Size-resolved Aerosol Hygroscopicities Under Both Supersaturated and Subsaturated Conditions at a Rural Site During TRACER

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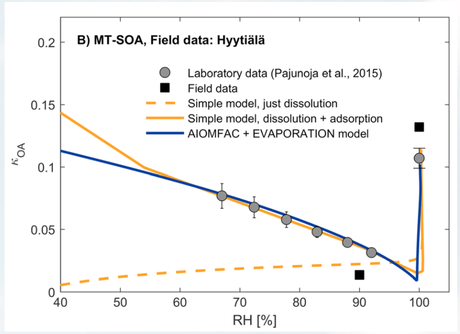
1. Introduction

The uptake of water by aerosol particles is of critical importance for both droplet activation and the direct interaction of aerosols with radiation. The hygroscopicity under supersaturated condition (i.e., κ_{CCN}, relevant to droplet activation) can be substantially higher than that under subsaturated conditions (i.e., κ_{GF} relevant to hygroscopic growth). In the subsaturated regime, particle hygroscopicity (κ_{GF}) can also vary strongly with RH[1,2]. However, the prevalence of such difference, the dependence of the difference on particle composition, and their underlying mechanisms are still not well understood for ambient aerosols. During the Tracking Aerosol Convection interactions ExpeRiment (TRACER) campaign, we characterized size-resolved aerosol hygroscopicities from 75% RH to supersaturation at a rural site (i.e., ANC site) located in Guy, Texas, a rural area 60 km southwest of Houston from July to September 2022.

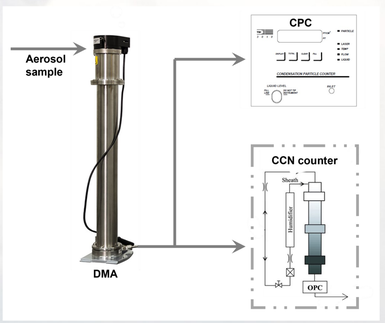


Elevated κ_{CCN} relative to κ_{GF} and the variation of κ_{GF} with RH for monoterpene SOA[3].

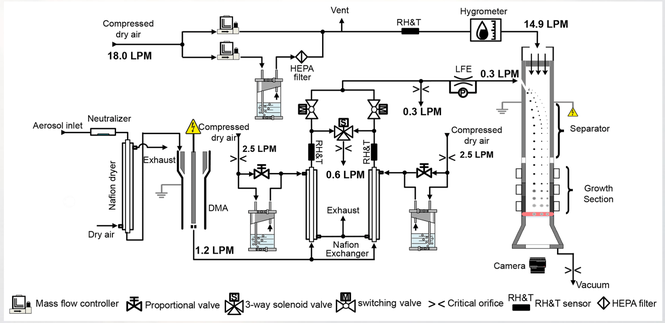
2. Measurements

During TRACER, size-resolved cloud condensation nuclei counter (SCCN) and humidity-controlled fast integrated mobility spectrometer (HFIMS) were deployed to measured the hygroscopicities under supersaturated and subsaturated conditions, respectively.

SCCN[4]



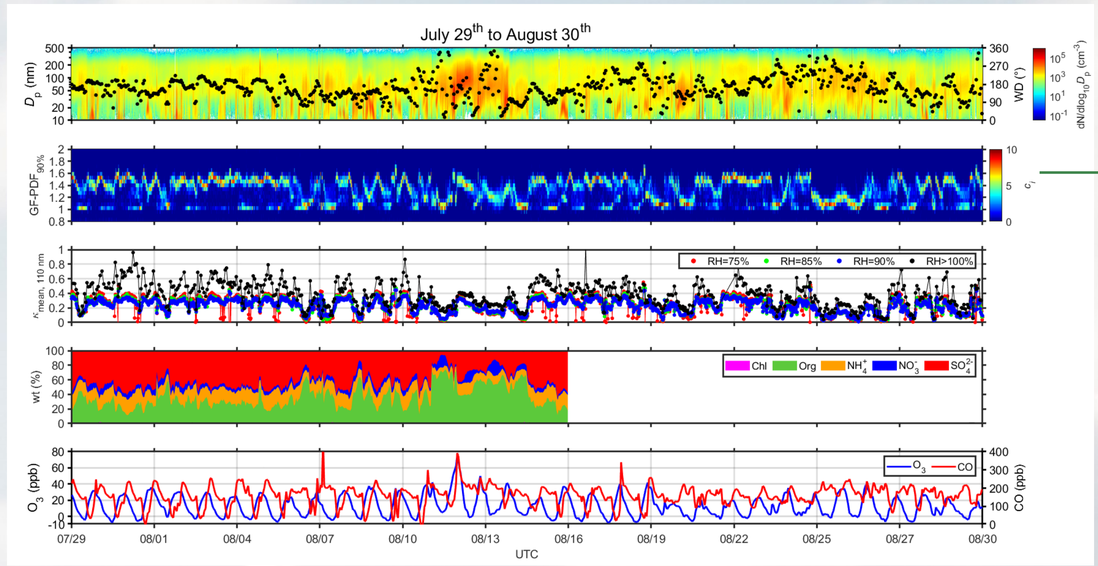
HFIMS[5]



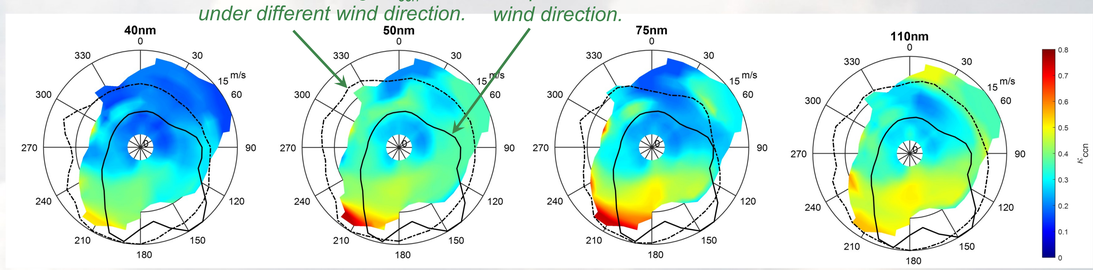
Supersaturation range: 0.08 – 1.8%
Particle sizes: 40, 50, 75, 110, 165 nm
Time resolution: ~1 hour

Relative humidity: 75, 85, and 95 %
Particle sizes: 35, 50, 75, 110, 165, 265 nm
Time resolution: ~ 30 minutes

3. Overview of Measurements

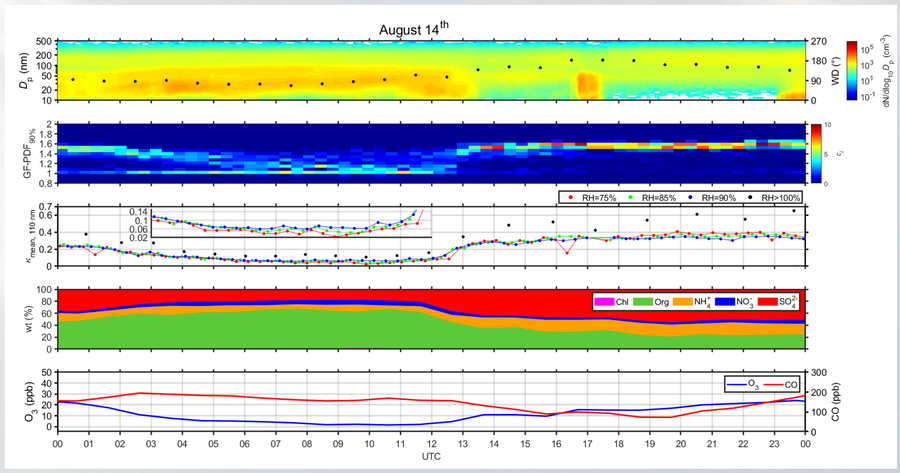


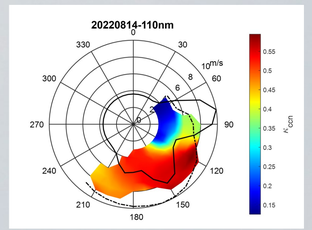
Probability density function of the hygroscopic growth factor at 110 nm

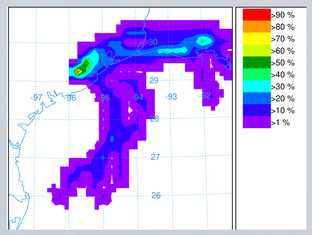


- κ has strong diurnal variations and varies with wind directions (i.e., aerosol sources).
- External mixtures of hydrophobic and hydrophilic particles
- Correlation of κ with sulfate volume fraction.
- Strong size-dependence
- The highest κ occurs when the wind is from the south (i.e., gulf region).

4. Case study - August 14th







Backward trajectories frequencies for August 14th

- κ_{GF} increases with RH when wind is from the urban region and decreases with RH when wind is from the gulf region.
- κ_{CCN} is larger than κ_{GF} especially when wind is from gulf region.

5. Future work

- Analyze the conditions where there are significant differences between κ_{CCN} and κ_{GF} and strong variation of κ_{GF} with RH
- Examine the size and chemical composition dependence of the difference between κ_{CCN} and κ_{GF} and the variation of κ_{GF} with RH
- Investigate the underlying mechanisms for observed differences between κ_{CCN} and κ_{GF} and the variation of κ_{GF} with RH

References: [1] *Pajunoja, A., et al., Geophys. Res. Lett. 2015, 42, (8), 3063-3068.*
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