The Cloud Condensation Nuclei (CCN) Rack on board of the HALO aircraft during ACRIDICON-CHUVA
–
Current state of data analysis

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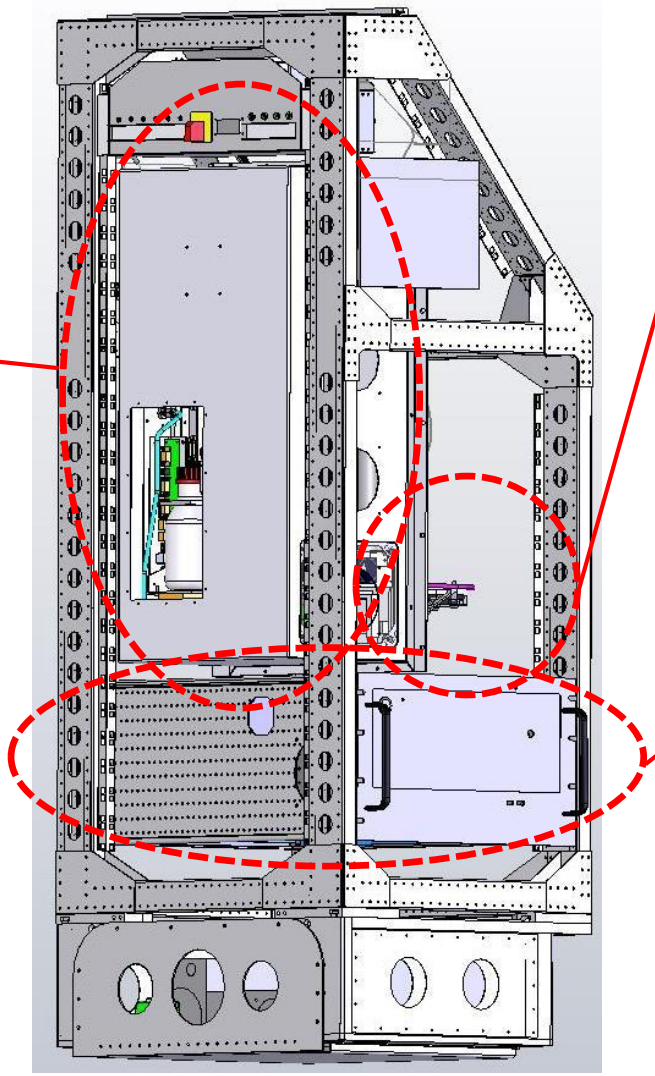
as well as the whole ACRIDICON and ATTO teams

ACRIDICON-CHUVA Meeting, Ilha Bela, Feb/Mar 2016

CCN Rack & Outline

HASI **CVI**



(1)

Cloud Condensation Nuclei Counter (CCNC)

- Column A: HASI only, S scans (0.3-0.7 %)
- Column B: HASI/CVI, S = 0.5 %)

Status:

- All flights systematically analyzed

(2)

Aerosol sampling for micro-spectroscopy

- e.g., STXM-NEXAFS, SEM-EDX, AFM, Raman, etc.
- particle microstructure and composition

Status:

- 2 beamtimes invested; more is planned
- So far: AC12 & AC18

Single Particle Soot Photo-meter (SP2)

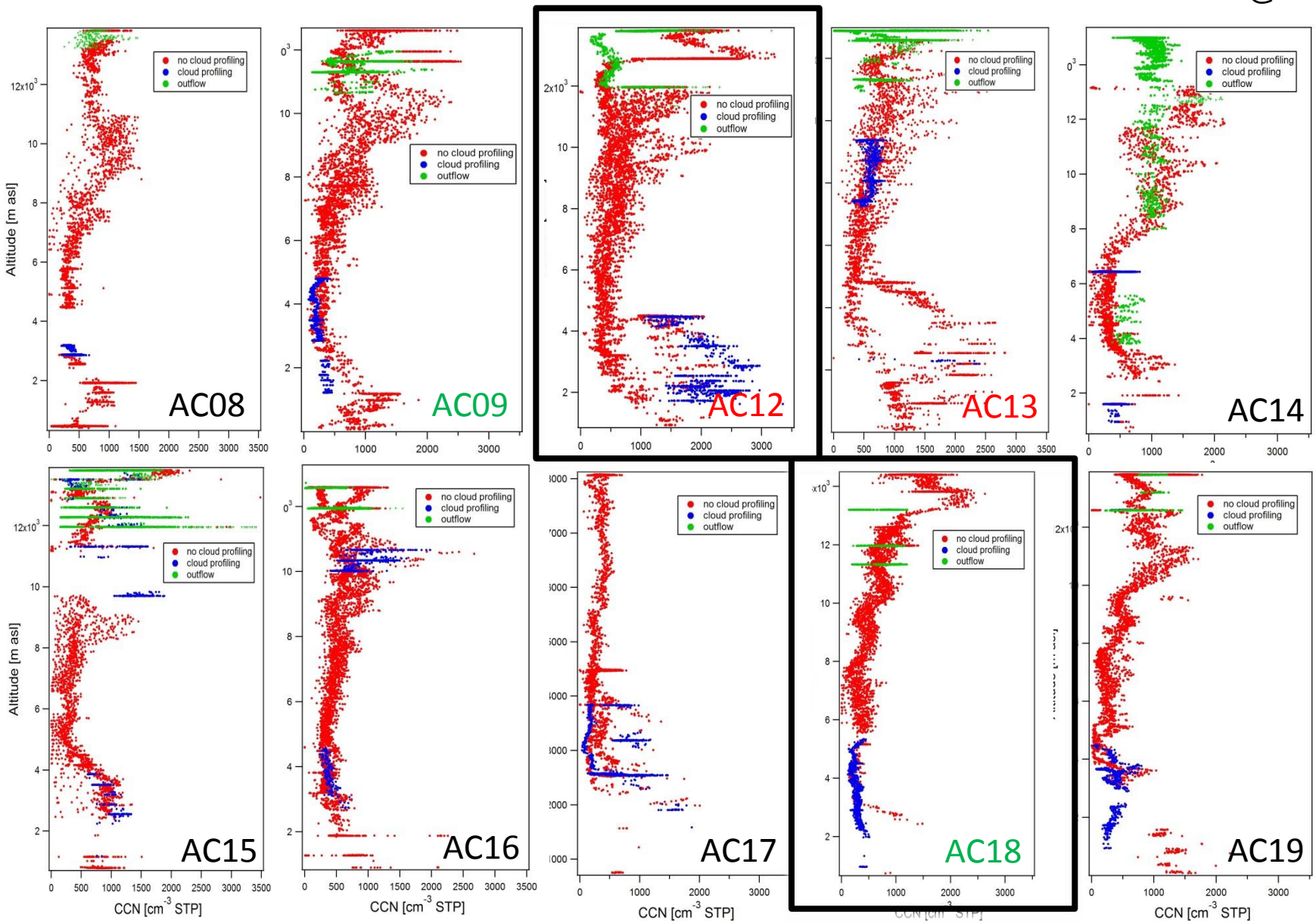
- BC concentration and coating

Status:

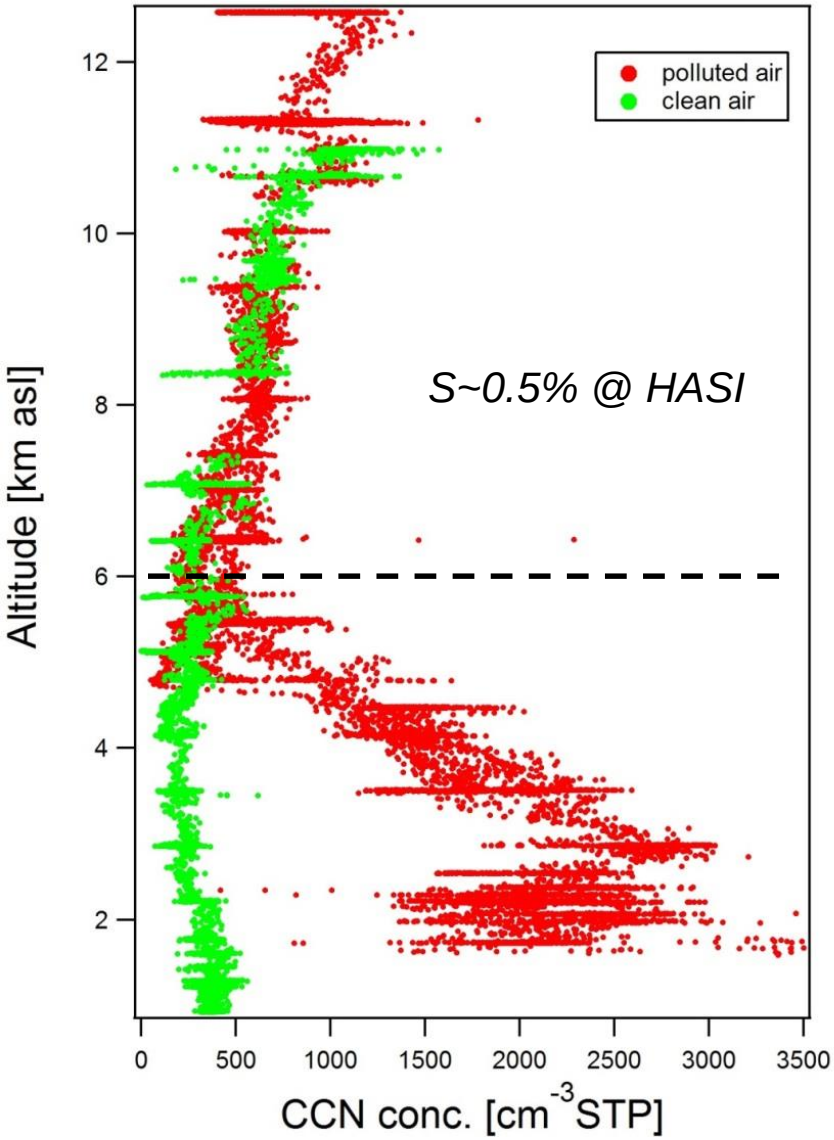
- Data analysis in progress

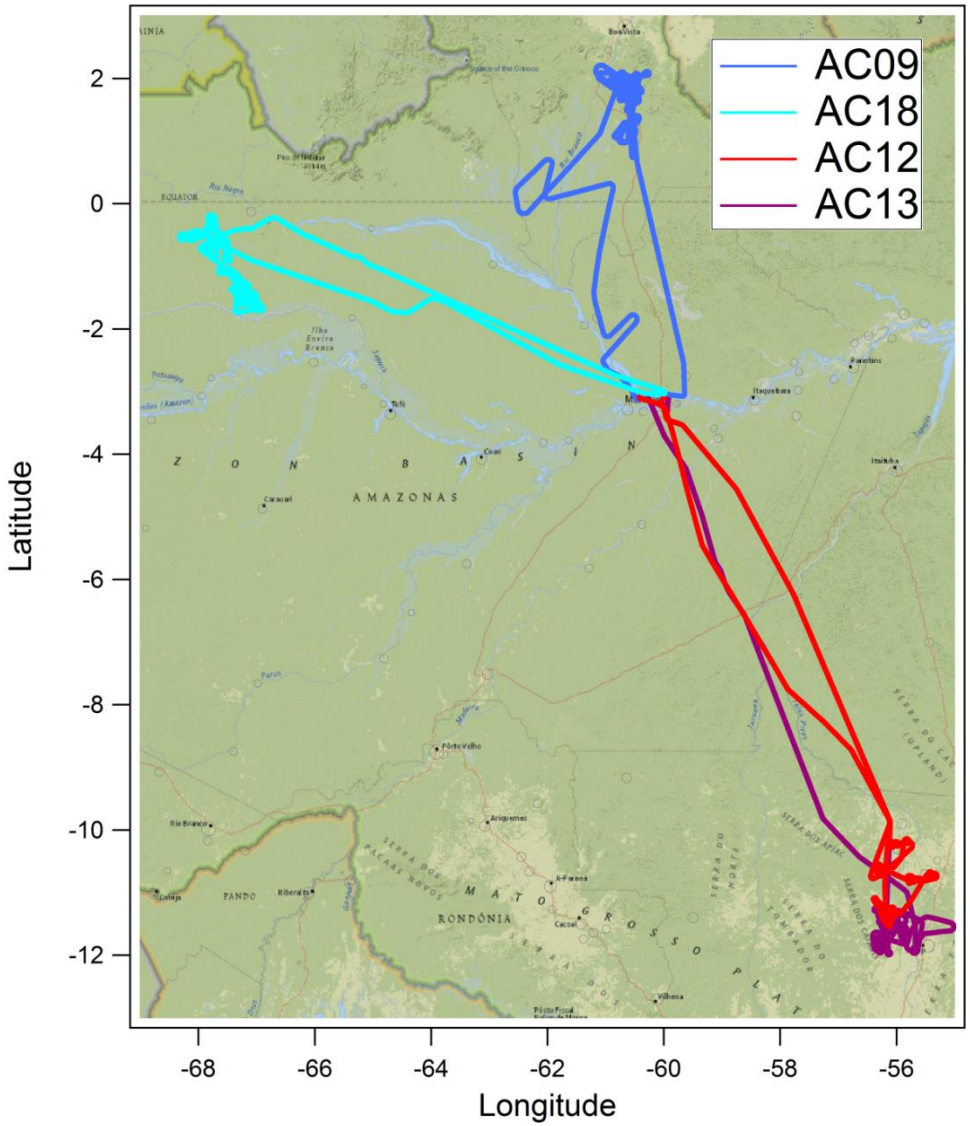
CCN Vertical Profiles - Overview

S~0.5% @ HASI

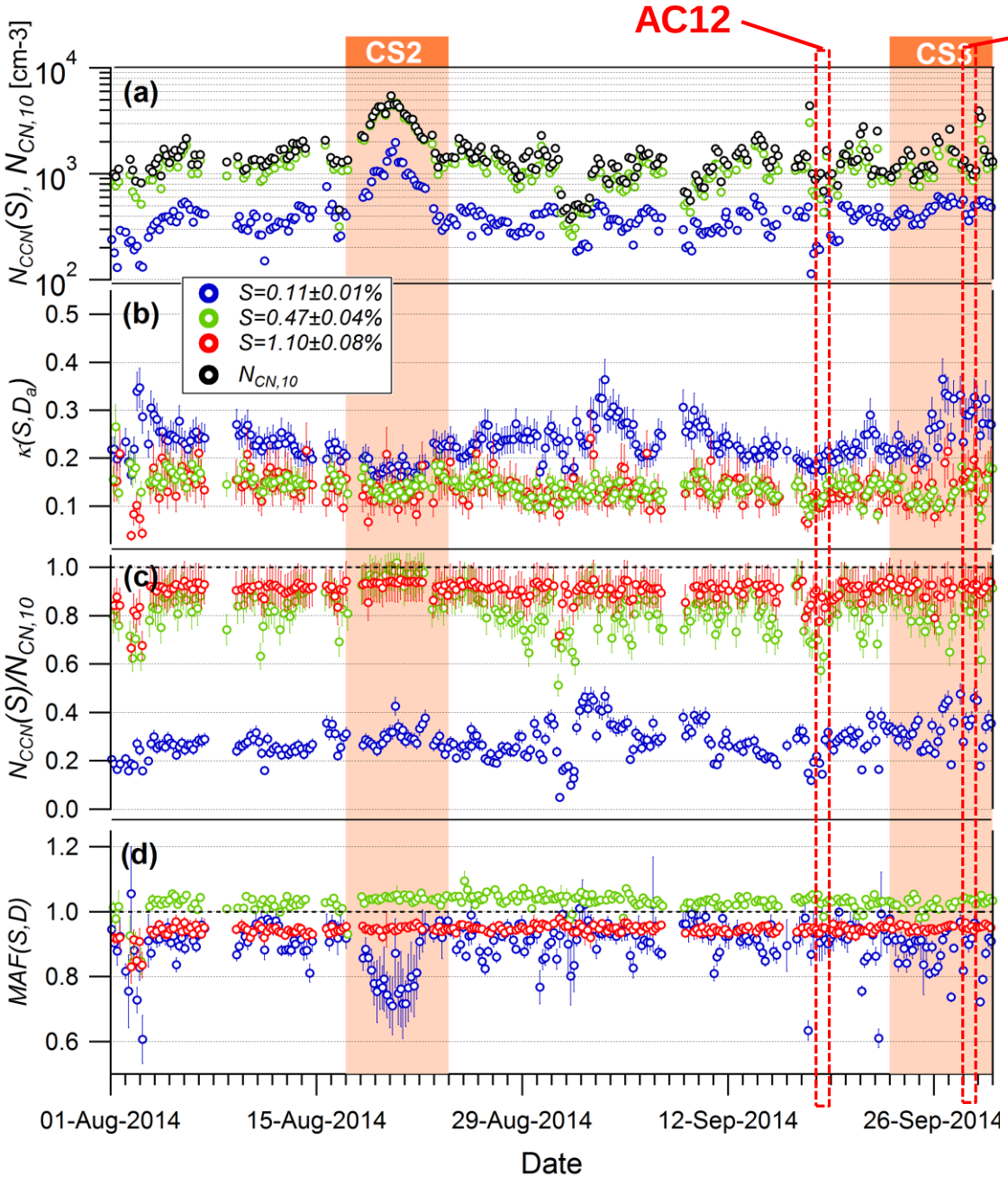


CCN Vertical Profiles - Clean vs. Polluted





CCN @ ATTO site during ACRIDICON-CHUVA



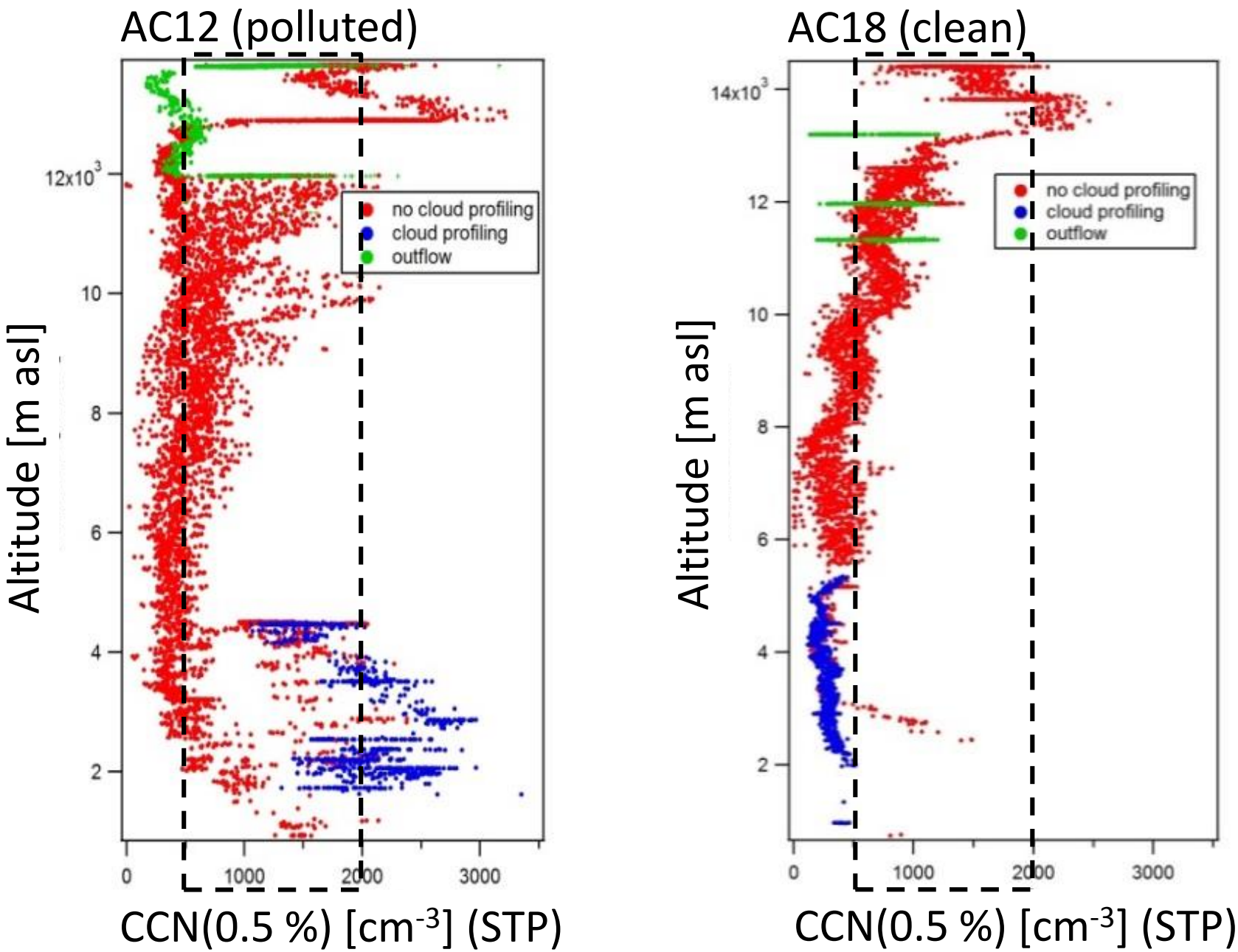
$N_{CCN}(0.47\%)$ = 500 - 2000 cm^{-3}

$\kappa(0.47\%)$ = 0.1 - 0.2

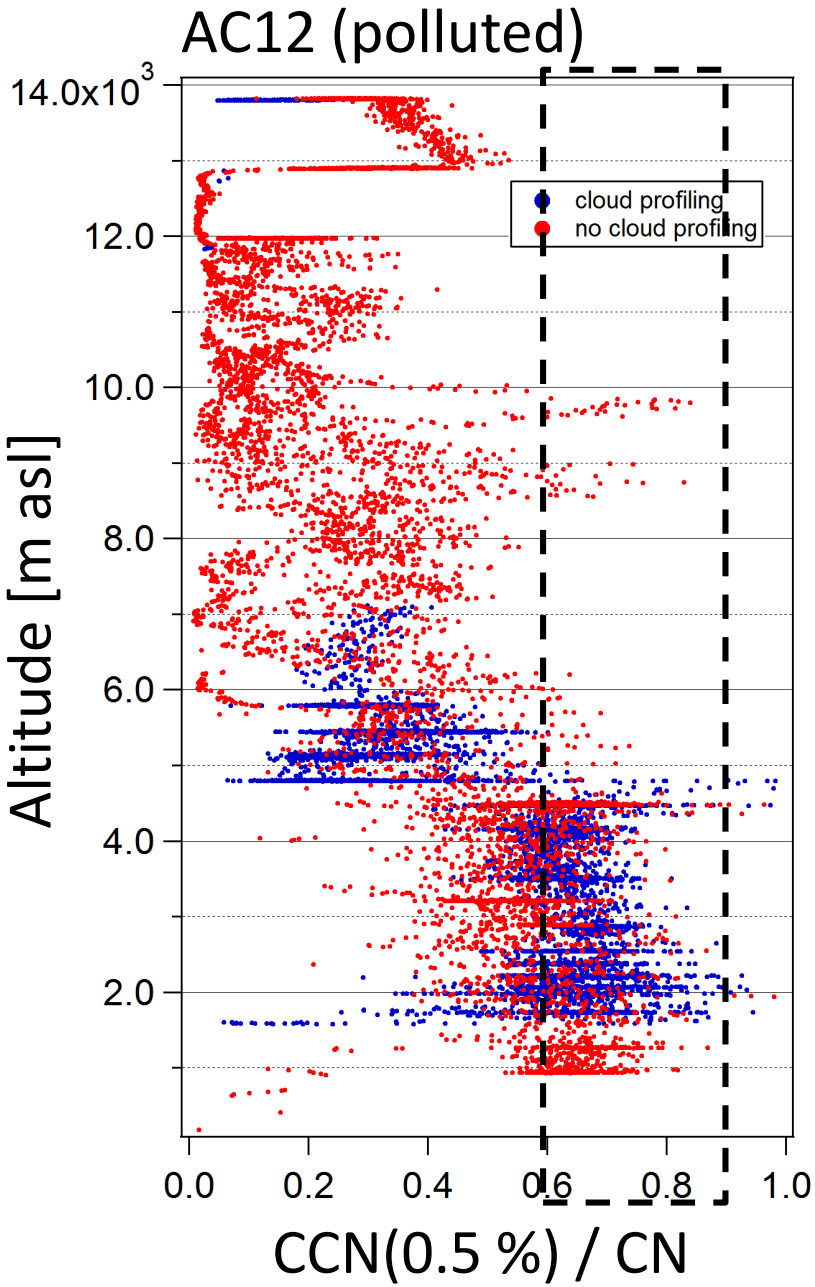
$N_{CCN}(0.47\%)/CN_{10}$ = 0.6 - 0.9

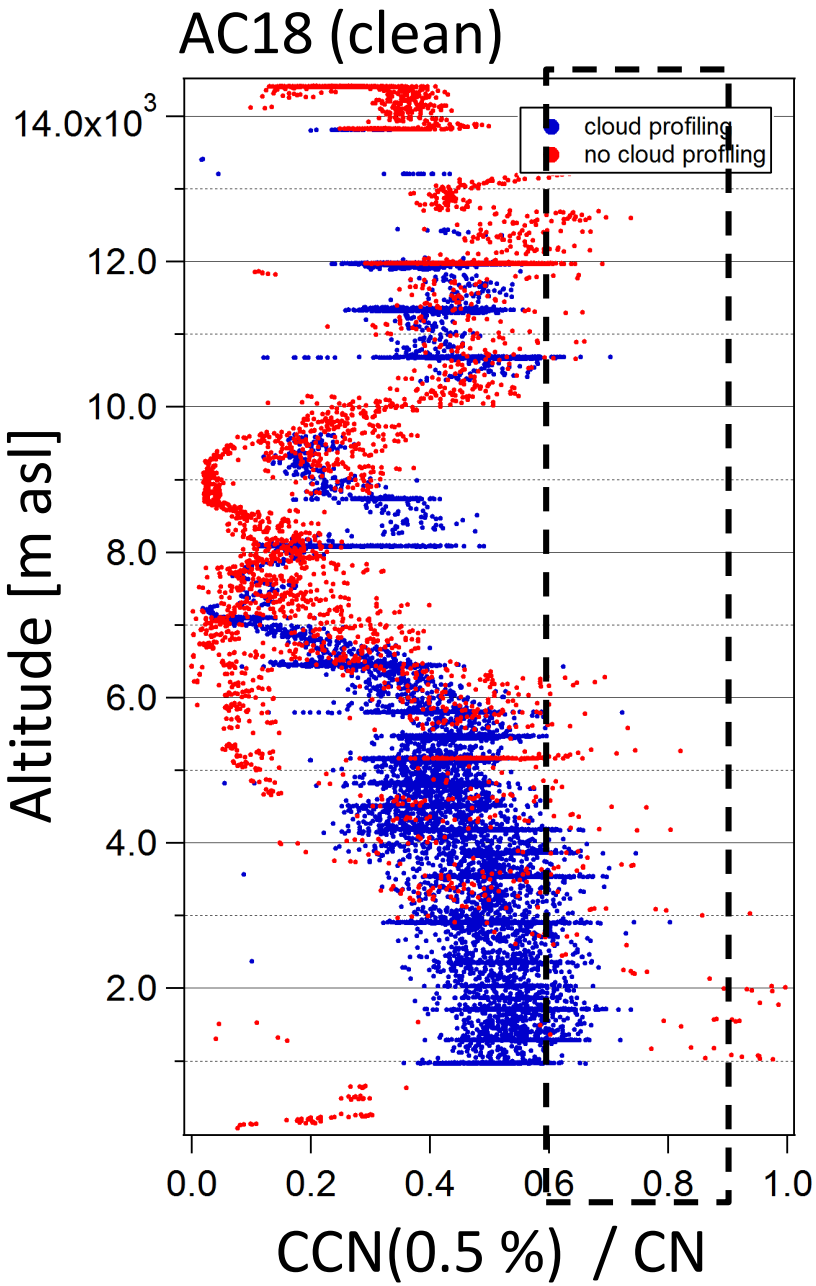
Mira Pöhlker et al., ACP in prep.

CCN Vertical Profiles - Clean vs. Polluted

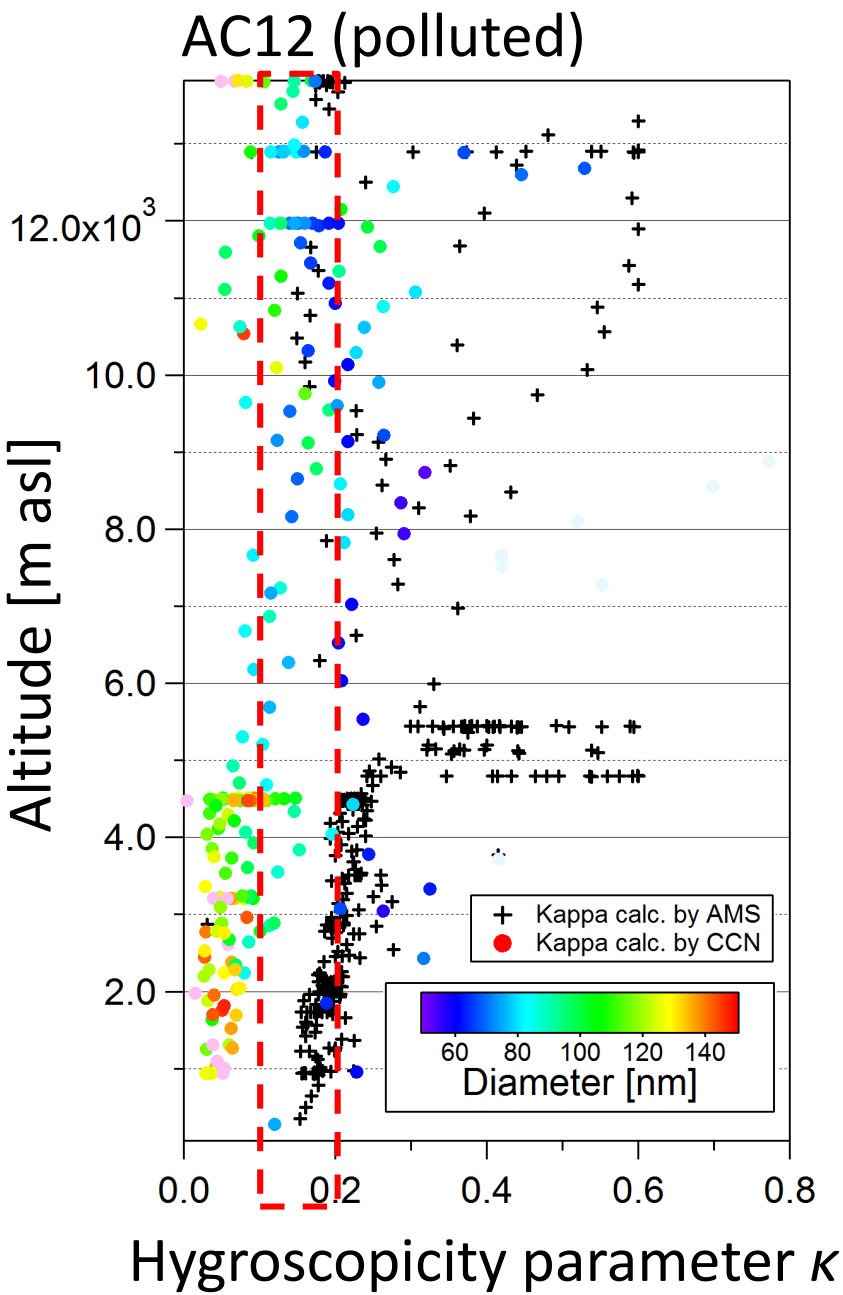


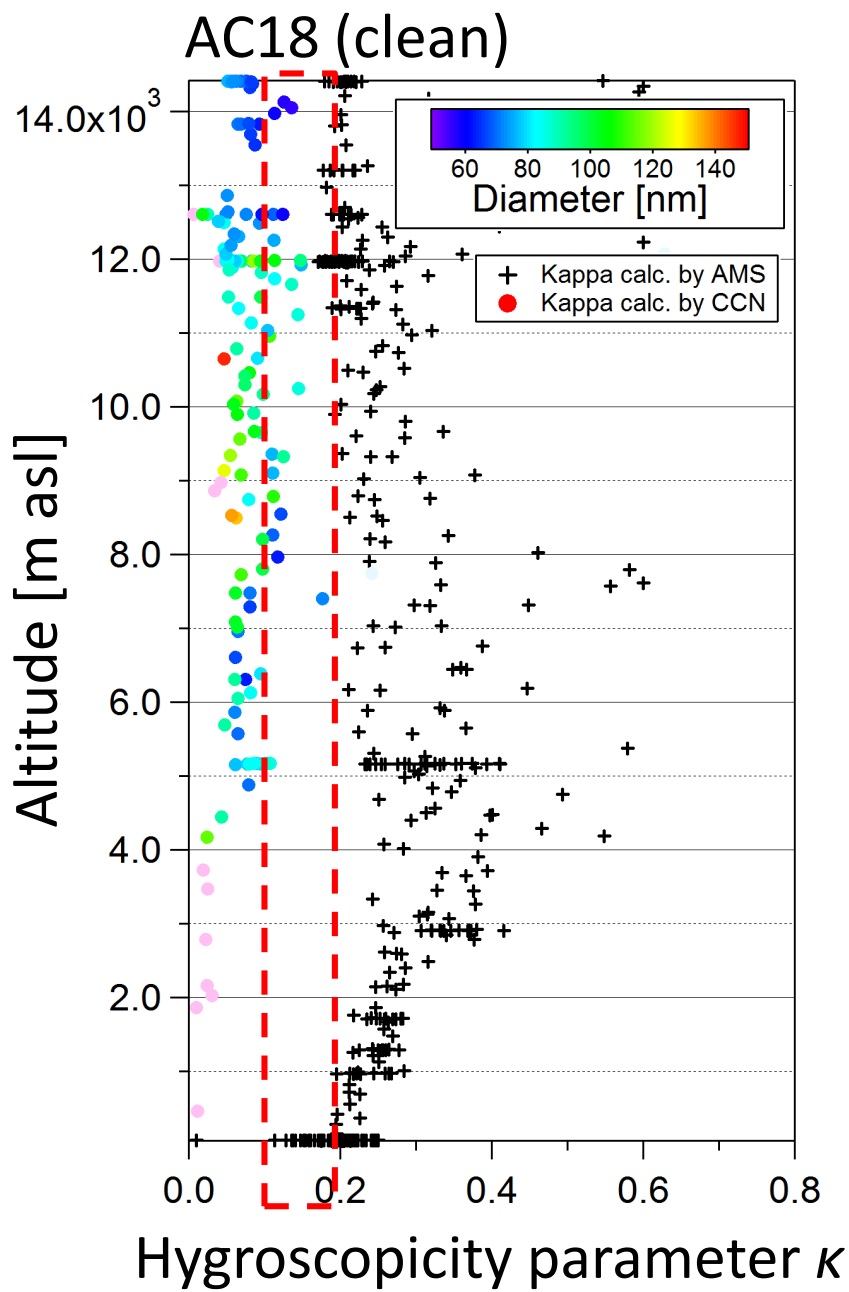
CCN Vertical Profiles - Clean vs. Polluted



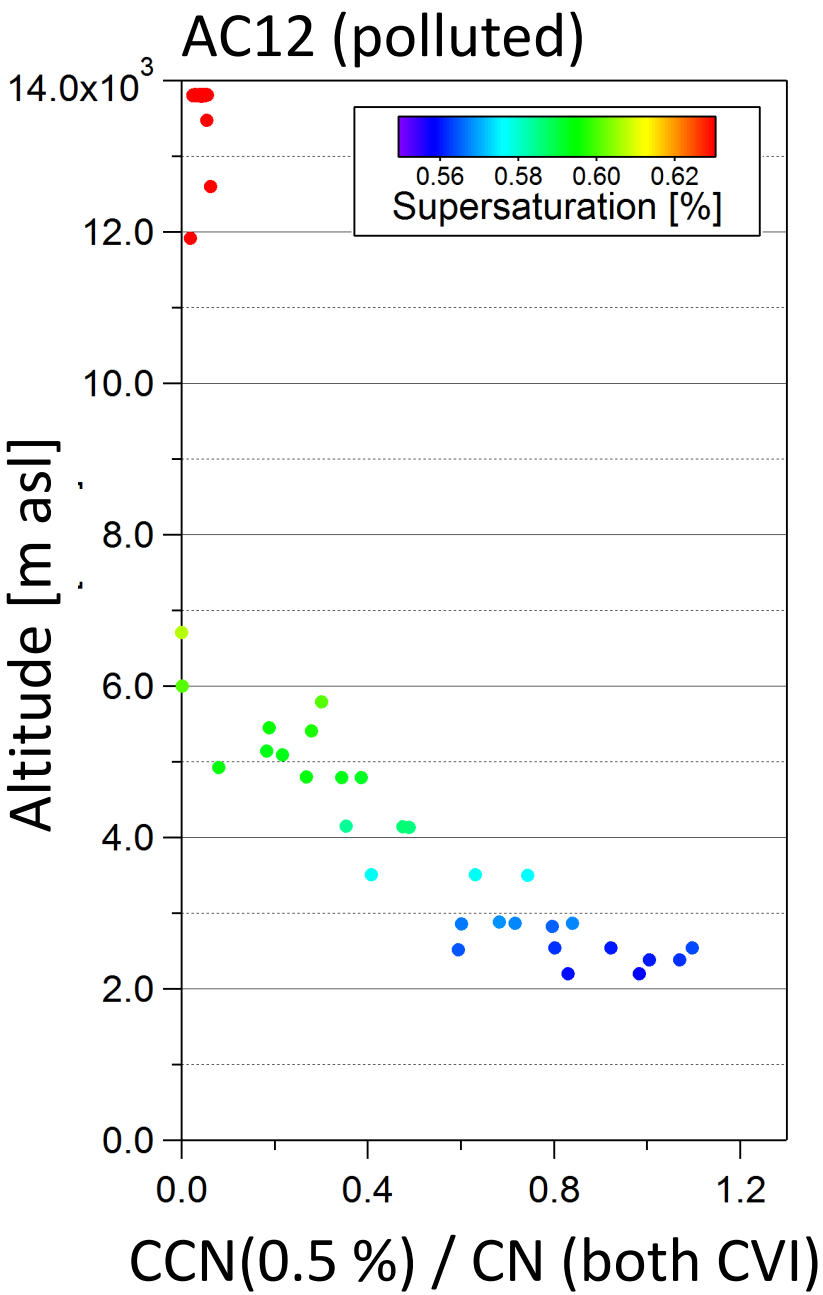


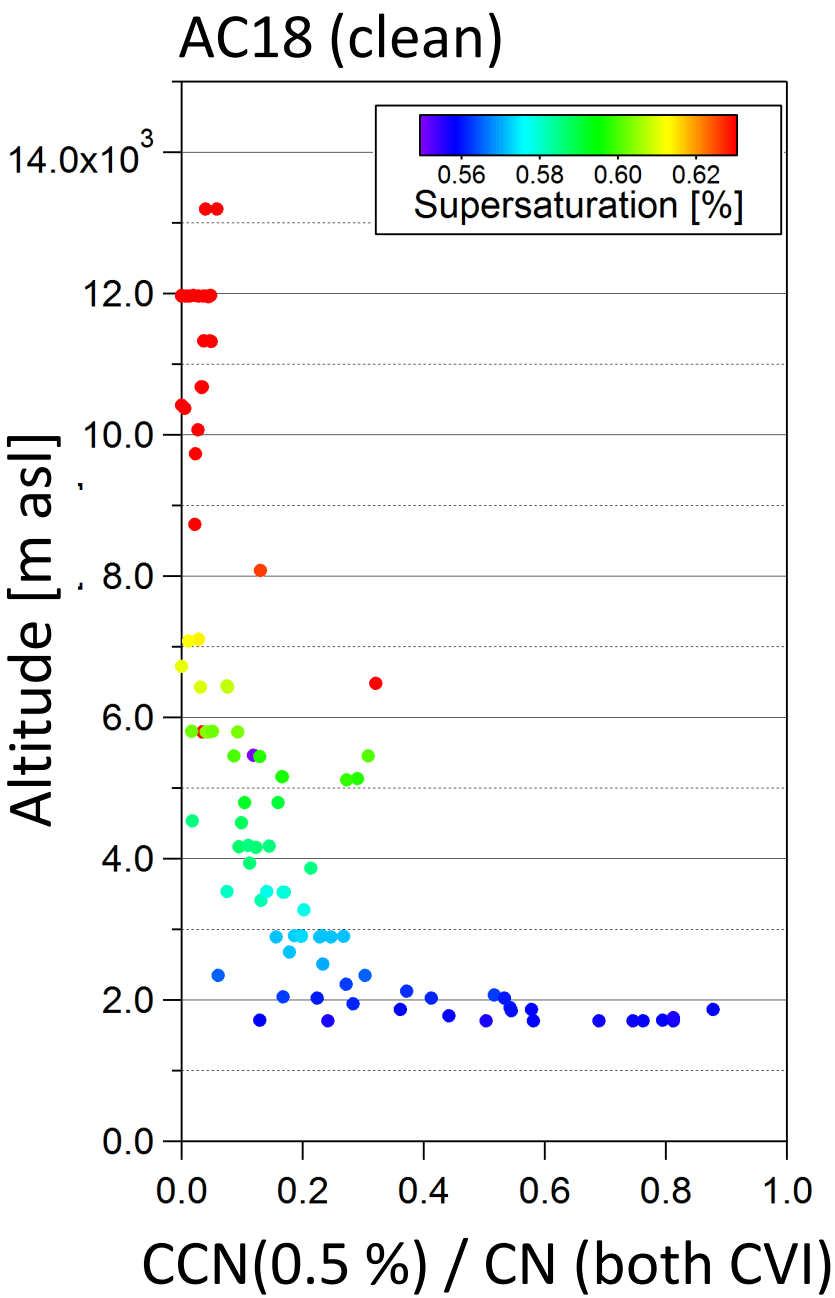
CCN Vertical Profiles - Hygroscopicity Parameter κ



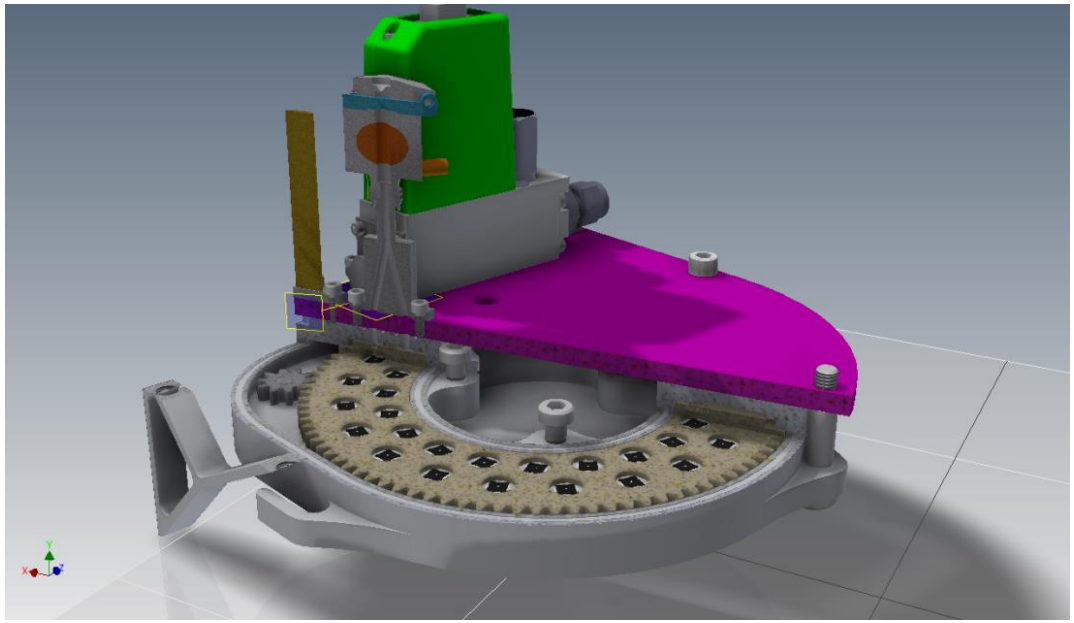


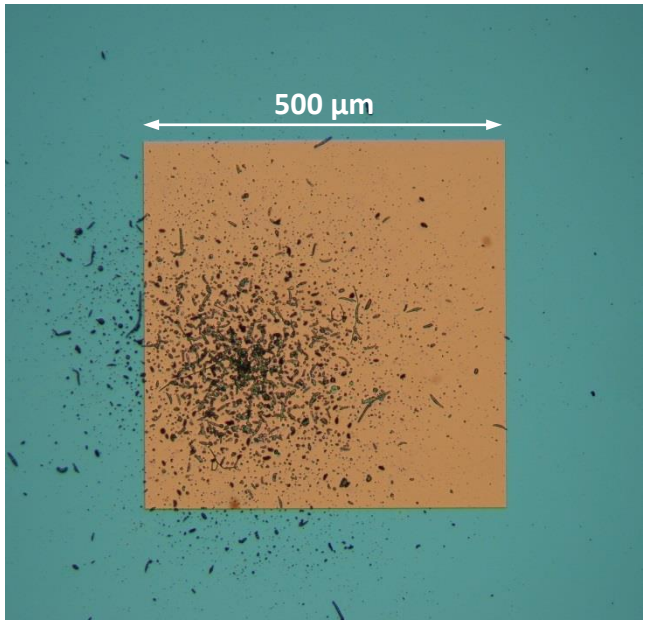
CCN Vertical Profiles – Estimating S Levels

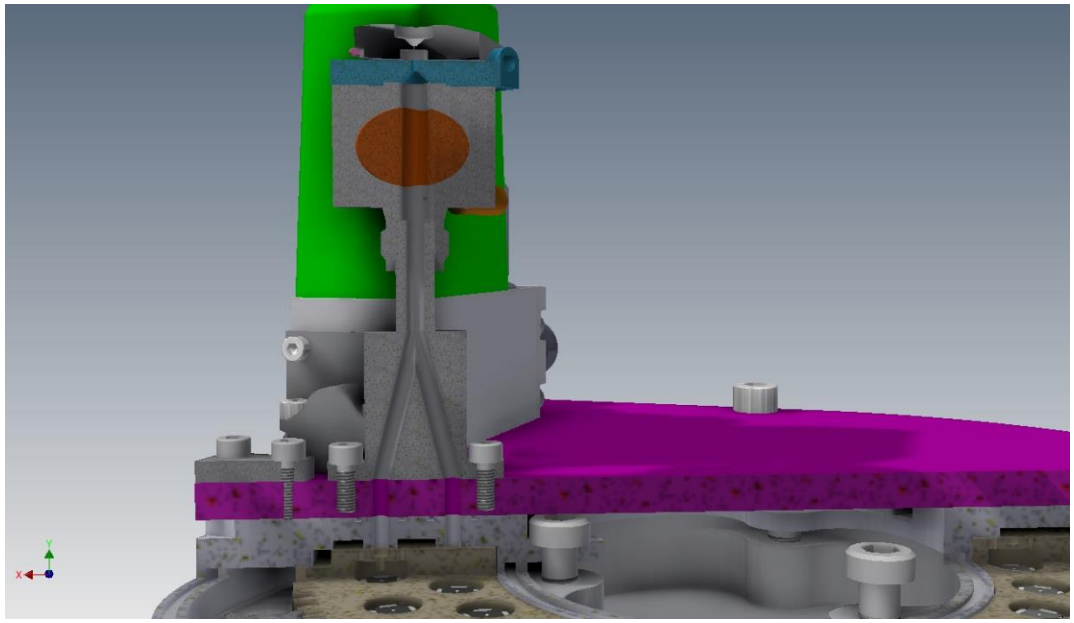




Aerosol Sampler in CCN Rack





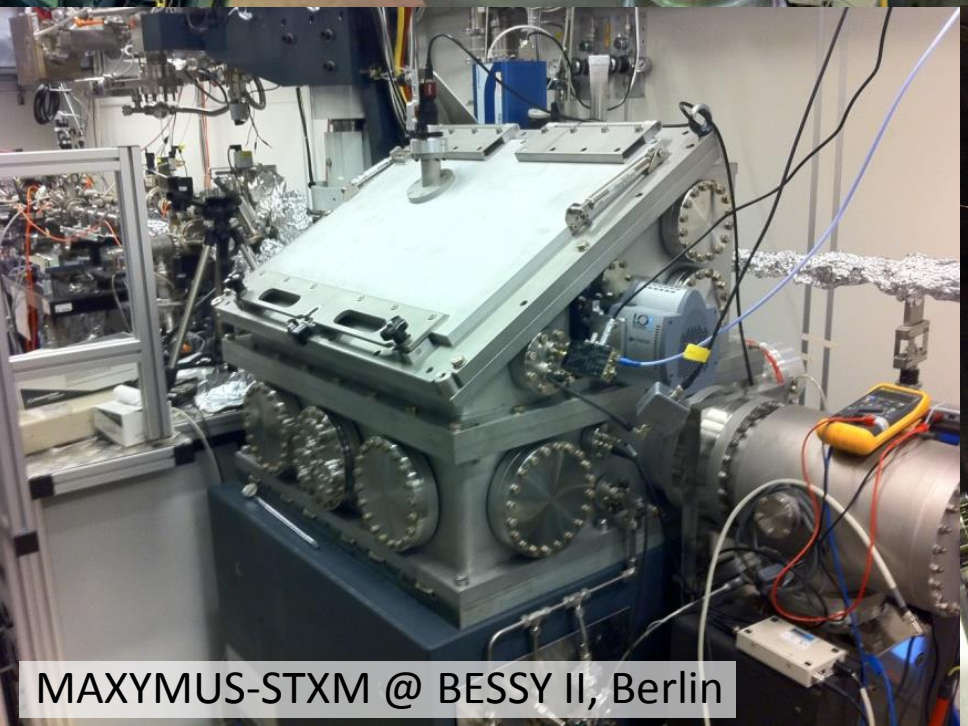


- Automated impaction sampling (42 substrates)
- Cuf-off: ~200 nm, also diffusive deposition
- Sampling of in cloud and out of cloud conditions linked with CCNC and SP2 operation

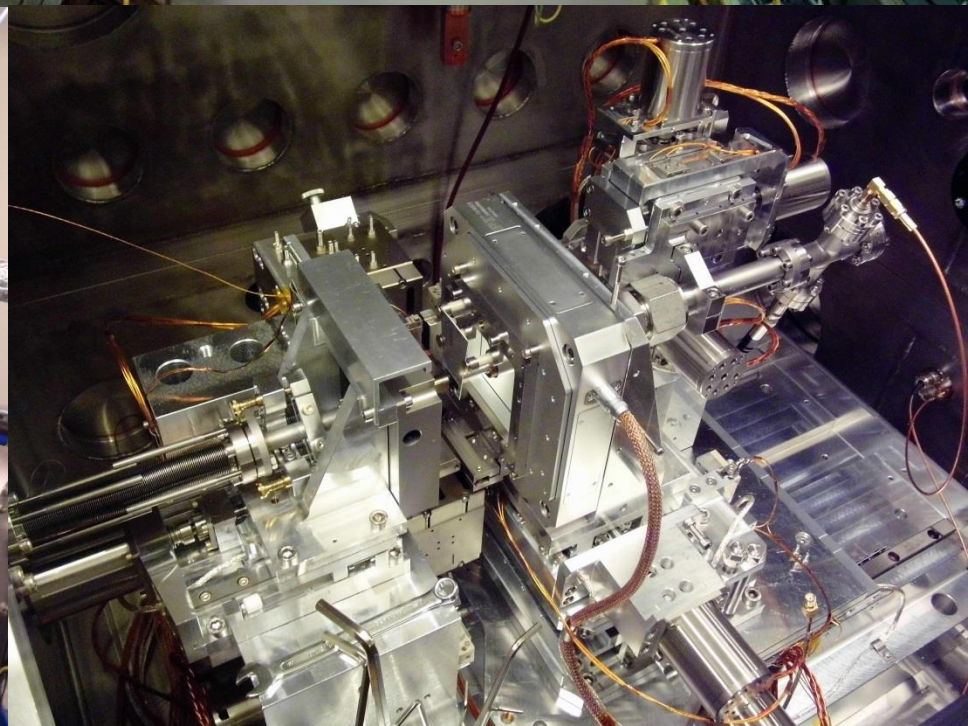
X-ray Microspectroscopy on Aerosols

Scanning **T**ransmission **X**-ray **M**icroscopy with
Near-**E**dge **X**-ray **A**bsorption **F**ine **S**tructure analysis

ALS (LBNL), Berkeley, CA, USA

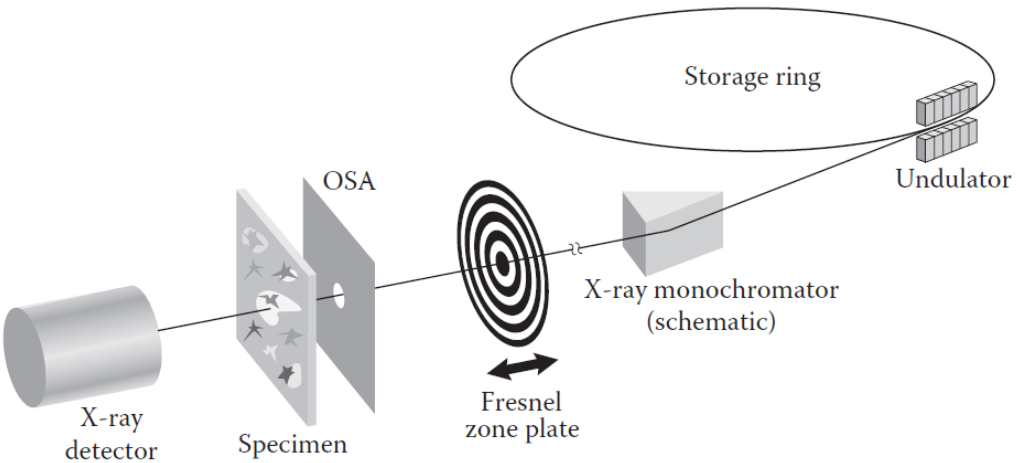


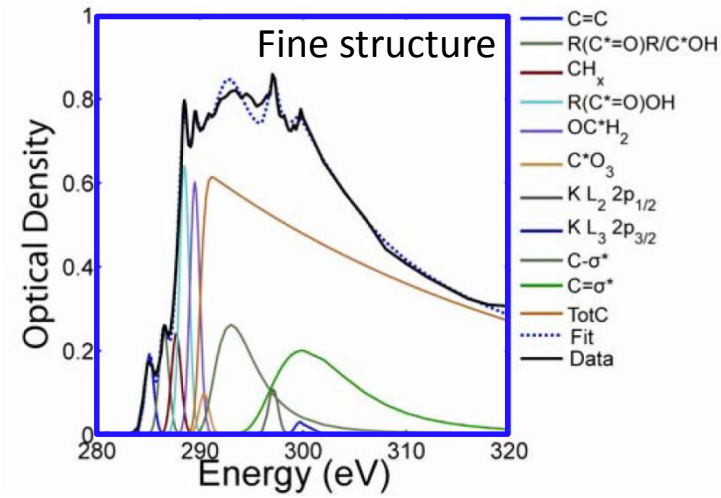
MAXYMUS-STXM @ BESSY II, Berlin

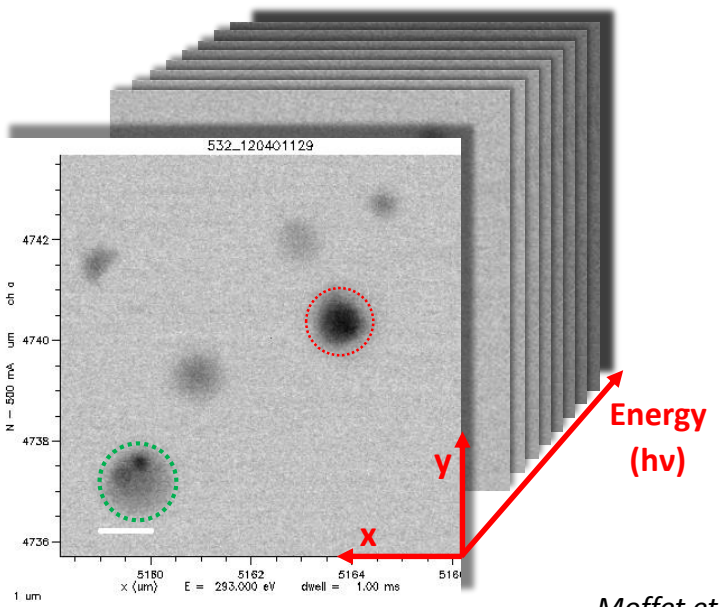


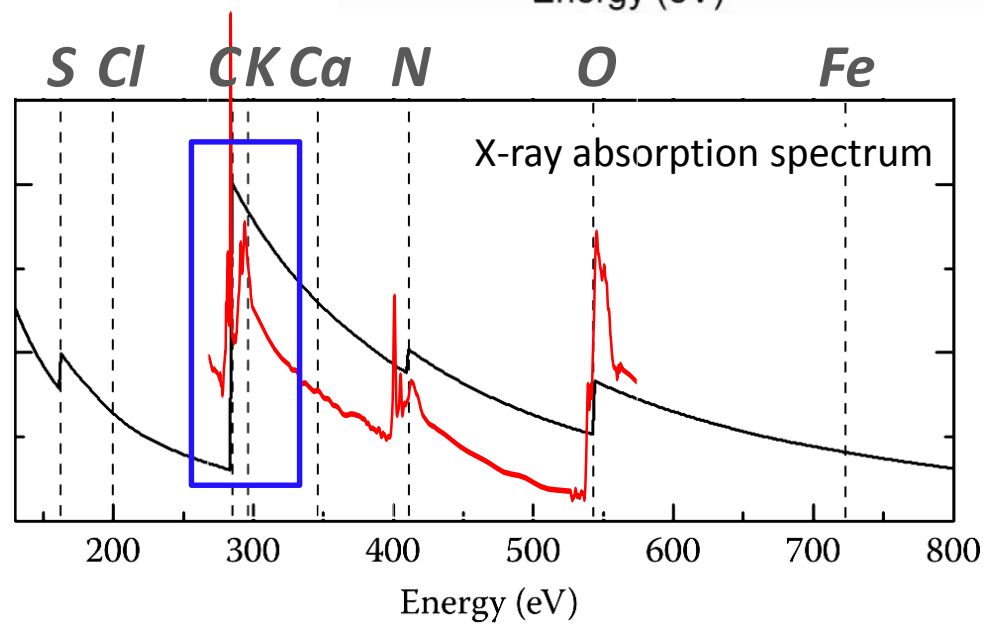
STXM-NEXAFS – Concept

Scanning **T**ransmission **X**-ray **M**icroscopy with
Near-**E**dge **X**-ray **A**bsorption **F**ine **S**tructure analysis









Moffet et al. STXM - Applications in atmospheric aerosol research, 2010; Moffet et al., ACP 2010

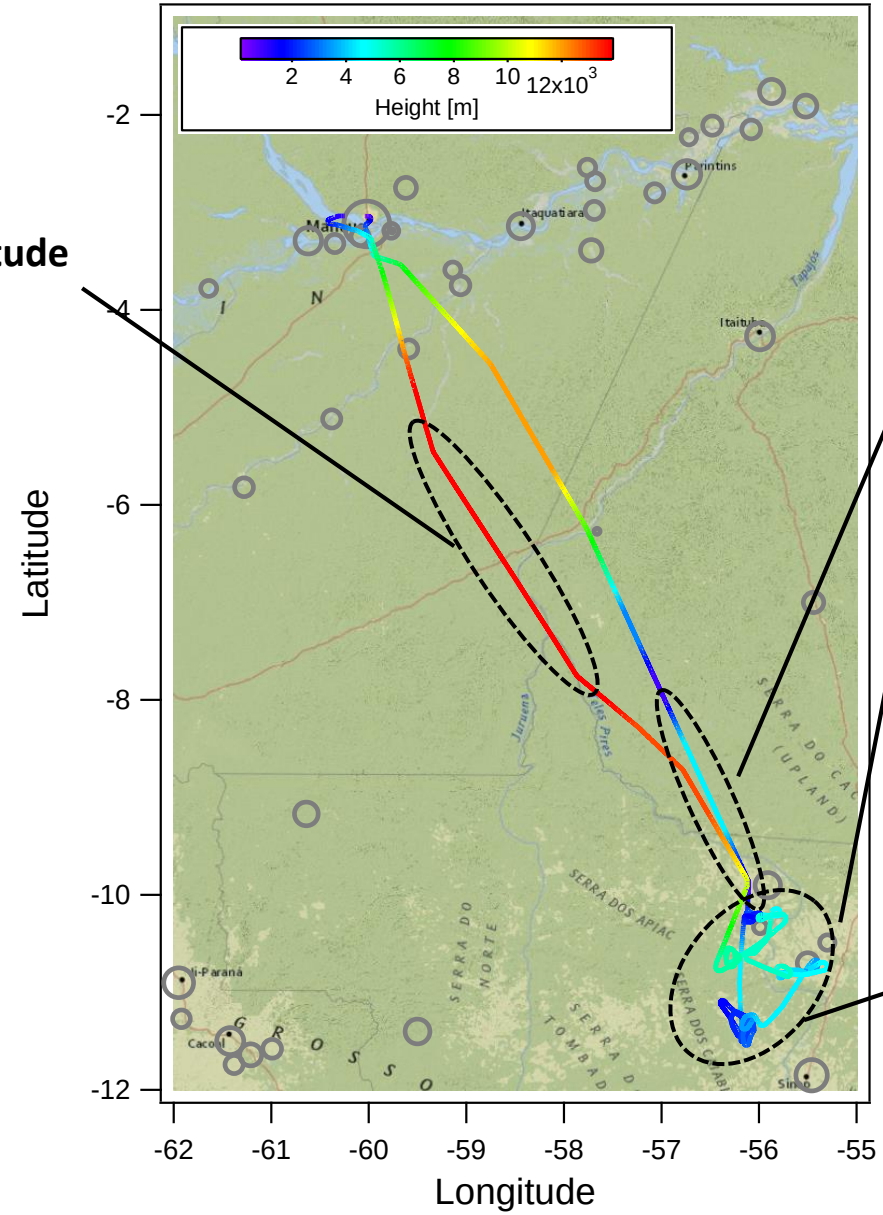
STXM @ AC12 – Dark Field Microscopy

STXM @ AC12: Flight Map

(3)

Nucleation at high altitude

- SEM-EDX, AFM
- 1 sample @ HASI



(1)

Characterization of biomass burning aerosol

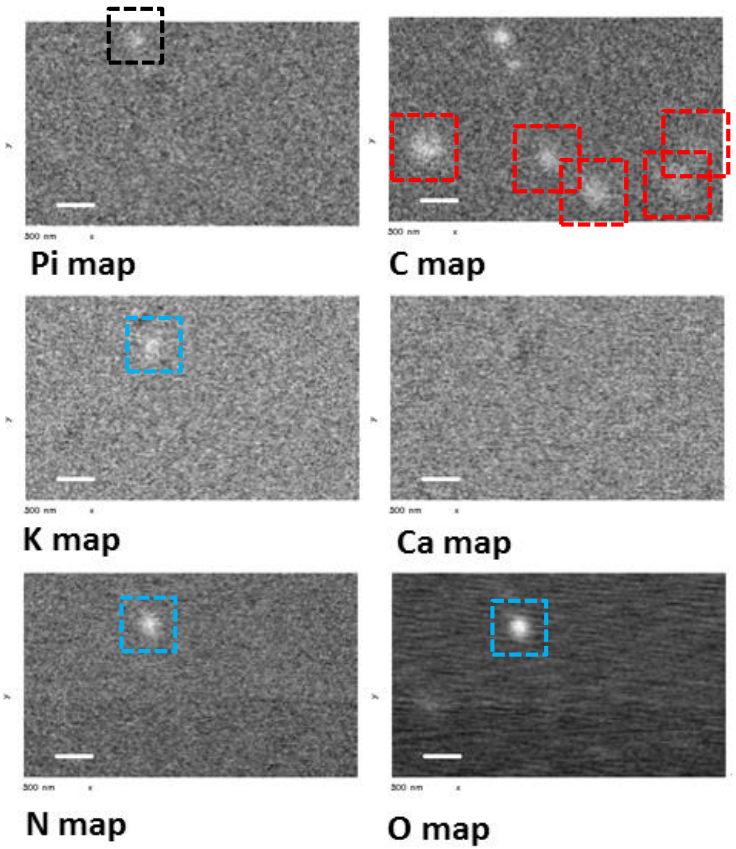
- STXM-NEXAFS
- 2 sample @ HASI

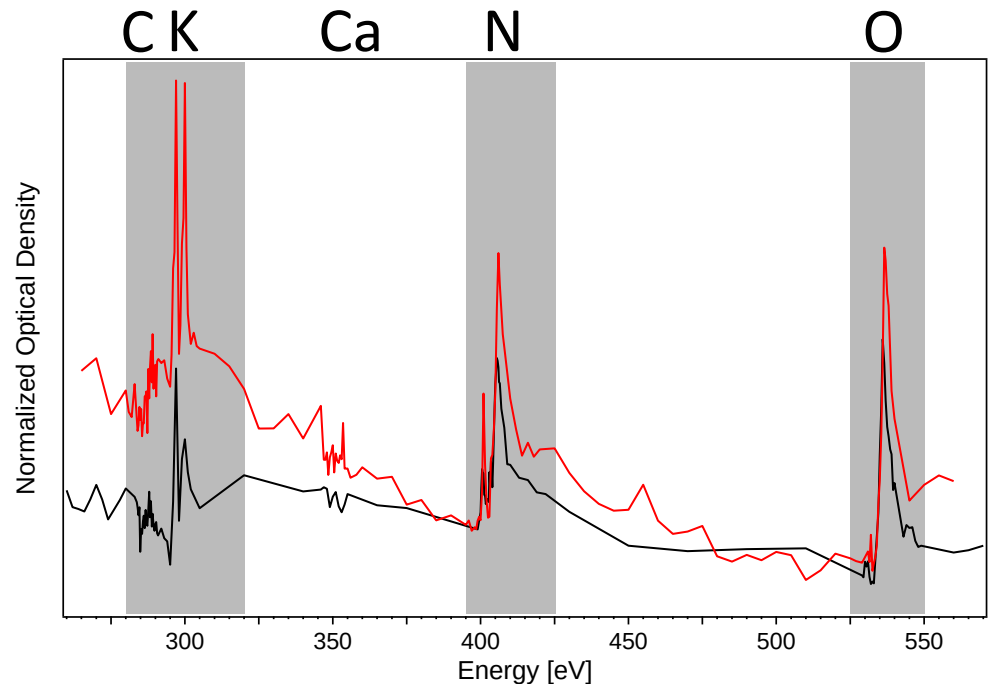
(2)

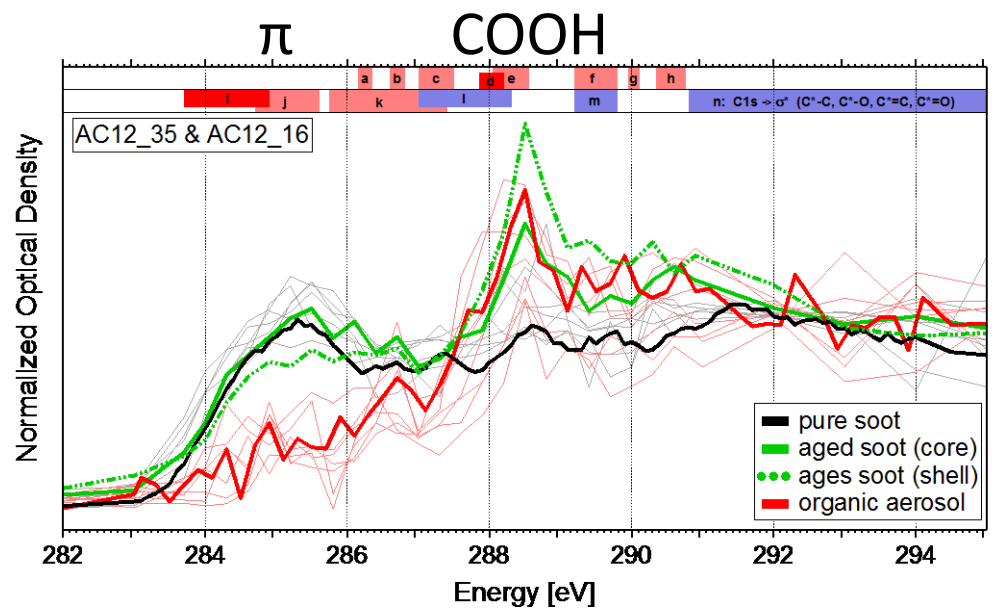
Contrasting CVI and HASI during cloud profiling

- STXM-NEXAFS
- 2 sample @ HASI
- 4 sample @ CVI

STXM @ AC12: Biomass Burning Smoke

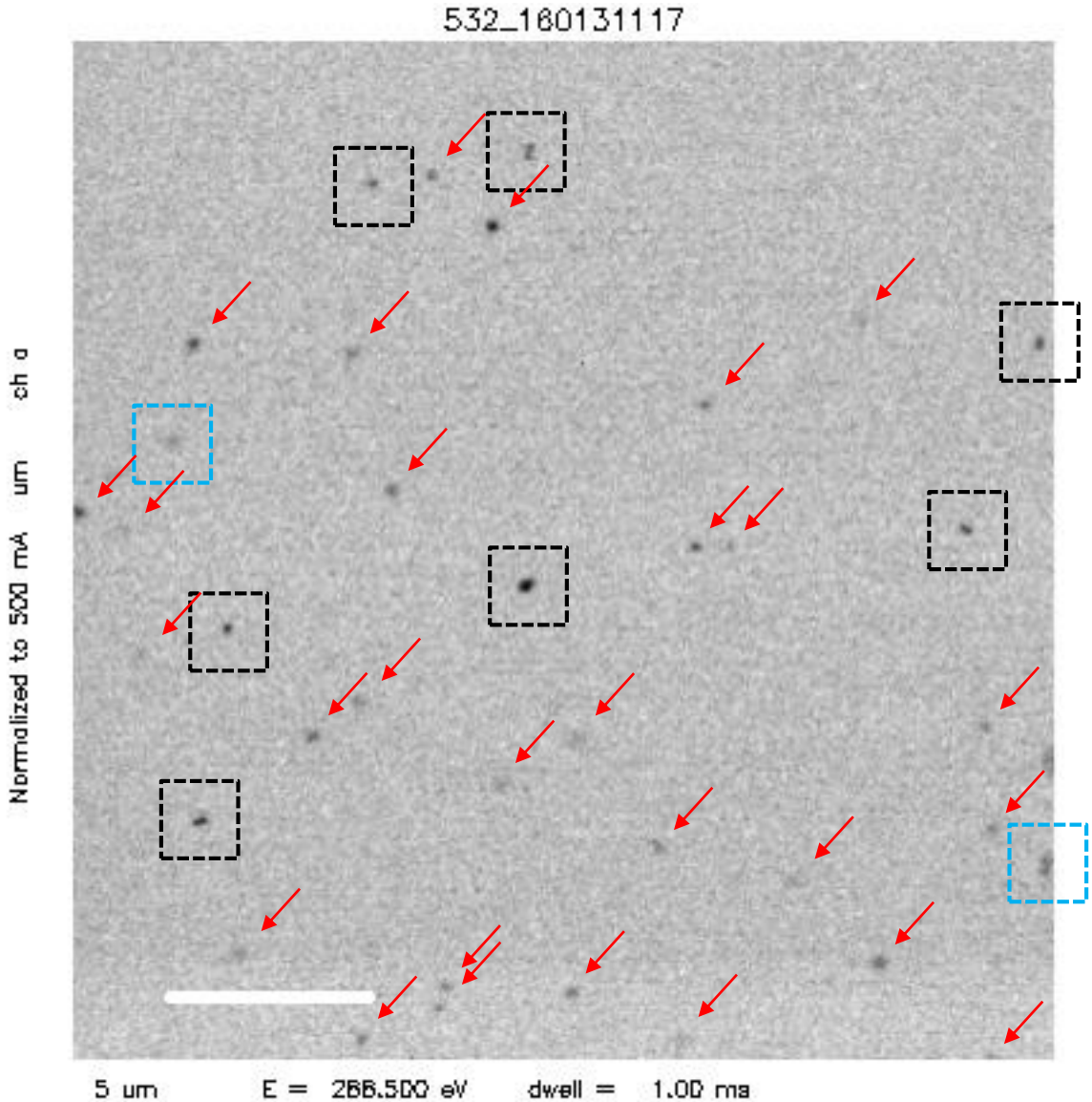






1. Organic Aerosol
2. Soot (rather fresh)
3. $K_x(NH_4)_YSO_4$ (+ Mg ?)

STXM @ AC12: Biomass Burning Smoke



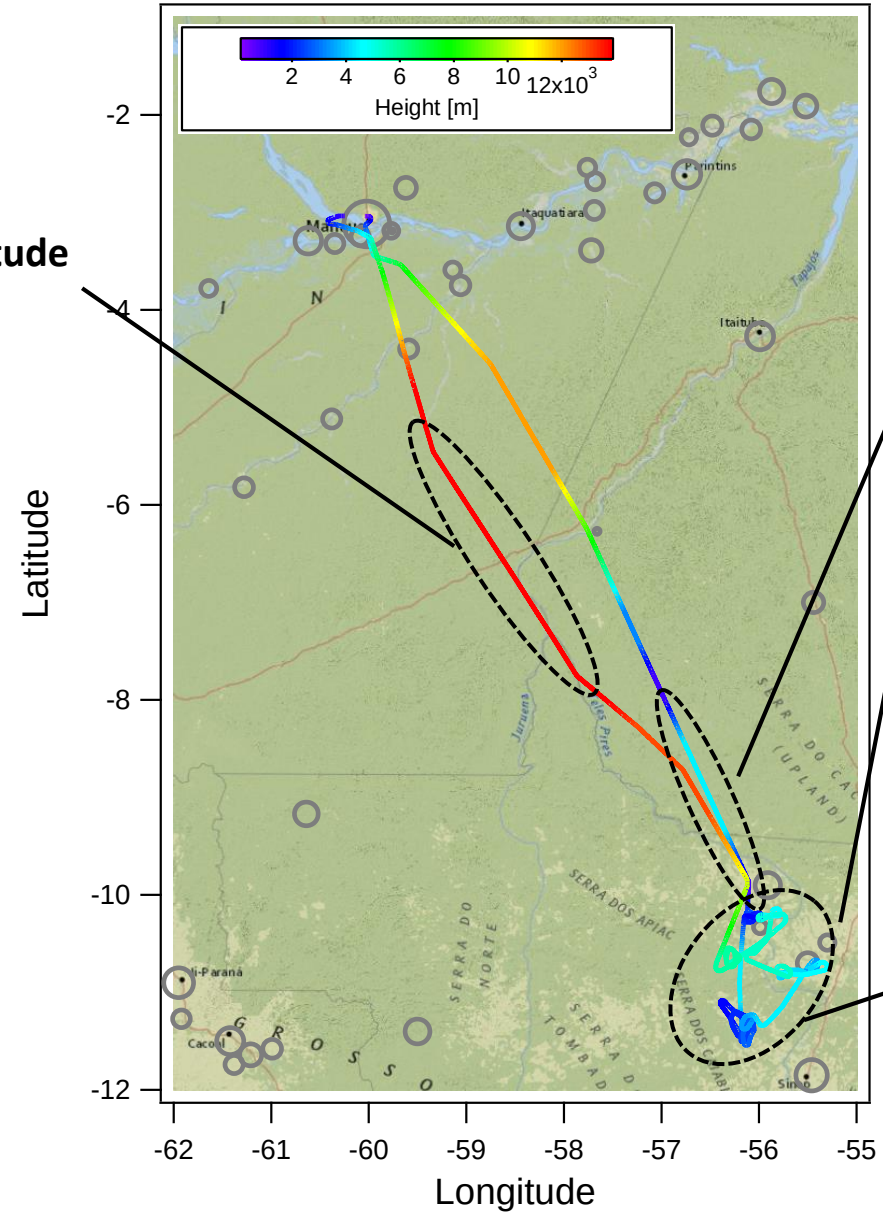
1. Organic Aerosol (~ 60 %)
2. Soot (rather fresh) (~ 30 %)
3. $K_x(NH_4)_YSO_4$ (+ Mg) (~ 10 %)

STXM @ AC12: Flight Map

(3)

Nucleation at high altitude

- SEM-EDX, AFM
- 1 sample @ HASI



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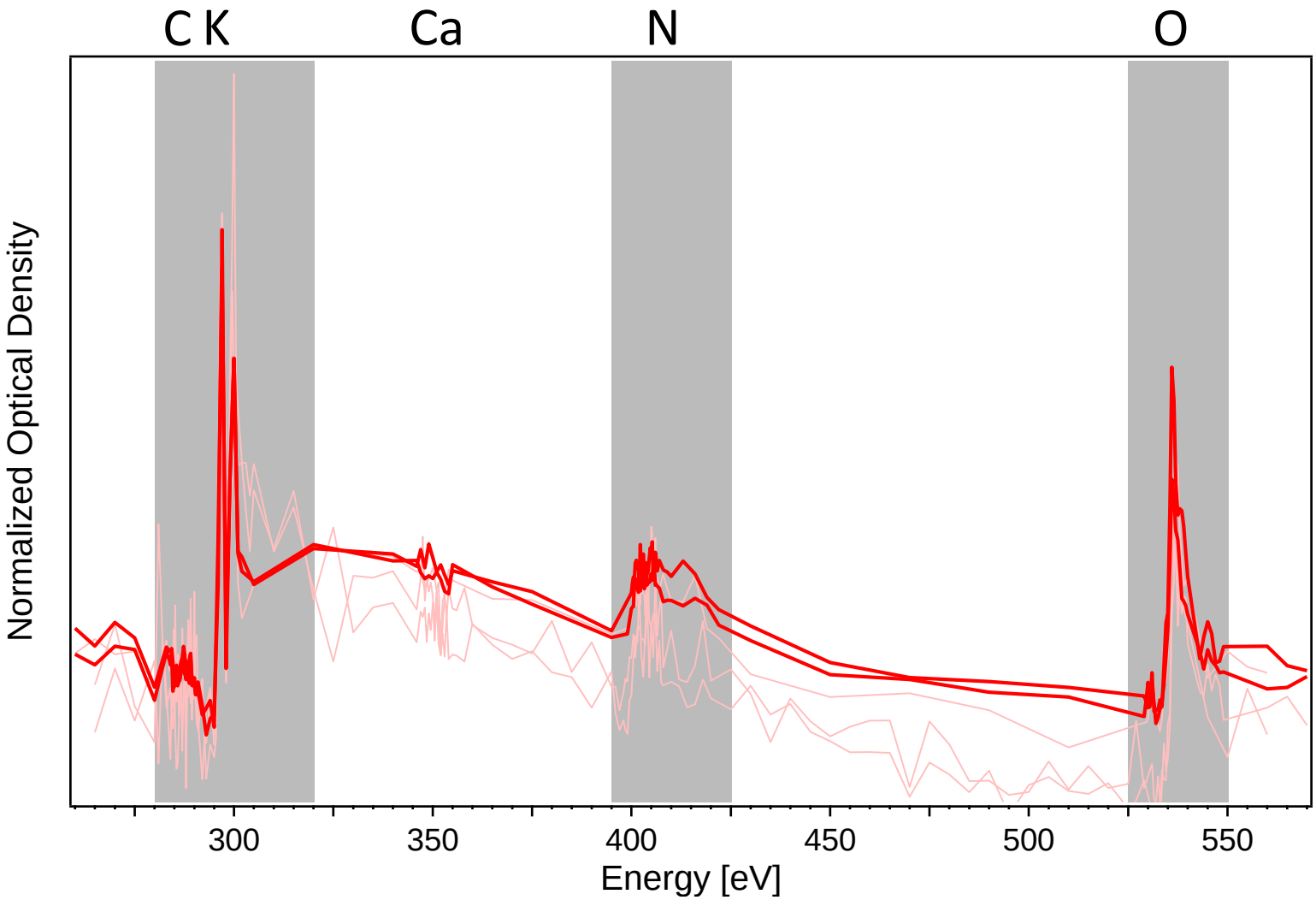
STXM @ AC12: HASI vs. CVI



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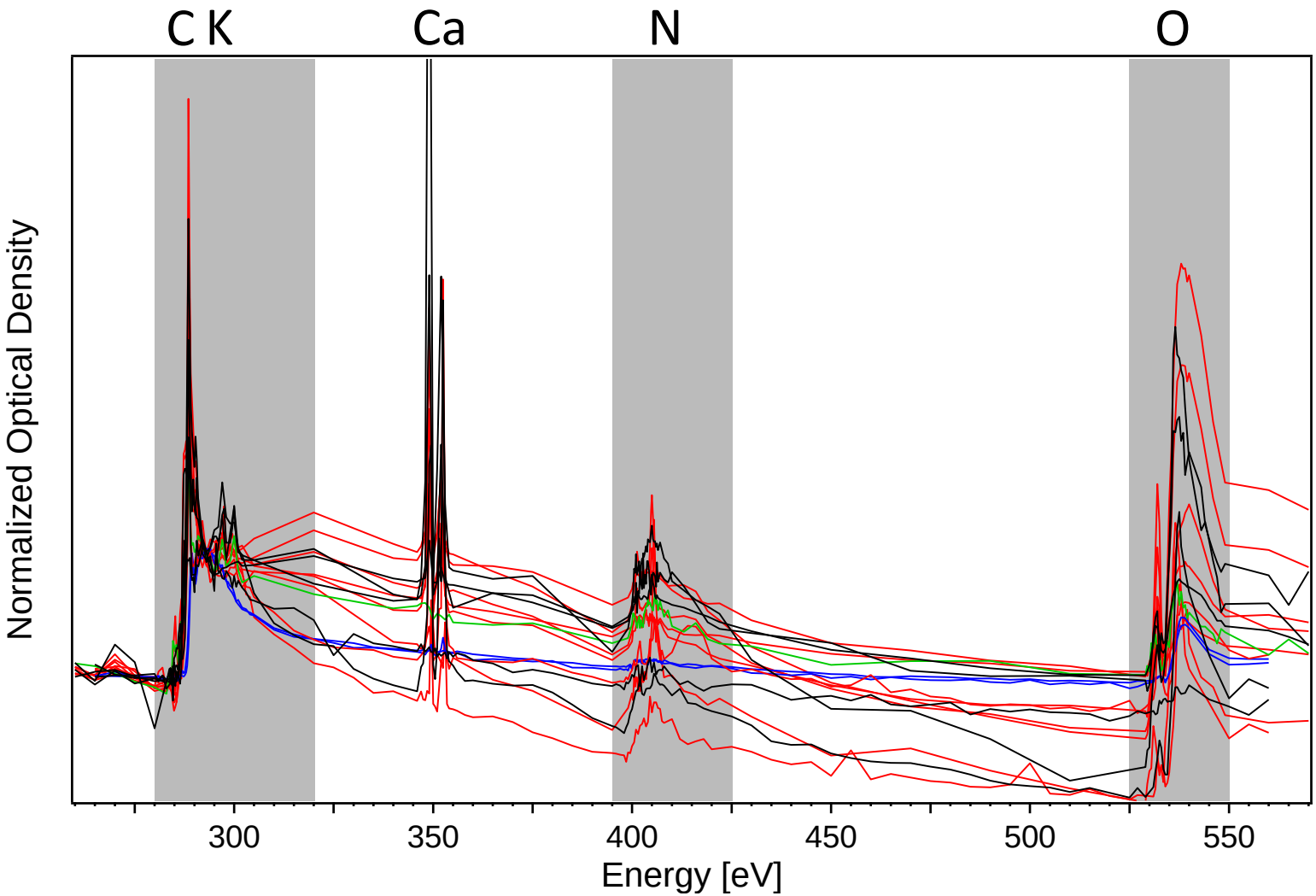
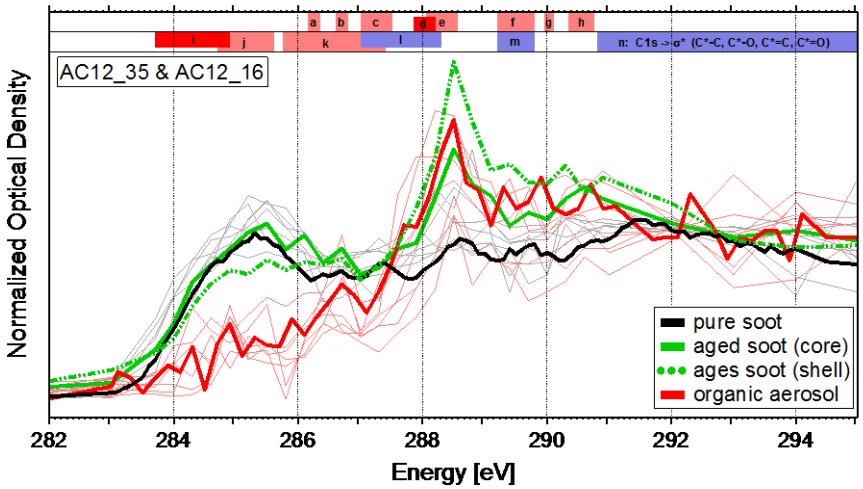
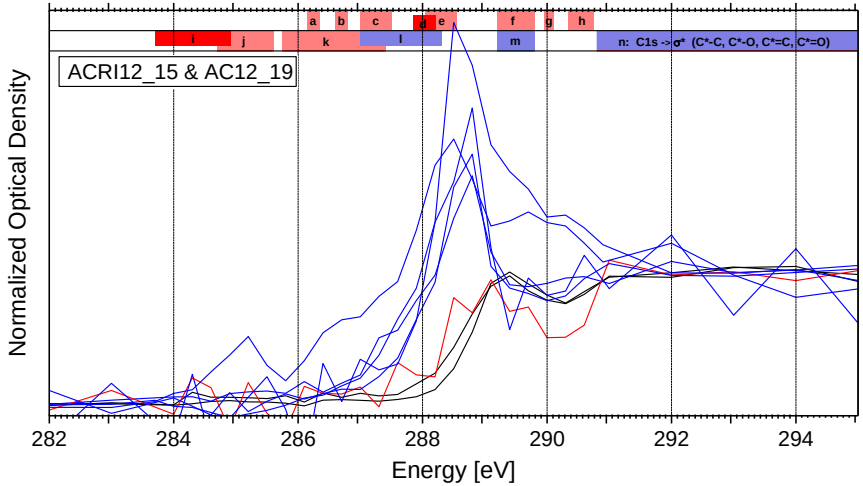
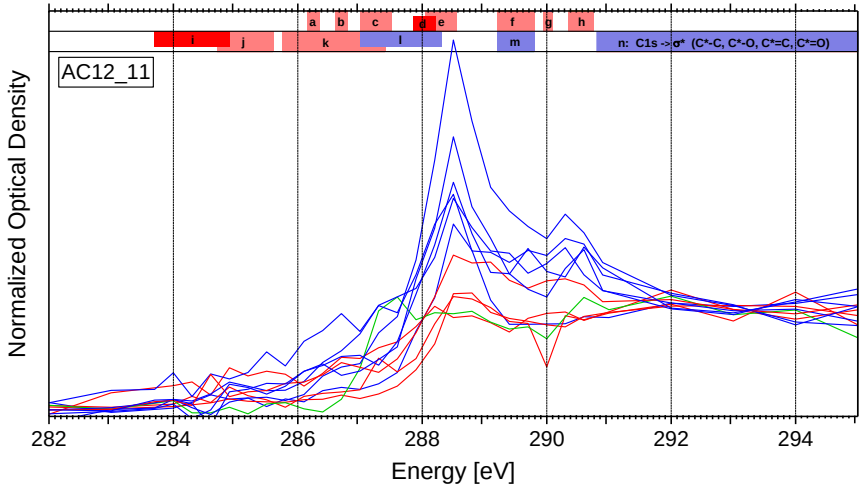
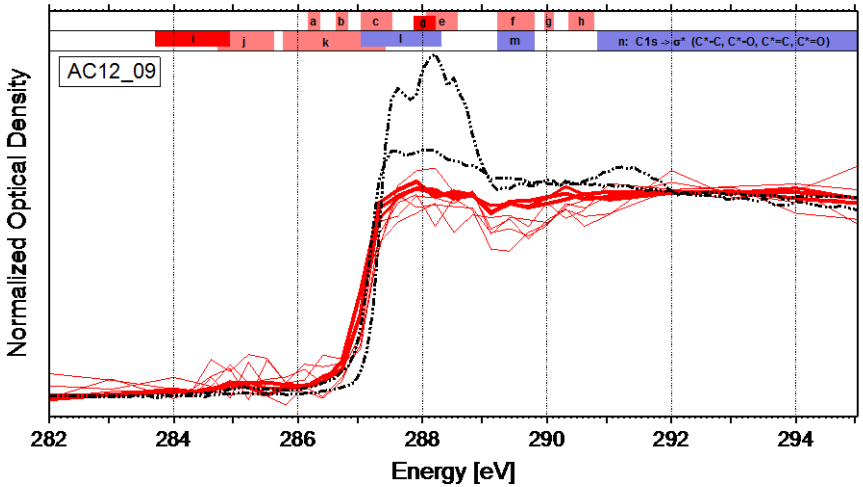


STXM @ AC12: HASI vs. CVI









STXM @ AC12: Flight Map

(3)

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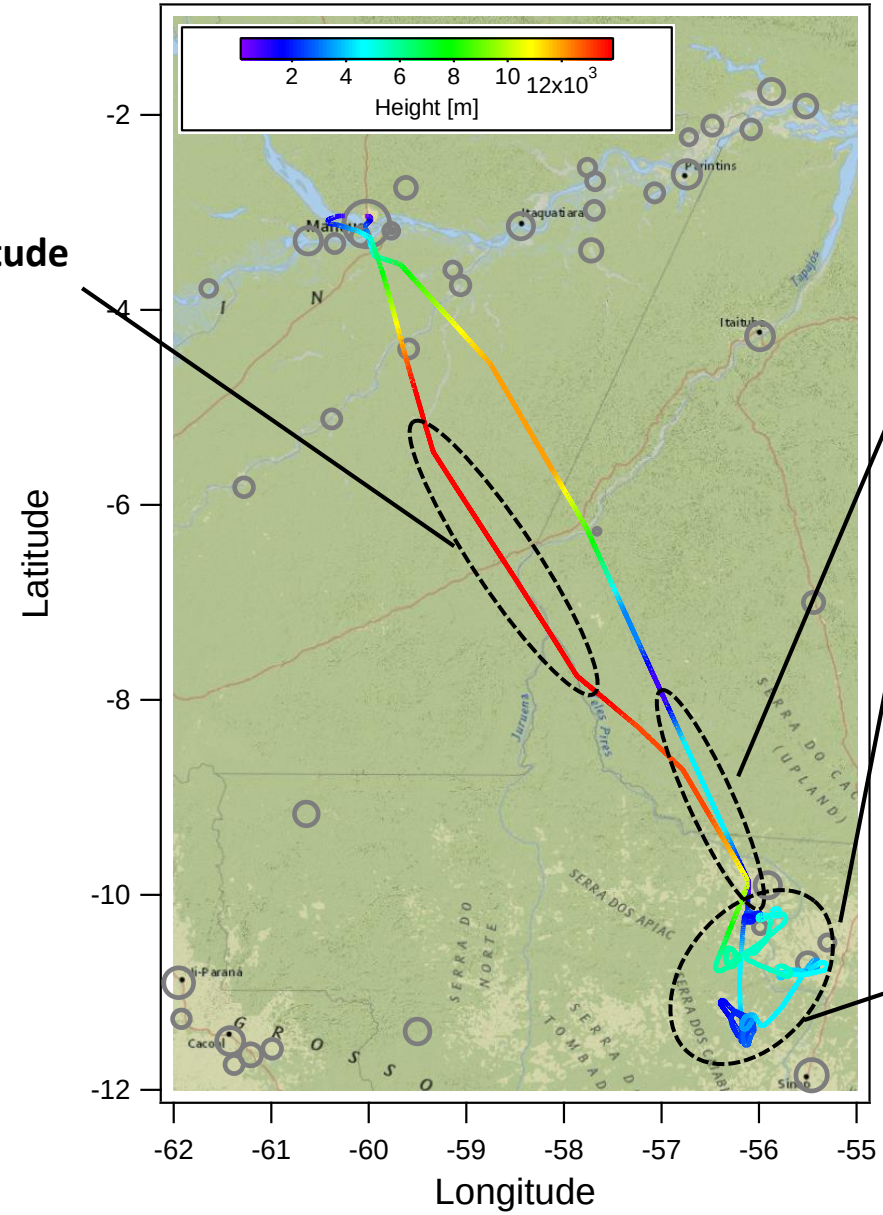
- 1 sample @ HASI



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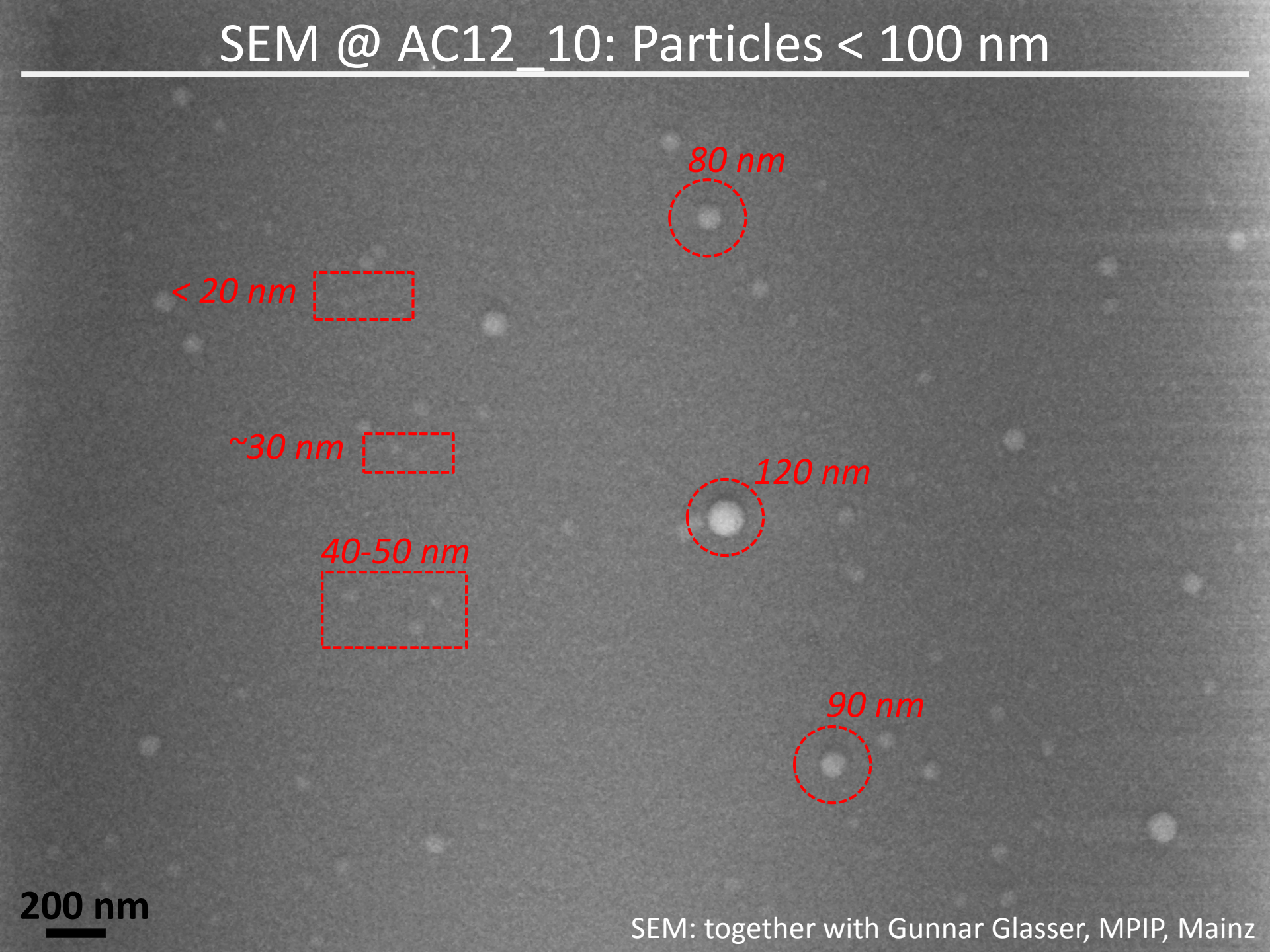
SEM @ AC12_10: Particles < 100 nm

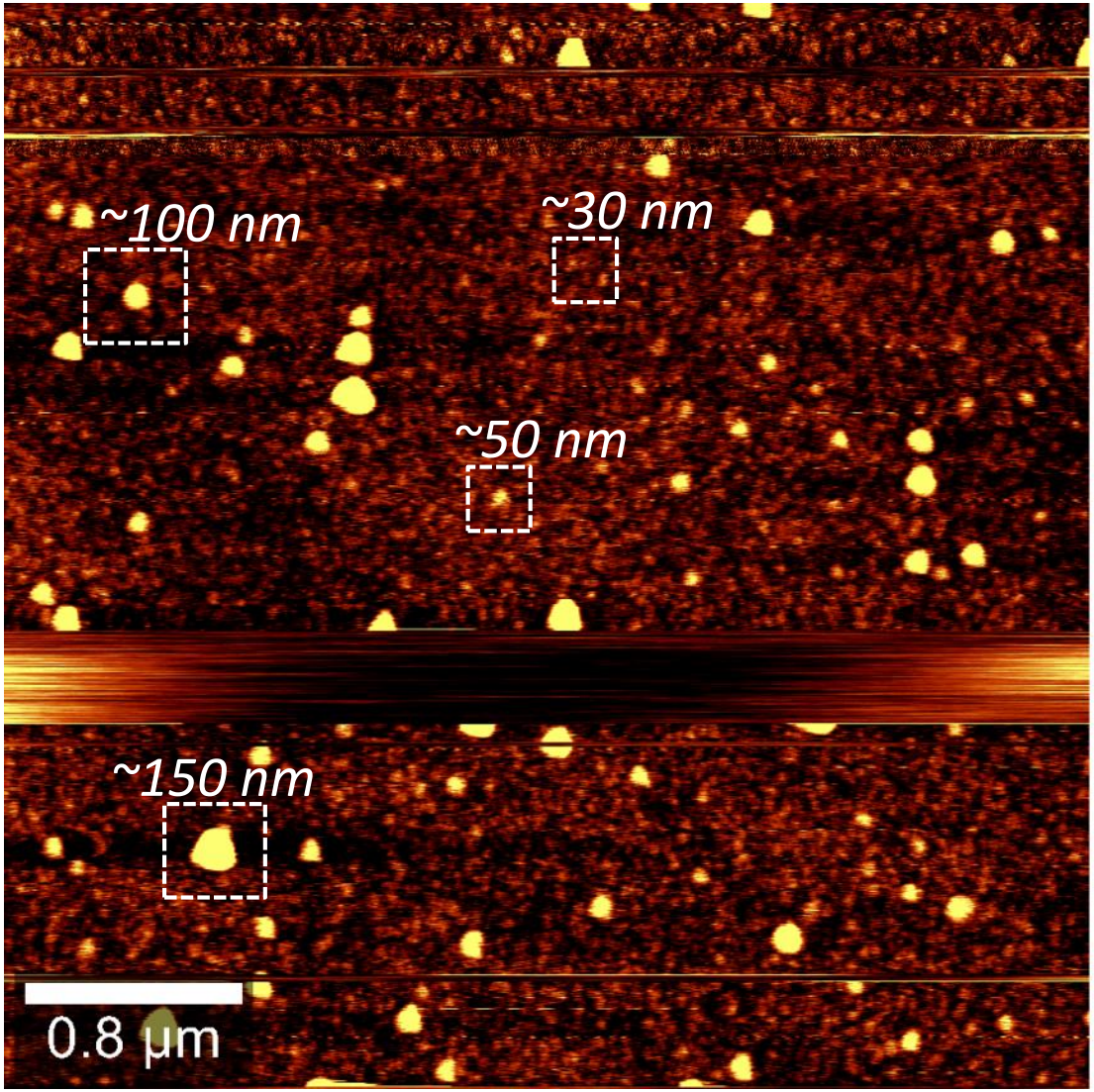
SEM: together with Gunnar Glasser, MPIP, Mainz

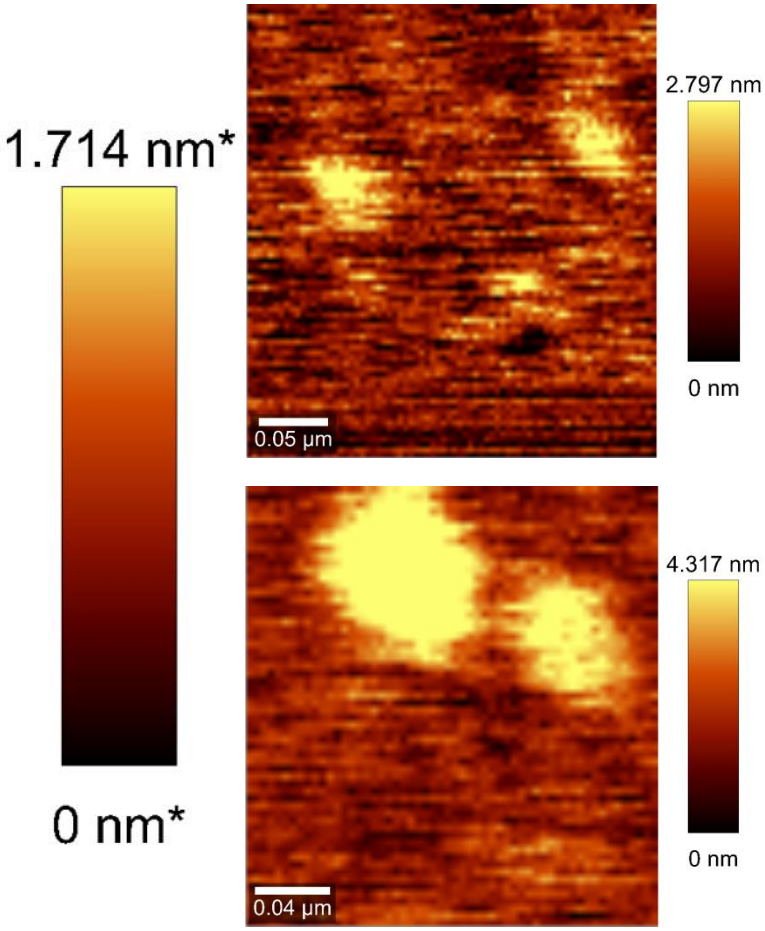
SEM @ AC12_10: Particles < 100 nm



SEM: together with Gunnar Glasser, MPIP, Mainz

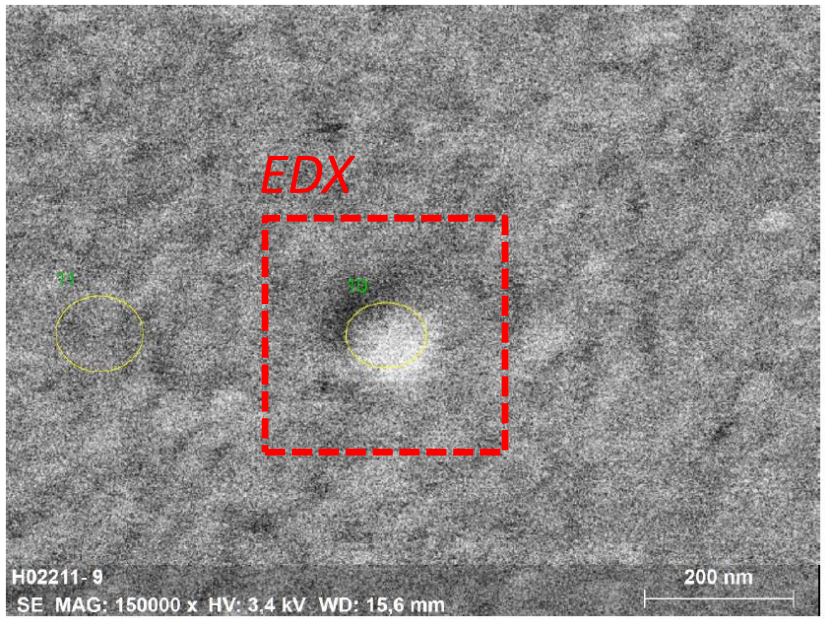
AFM @ AC12_10: Particles < 100 nm

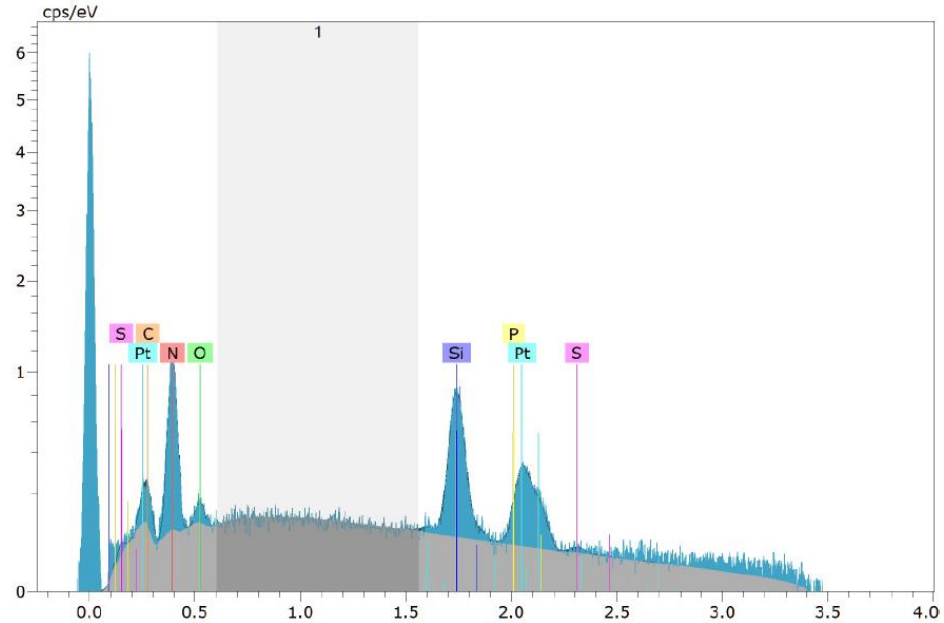


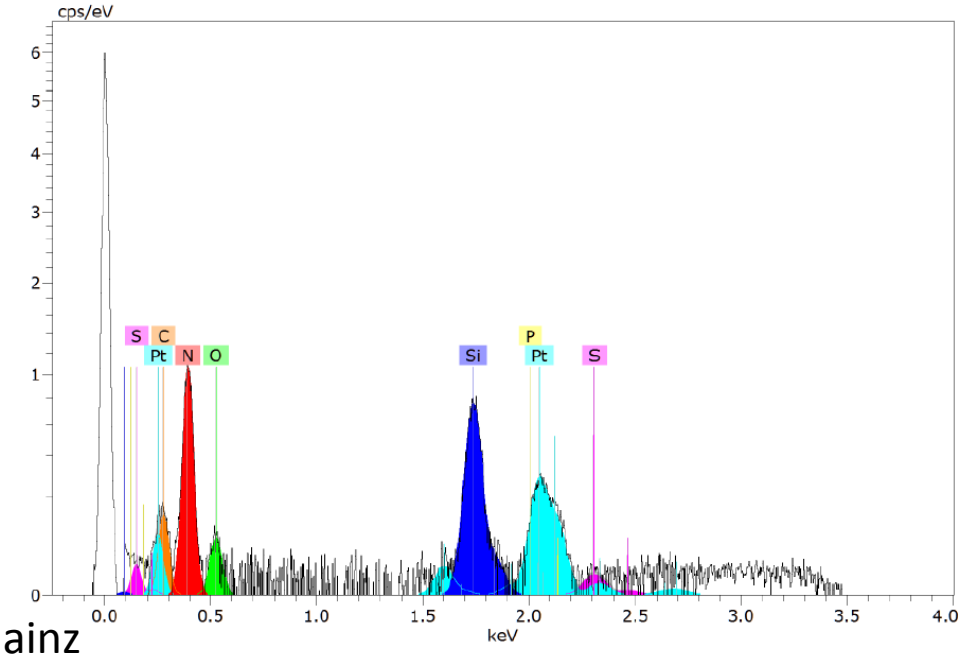


AFM data from Johannes Ofner, TU Vienna

SEM-EDX @ AC12_10: Particles < 100 nm







SEM: together with Gunnar Glasser, MPIP, Mainz

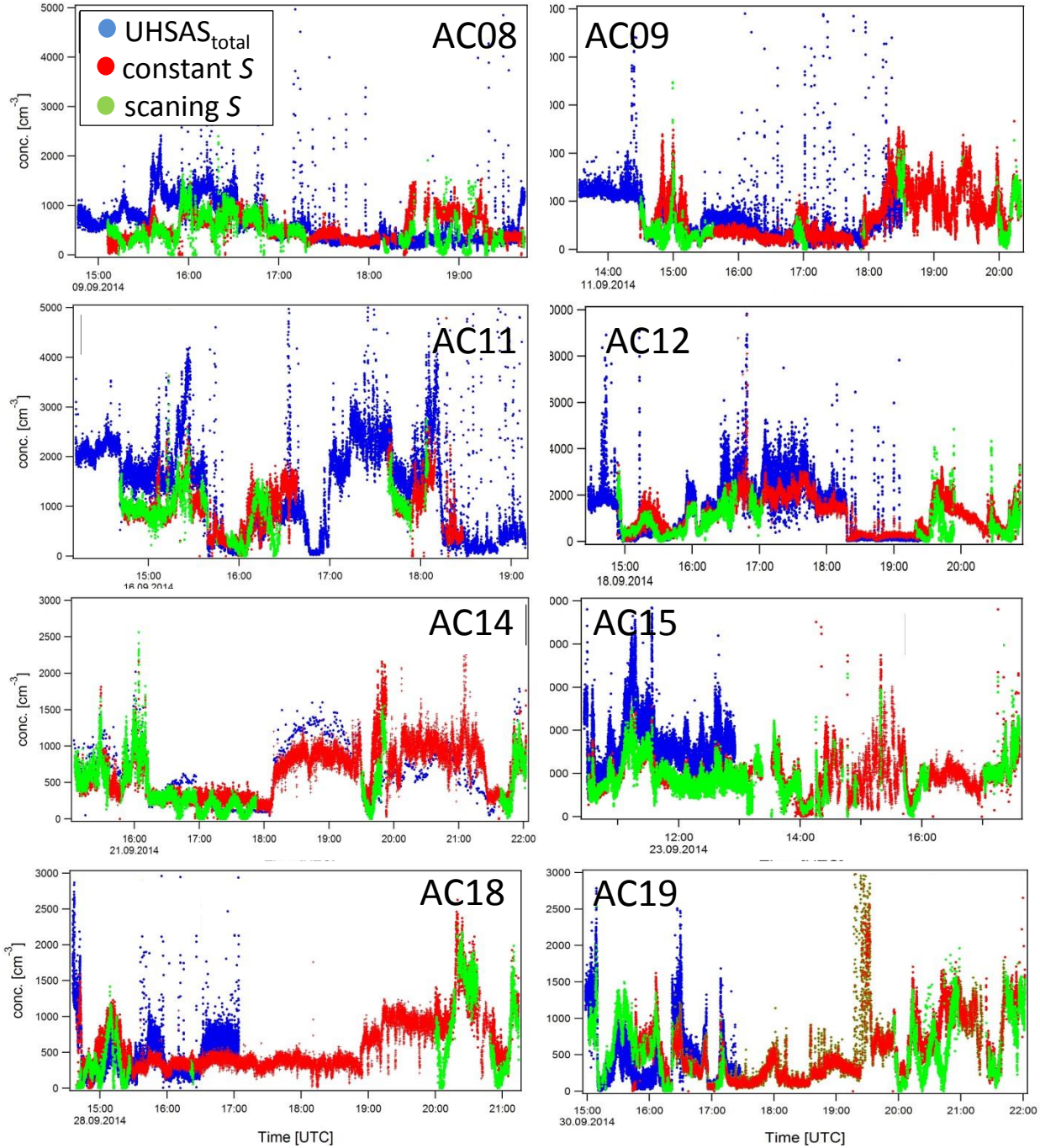
Summary

CCNC

- Data systematically analyzed *(contact Mira)*
- Major trends are plausible *(e.g., pollution vs. clean, CCN profiles, ACRI/ATTO comparison)*
- Certain questions remain to be discussed *(e.g., low kappa, cloud S levels, etc.)*

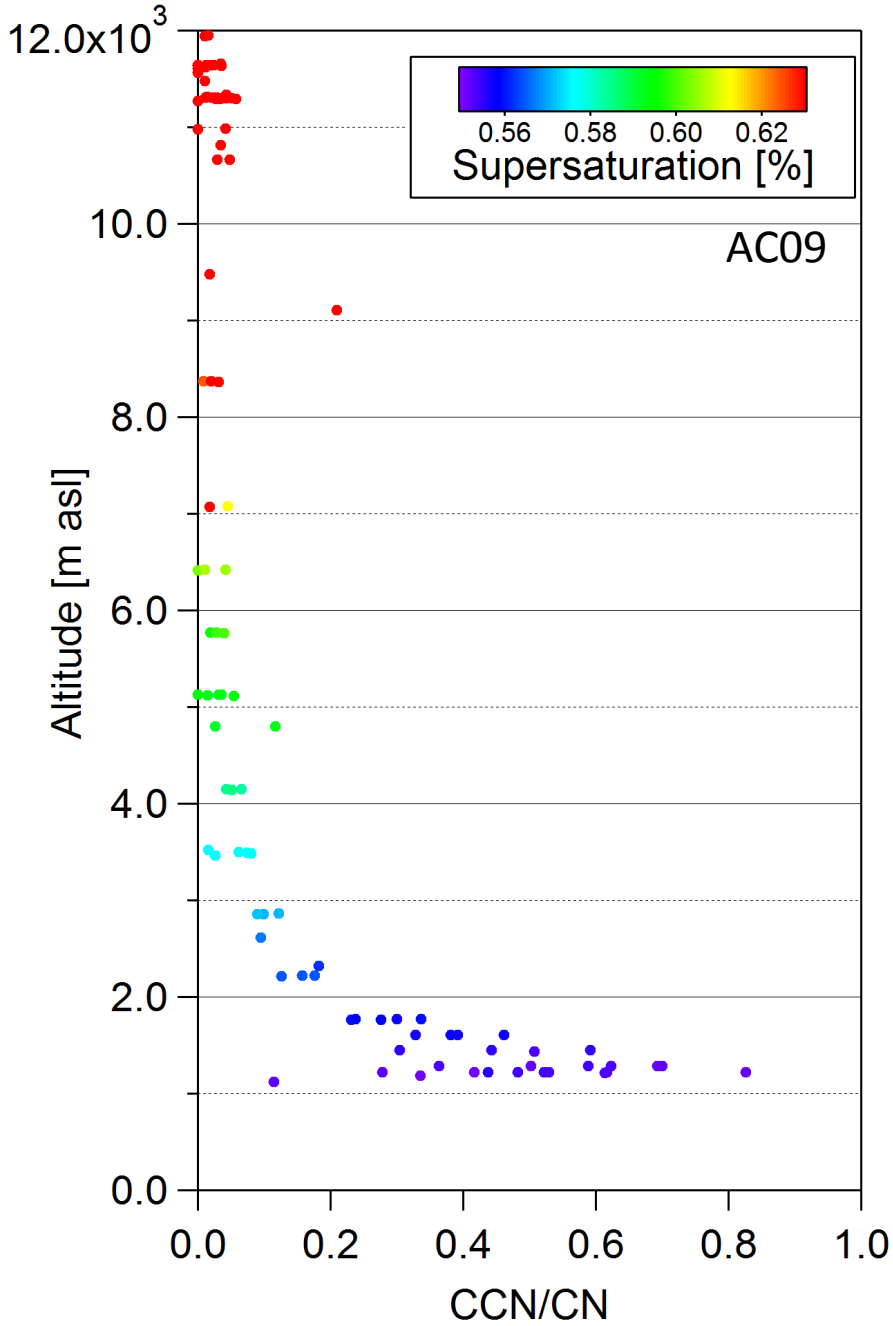
Aerosol Sampling & Microspectroscopy

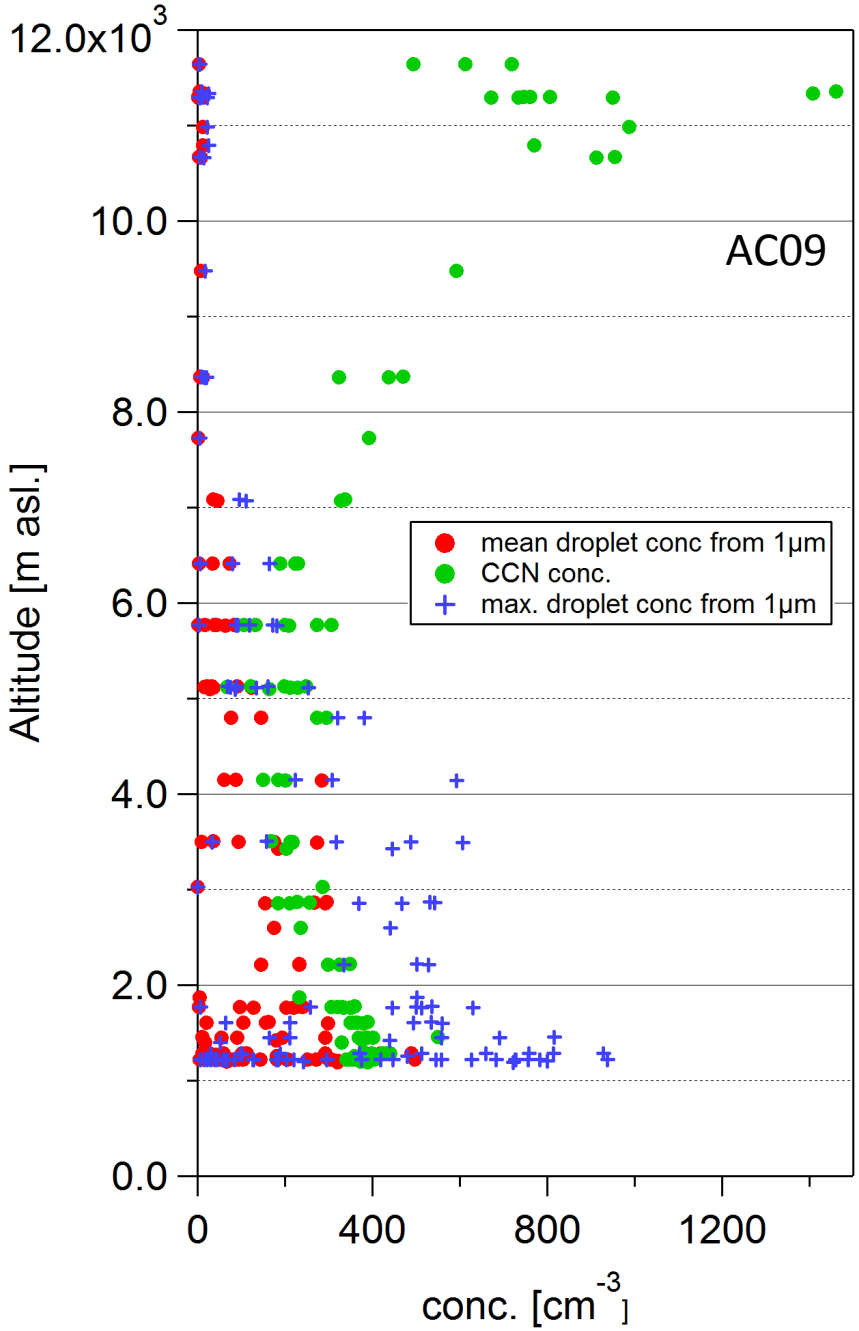
- So far: Analysis of 2 flights - work in progress
- X-ray microscopy provides further insights in combination with e.g. AMS, CCNC, SP2, etc.
- Analysis so far: Some plausible trends + several open questions

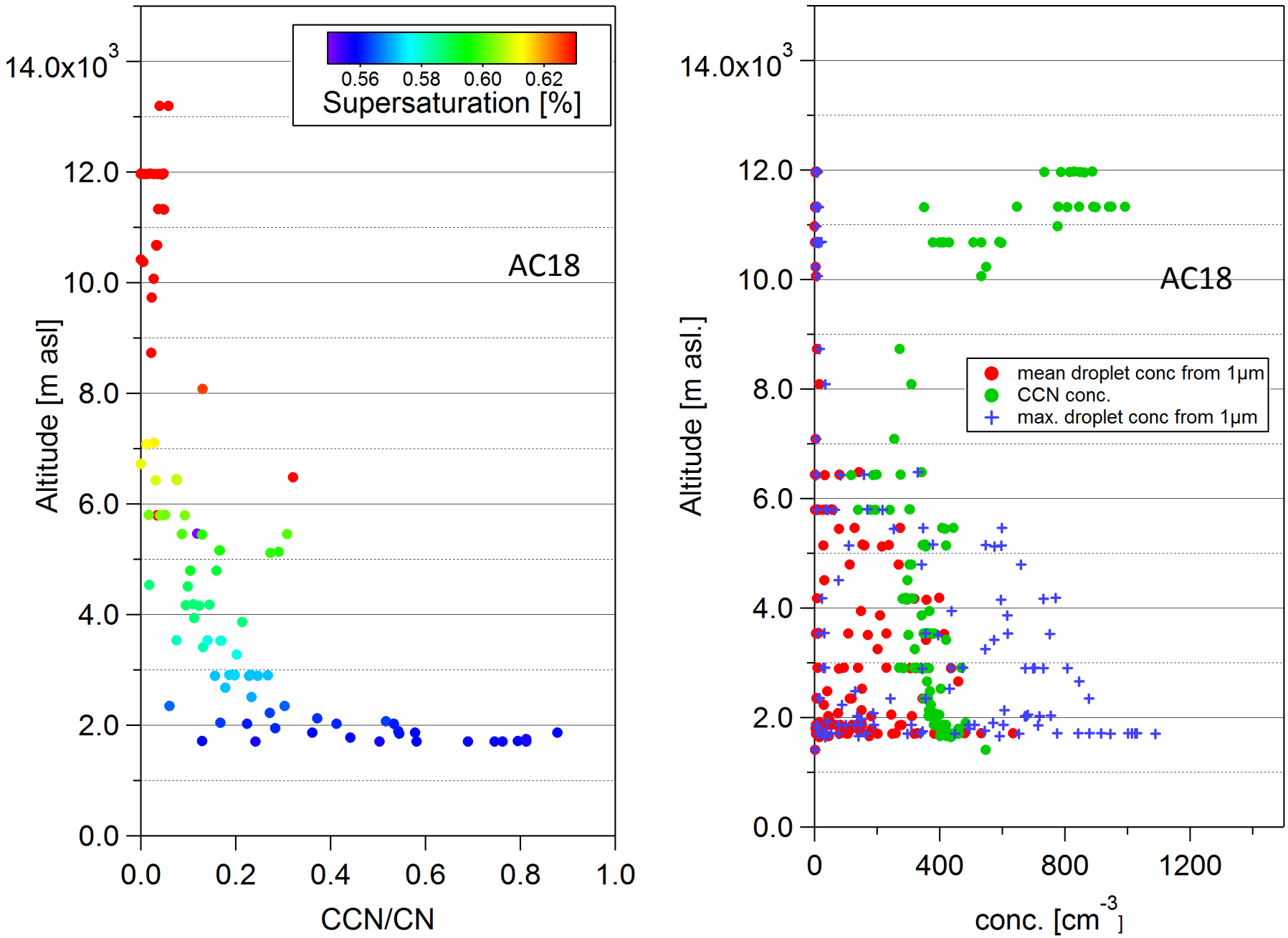


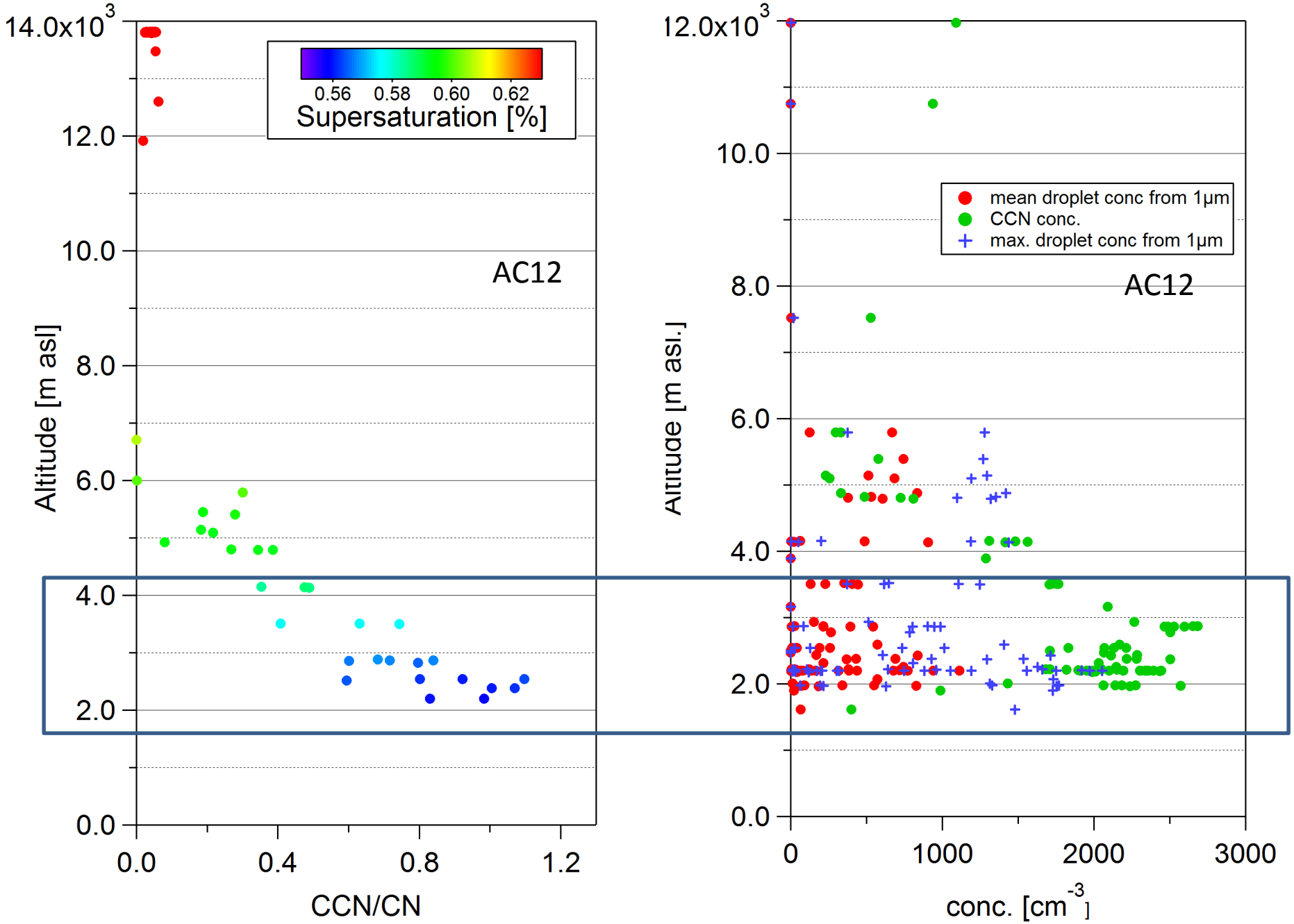
- UHSAS & CCN Data shows good agreemant

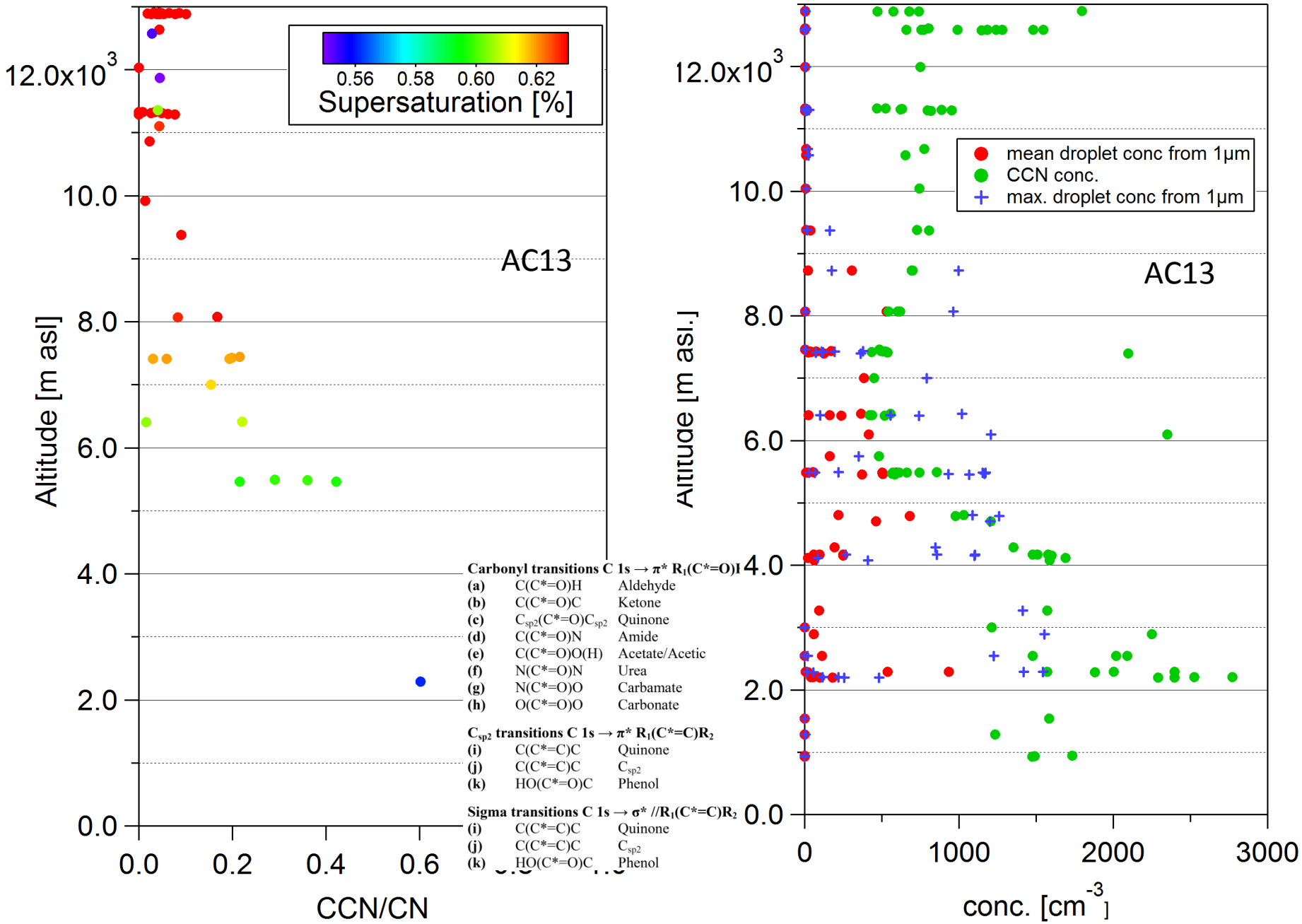
UHSAS Data Weinzierl[5] et. al. DLR.


12.0x10^3
10.0
8.0
6.0
4.0
2.0
0.0
Altitude [m asl]
0.0
0.2
0.4
0.6
0.8
1.0
CCN/CN
0.56
0.58
0.60
0.62
Supersaturation [%]
AC09


12.0x10^3
10.0
8.0
6.0
4.0
2.0
0.0
Altitude [m asl.]
0
400
800
1200
conc. [cm^-3]
AC09
mean droplet conc from 1µm
CCN conc.
max. droplet conc from 1µm


14.0x10^3
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Altitude [m asl]
0.0
0.2
0.4
0.6
0.8
1.0
CCN/CN
0.56
0.58
0.60
0.62
Supersaturation [%]
AC18
14.0x10^3
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Altitude [m asl.]
0
400
800
1200
conc. [cm^-3]
AC18
mean droplet conc from 1µm
CCN conc.
max. droplet conc from 1µm


14.0x10^3
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Altitude [m asl]
0.0
0.4
0.8
1.2
CCN/CN
0.56
0.58
0.60
0.62
Supersaturation [%]
AC12
12.0x10^3
10.0
8.0
6.0
4.0
2.0
0.0
Altitude [m asl.]
0
1000
2000
3000
conc. [cm^-3]
mean droplet conc from 1µm
CCN conc.
max. droplet conc from 1µm
AC12



Carbonyl transitions C 1s → π* $R_1(C^*=O)R$

(a)	C(C*=O)H	Aldehyde
(b)	C(C*=O)C	Ketone
(c)	$C_{sp2}(C^*=O)C_{sp2}$	Quinone
(d)	C(C*=O)N	Amide
(e)	C(C*=O)O(H)	Acetate/Acetic
(f)	N(C*=O)N	Urea
(g)	N(C*=O)O	Carbamate
(h)	O(C*=O)O	Carbonate

C_{sp2} transitions C 1s → π* $R_1(C^*=C)R_2$

(i)	C(C*=C)C	Quinone
(j)	C(C*=C)C	C_{sp2}
(k)	HO(C*=O)C	Phenol

Sigma transitions C 1s → σ* //$R_1(C^*=C)R_2$

(i)	C(C*=C)C	Quinone
(j)	C(C*=C)C	C_{sp2}
(k)	HO(C*=O)C	Phenol

STXM @ AC12 - Overview