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LONG-TERM SIZE-SEGREGATED CCNC MEASUREMENTS IN A BOREAL ENVIRONMENT AND THE IMPLICATIONS FOR CLOUD DROPLET ACTIVATION

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Besides directly influencing the radiative balance of the Earth, aerosol particles play a crucial role in cloud formation and modification. They influence the albedo, lifetime and precipitation patterns of clouds in what is known as indirect effects of aerosols on climate.

- What determines the ability of the particle to act as CCN?
- How can aerosol in the boreal environment be described with respect to its CCN potential?
- What is special about size-segregated CCNC measurements and what do they provide?

WHAT?

- particles in 20–300 nm size range at 5 levels of supersaturation S_{eff} (0.1%, 0.2%, 0.4%, 0.6% & 1.0%)

WHERE?

- Hyytiälä Forestry Field Station in Southern Finland (61° 50' 50.685''N, 24° 17' 41.206''E, 179 m a.m.s.l.)

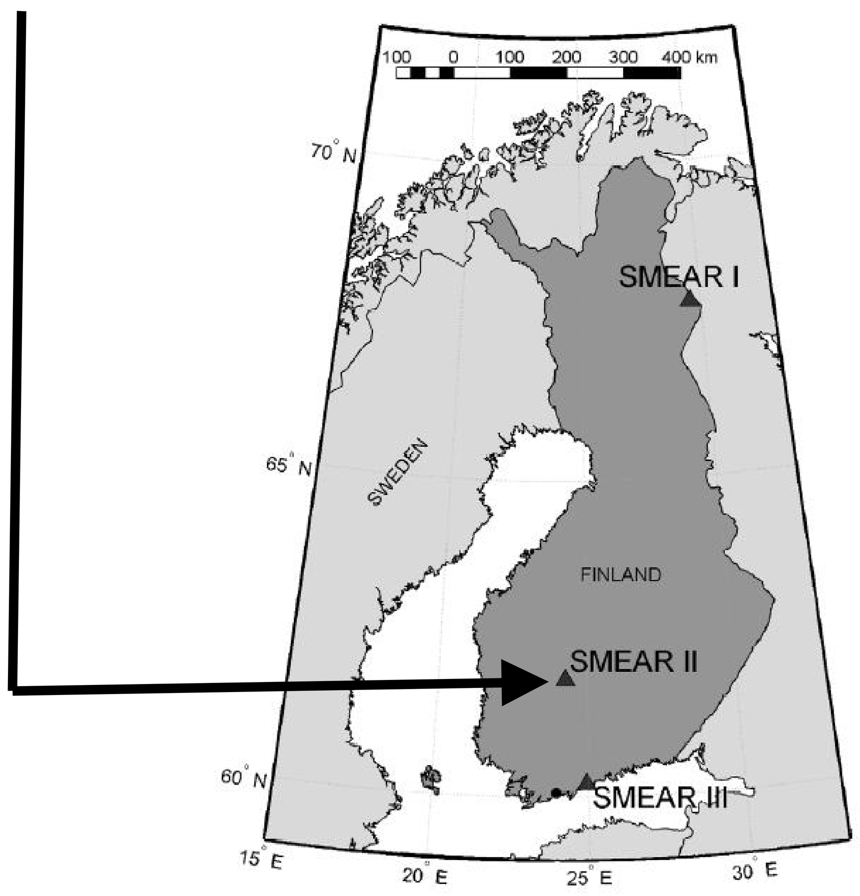

Figure 1. The location of SMEAR stations in Finland.

WHEN?

- February 2009–June 2010
- May 2011–April 2012

HOW?

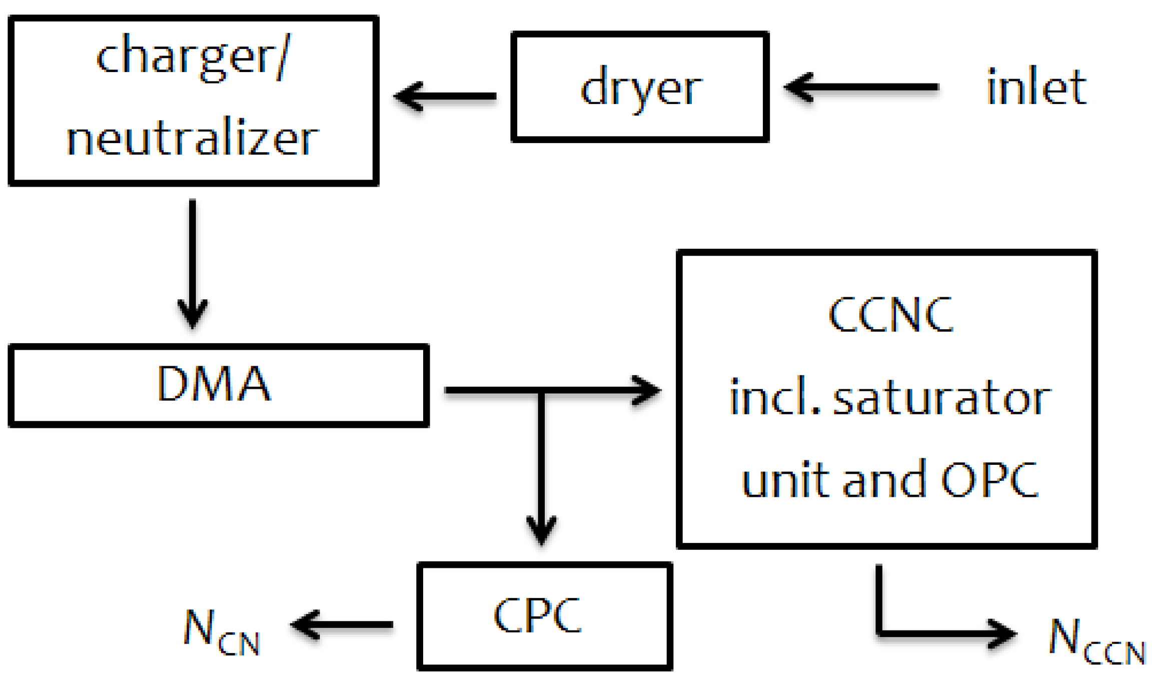

Figure 2. Simplified diagram of the measurement setup.

- DMA – differential mobility analyzer
- CPC – condensation particle counter
- CCNC – cloud condensation nuclei counter
- OPC – optical particle counter

DATA OVERVIEW

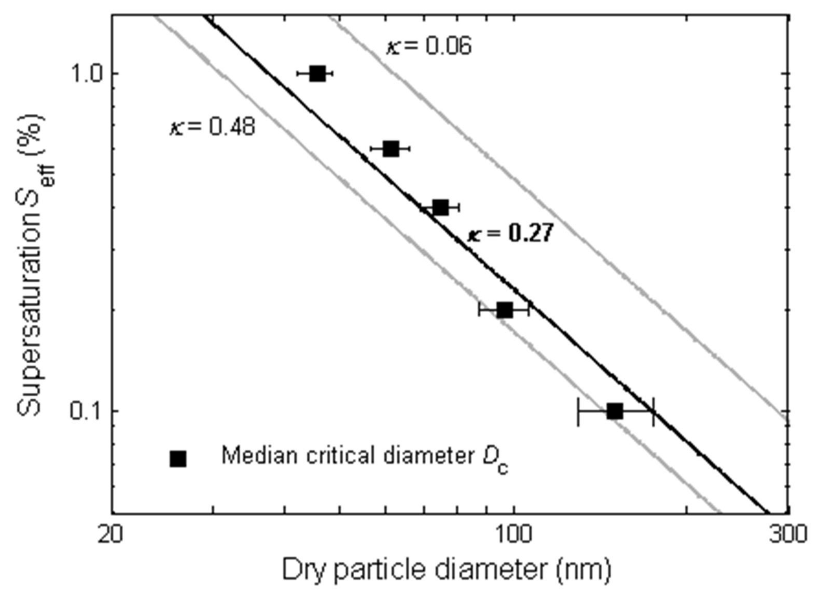

Figure 3. Particle dry size as a function of S_{eff}. The black line – hygroscopicity κ value of 0.27, grey lines – κ values of 0.06 and 0.48, representing the global continental mean of κ of 0.27±0.21 (Pringle et al. 2010).

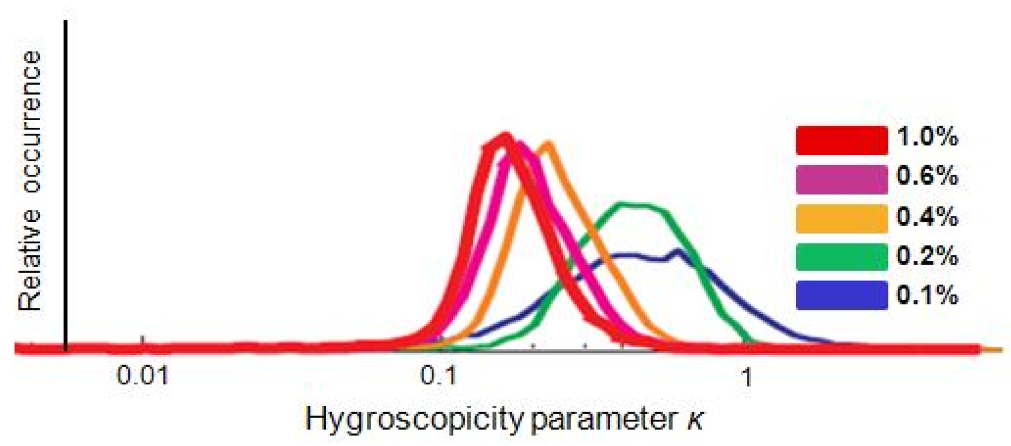

Figure 4. Relative occurrence of κ calculated with log-equal bins for five levels of S_{eff}.

- significant increase in κ and difference in distribution shape between S_{eff} 0.4% and 0.2%, consistent with change from Aitken to accumulation mode around 100 nm – cloud processing
- **distributions of κ are lognormal and vary between S_{eff} levels – the use of a single, mean or median, κ for an aerosol population is discouraged**

INTERCOMPARISON

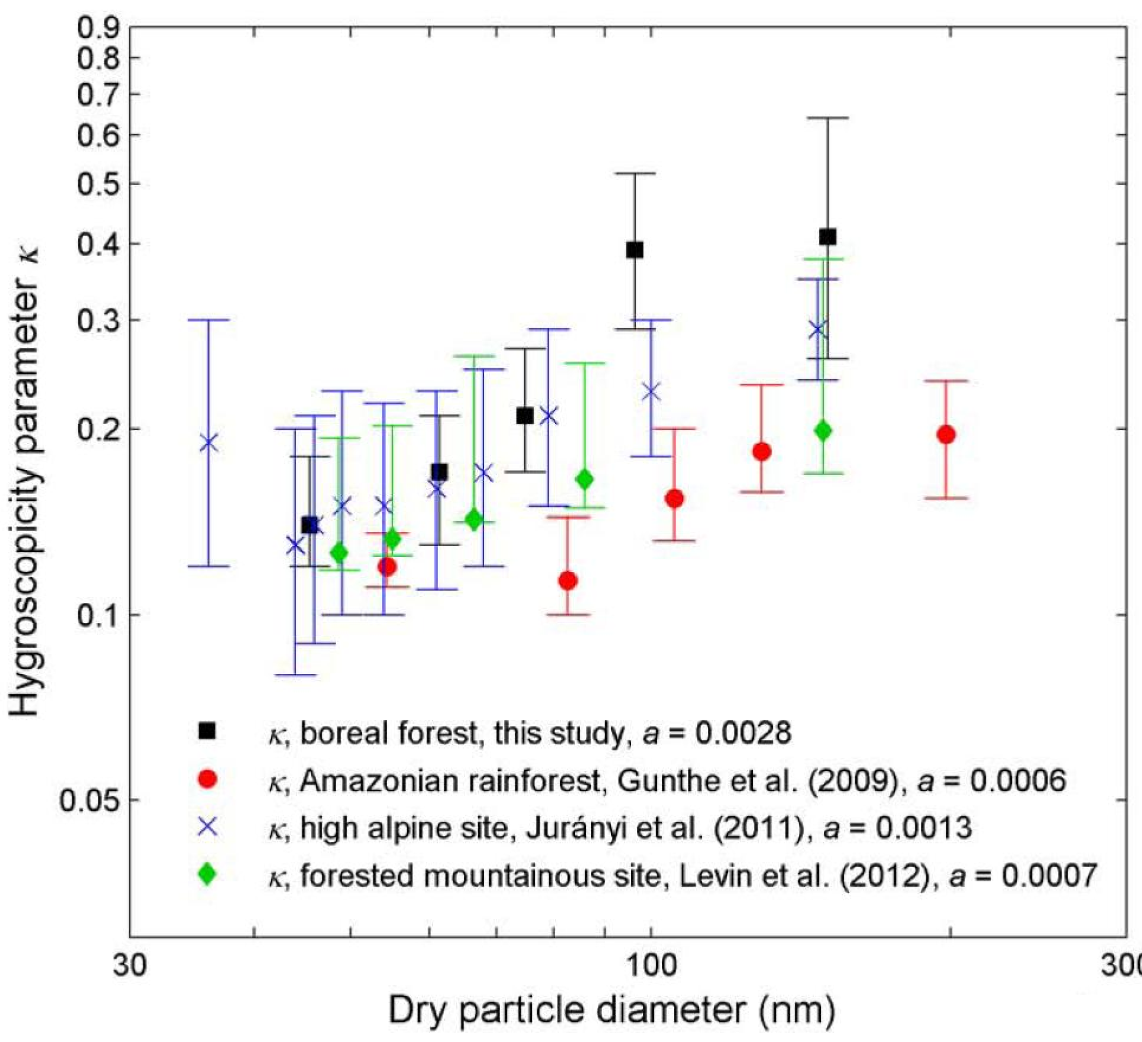

Figure 5. Relationship between particle dry size (taken as D_c) and κ for 4 different sites. Shown are the median values with error bars being 25th and 75th percentiles. Legend entries indicate the slope of the linear regression $y = ax + b$ fit.

- **both κ and rate of change of κ with size are highest in Hyytiälä among 4 sites – differences in condensing species and oxidation and aging processes**
- **rate of change of κ with size in Hyytiälä is highest in winter – higher sulphate fraction & slower growth**

TEMPORAL TRENDS

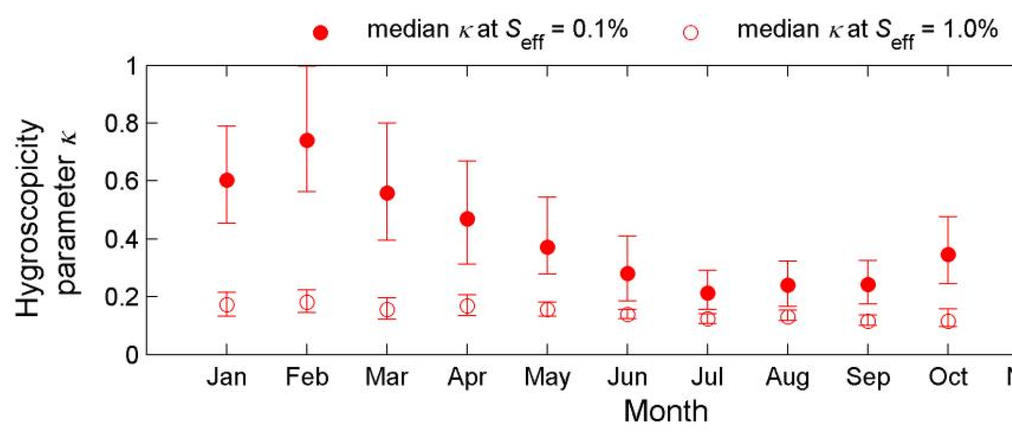

Figure 6. Monthly κ shown for two levels of S_{eff}.

- seasonal trend for larger (~150 nm) particles only
- aerosol measured at S_{eff}=0.1% is more hygroscopic in winter – higher sulphate (long-range transport)
- summer – more active SOA formation and higher organic fraction
- diurnal trend for smaller (~50 nm) particles only, present only in spring and summer
- aerosol measured at S_{eff}=1.0% is more hygroscopic in the afternoon – photochemistry
- no distinguishable effect of NPF on aerosol CCN activation and hygroscopic properties

ZOOMING IN ON CHEMISTRY

- gas phase H_2SO_4 and sulphate both increase aerosol hygroscopicity, with a larger effect of H_2SO_4 in the spring
- organics decrease aerosol hygroscopicity in all seasons except winter
- these patters more pronounced for larger particles (> 100 nm)

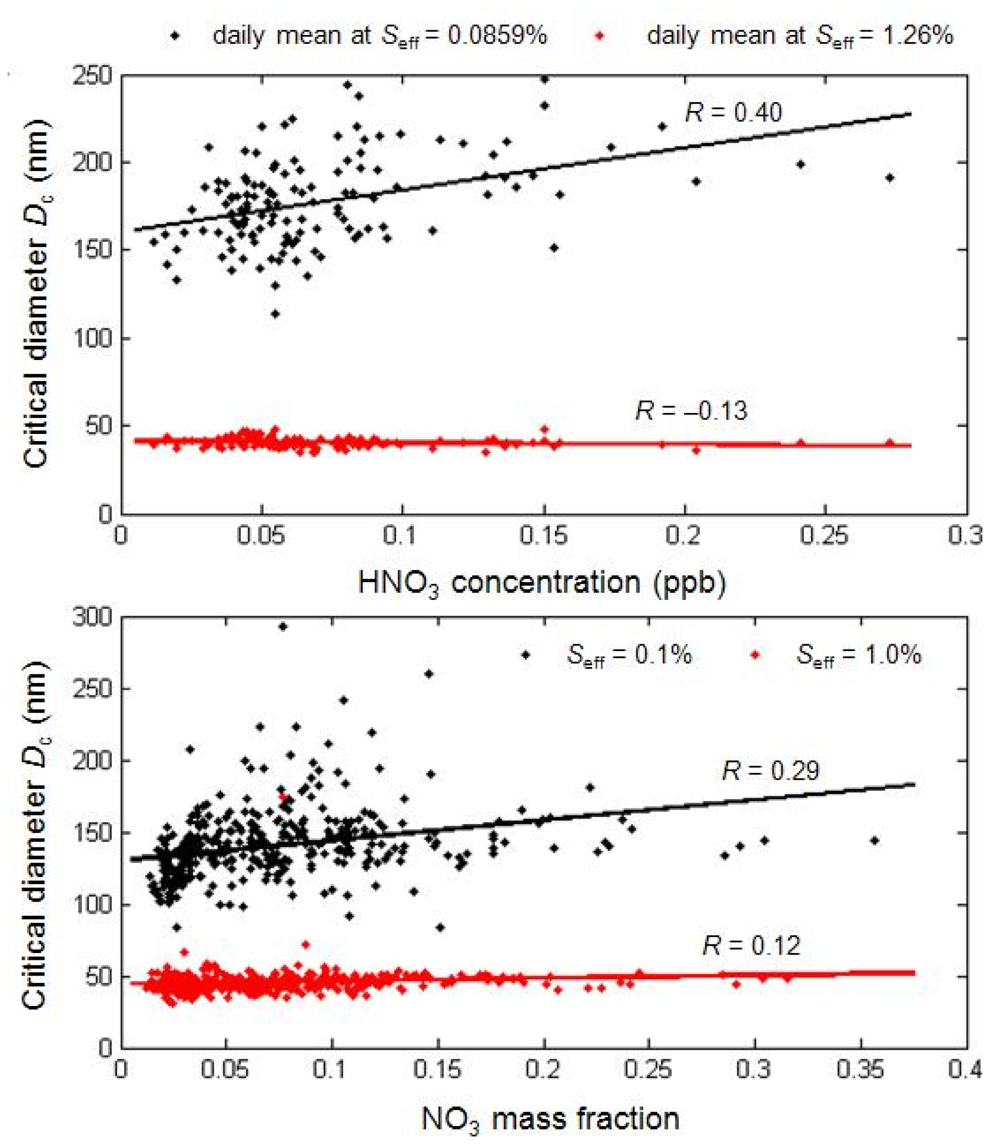

Figure 7. Critical diameter D_c as a function of HNO_3 concentration (top) and NO_3 mass fraction (bottom).

- **correlations with HNO_3 and NO_3 are poor, but nitrogen species seem to decrease aerosol hygroscopicity**
- HNO_3 seems to increase D_c for particles ~170 nm in spring and summer
- positive correlation with NO_3 for all S_{eff} levels in the summer – organic nitrate/air mass feature?

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