Relating particle hygroscopicity and CCN activity to chemical composition during HCCT-2010 field campaign

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Particle hygroscopic growth at RH =90%, cloud condensation nuclei (CCN) activity, and size-resolved chemical composition were concurrently measured in the Thüringer Wald mid-level mountain range in central Germany in fall season of 2010. The median hygroscopicity parameter values, κ, of 50, 75, 100, 150, 200, and 250 nm particles derived from hygroscopicity measurements are respectively 0.14, 0.14, 0.17, 0.21, 0.24, and 0.28 during the sampling period. The closure between HTDMA-measured (κHTDMA) and chemical composition-derived (κchem) hygroscopicity parameters was performed based on the Zdanovskii-Stokes-Robinson (ZSR) mixing rule. Using size-averaged chemical composition, the κ values are substantially overpredicted (30% and 40% for 150 and 100 nm particles). Introducing size-resolved chemical composition substantially improved closure, and the differences between κHTDMA and κchem are within 10%. We found that the evaporation of NH4NO3, which may happen in H-TDMA system, could lead to a discrepancy in predicted and measured particle hygroscopic growth. The hygroscopic parameter of the organic fraction, κorg is positively correlated with the O : C ratio (κorg =0.19 · (O : C)-0.03). Such correlation is helpful to define the κorg value in the closure study. κ derived from CCN measurement was around 30% (varied with particle diameters) higher than that determined from particle hygroscopic growth measurements (here, hydrophilic mode is considered only). This difference might be explained by the surface tension effects, solution non-ideality, and the partial solubility of constituents or non-dissolved particle matter. However, due to these effects being included in HTDMA-derived κ calculations, we could not distinguish the specific roles of these effects in creating this gap. Therefore, extrapolating from HTDMA data to properties at the point of activation should be done with great care. Finally, closure study between CCNc-measured (κCCN) and chemical composition (κCCN,chem) was performed using CCNc-derived κ values for individual components. The results show that the κCCN can be well predicted using particle size-resolved chemical composition and the ZSR mixing rule.

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