{4\sigma_{\mathrm{s/a}} M_{\mathrm{W}}}{RT\rho_{\mathrm{W}} D_{\mathrm{P}} HGF}\right) - 1\right] \quad (1)$$

where S is the saturation ratio, $\sigma_{\mathrm{s/a}}$ the surface tension of the interface solution/air, M_{W} the molecular weight of water, R the universal gas constant, T the absolute temperature, ρ_{W} the density of water, and D_{P} the particle dry diameter. In order to obtain a parameterized κ, some analysis steps are required. First, for each D_{P} and S the measured HGF was averaged over the whole measurement period. In a second step the Köhler equation (1) was aligned to the point quantity (S, HGF) with κ as variable fitting parameter. The results are shown in Fig. 1. To get a parameterized κ in dependence on D_{P} a sigmoid curve (Fig. 2) approach was used:

$$\kappa\left(D_{\mathrm{P}}\right) = A_2 + \frac{A_1 - A_2}{1 + \exp\left(\frac{D_{\mathrm{P}} - D_0}{\Delta D}\right)} \quad (2)$$

with the fitting parameter A_1, A_2, D_0 and ΔD.

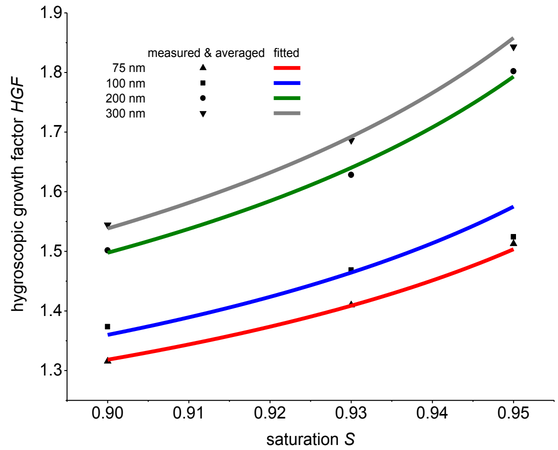

Fig. 1: The hygroscopic growth of different particles sizes (75, 100, 200 and 300 nm). The HGFs are the mean values of the measured HGF corrected to their target RHs (90, 93, 95 %). The red, blue, green and grey lines represent the fitted κ-Köhler curves.

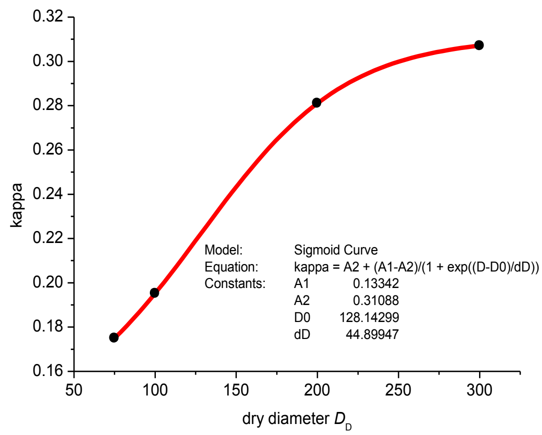

Fig. 2: The hygroscopicity parameter κ for four different particle sizes (75, 100, 200 and 300 nm). The black points are the fitted κs from the Köhler equation (1). The κ sigmoid curve (eq. 2) is displayed as red line.

References:

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