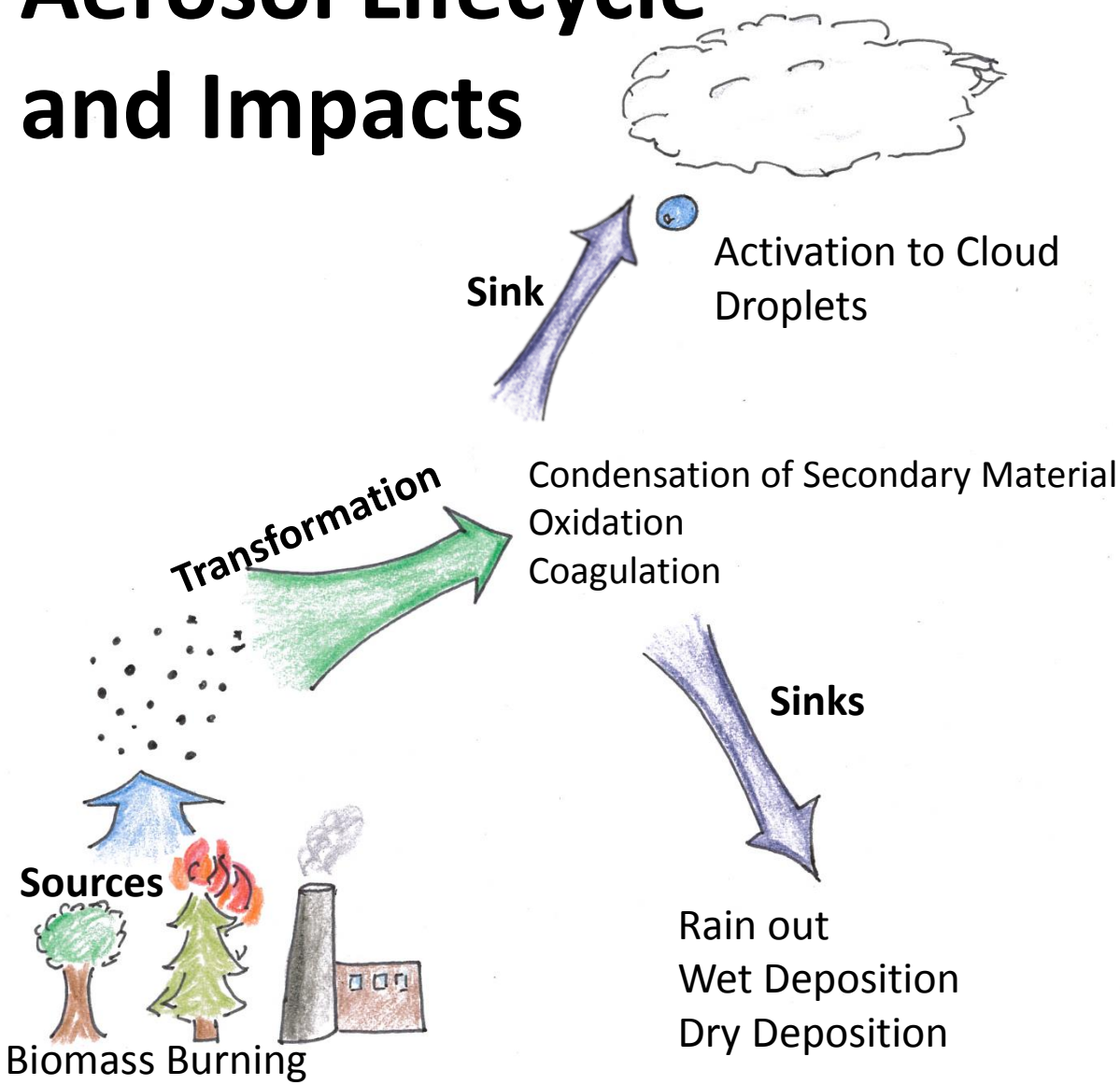
Ground measurements of aerosol hygroscopicity during Acridicon/Chuva campaign

H.M.J. Barbosa, M. L. Kruger, R. Thalman and J. Wang on behalf of the GoAmazon and ATTO teams

ACRIDICON-CHUVA

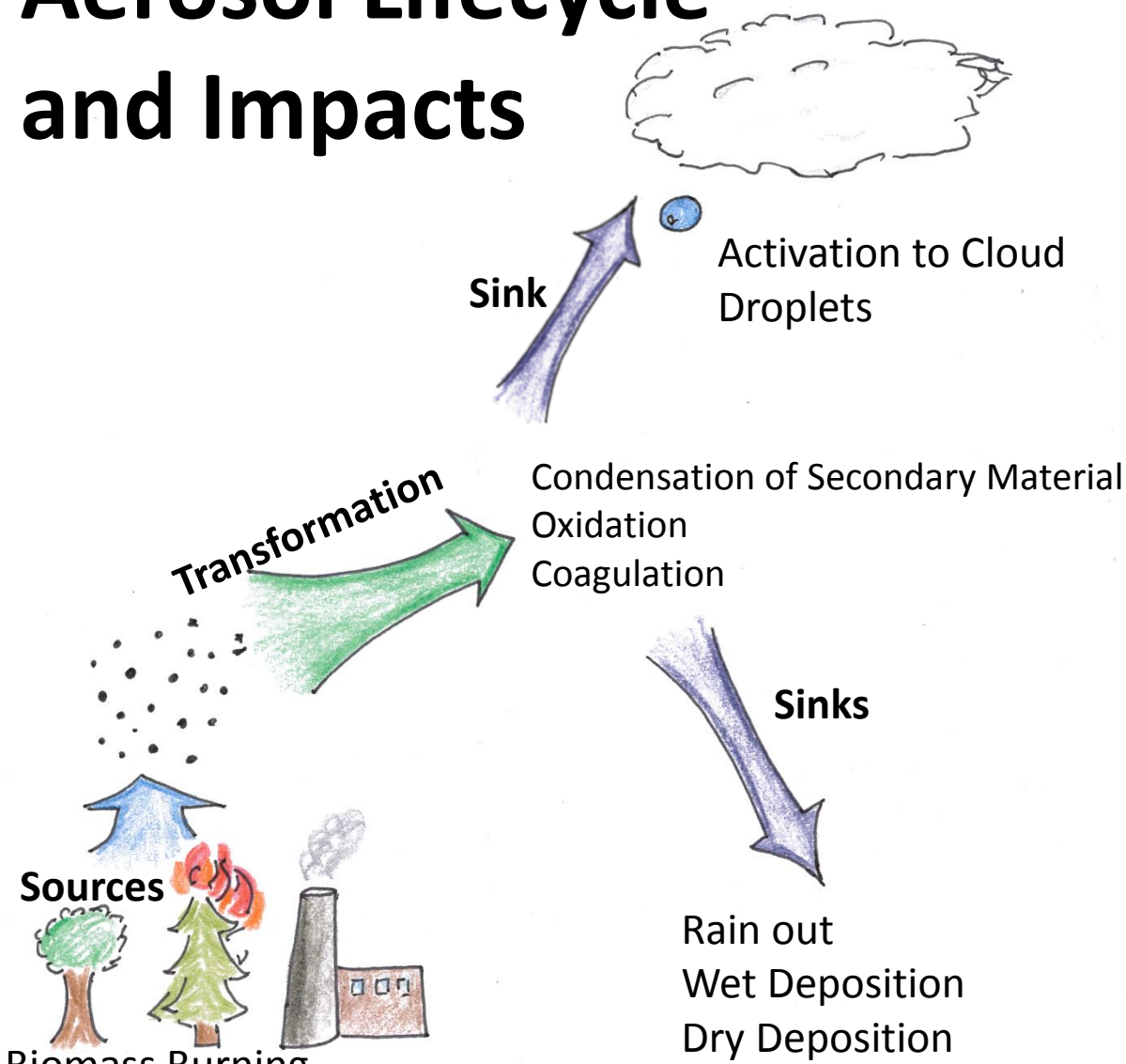
Ilha Bela, March 1st 2016

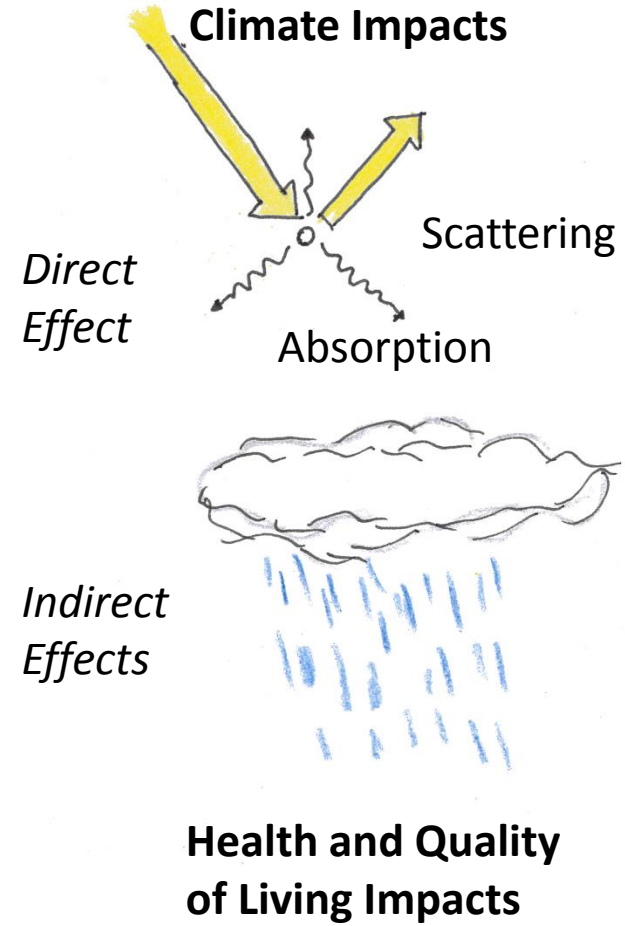
Aerosol Lifecycle and Impacts



R. Thalman

Aerosol Lifecycle and Impacts



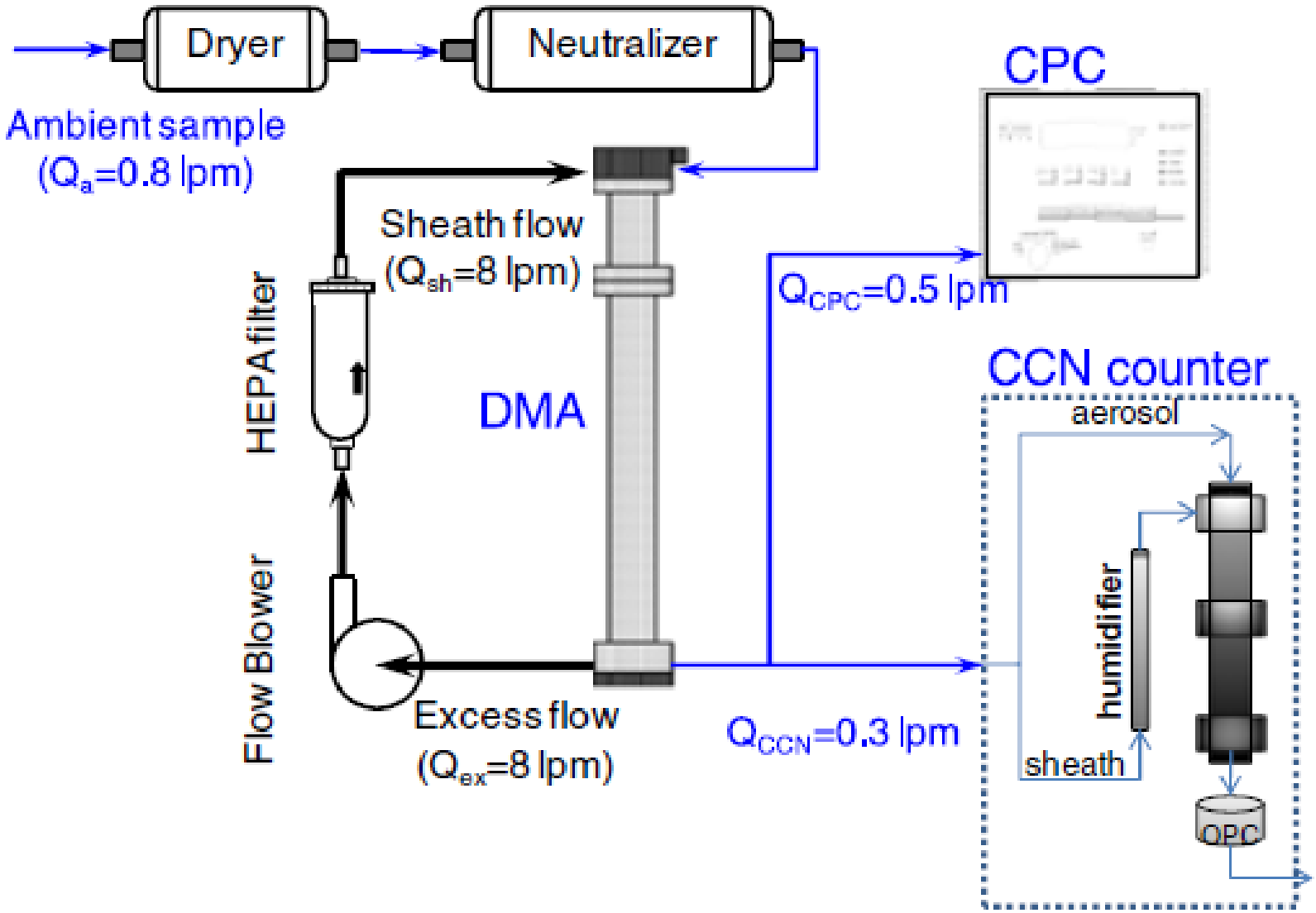


R. Thalman

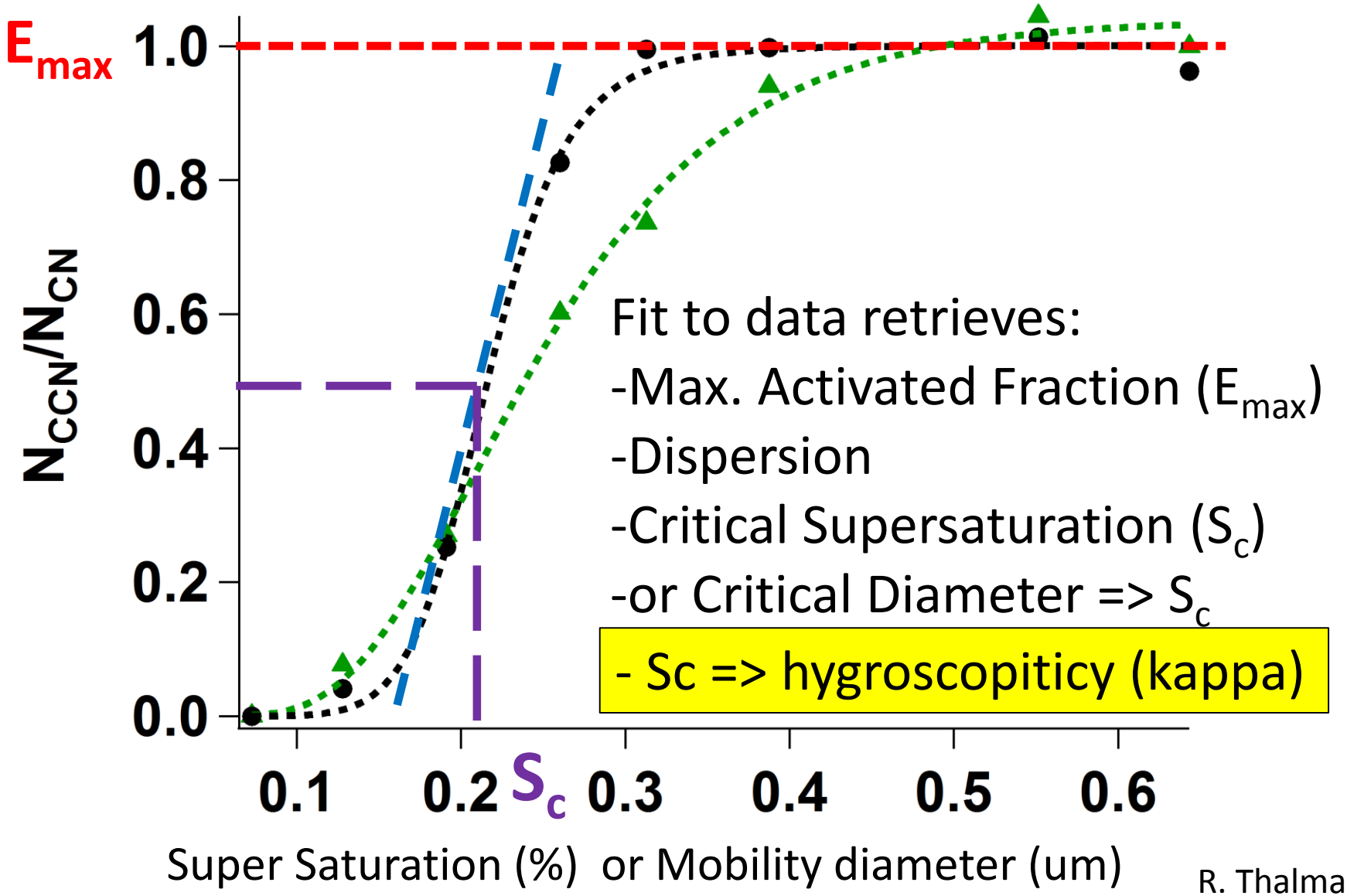
Motivation

- To quantify aerosol indirect forcing requires the knowledge of CCN concentration.
- Organics often dominate submicron aerosol mass, and consist of thousands of species with hygroscopicities (κ, Petters & Kreidenweis, 2007) ranging from 0 to 0.3.
- CCN concentration are sensitive to organic hygroscopicities, especially for aerosols under natural conditions (i.e., pre-industrial era, Liu and Wang, 2010).

Size resolved CCN measurements



Particle Activation



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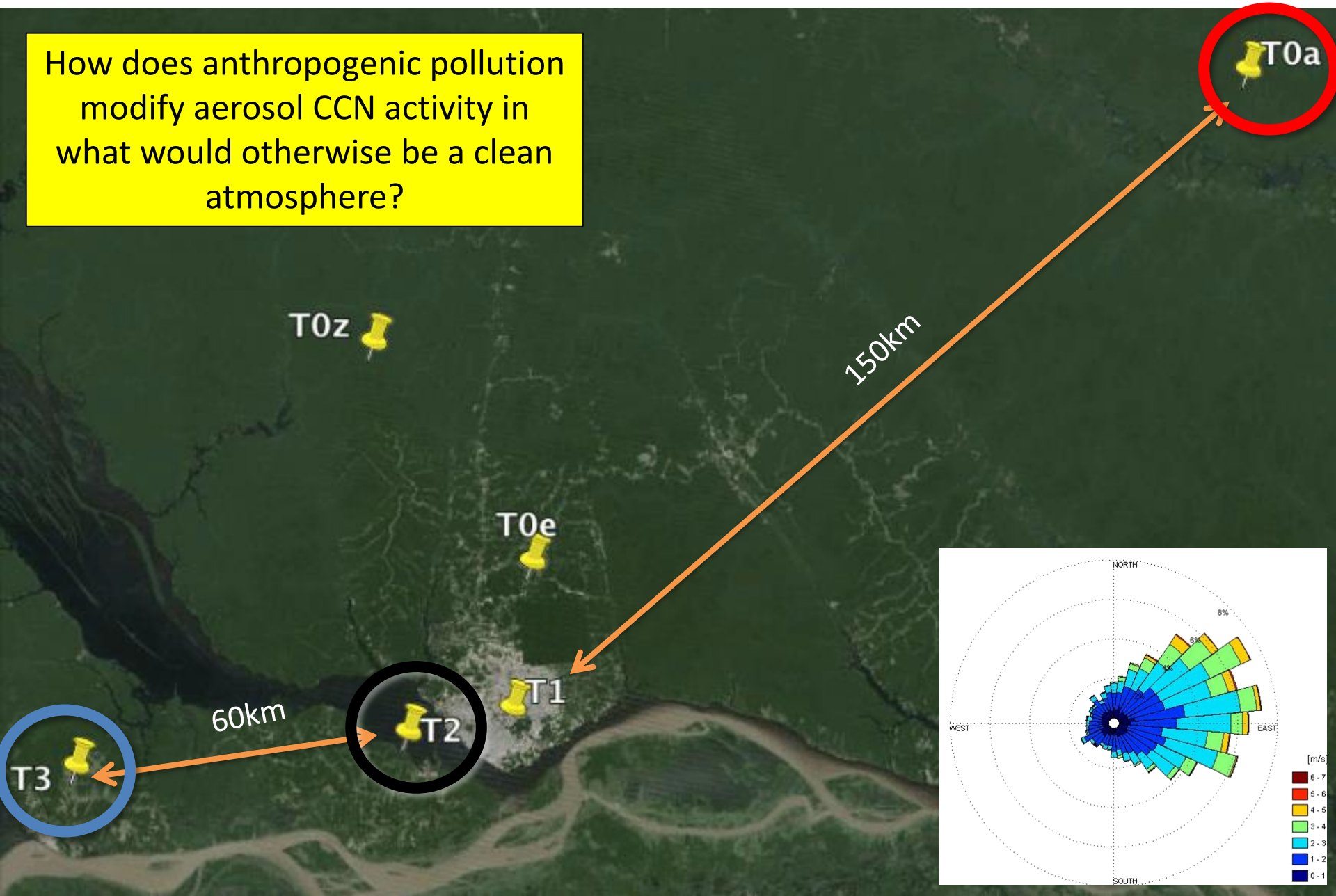
Experimental Sites

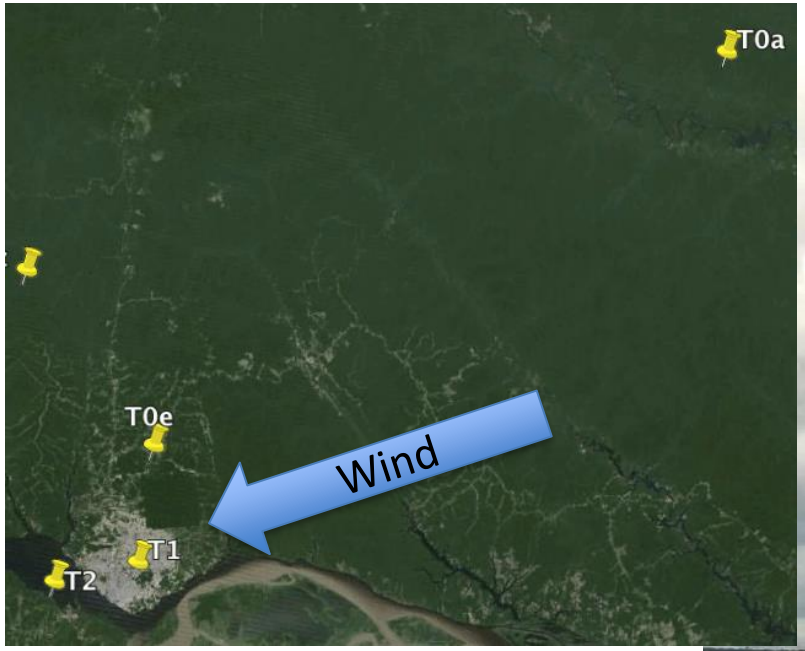
How does anthropogenic pollution modify aerosol CCN activity in what would otherwise be a clean atmosphere?



Instrument Setups

- T3, 70km downwind, 10/Mar/14 to 3/Mar/15
  - Fix size, scan SS (changing Temp & Flow)
  - Long DMA
- T2, 5km downwind, 15/Sep/14 to 28/Feb/15
  - Fix SS, scan size
  - Long DMA
- T0, 150km upwind, continuous from Mar/14
  - Fix SS, scan size
  - Nano DMA (different transfer function)

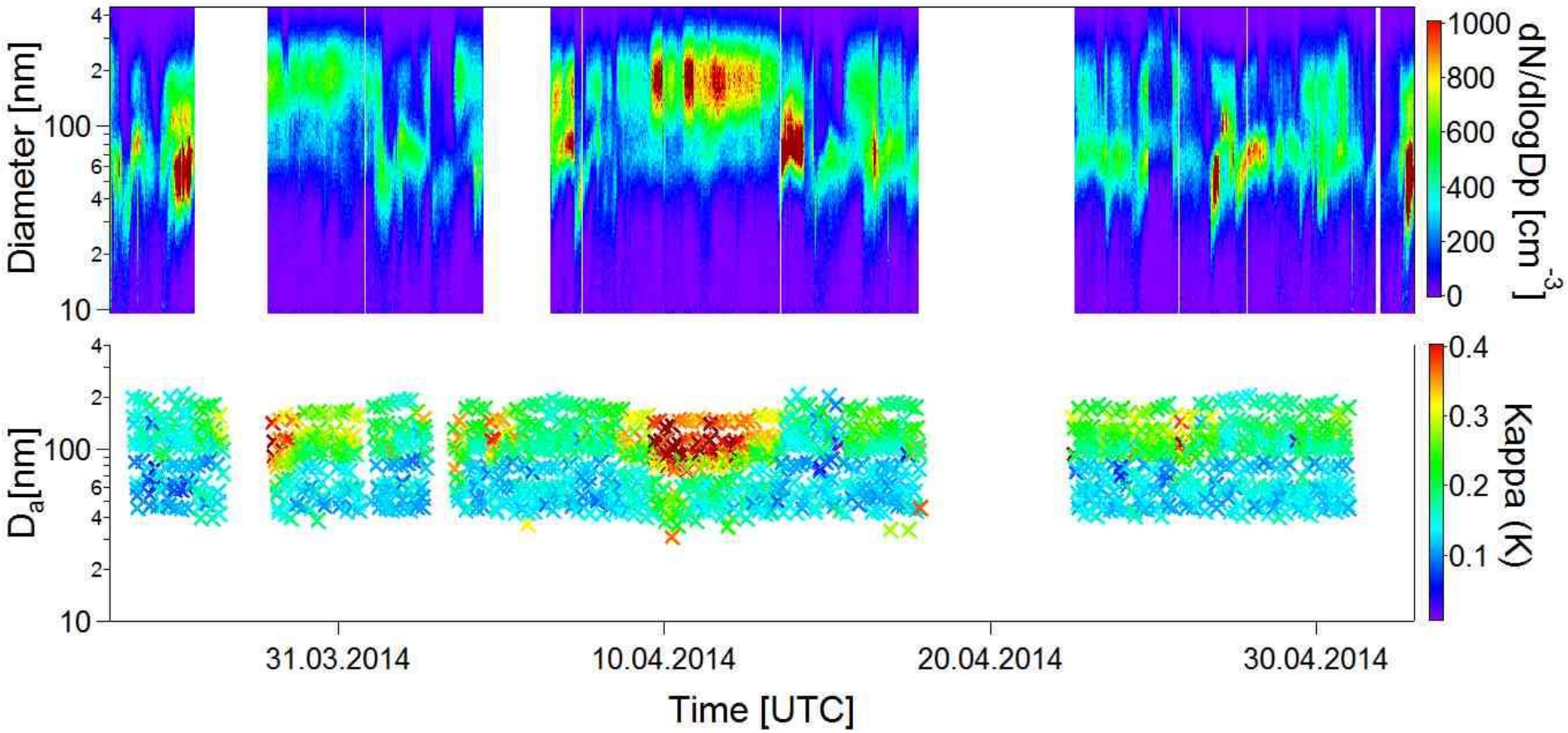
T0a site – 150km upwind



- Not affected by Manaus plume
- Affected by long-range BB

Photos: ATTO team

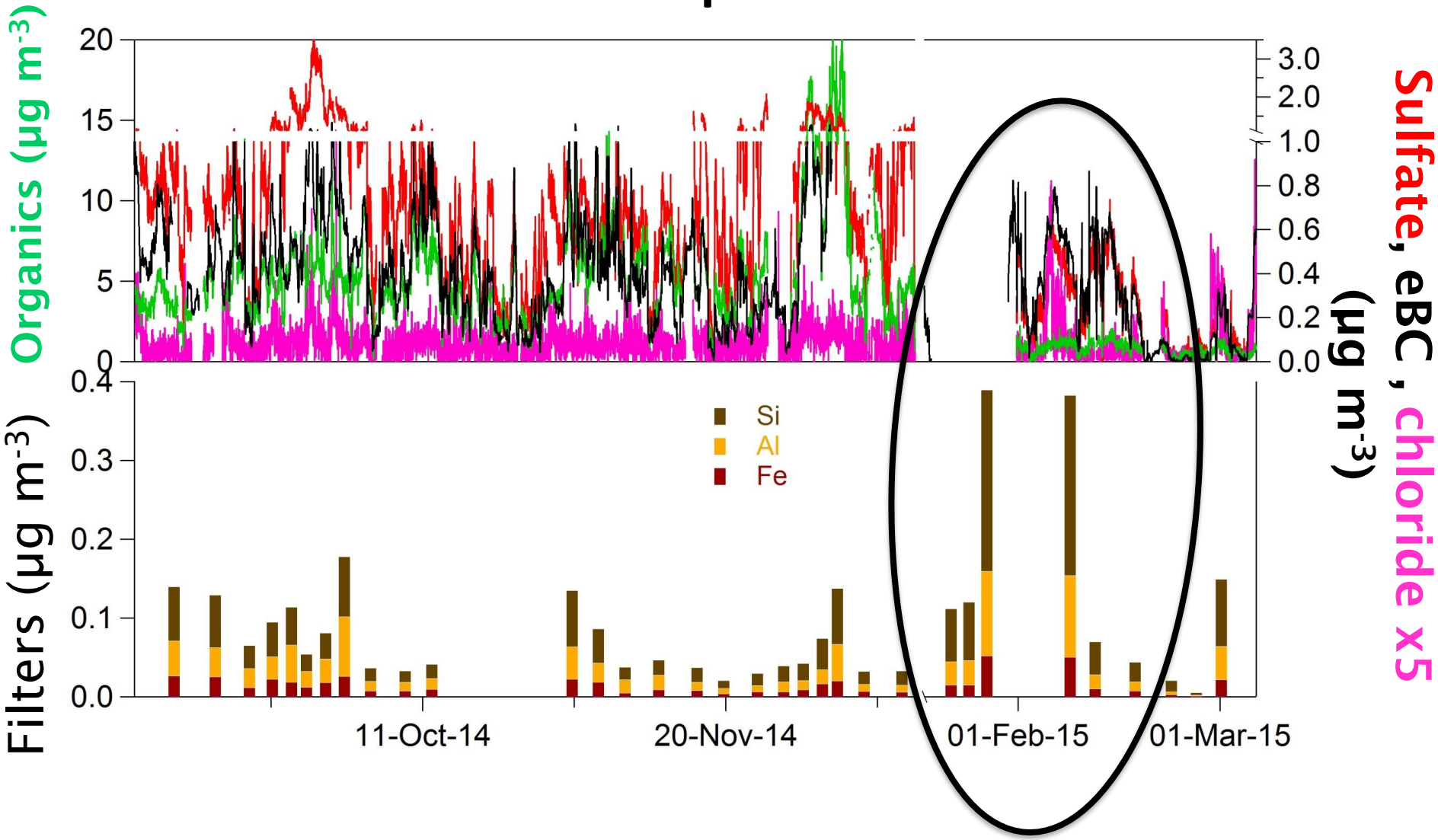
CCN Data @ ATTO during Apr 2014



- long range transport ~10 Apr 2014
- high CN conc. correlate with low K → high organic fraction

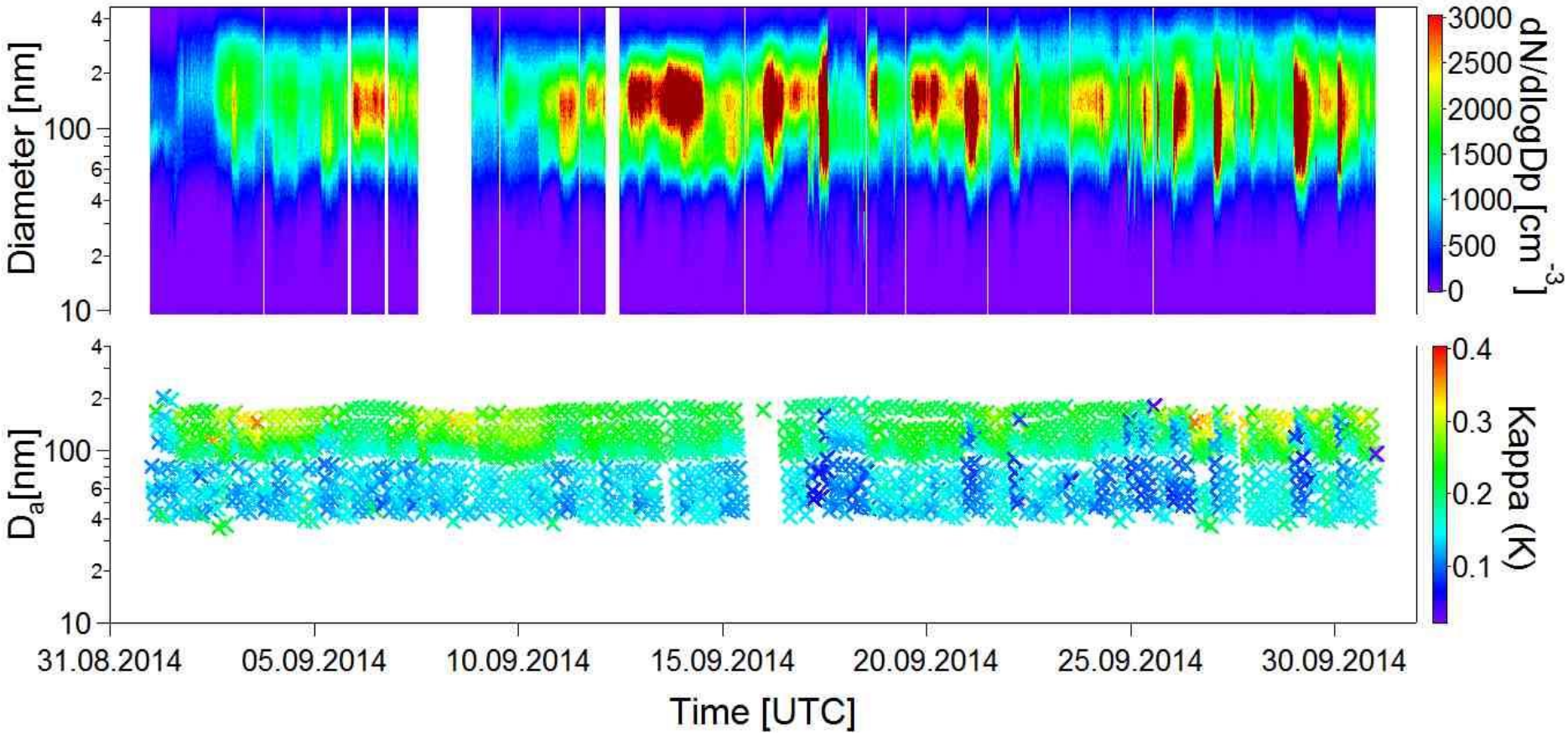
Mira Pöhlker et. al. ACP, in prep.

Events of transport over ocean



S. Carbone, AGU 2015 ,A31A-0019

CCN Data @ ATTO during Sep 2014



- Kappa (K) for Aitken mode ≠ K for Accumulation mode

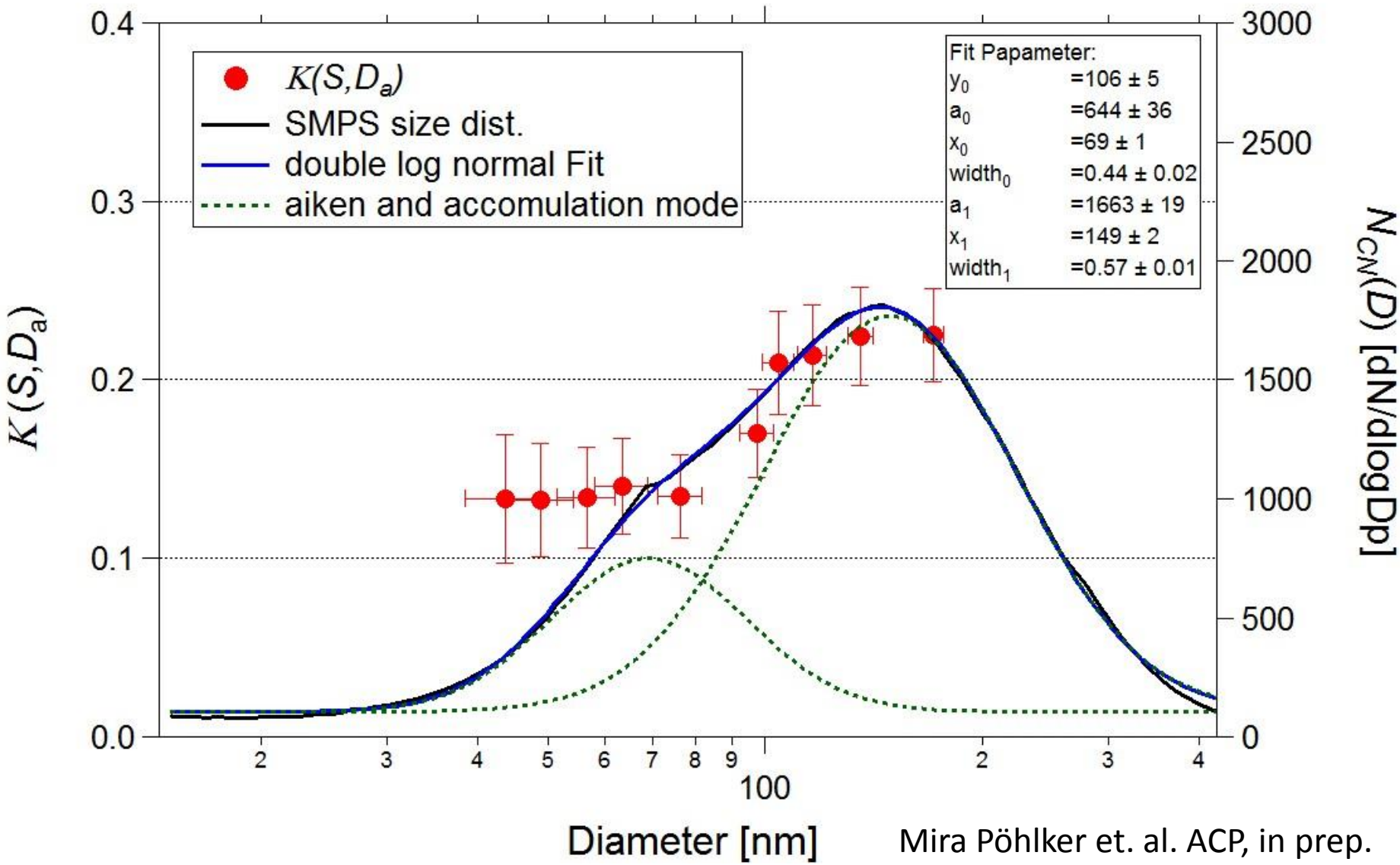
  → differences in chemical composition

- high CN conc. correlate with low K → high organic fraction

Mira Pöhlker et. al. ACP, in prep.

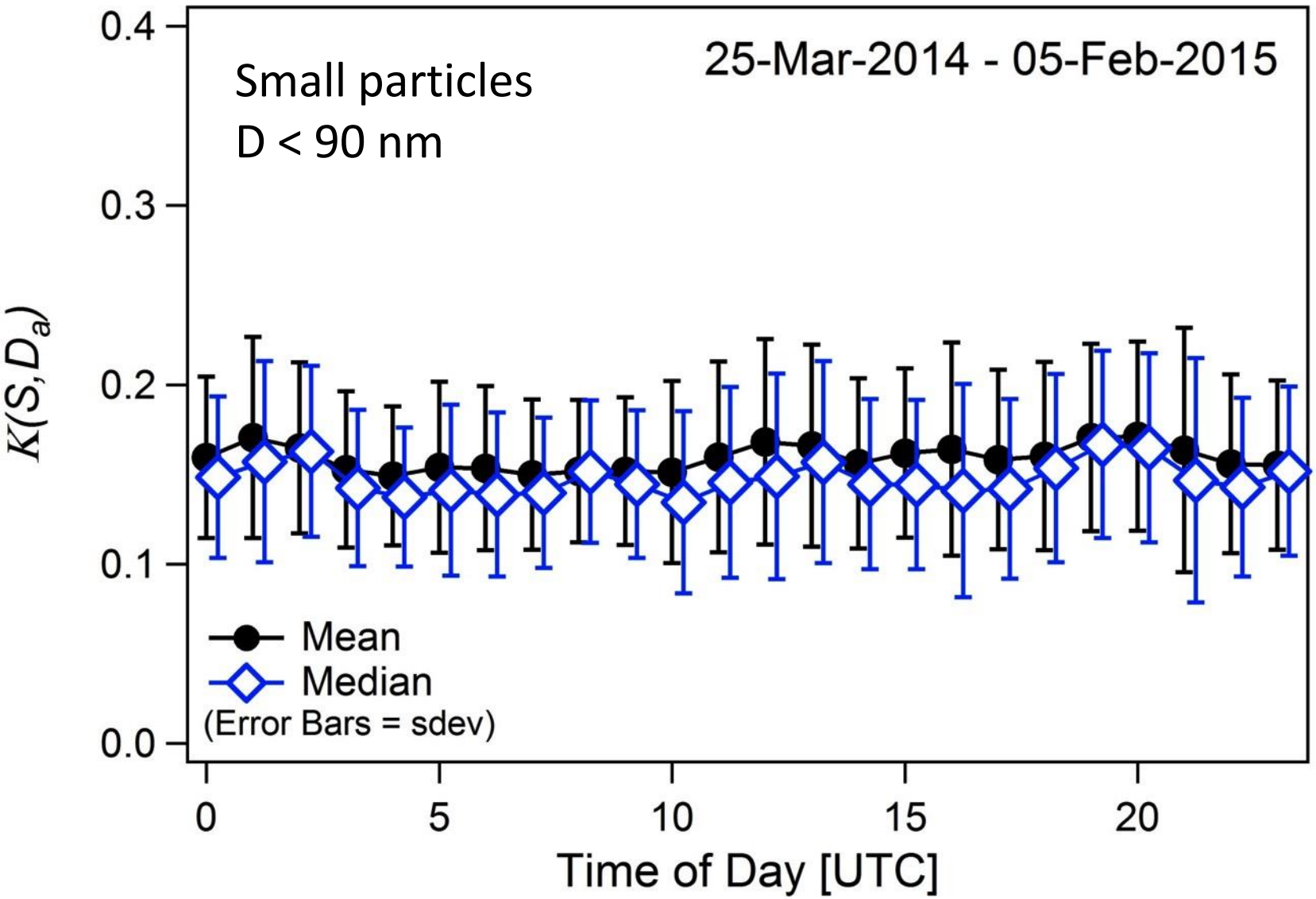
kappa size dependence @ ATTO

ATTO Mar 2014- Feb 2015



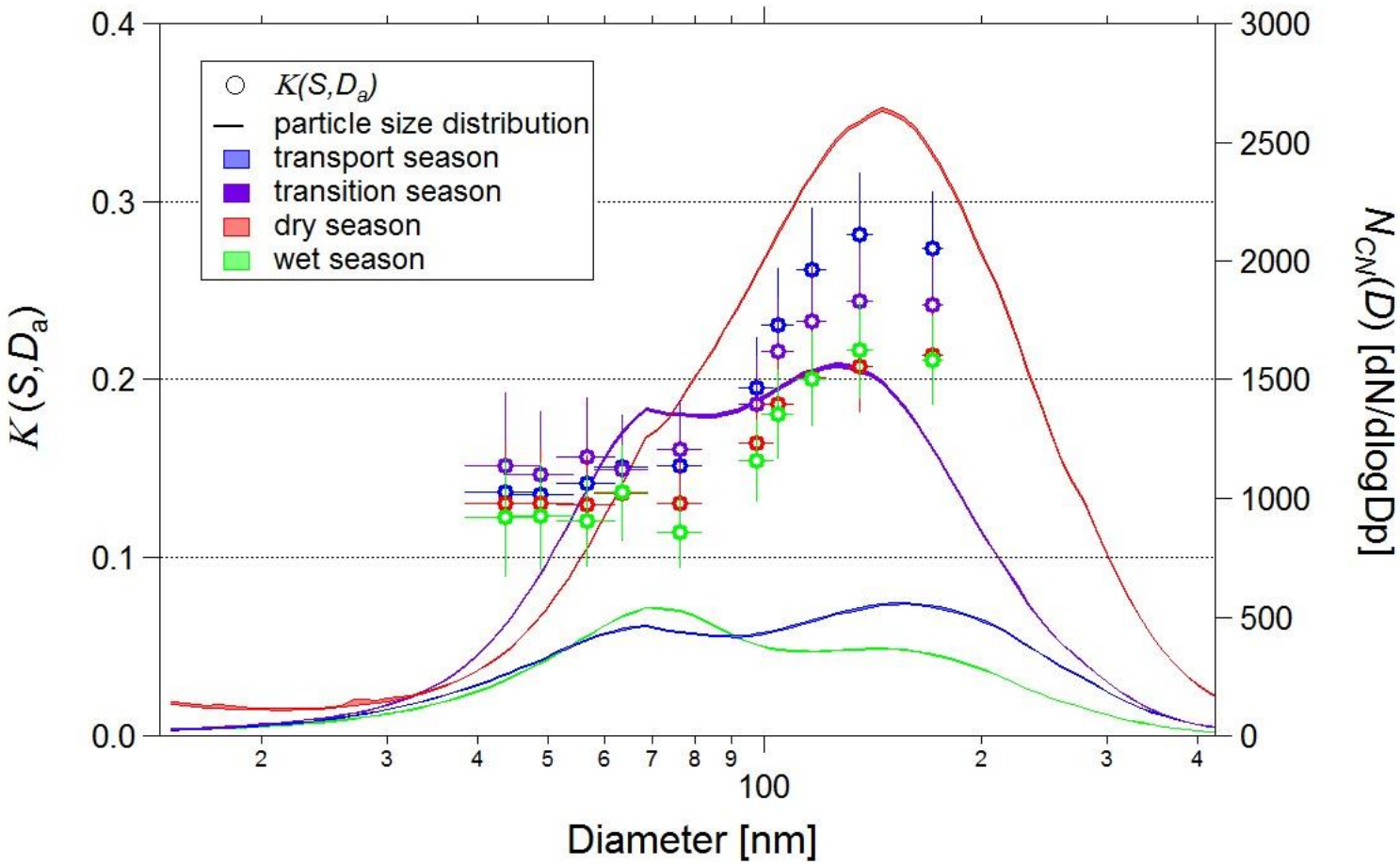
Mira Pöhlker et. al. ACP, in prep.

Diurnal cycle @ ATTO



Mira Pöhlker et. al. ACP, in prep.

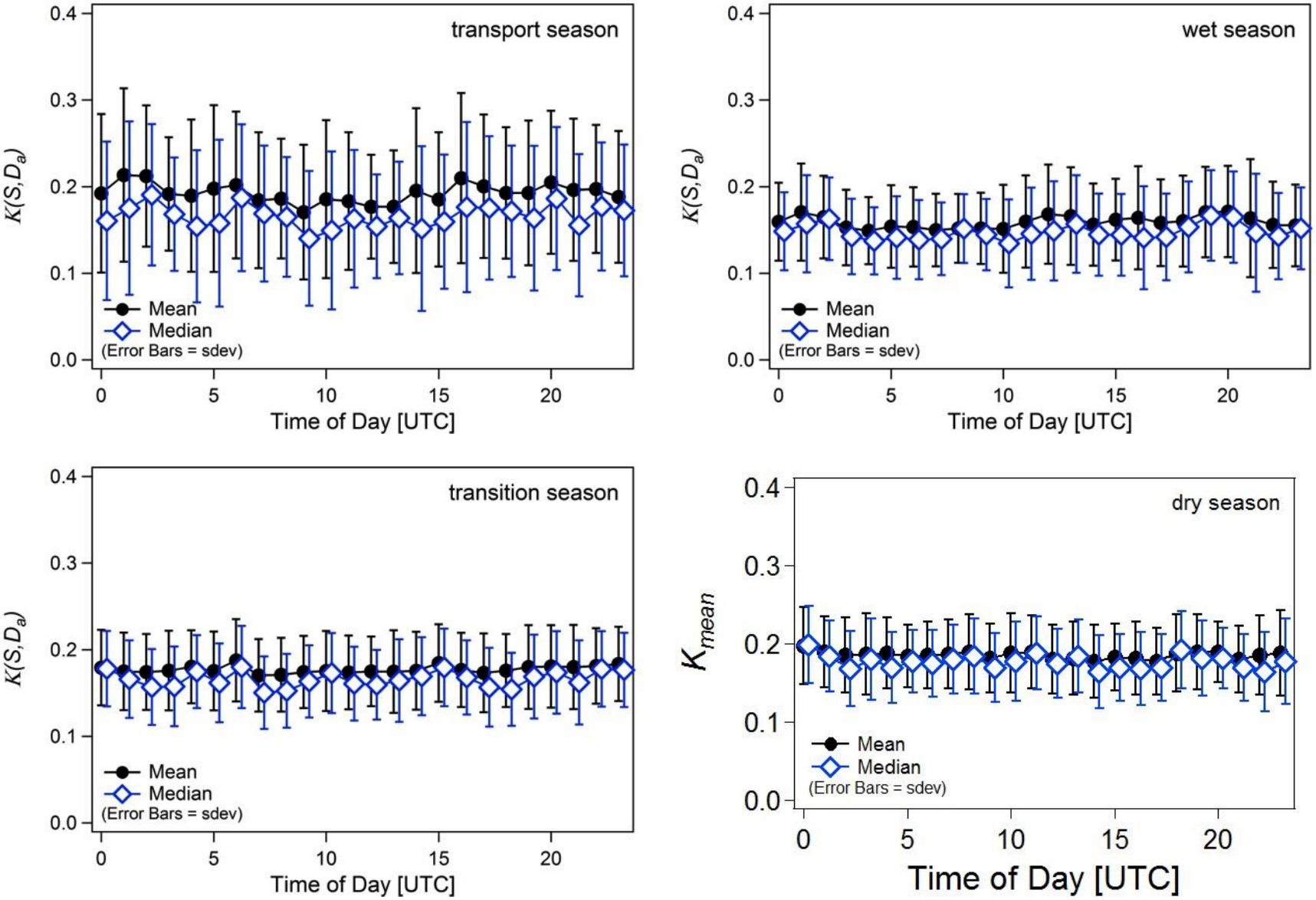
kappa size dependence @ ATTO



transport season → Mar to Apr-13-2014 and Jan to Feb-2015
wet season → Apr-13 to May-2014
transition season → Jun to Jul-2014
dry season → Aug to Dec-2014

Mira Pöhlker et. al. ACP, in prep.

Diurnal cycle @ ATTO



Mira Pöhlker et. al. ACP, in prep.

T3 site – 70km downwind

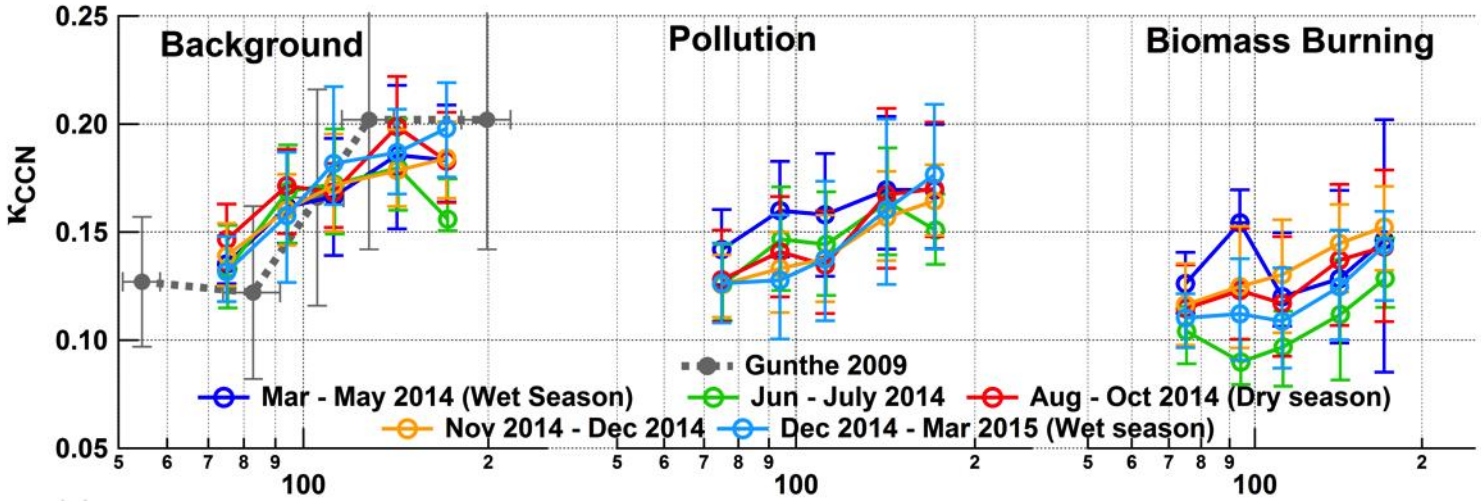
Photo: R. Thalman

- Mixed medium-field Manaus aged plume and clean conditions
- Affected by long and short-range BB

Photo: J. Beat

Particle and organic κ @ T3

Accumulation mode (ave 112, 142 and 171nm)



Organic hygroscopicity (κ_{org}):

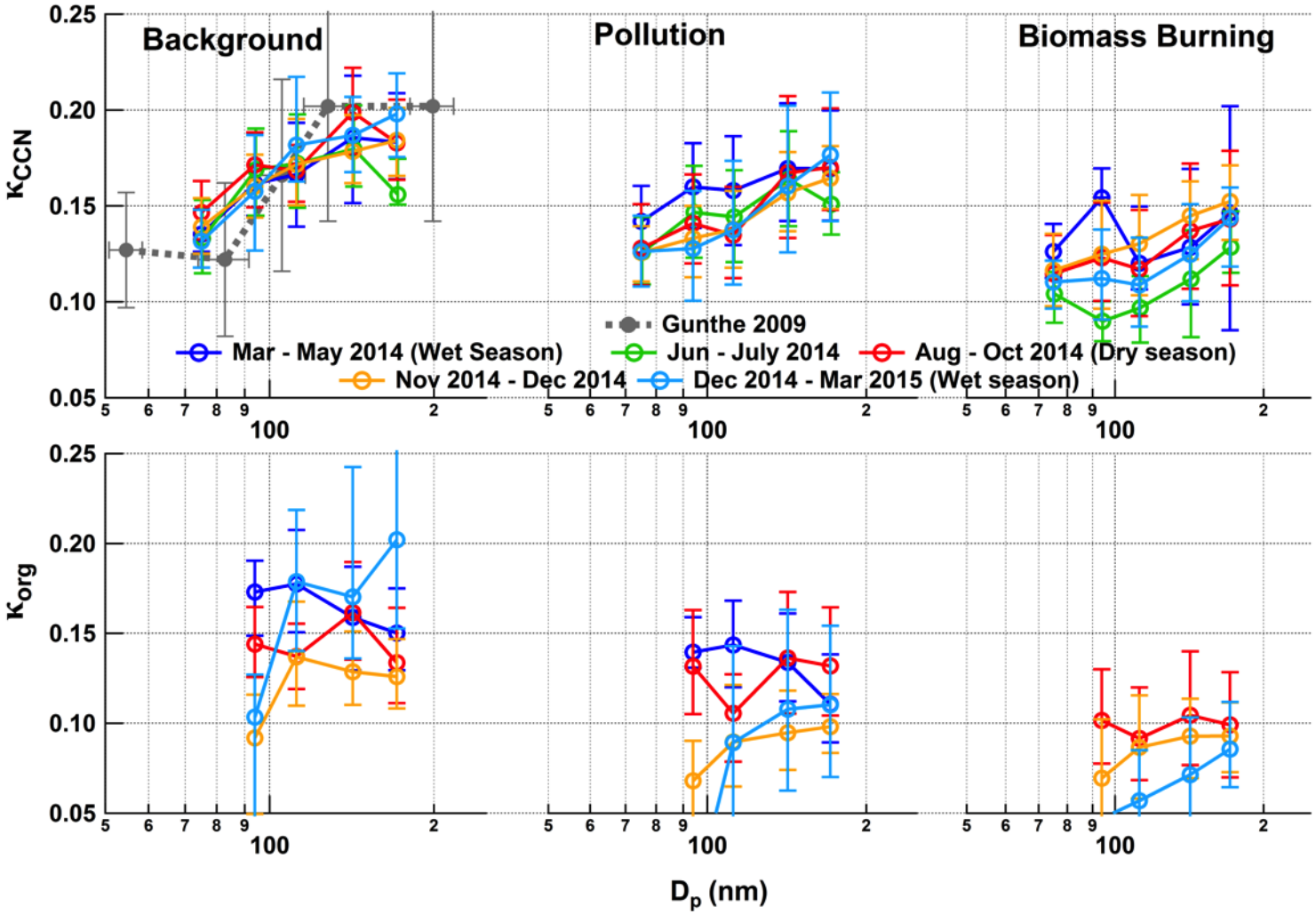
$$k_{org} = \frac{1}{x_{org}}\left(k_{CCN} - k_{NH_4NO_3}\, x_{NH_4NO_3} - k_{(NH_4)_2SO_4}\, x_{(NH_4)_2SO_4}\right)$$

Volume fractions derived from AMS and absorption data

R. Thalman et al, ACP in prep

Particle and organic κ @ T3

Accumulation mode (ave 112, 142 and 171nm)



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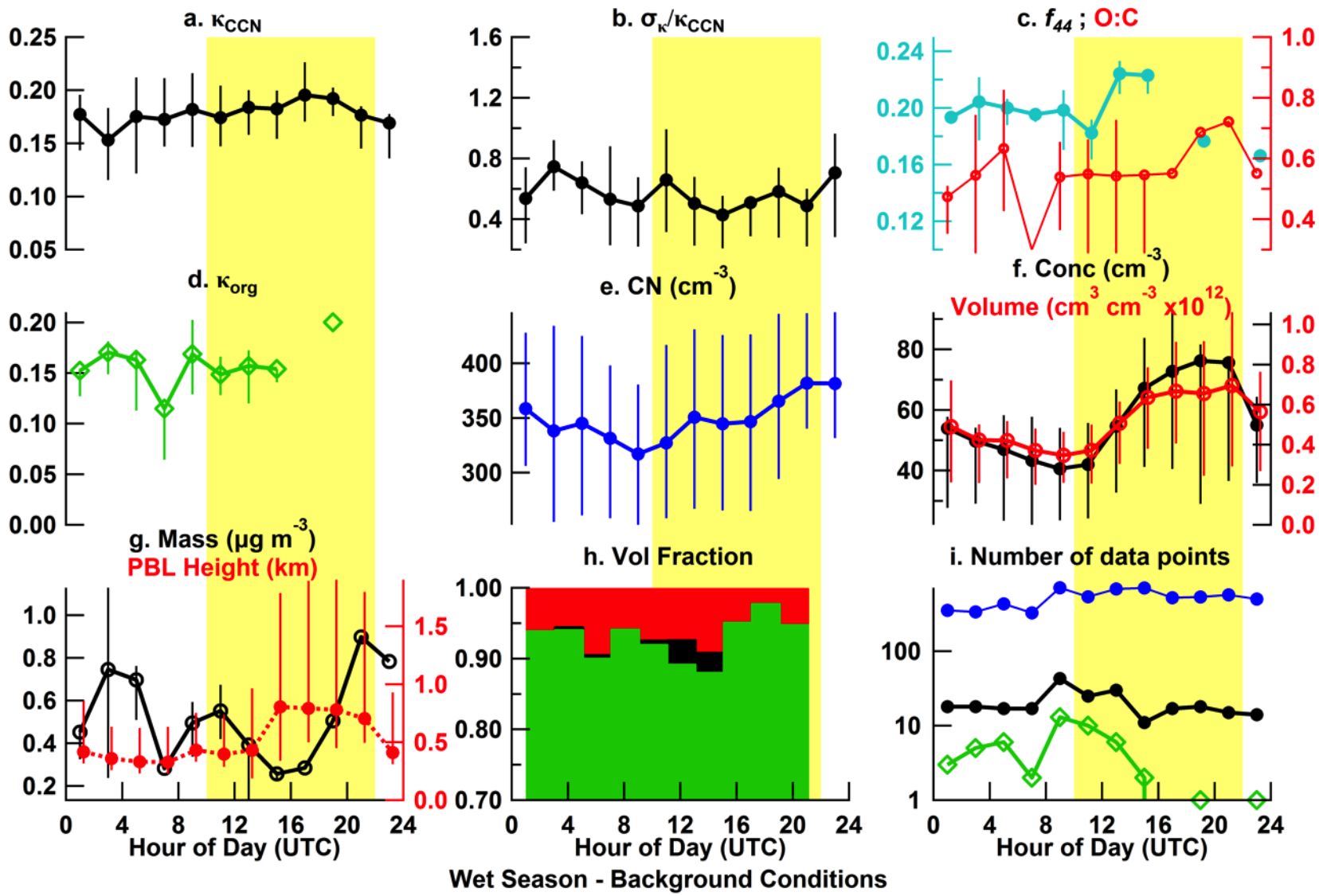
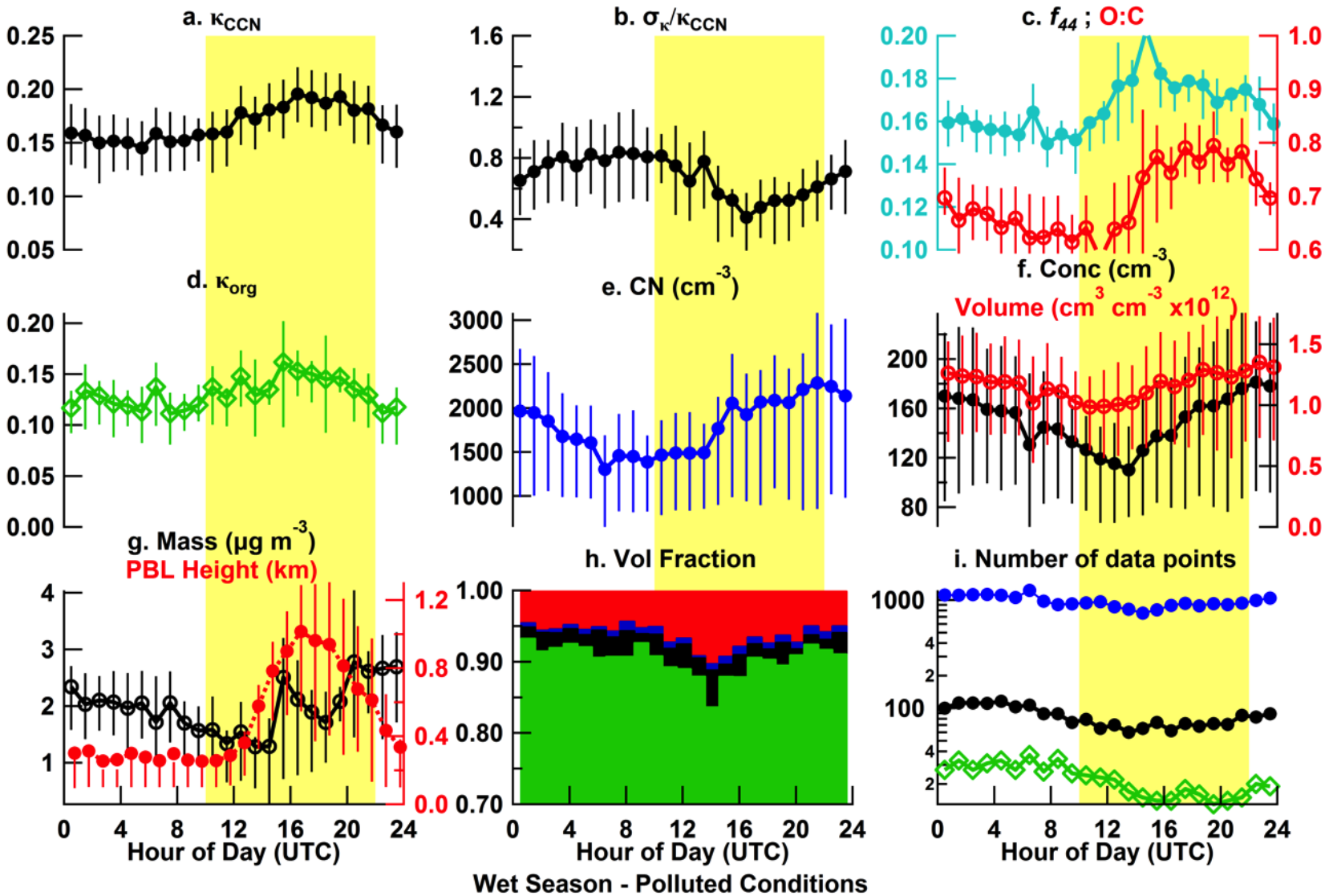
Diel cycle, background, wet season @ T3



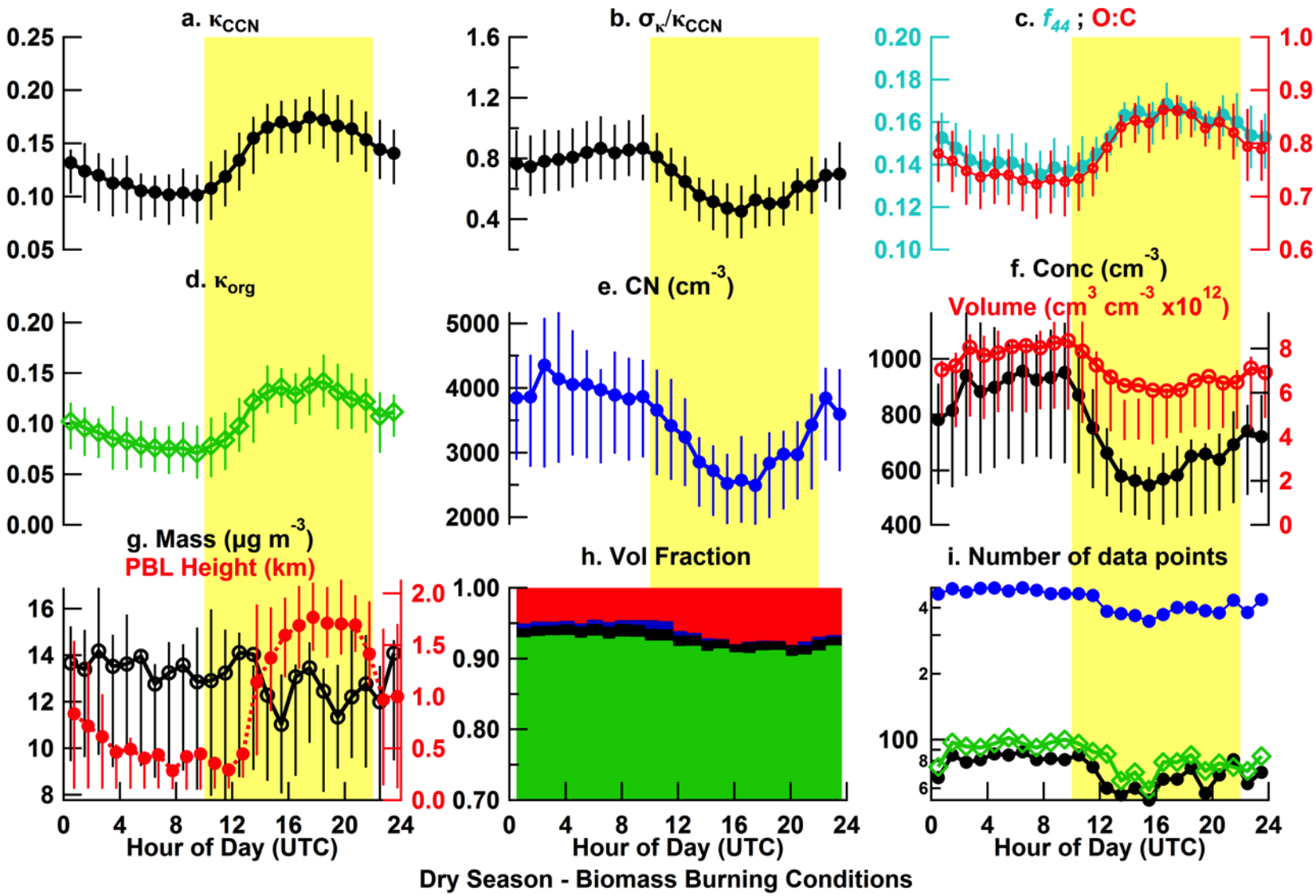
R. Thalman et al, ACP in prep

Diel cycle, polluted, wet season @ T3



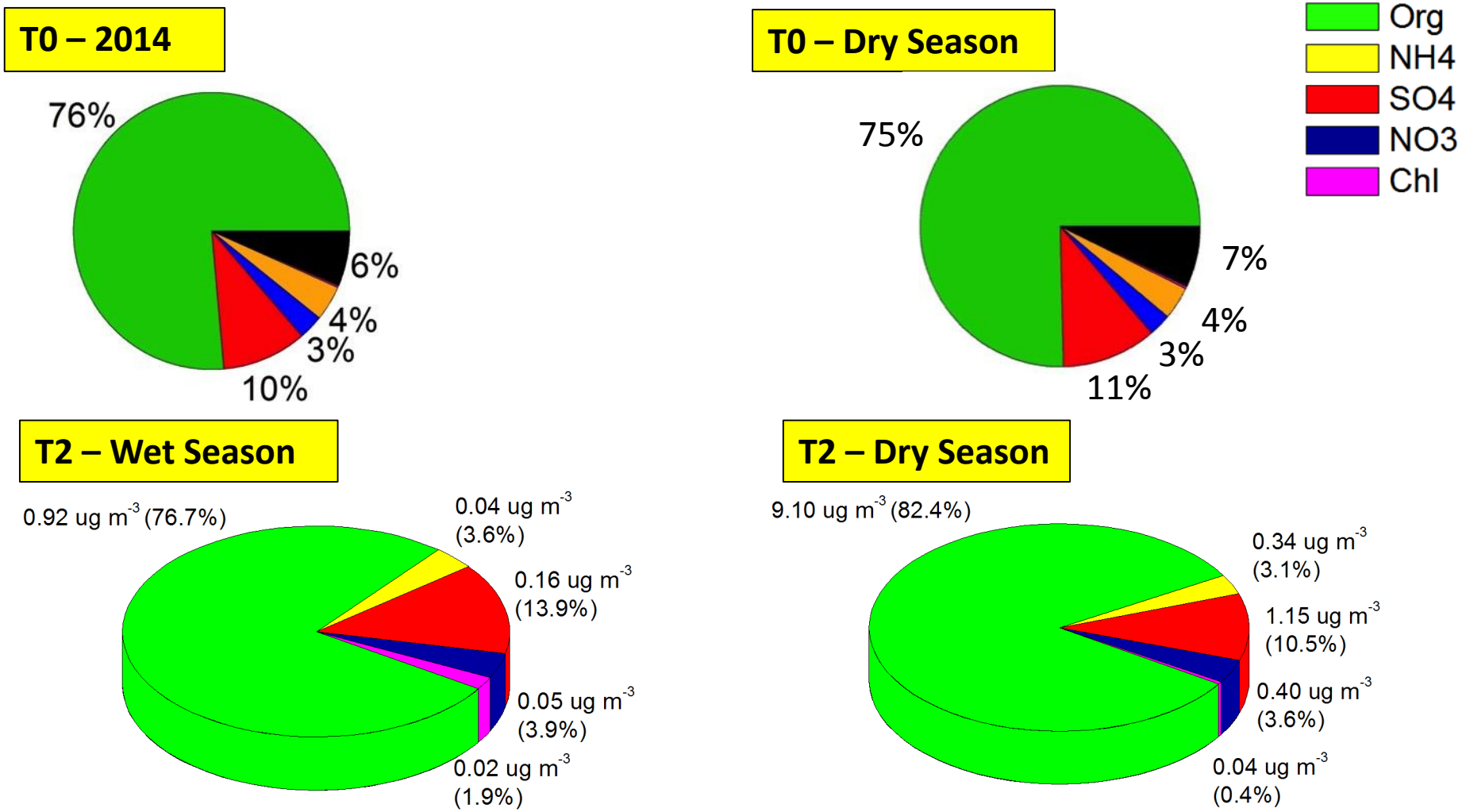
R. Thalman et al, ACP in prep

Diel cycle, biomass burning, dry @ T3



R. Thalman et al, ACP in prep

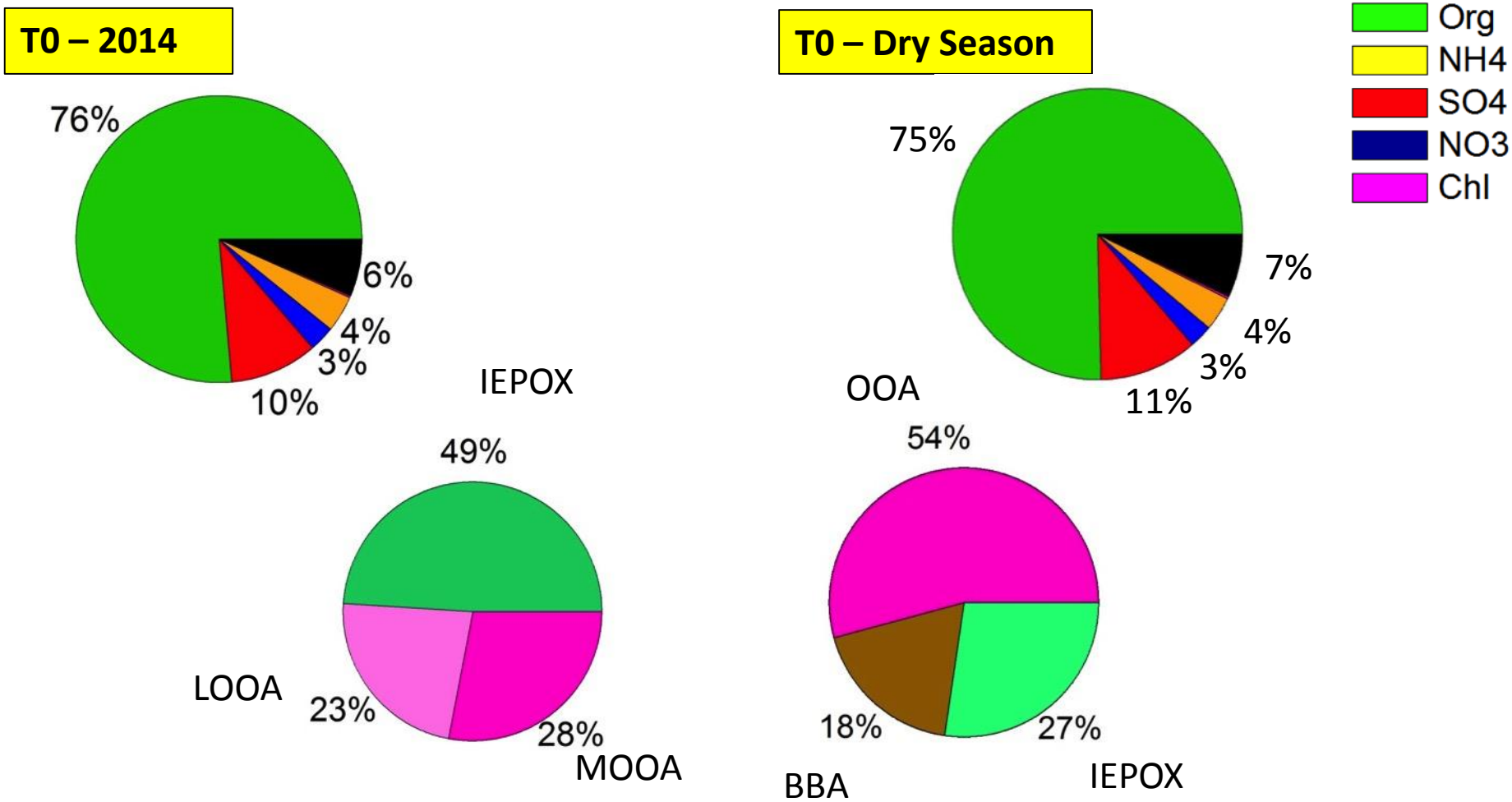
Non-refractory species



S. Carbone, AGU 2015 A31A-0019

J. Brito, AGU 2014

Non-refractory species



S. Carbone, AGU 2015 A31A-0019

Hygroscopicities of PMF factors

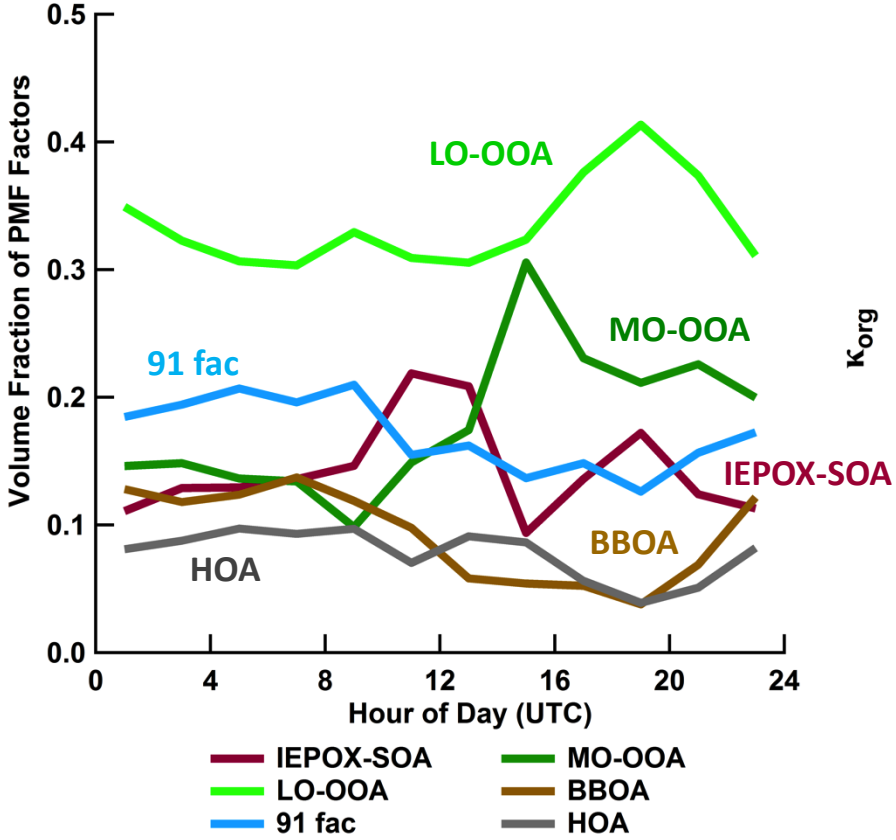
- Factors were identified through positive matrix factorization (PMF) analysis of HR-ToF-AMS data during the two IOPs.

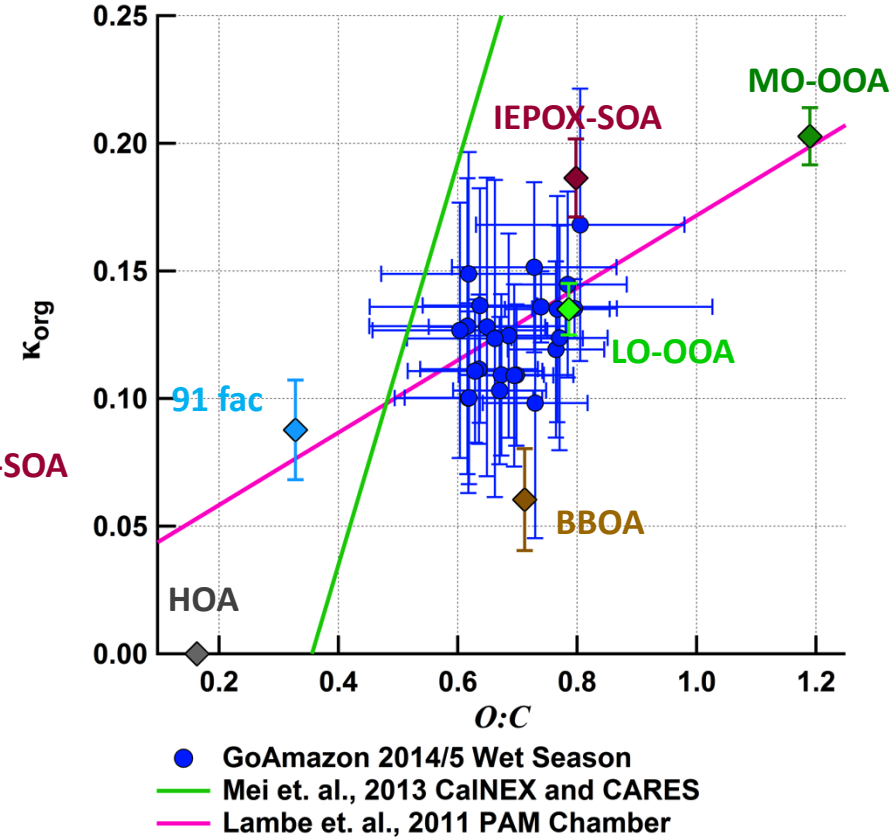
$$k_{org} = x_{factor1} k_{factor1} + x_{factor2} k_{factor2} + \ldots$$

- Hygroscopicities of PMF factors were derived using multivariable linear regression of the time series of κ_{org} and PMF factor volume fractions.

R. Thalman , AGU 2015 A31A-0013

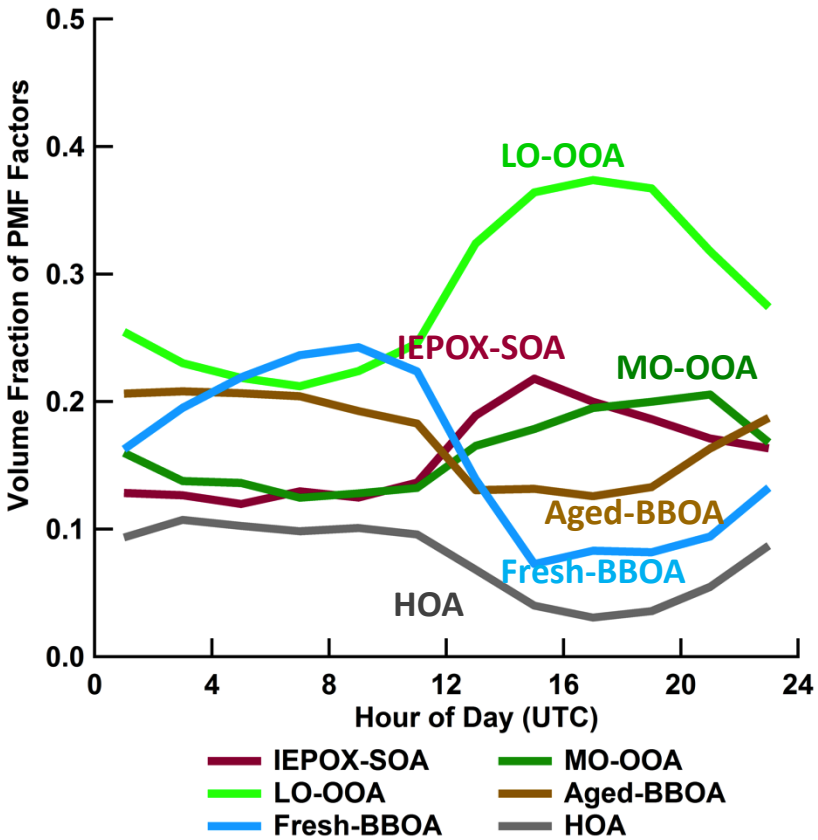
Variations of organic hygroscopicity (wet season)

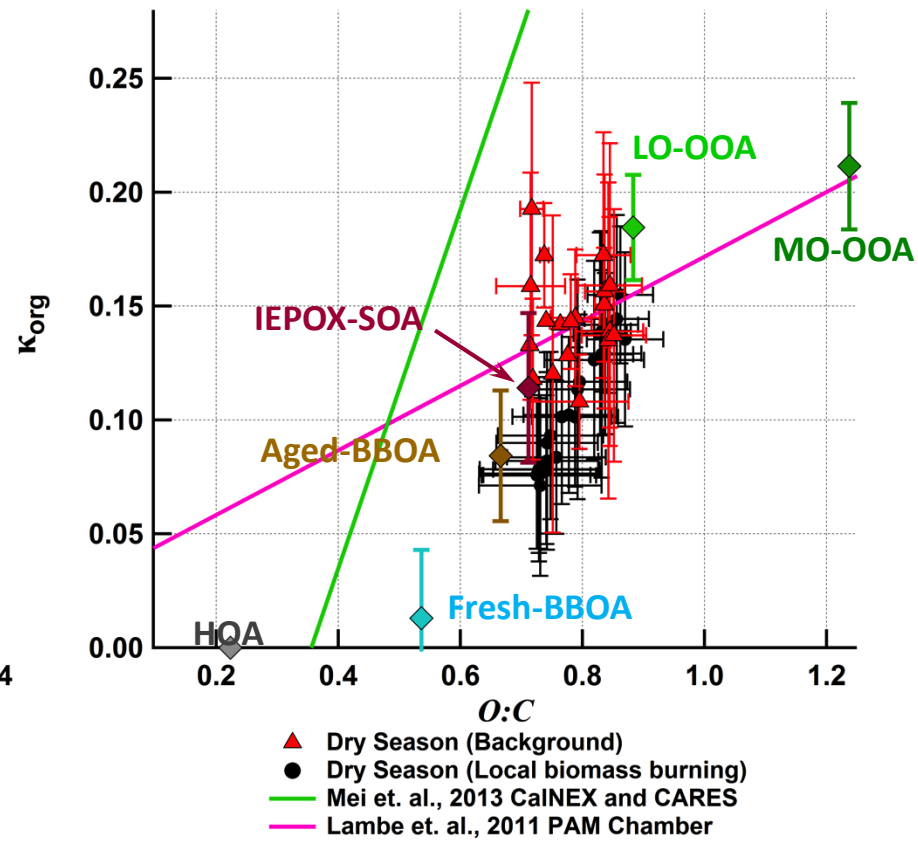




The variation of O:C is largely due to the variation of POA volume fraction in the particles

Variation of organic hygroscopicity (dry season)





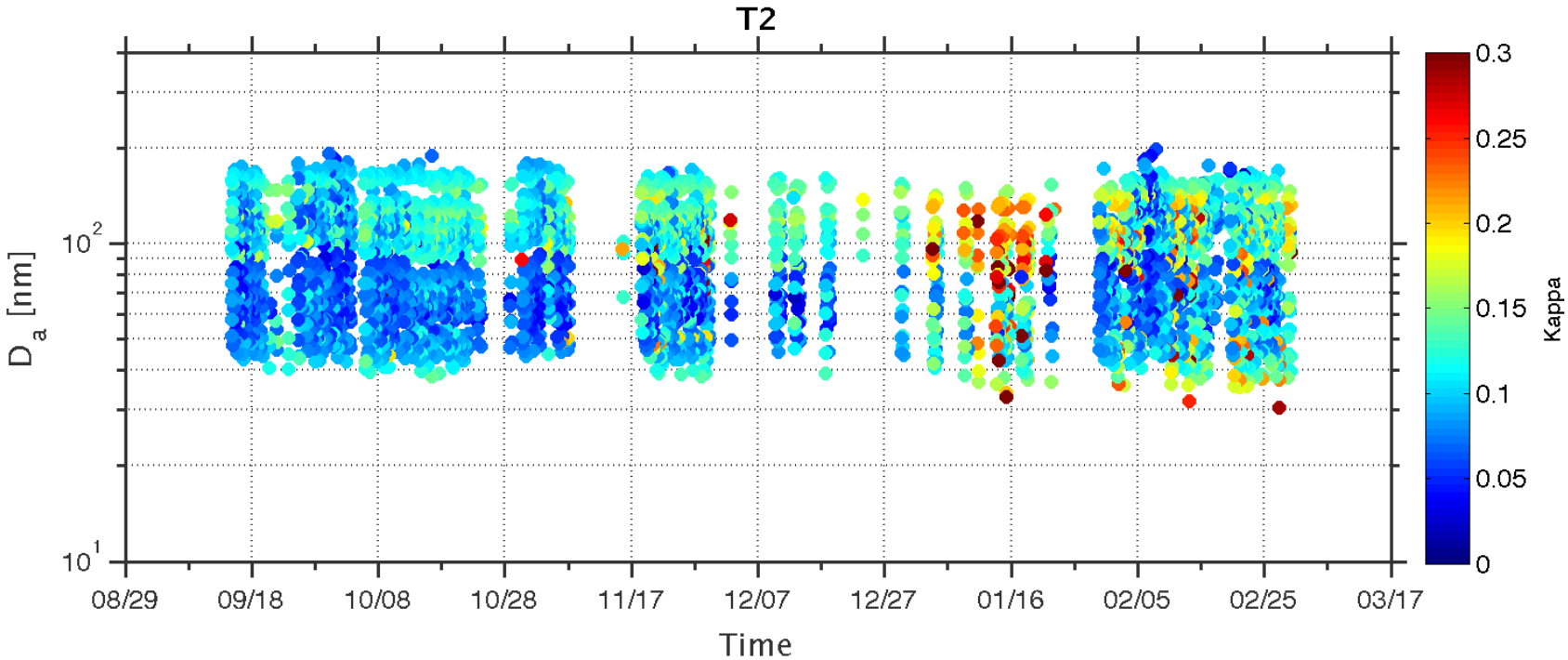
The variation of O:C is largely due to the variation of POA volume fraction in the particles

T2 site – 5km downwind

Photo: P. Artaxo

- Most of the time in near-field Manaus plume
- Affected by long-range BB

CCN data @ T2
14/Sep/2014 – 1/Mar/2015



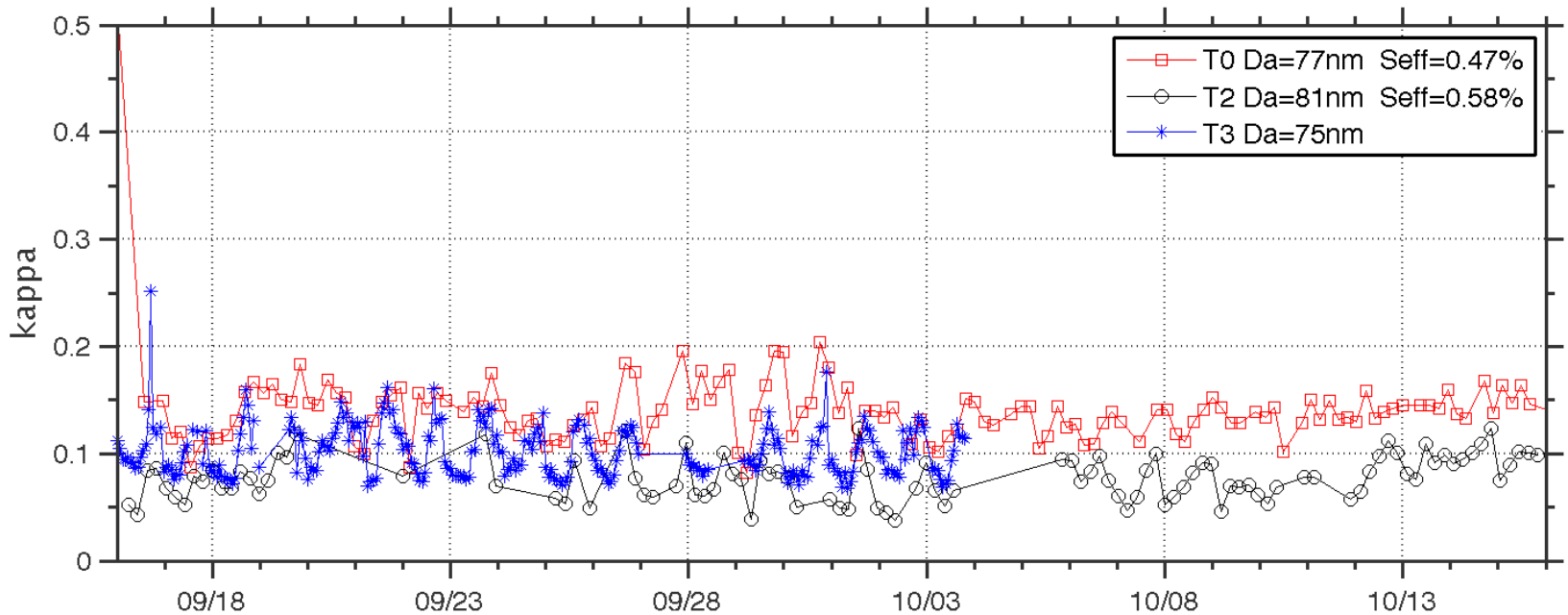
- Kappa (K) for Aitken mode ≠ K for Accumulation mode

  → differences in chemical composition

- Episodes of high hygroscopicity in Feb/2015

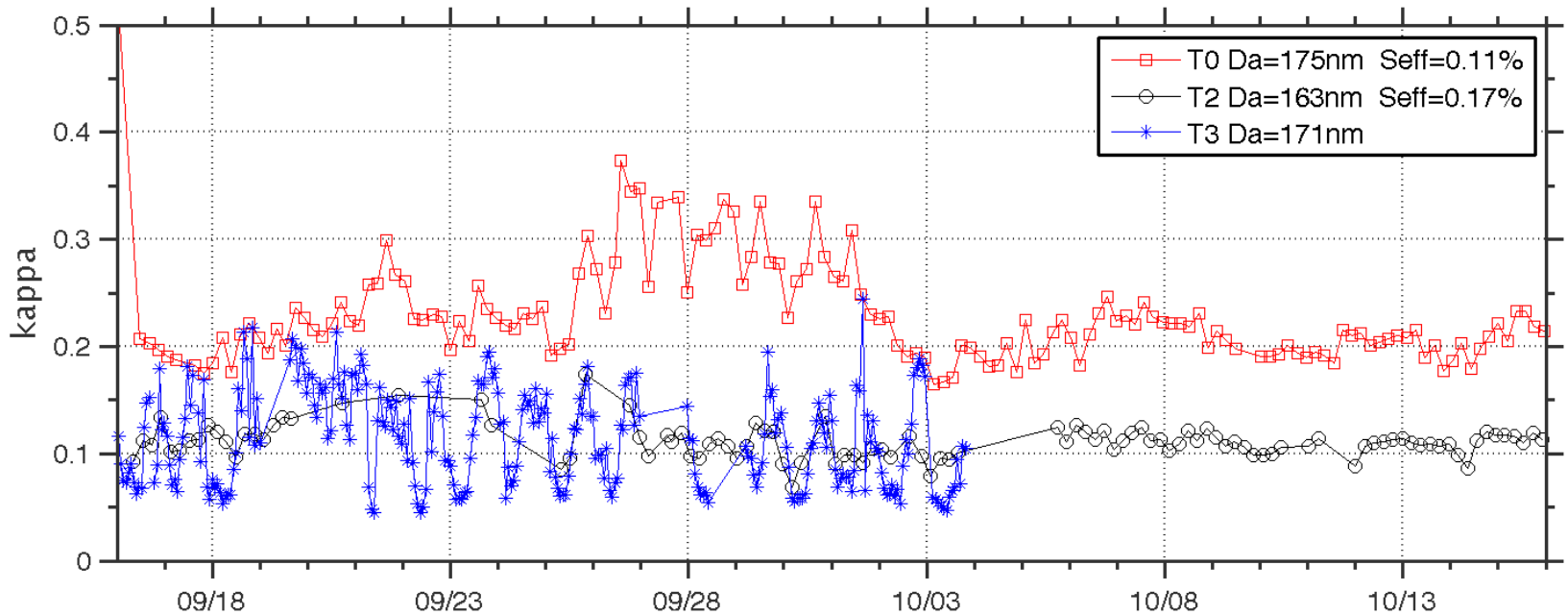
For IOP2, dry season – High SS

	D_c	S_c	Kappa
T0	77 nm	0.47 %	0.14±0.03
T2	81 nm	0.58 %	0.08±0.02
T3	75 nm	0.57 %	0.10±0.04

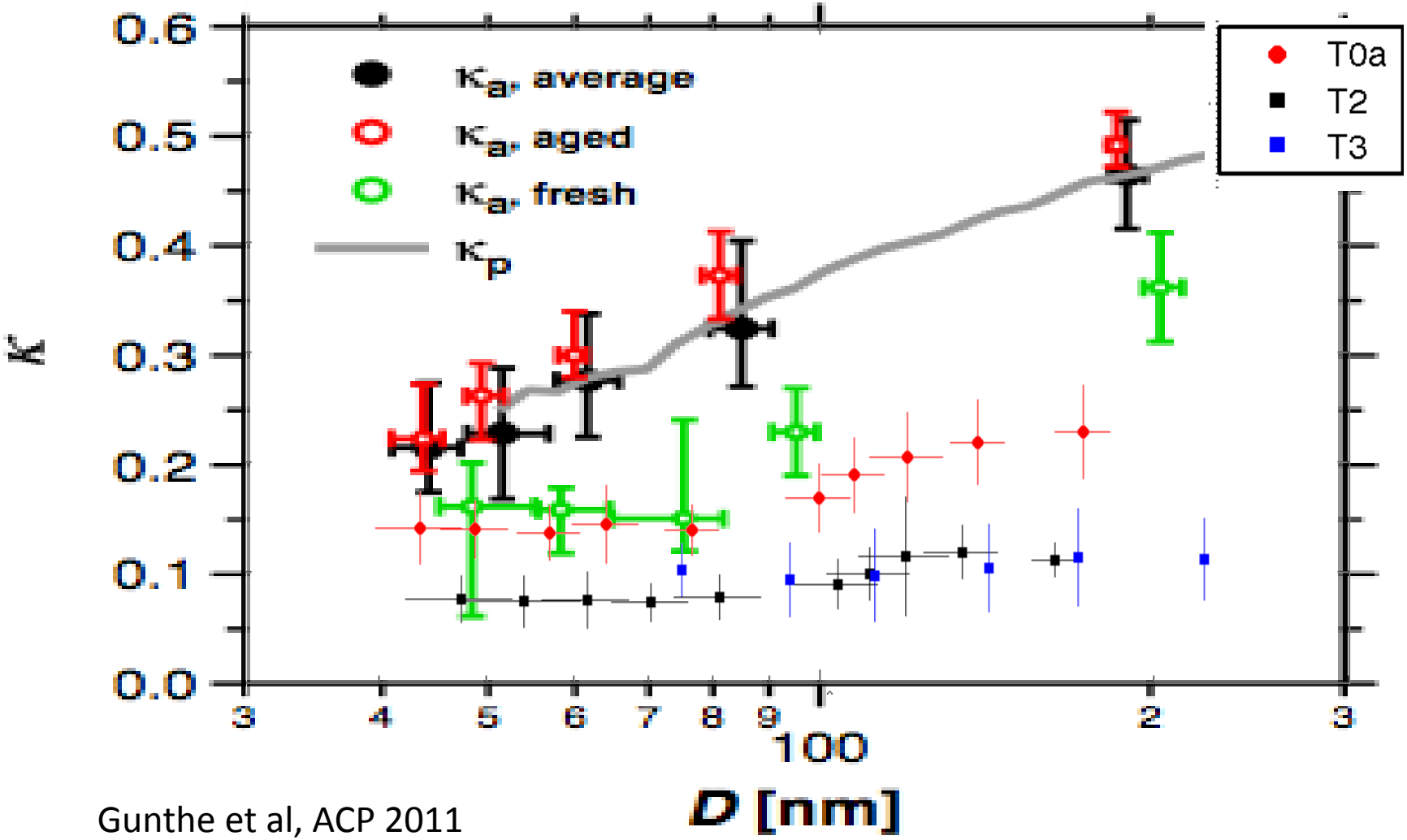


For IOP2, dry season – Low SS

	D_c	S_c	Kappa
T0	175 nm	0.11 %	0.22±0.05
T2	165 nm	0.09 %	0.11±0.02
T3	171 nm	0.16 %	0.11±0.04



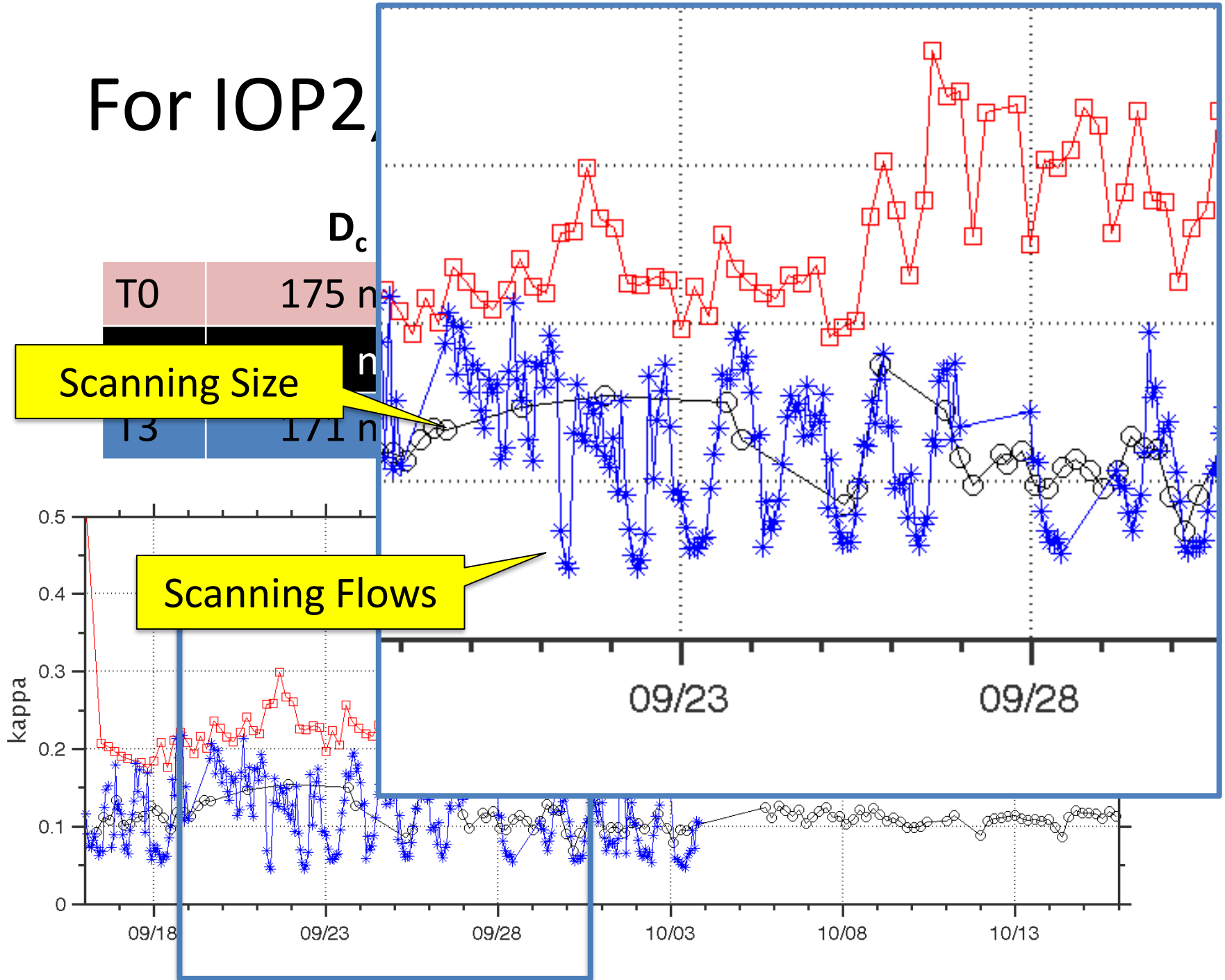
Kappa x Activation Diameter
IOP2, Sep 16-Oct 16



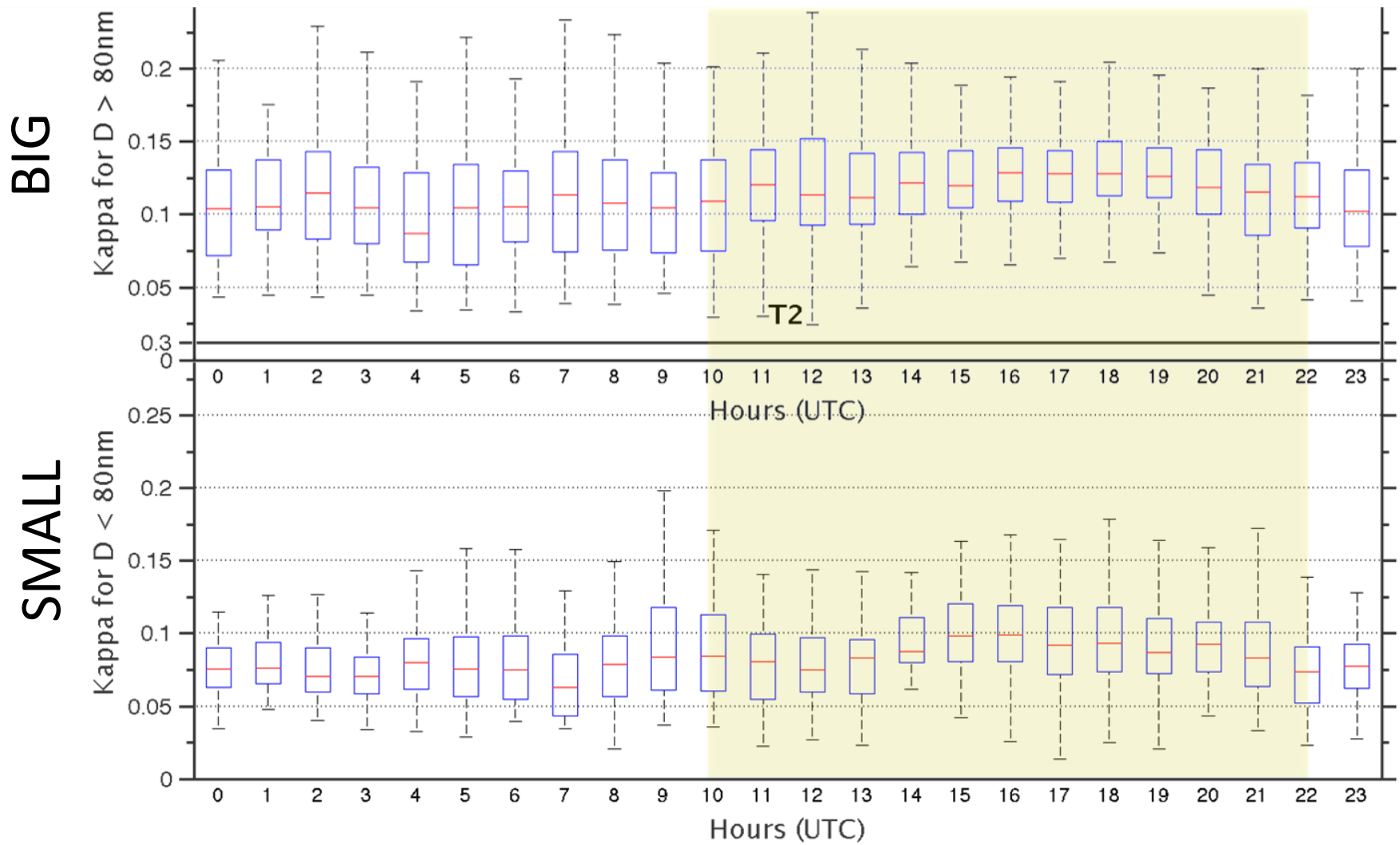
Gunthe et al, ACP 2011

For IOP2,

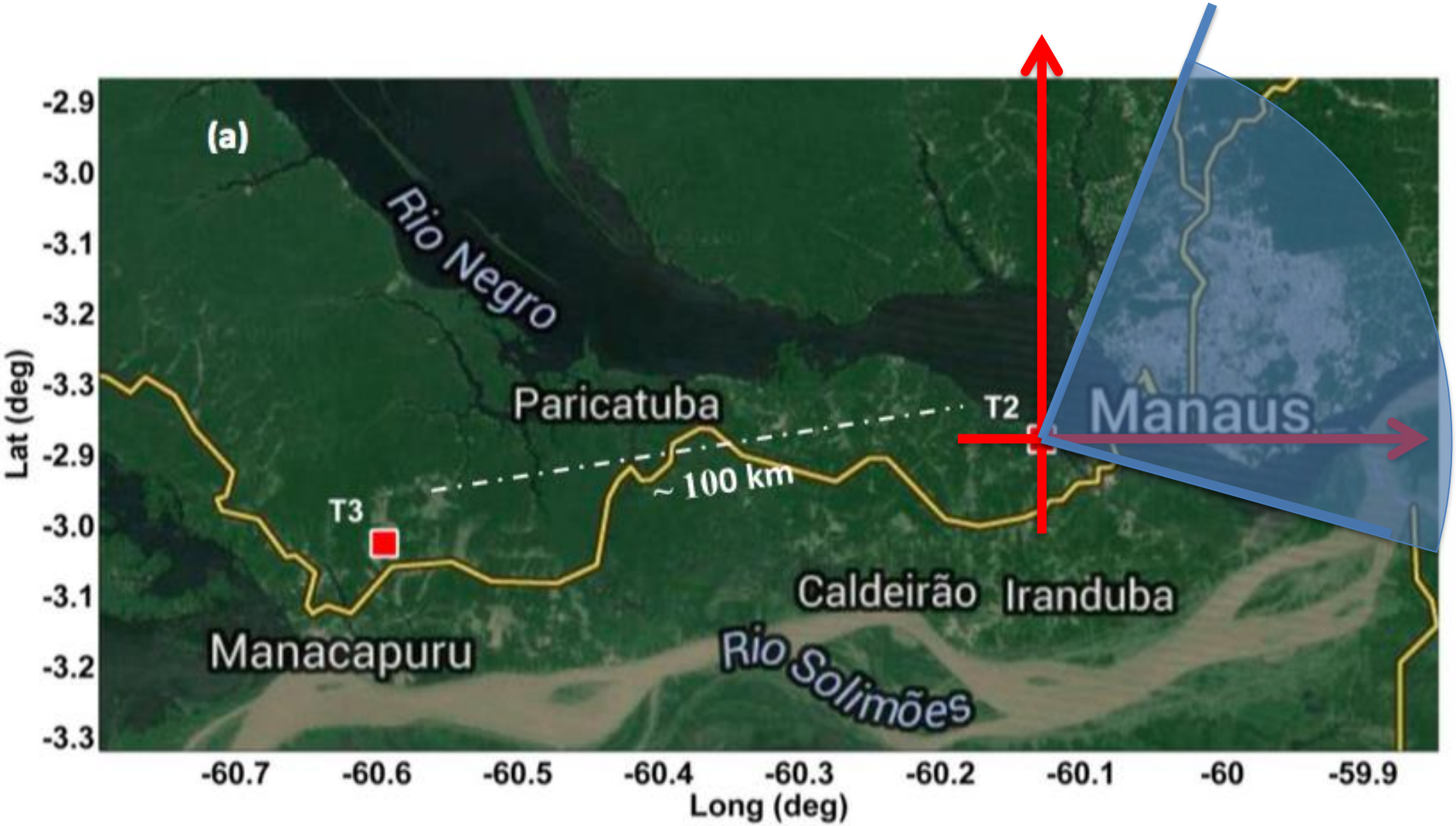
	D_c
T0	175 n
[redacted]	[redacted]
T3	171 n



CCN data @ T2
14/Sep/2014 – 1/Mar/2015



Manaus direction



CCN data @ T2
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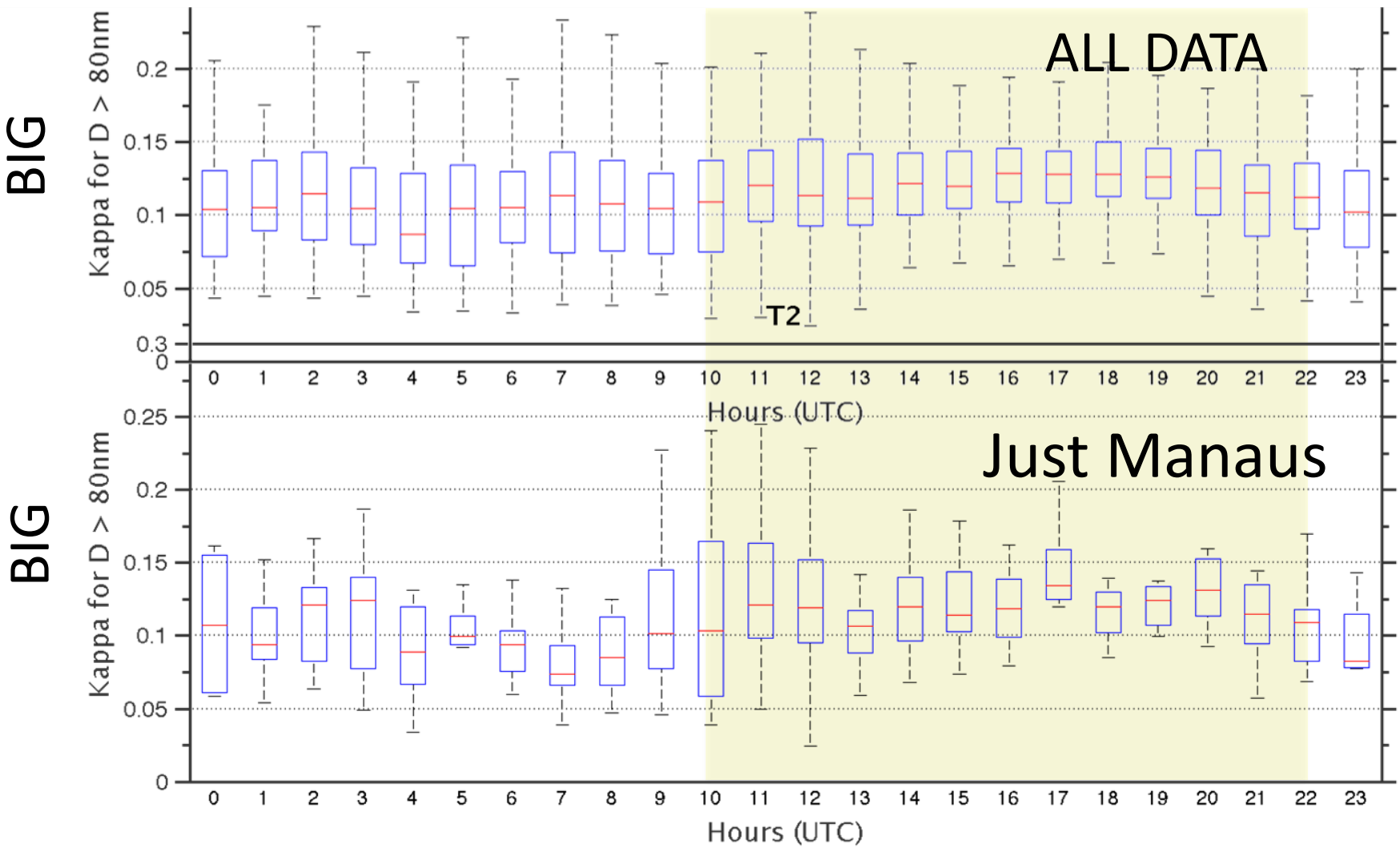

CCN data @ T2
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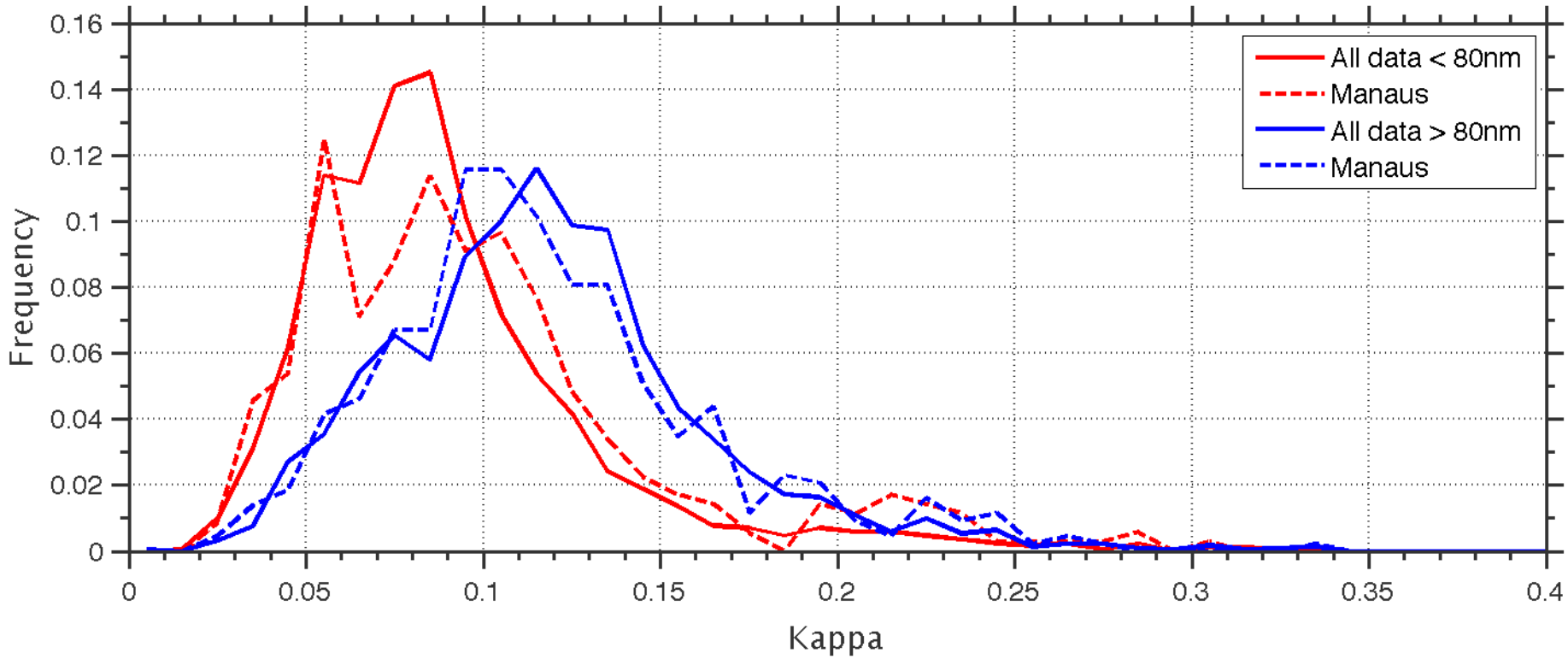

Small

ALL	k=0.09 +- 0.04 (N=1695)
Manaus	k=0.10 +- 0.05 (N=352)

Large

ALL	k=0.12 +- 0.04 (N=2208)
Manaus	k=0.12 +- 0.05 (N=433)

Conclusions

- UnpreAt all sites, the Aitken and Accumulation modes show different **K** with smooth transition at T3, but sharp at T0 and T2
- **K** shows no clear diurnal cycle, except in dry season
- **T0:** Well mixed and aged aerosol. High CN conc. correlate with low **K** => high organic fraction
- **T3:** κ_{org} under natural conditions during the wet season is ~0.15, higher than plume or BBA
- **T2:** Least hygroscopic. Aitken mode not as oxidized as at T3, but accumulation mode is.