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

Zhijun Wu, Laurent Poulain, Silvia Henning, Katrin Dieckmann, Wolfram Birmili, Maik Merkel, Dominik van Pinxteren, Frank Stratmann, Herrmann Hartmut, Alfred Wiedensholer

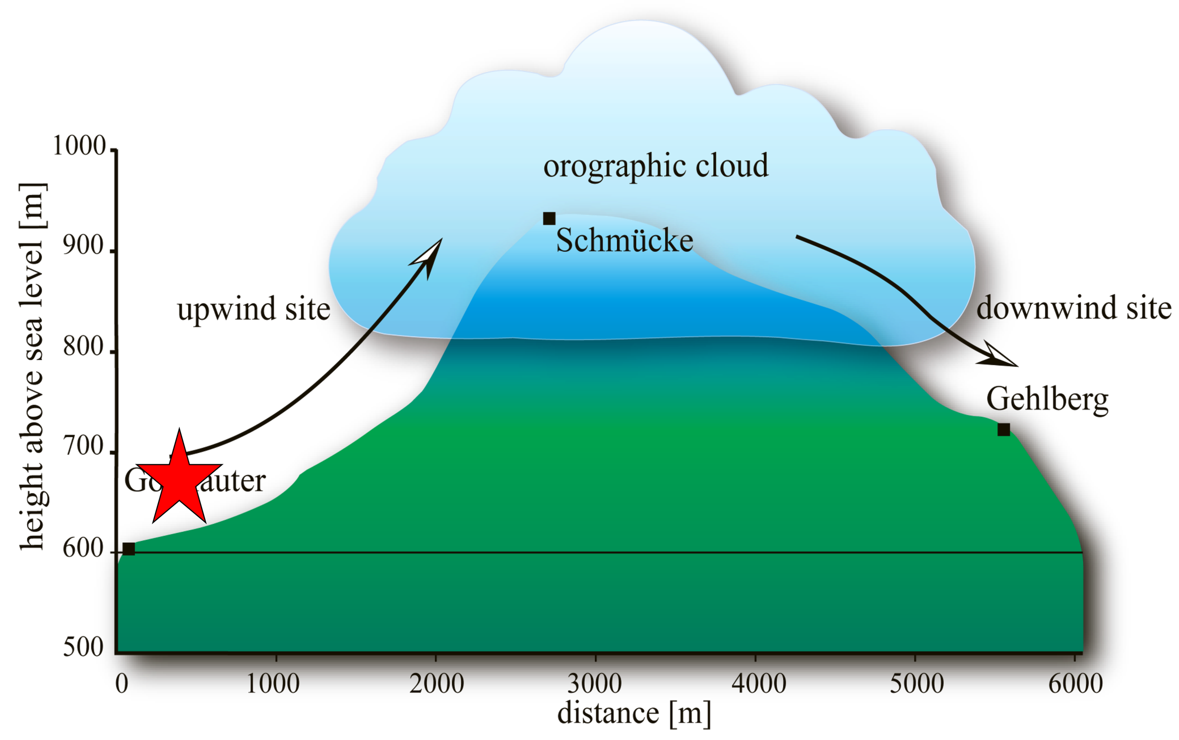
Leibniz Institute for Tropospheric Research, Leipzig, Germany

E-mail: wuzhijun@tropos.de

LEIBNIZ INSTITUTE FOR TROPOSPHERIC RESEARCH

HCCT 2010

1. Experiment and instruments



Scheme of the HCCT-2012 sampling sites

The main objective of the Hill Cap Cloud Thuringia 2010 (HCCT-2010) was to perform a ground-based Langrangian-type experiment for investigating the influences of clouds on aerosol chemistry. Here, we will refer to measurements at Goldlauter (upwind site) only, i.e. where HTDMA, CCNc, and AMS measurements were concurrently made.

Parameters	Instrumentation
Particle number size distribution	Scanning Mobility Particle Sizer (SMPS)
Particle chemical composition	High Resolution Time-of-Flight Aerosol Mass Spectrometer (AMS)
Particle hygroscopic growth (RH=90%)	Hygroscopicity Tandem Differential Mobility Analyzer (HTDMA)
CCN	Cloud Condensation Nuclei counter (CCNc)
Black carbon	Multi-Angle Absorption Photometer (MAAP)

2. Methodology

The three ways to calculate particle hygroscopicity parameters

(1) $$\kappa_{HTDMA} = (HGF^3 - 1)\left(\frac{exp\left(\frac{A}{D_d \cdot HGF}\right)}{RH} - 1\right)$$ HTDMA measurements

(2) $$\kappa_{CCN} = \frac{4A^3}{27D_d^3 ln^2 S_c}$$ CCN measurements

(3) $$\kappa_{chem} = \sum_i \varepsilon_i \kappa_i$$ AMS and MAAP measurements

Species	NH_4NO_3	H_2SO_4	NH_4HSO_4	$(NH_4)_2SO_4$	Organics	Black carbon
Density [kg/m³]	1720	1830	1780	1769	1400	1700
kappa	0.58	0.89	0.56	0.48	0.09	0.0

Ref.1: Petters, M. D., and Kreidenweis, S. M.: Atmos. Chem. Phys., 7, 1961-1971, 10.5194/acp-7-1961-2007, 2007.

3. Particle hygroscopicity and CCN activity

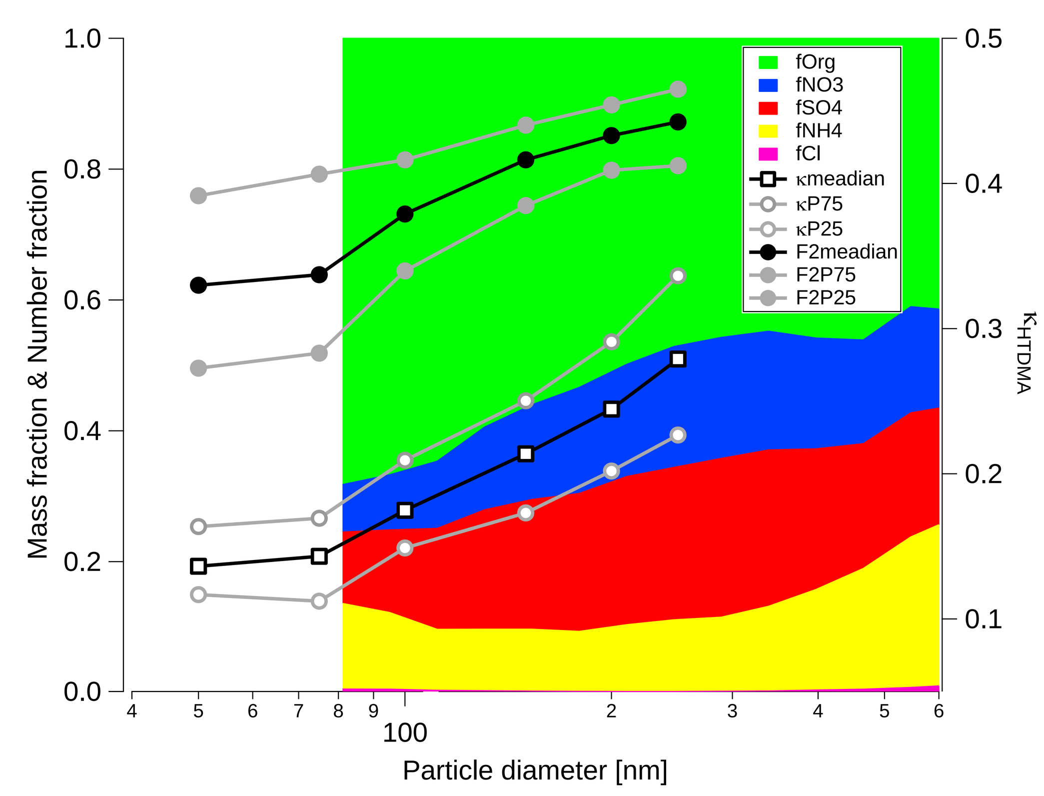


Fig.1: Size-dependency of particle hygroscopicity (κ_{HTDMA}), number fraction of hydrophilic mode (F2), and mass fraction of key components derived from AMS measurements averaging over the entire sampling period.

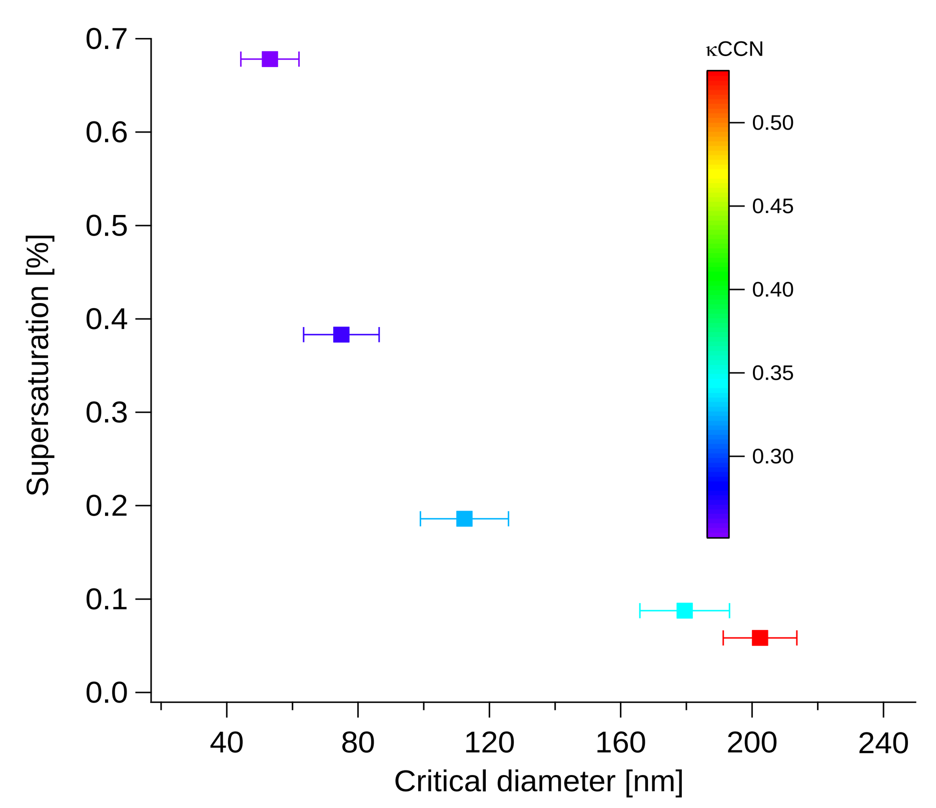


Fig.2: Critical diameters at different super-saturation. κ_{CCN} is derived from equation [2]. The data are the mean values averaging over the entire field campaign.

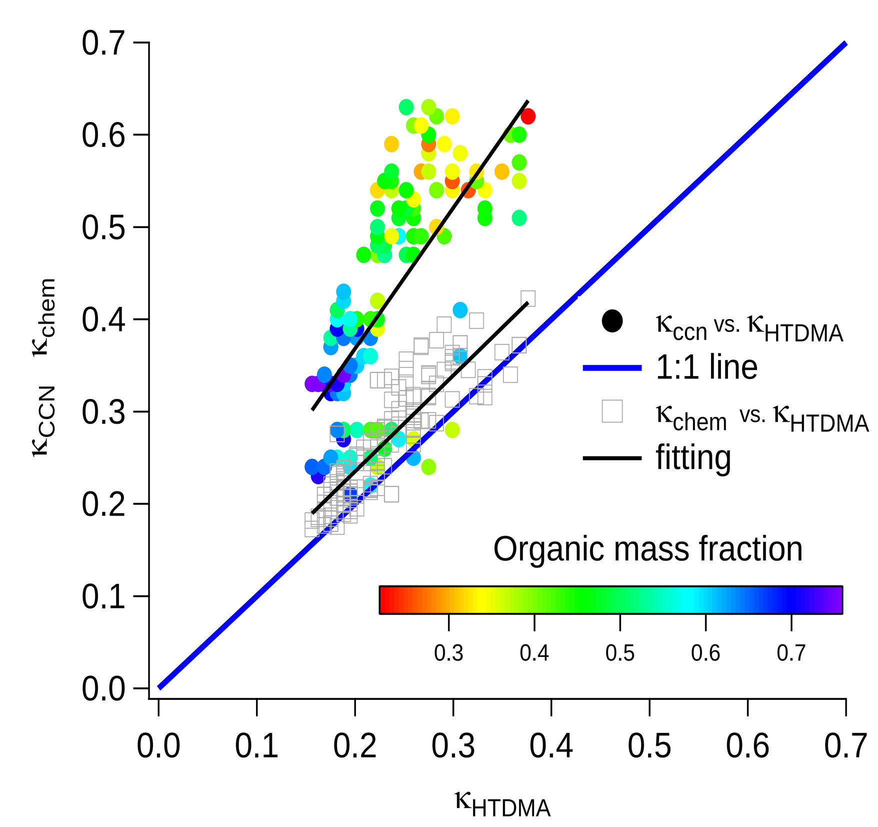


Fig.3: Comparison of κ_{HTDMA} (dry particle diameter=200 nm at RH=90%), κ_{CCN} (critical diameter=200±10 nm), and κ_{chem} (bulk chemical composition).

4. Link to particle chemical composition

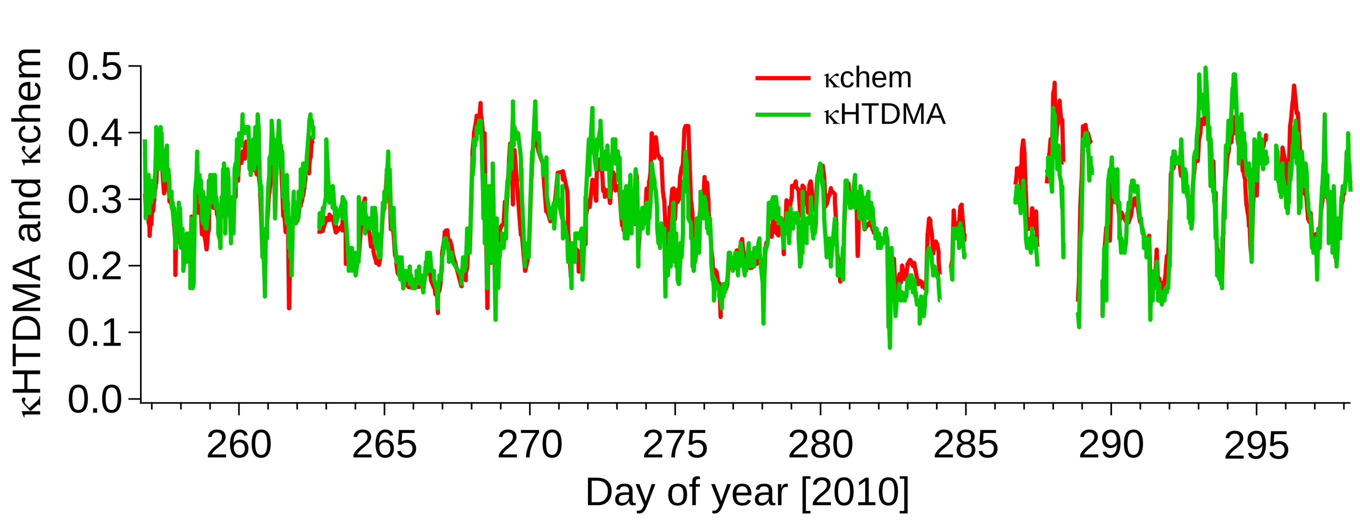


Fig.4: Comparison of κ_{HTDMA} (dry diameter=250 nm at 90%) and κ_{chem} (bulk chemical composition). κ_{chem}=0.991* κ_{HTDMA}, R^2=0.74

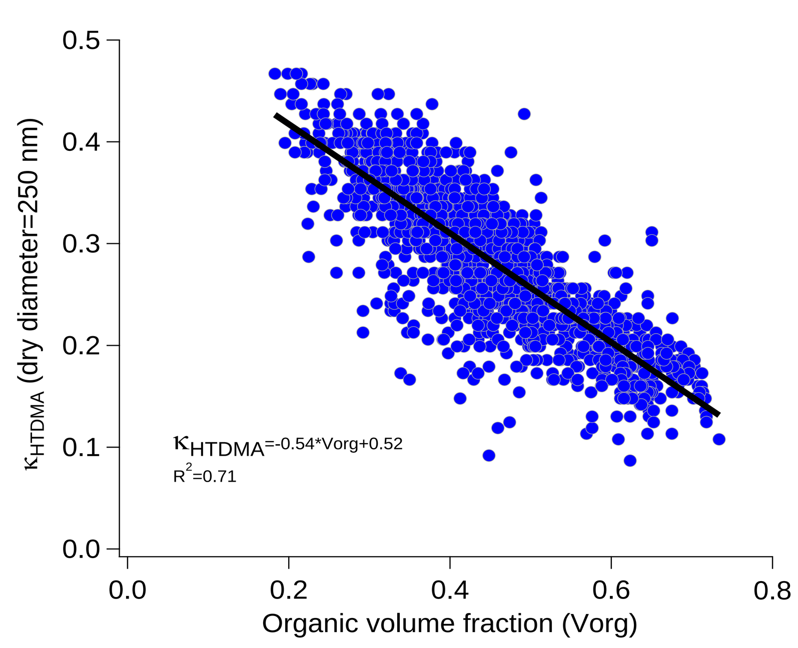


Fig.5: Relationship between organic volume fraction and κ_{HTDMA}.

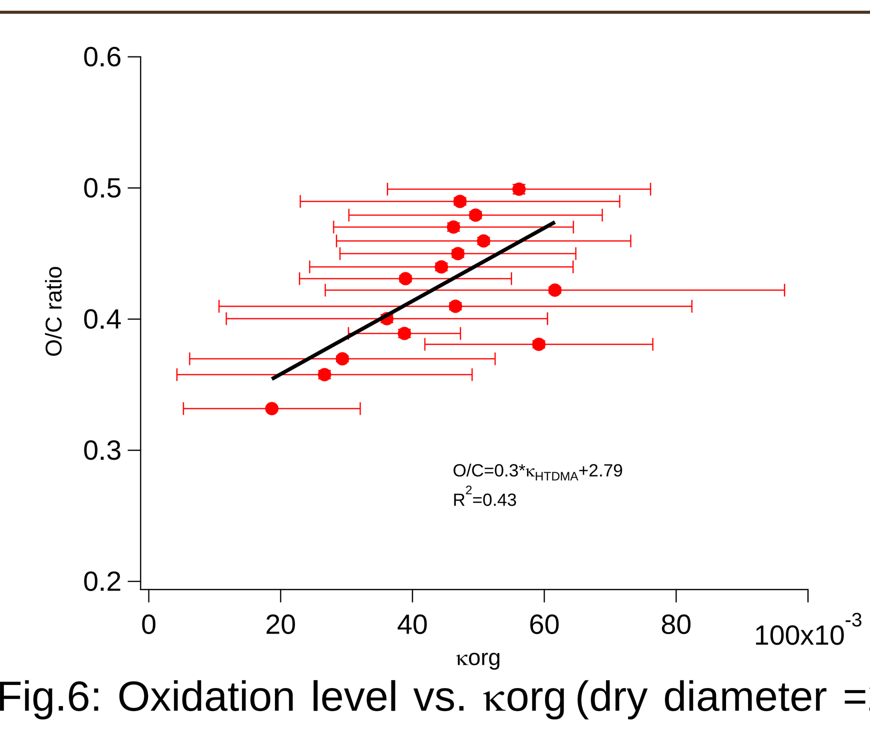


Fig.6: Oxidation level vs. κorg (dry diameter =250 nm). κorg of organic fraction is estimated using equation [3]: $\kappa_{org} = \left(\kappa_{HTDMA} - \sum_j \varepsilon_j \kappa_j\right)/\varepsilon_{org}$

5. Summary

(1) Consistency between κ_{CCN} and κ_{HTDMA} (200 nm) is not obtained due to in part a change solution non-ideality, and surface tension effects.
(2) κ_{HTDMA} (250 nm at 90%) can be well predicted by bulk chemical composition derived from AMS and black carbon measured by MAAP.
(3) κ_{HTDMA} and oxidation level (O/C) are positively correlated.

tropospheric aerosols

Member of the Leibniz Association