Aerodyne AMS Users Meeting, St Louis, 8-10 September 2018

2001	**1st/2nd**	**AMS Users Meeting Portland / Aerodyne**	
2002	**3rd**	**Aerodyne**	
2003	**4th**	**Caltech**	
2004	**5th**	**GaTech**	
2005	**6th**	**Juelich**	
2006	**7th**	**Minnesota**	
2007	**8th**	**DRI, Reno, NV**	
2008	**9th**	**Manchester**	**Hi-Res Clinic Boulder**
2009	**10th**	**Toronto**	**Data Analysis Clinics Boulder, PSI**
2010	**11th**	**Hyytiälä**	**PSI (EUCAARI)**
2011	**12th**	**Orlando**	**Barcelona, Boulder**
2012	**13th**	**Minnesota**	**Boulder, PSI (ACSM)**
2013	**14th**	**Prague**	**Boulder (AMS + CIMS)**
		AMS Meeting at PKU	
2014	**15th**	**Korea / Orlando**	**CIMS Aerodyne**
2015	**16th**	**Milan**	**Boulder CIMS Fort Collins**
2016	**17th**	**Portland**	**CIMS Boulder**
		AMS Workshop at IAP	**PAM AGU**
2017	**18th**	**AMS/CIMS PKU, Beijing**	**CIMS Helsinki PAM AGU**

2018 Nanjing Chinese AMS Clinic CIMS(UWash.) 19th *AMS (IAC, St Louis)* [PAM]

AMS Introduction

Doug Worsnop

AMS Users Meeting

~~Aerodyne~~

~~Caltech~~

~~Georgia Tech~~

~~FZ - Juelich~~

~~University of Minnesota~~

~~Desert Research Institute~~

~~Manchester~~

~~Toronto → Hyytiala → Orlando -> Minnesota -> Prague → Busan~~

~~October 2001/2002~~

~~October 24, 2003~~

~~October 8, 2004~~

~~25 August, 2005~~

~~16 September, 2006~~

~~29 September, 2007~~

~~5 September 2008~~

~~October 2009 → September 2010 → October 2011-> October 2012 →2013 → 2014 → 2015~~

~~Portland 2016; Beijing, 2017~~ **St Louis, 2018**

PMF/ME-2 → "source apportionment"

"Molecular Revolution"

Nitrate

Sulfate

Ammonia

Organics (44,57)

OOA, HOA

OOA1, OOA2

O/C/N/H ratios

SV-OOA, LV-OOA

OOA/HOA

SP -> BC

CIMS -> HOM

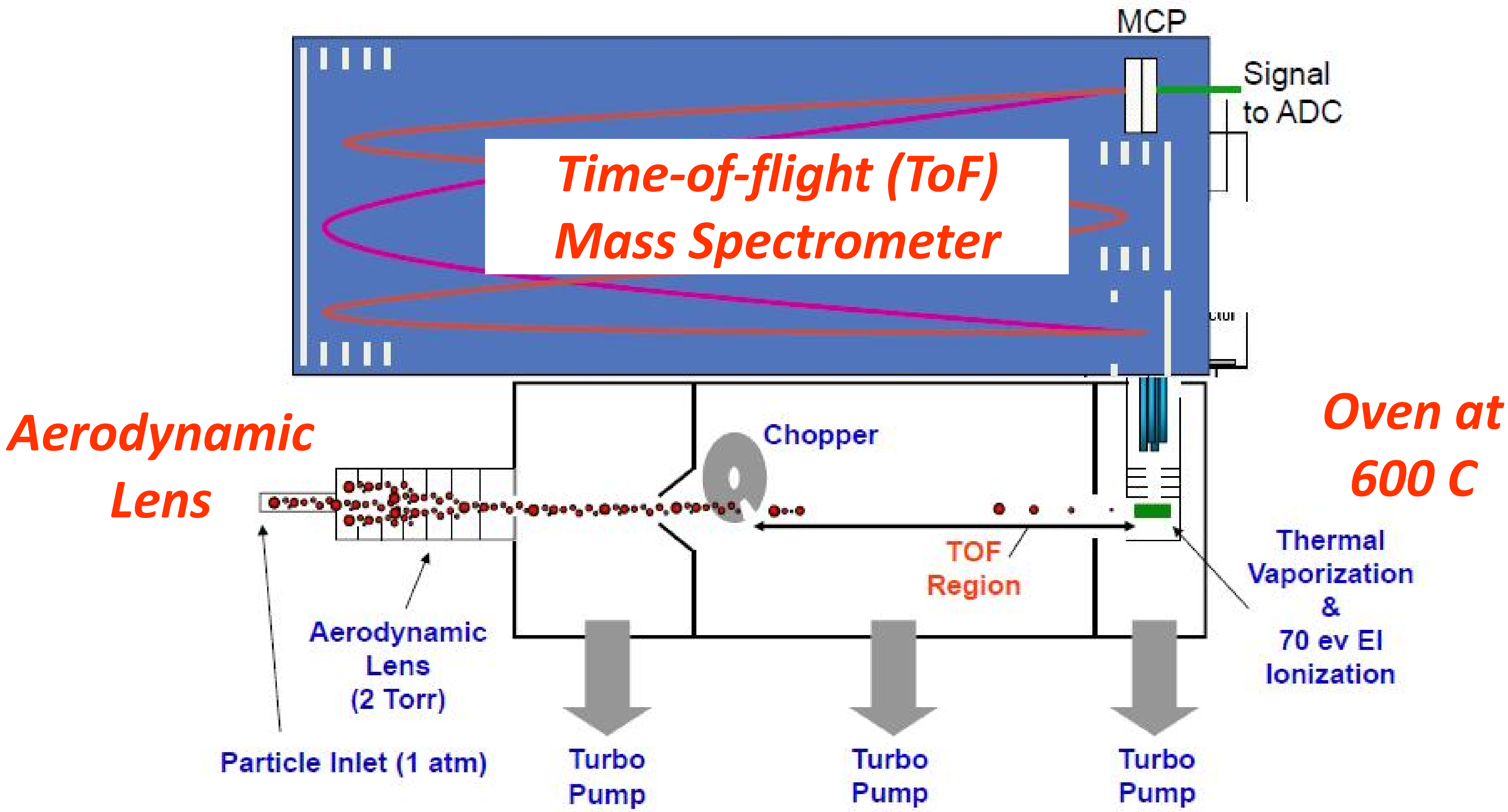
ELVOC

$C_2H_3O_2^-$, I^-, NO_3^-

PM2.5, CE = 1

Size and (elementally) chemically resolved sub-micron aerosol composition

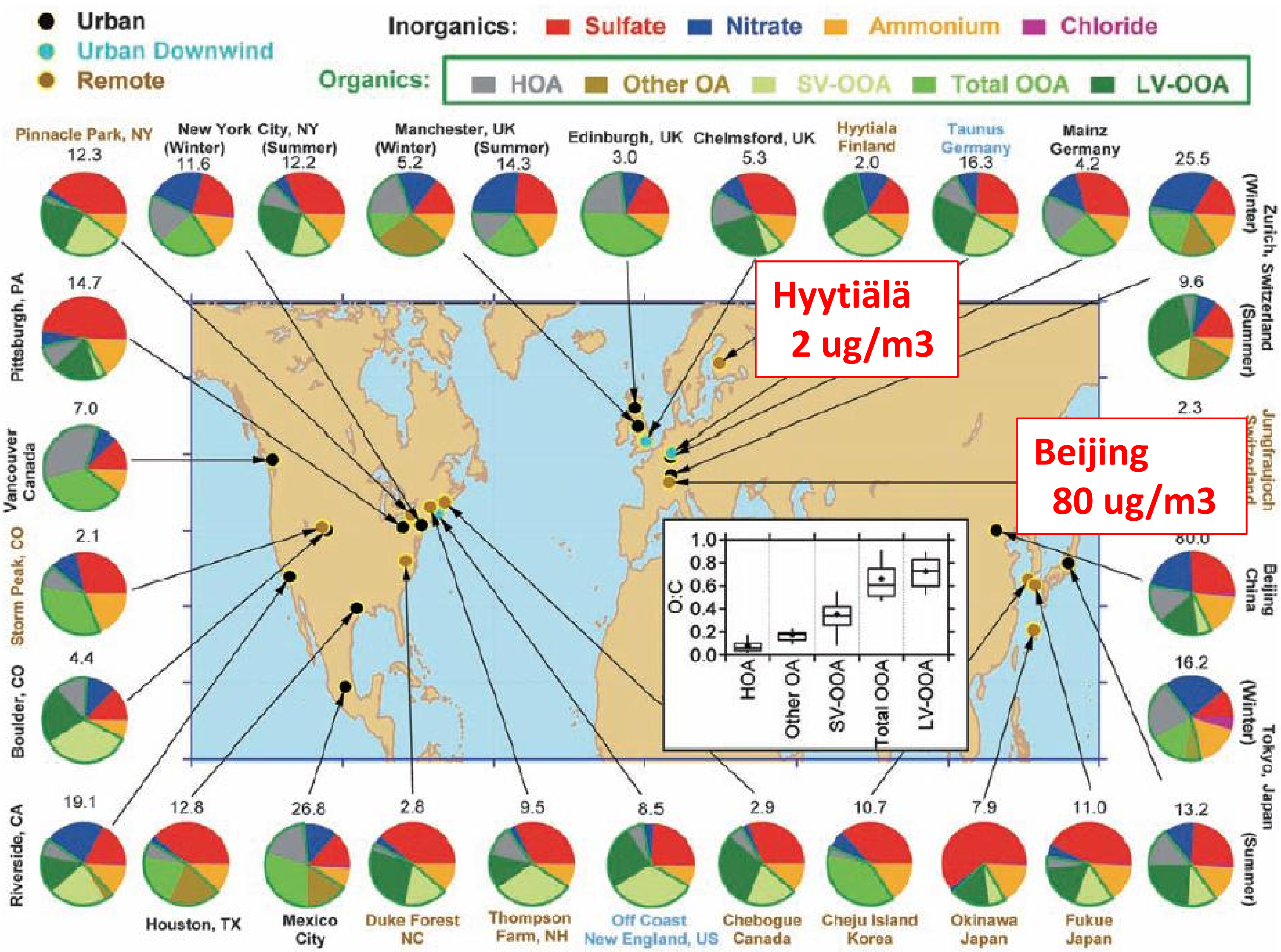
“ A simple molecular beam mass spectrometer ”



Jayne et al, 2000; Drewnick et al, 2005; DeCarlo et al., 2006; Onasch et al, 2012

Inorganic (SO4,NO3) ~ Organic (OOA)

O/C ~ 0.7

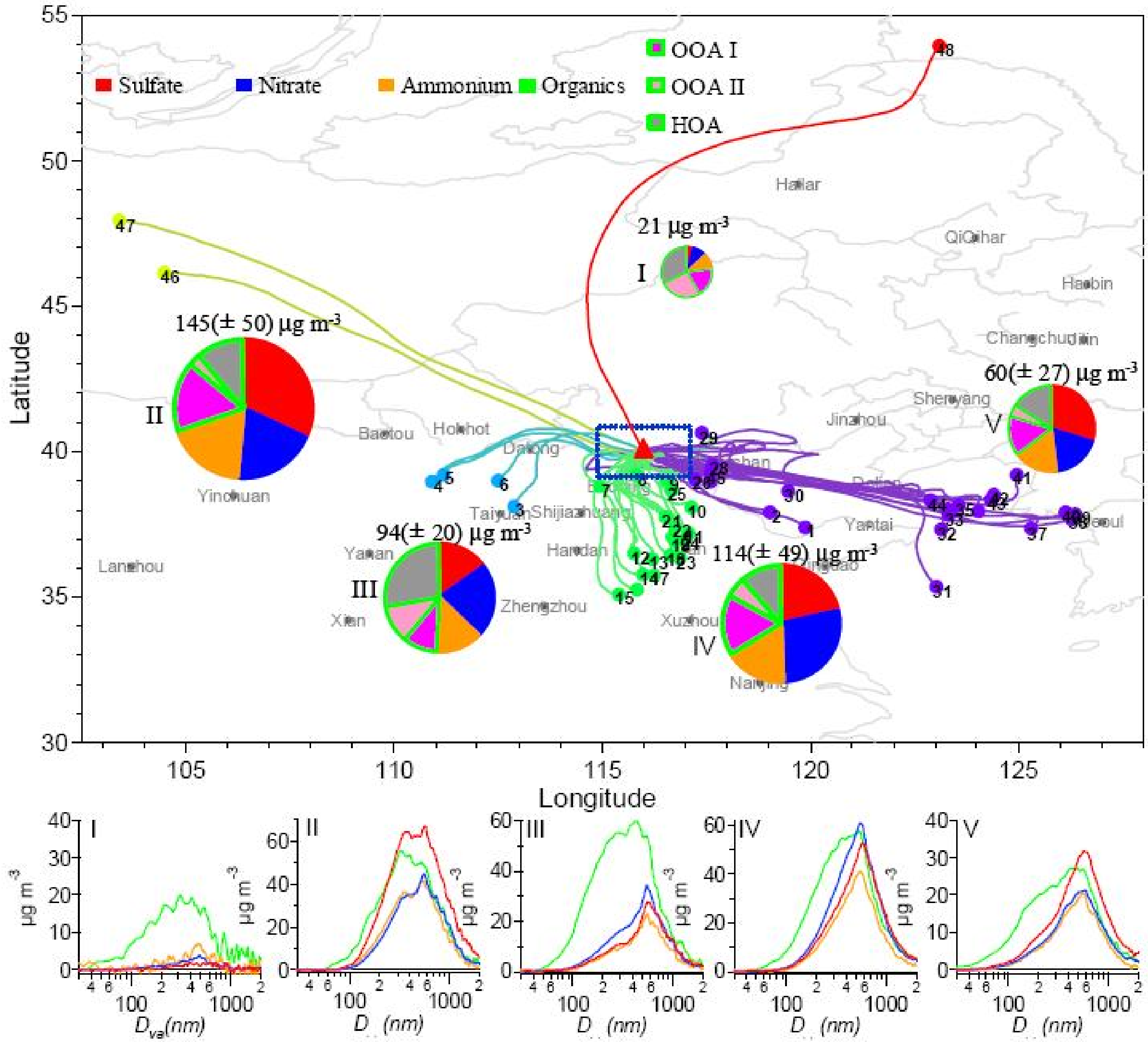


Jimenez et al, Science, 2009

Highly Time- and Size-Resolved Characterization of Submicron Aerosol Particles in Beijing, using an Aerodyne Aerosol Mass Spectrometer

Junying Sun*, Yangmei Zhang, Xiaochun Zhang, Xiaoye Zhang

Nga L. Ng, Manjula R. Canagaratna, John T. Jayne, Douglas R. Worsnop, Yele Sun, Qi Zhang,

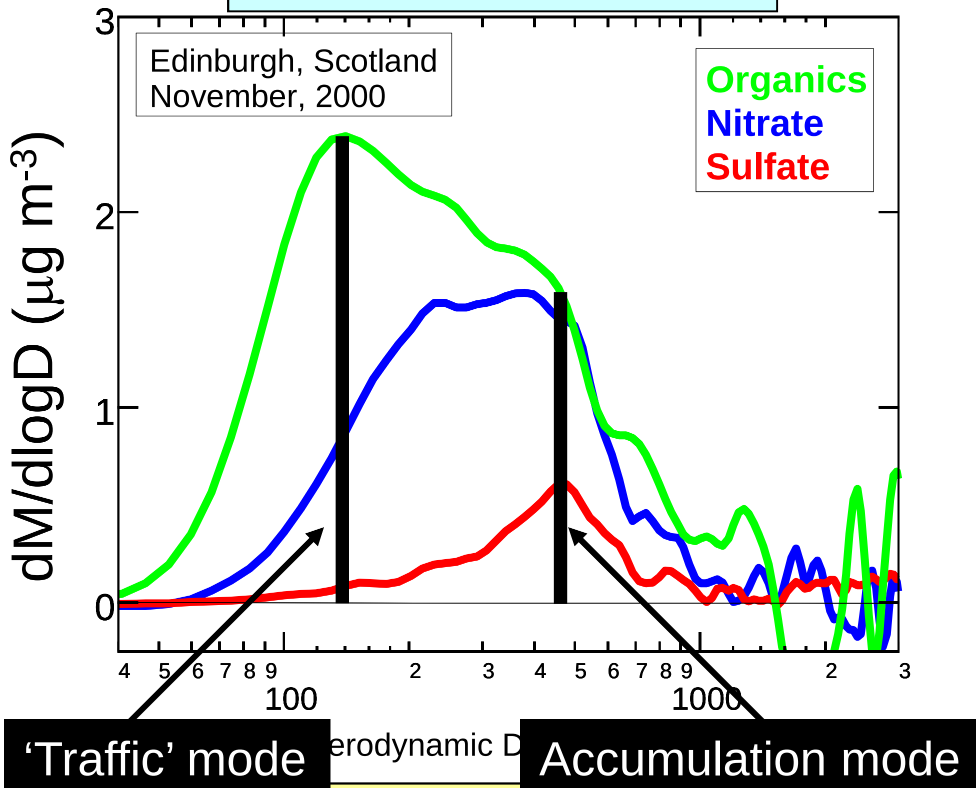


CAMS 2006

Atmospheric Environment (2009)

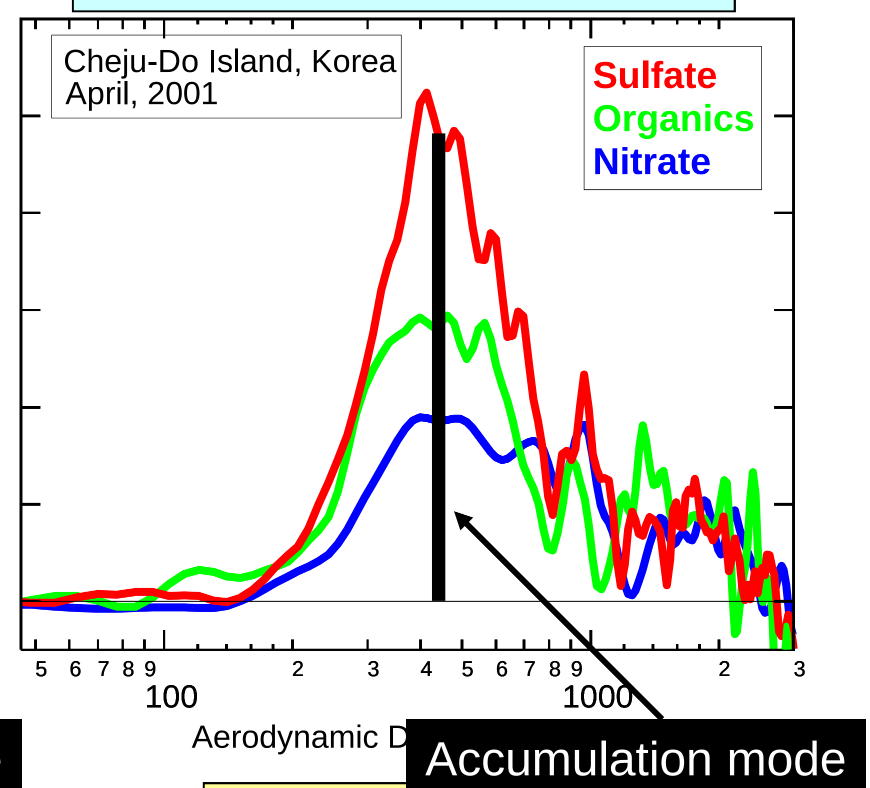
Observed ***'Urban'*** and ***'Remote'*** Size Modes

Urban Site *Bi-modal*
Local Sources



Scotland *SASUA-3*

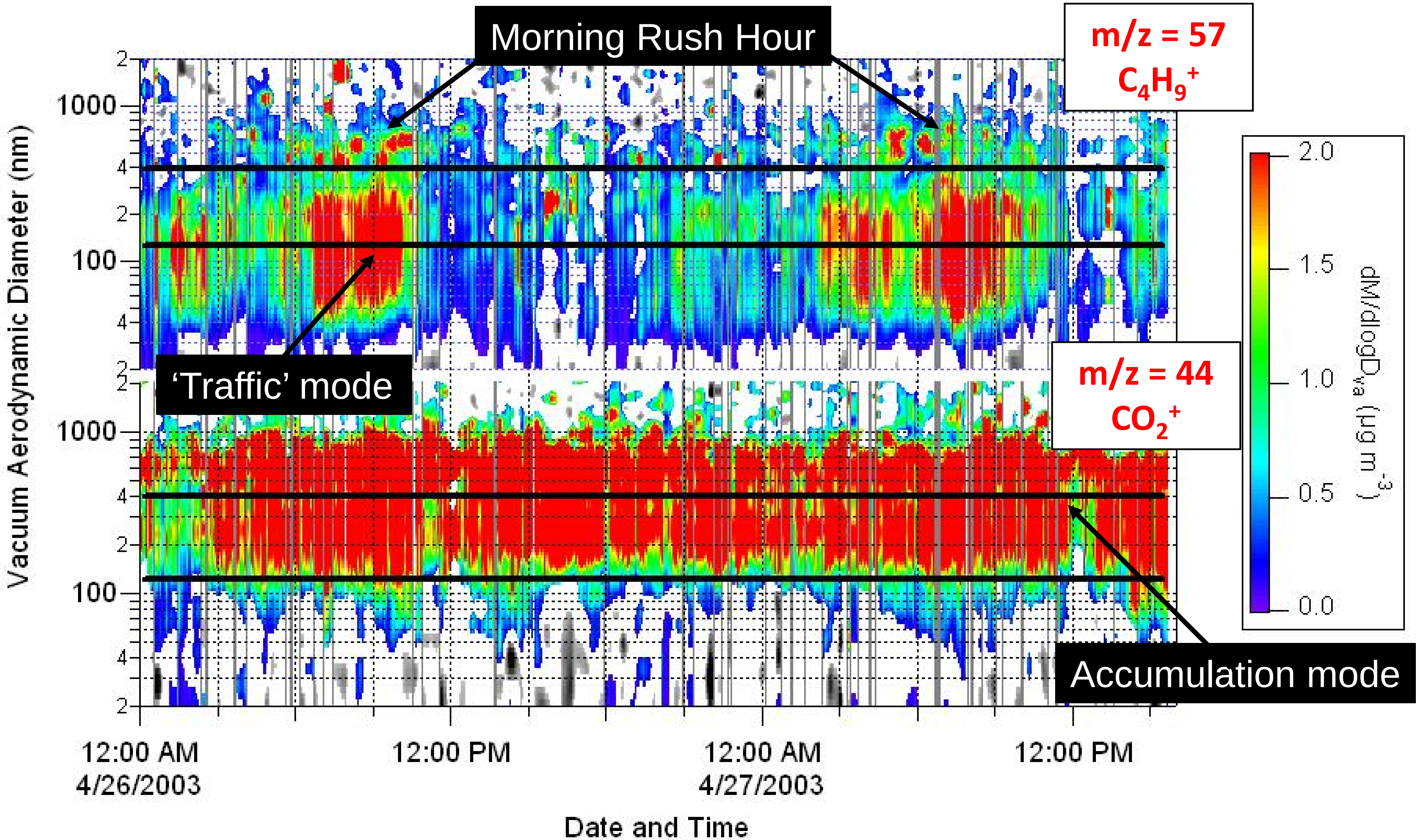
Remote Site *Mono-modal*
Aged-Transported



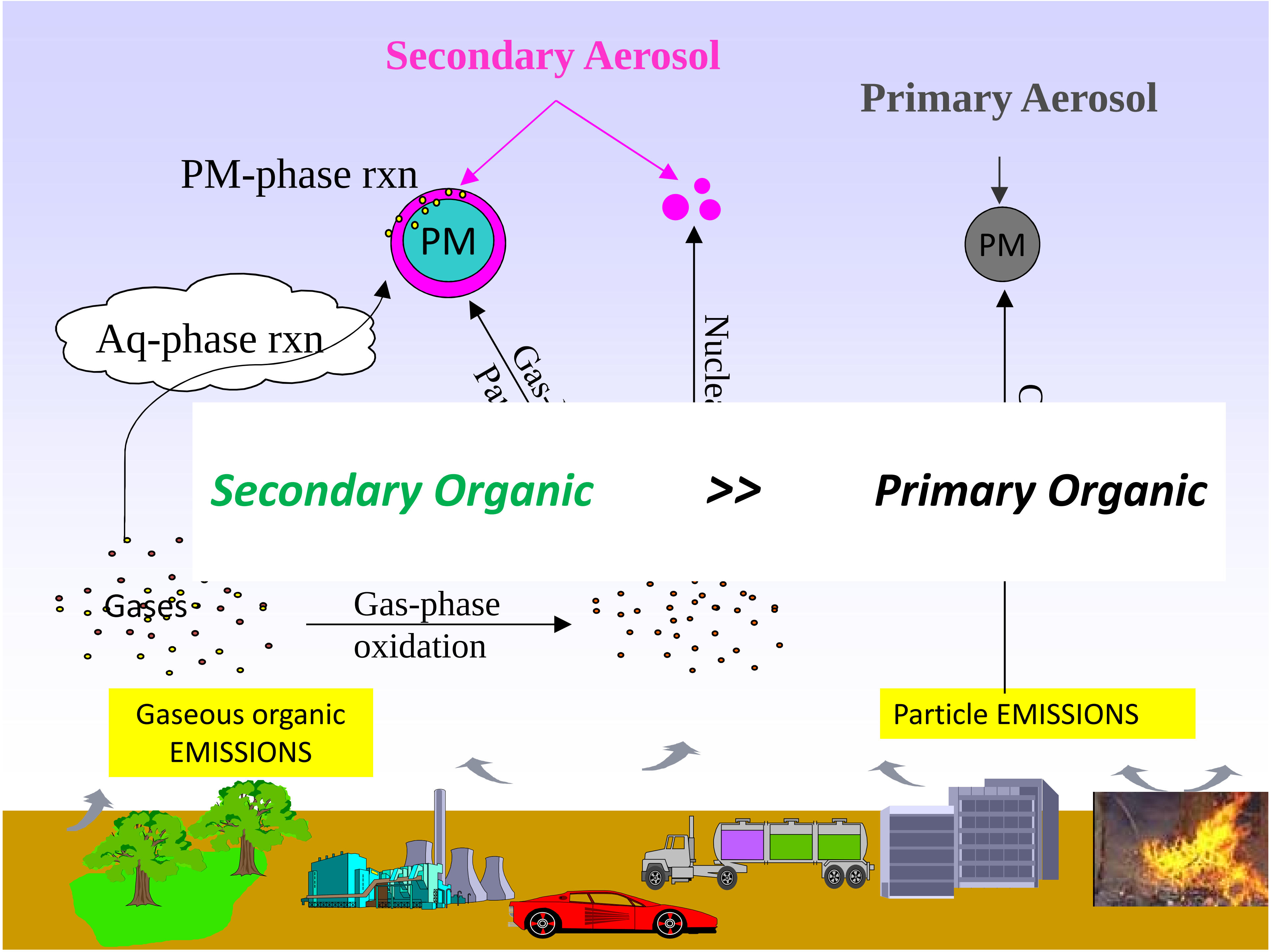
ACE ASIA

Allan, Alfarra et al. (U. Manchester)

Organic Mass Distributions



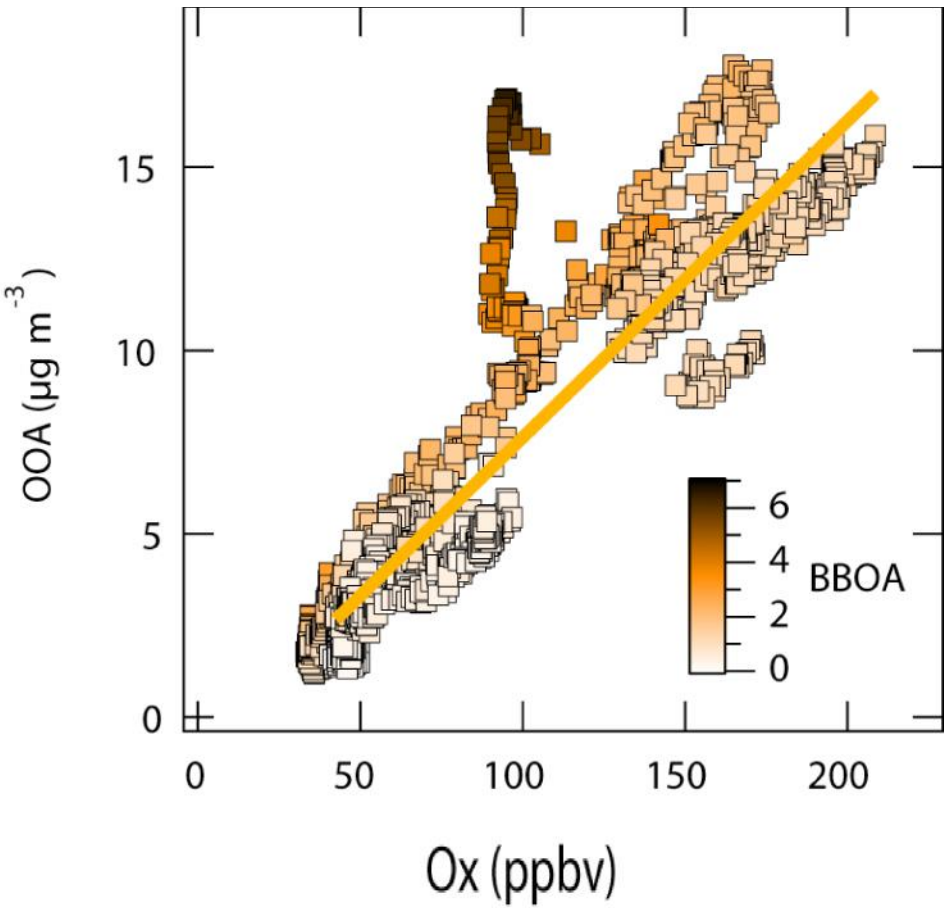
- Small mode, hydrocarbon-based, primary traffic organic PM
- Accumulation mode oxidized organic PM


Secondary Aerosol
Primary Aerosol
PM-phase rxn
PM
PM
Aq-phase rxn
Secondary Organic >> Primary Organic
Gases
Gas-phase
oxidation
Gaseous organic
EMISSIONS
Particle EMISSIONS

GEOPHYSICAL RESEARCH LETTERS, VOL. 35, L15804, doi:10.1029/2008GL034058, 2008

Correlation of secondary organic aerosol with odd oxygen in Mexico City

Scott C. Herndon,[1] Timothy B. Onasch,[1] Ezra C. Wood,[1] Jesse H. Kroll,[1] Manjula R. Canagaratna,[1] John T. Jayne,[1] Miguel A. Zavala,[2,3] W. Berk Knighton,[4] Claudio Mazzoleni,[5] Manvendra K. Dubey,[5] Ingrid M. Ulbrich,[6] Jose L. Jimenez,[6] Robert Seila,[7] Joost A. de Gouw,[8] Benjamin de Foy,[9] Jerome Fast,[10] Luisa T. Molina,[2,3] Charles E. Kolb,[1] and Douglas R. Worsnop[1]



$O_x = O_3 + NO_2$

Primary Emission | **Secondary Formation**

SO_2 → H_2SO_4

one compound

VOC → OOA

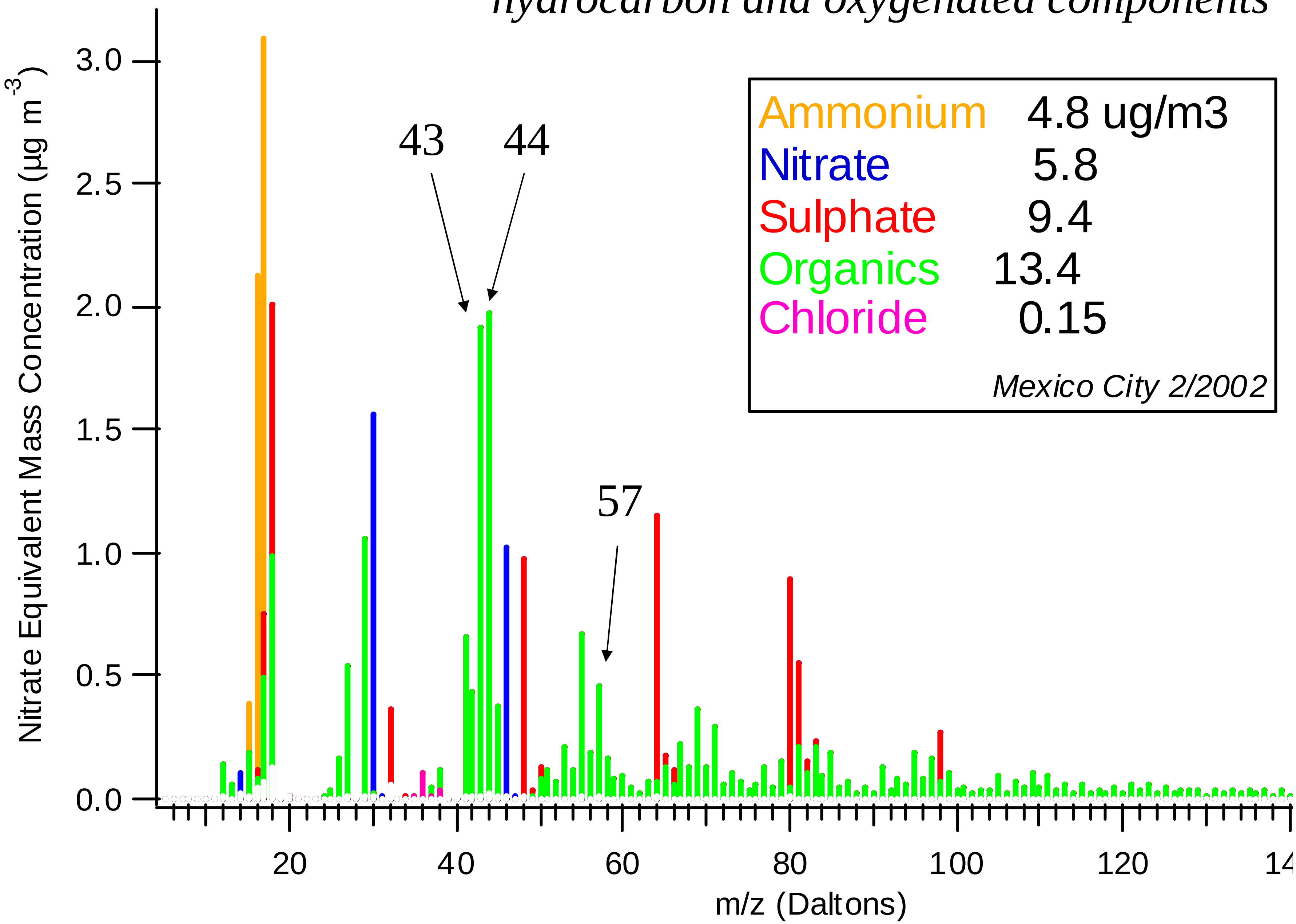
"Volatile Organic Compounds" | ***"Oxygenated Organic Aerosol"***

1,000's compounds

Analytical Challenge:

AMS mass spectra simplify classification of too many organic compounds to identify

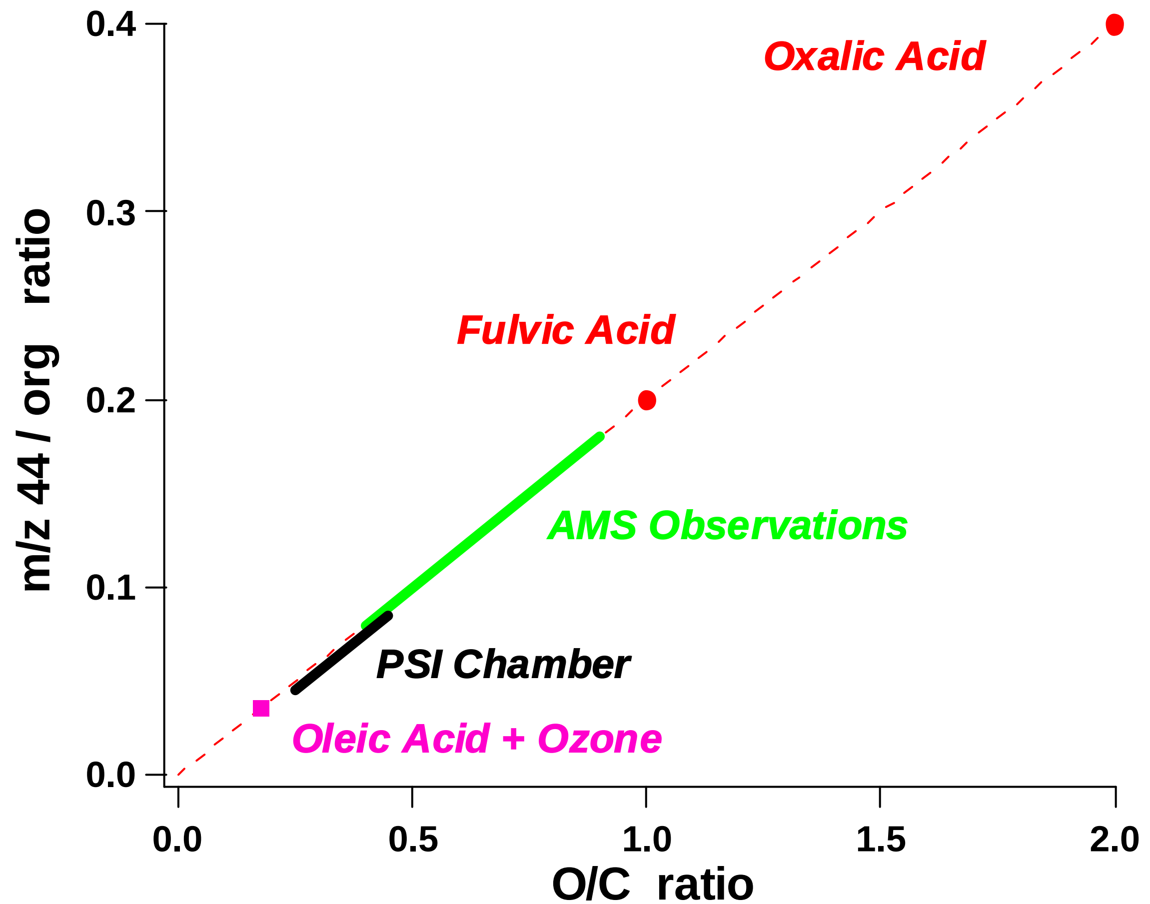
Urban organic aerosol is a mixture of hydrocarbon and oxygenated components



$$C_nH_mO_y \xrightarrow{600C,\ e^-} H_2O^+\ CO^+\ CO_2^+$$

18 28 44 43, 55

f44 vs O/C



2004

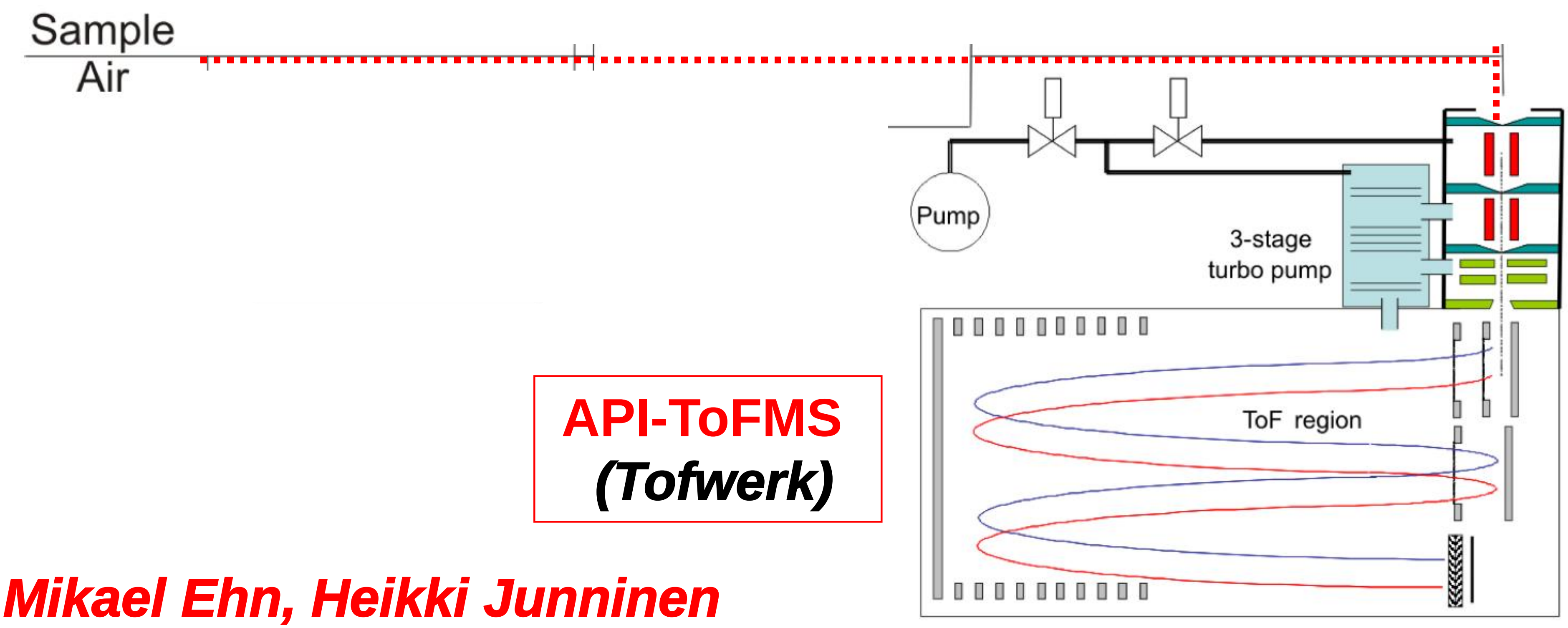
A high-resolution mass spectrometer to measure atmospheric ion composition

Atmos. Meas. Tech. Discuss., 3, 599–636, 2010

Atmospheric Measurement Techniques Discussions

H. Junninen[1], M. Ehn[1], T. Petäjä[1], L. Luosujärvi[2], T. Kotiaho[2,3], R. Kostiainen[3], U. Rohner[4], M. Gonin[4], K. Fuhrer[4], M. Kulmala[1], and D. R. Worsnop[1,5]

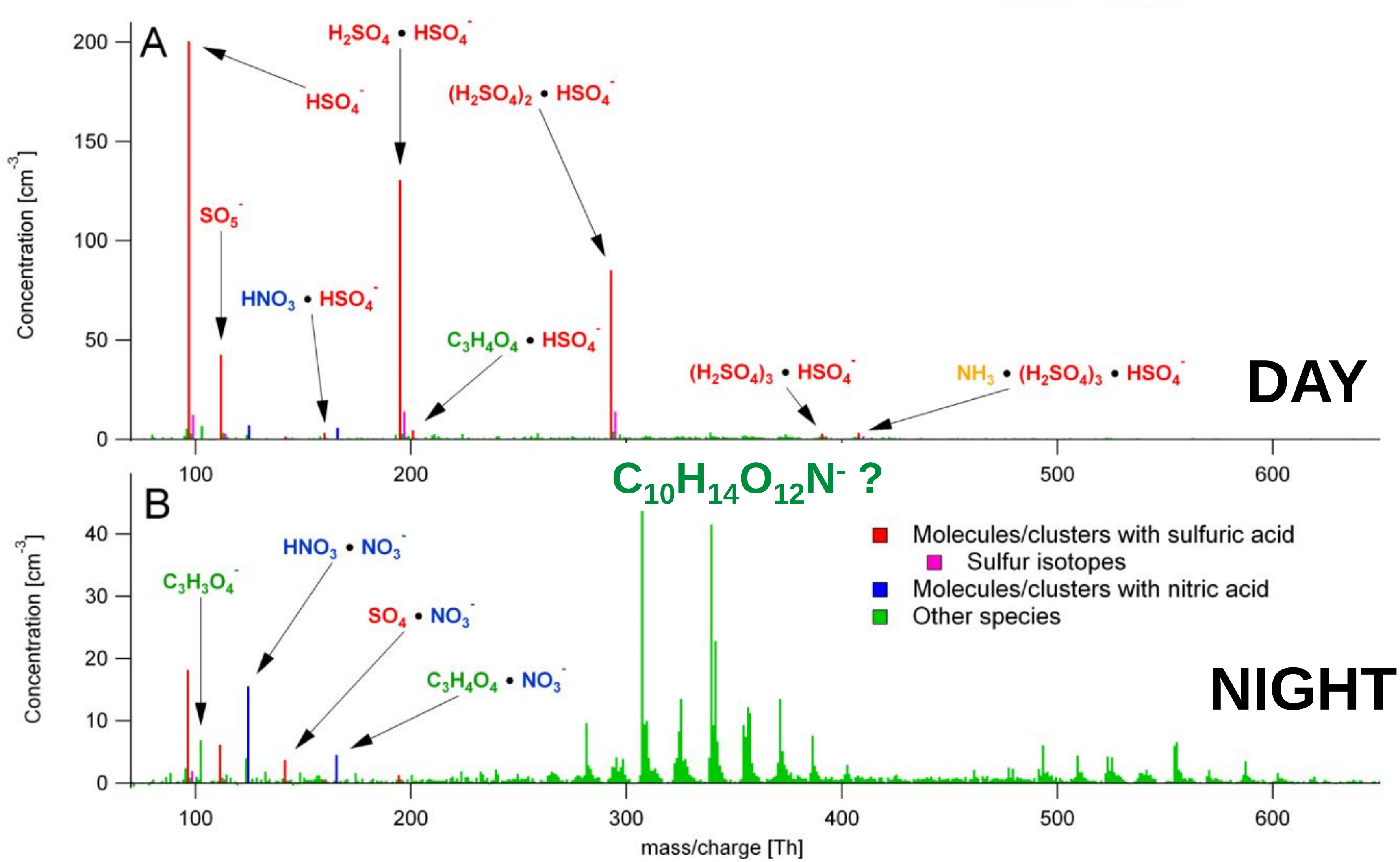
Atmospheric (pressure) Ions



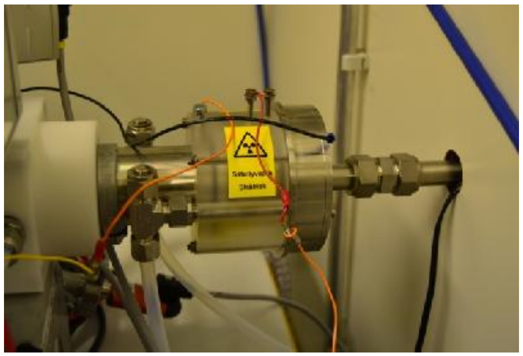
API-ToFMS
(Tofwerk)

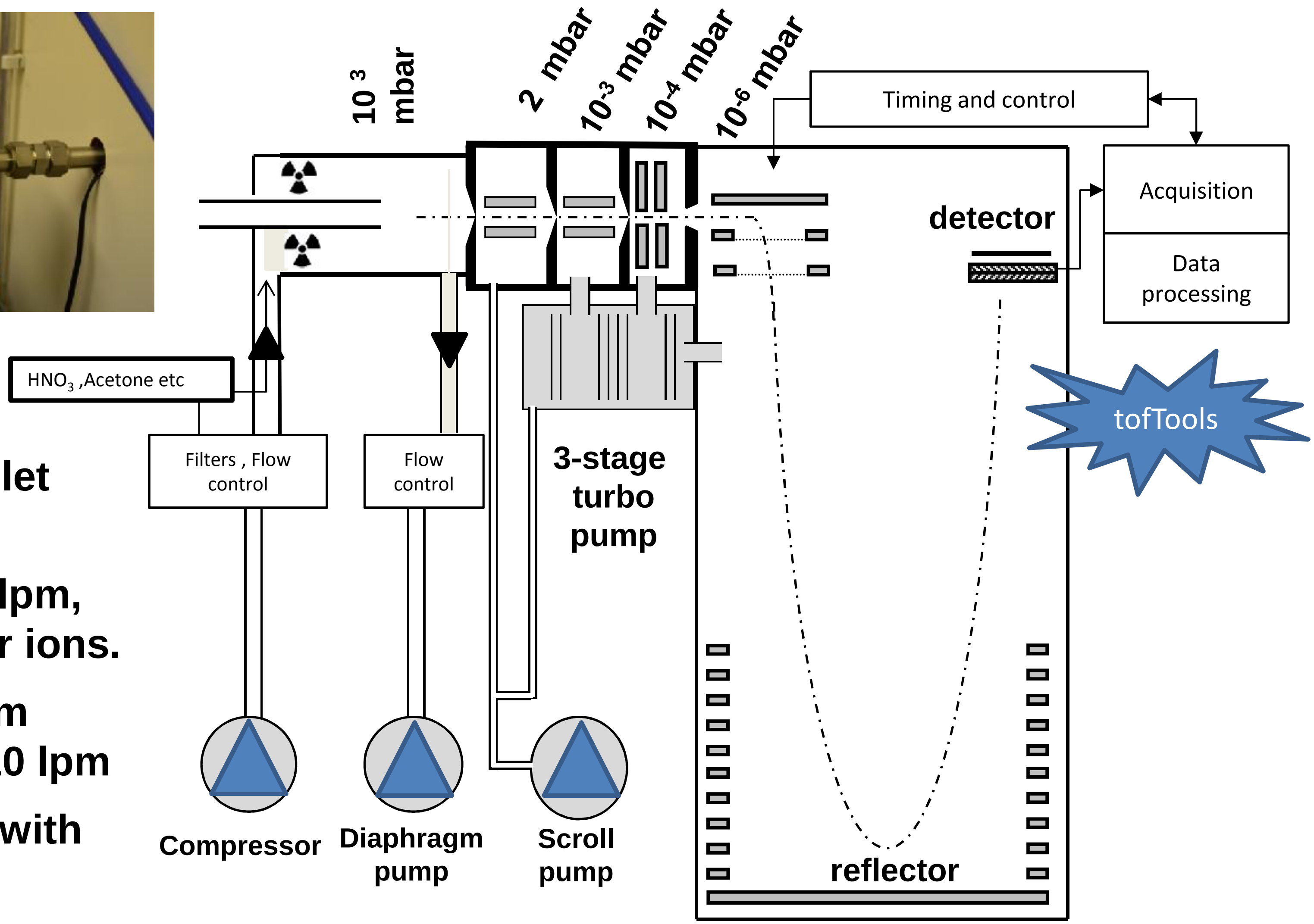
Mikael Ehn, Heikki Junninen

Negative ion spectra from Hyytiälä



CI-APi-TOF for neutral compound measurements





-"Eisele type" inlet design.

-Sheath flow 20 lpm, includes charger ions.

-Total flow 30 lpm
-> sample flow 10 lpm

-Sample mixing with electric field

-APi samples 0.8 lpm

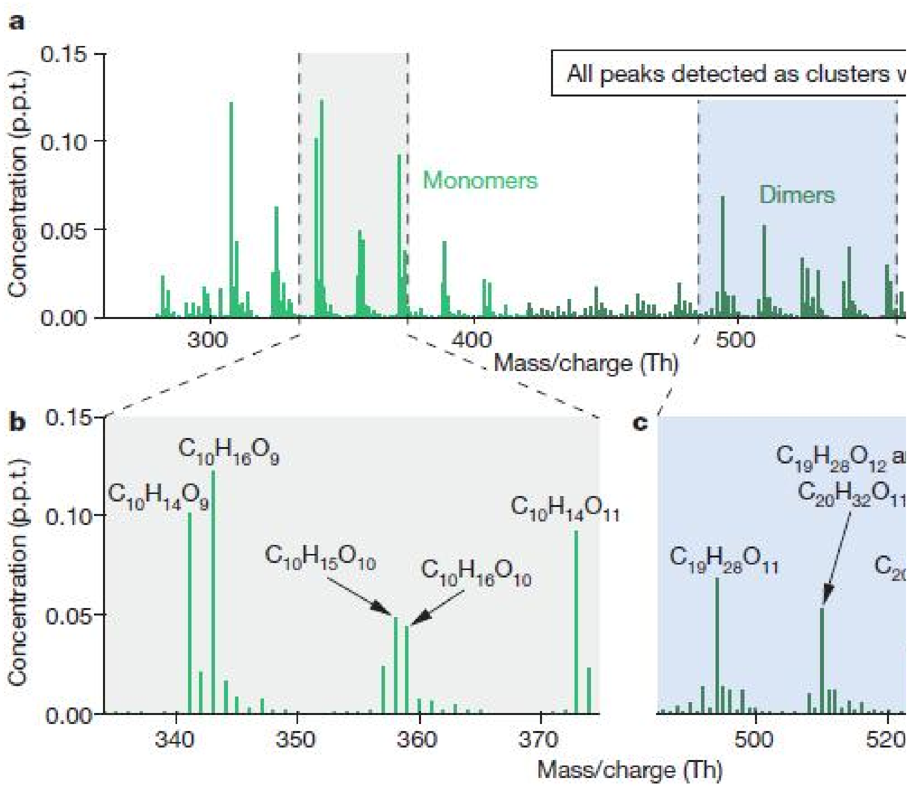
476 | NATURE | VOL 506 | 27 FEBRUARY 2014

LETTER

doi:10.1038/nature13032

A large source of low-volatility secondary organic aerosol

Mikael Ehn[1,2], Joel A. Thornton[2,3], Einhard Kleist[4], Mikko Sipilä[2], Heikki Junninen[2], Iida Pullinen[1], Monika Springer[1], Florian Rubach[1], Ralf Tillmann[1], Ben Lee[3], Felipe Lopez-Hilfiker[3], Stefanie Andres[1], Ismail-Hakki Acir[1], Matti Rissanen[2], Tuija Jokinen[2,5], Siegfried Schobesberger[2], Juha Kangasluoma[2], Jenni Kontkanen[2], Tuomo Nieminen[2,6], Theo Kurtén[7], Lasse B. Nielsen[8], Solvejg Jørgensen[8], Henrik G. Kjaergaard[8], Manjula Canagaratna[9], Miikka Dal Maso[10], Torsten Berndt[5], Tuukka Petäjä[2], Andreas Wahner[1], Veli-Matti Kerminen[2], Markku Kulmala[2], Douglas R. Worsnop[2,9], Jürgen Wildt[4] & Thomas F. Mentel[1]



ELVOC

C10,C20 in the gas phase

O/C > 0.7

Nucleation, Clusters

Nanoparticle growth

Evaluation of a New Vocus Reagent-Ion Source and Focusing Ion-Molecule Reactor for use in Proton-Transfer-Reaction Mass Spectrometry

Jordan Krechmer[1,%], Felipe Lopez-Hilfiker[2,%], Abigail Koss[3,4,5,6], Manuel Hutterli[2], Carsten Stoermer[2], Benjamin Deming[3,5], Joel Kimmel[1,2], Carsten Warneke[3,4], Rupert Holzinger[7], John Jayne[1], Douglas Worsnop[1], Katrin Fuhrer[2], Marc Gonin[2], Joost de Gouw[3,5,]*

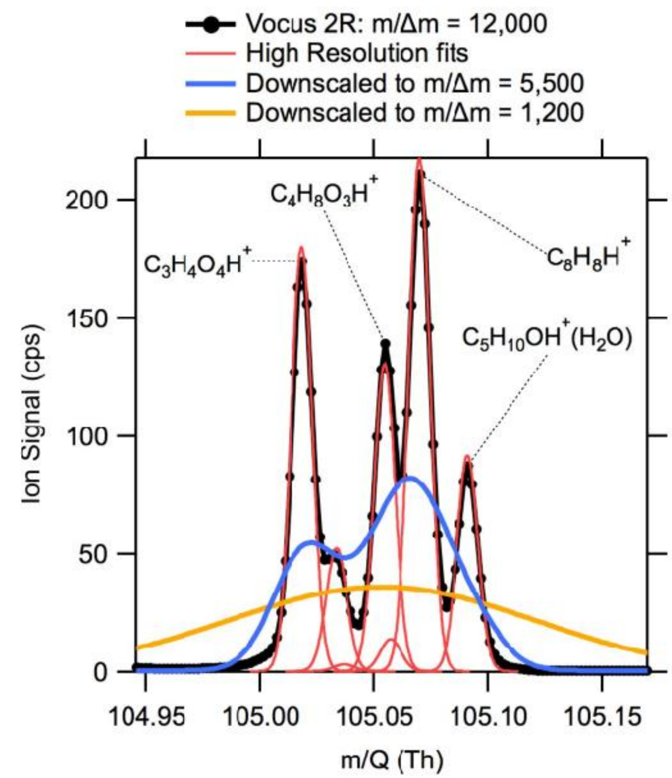
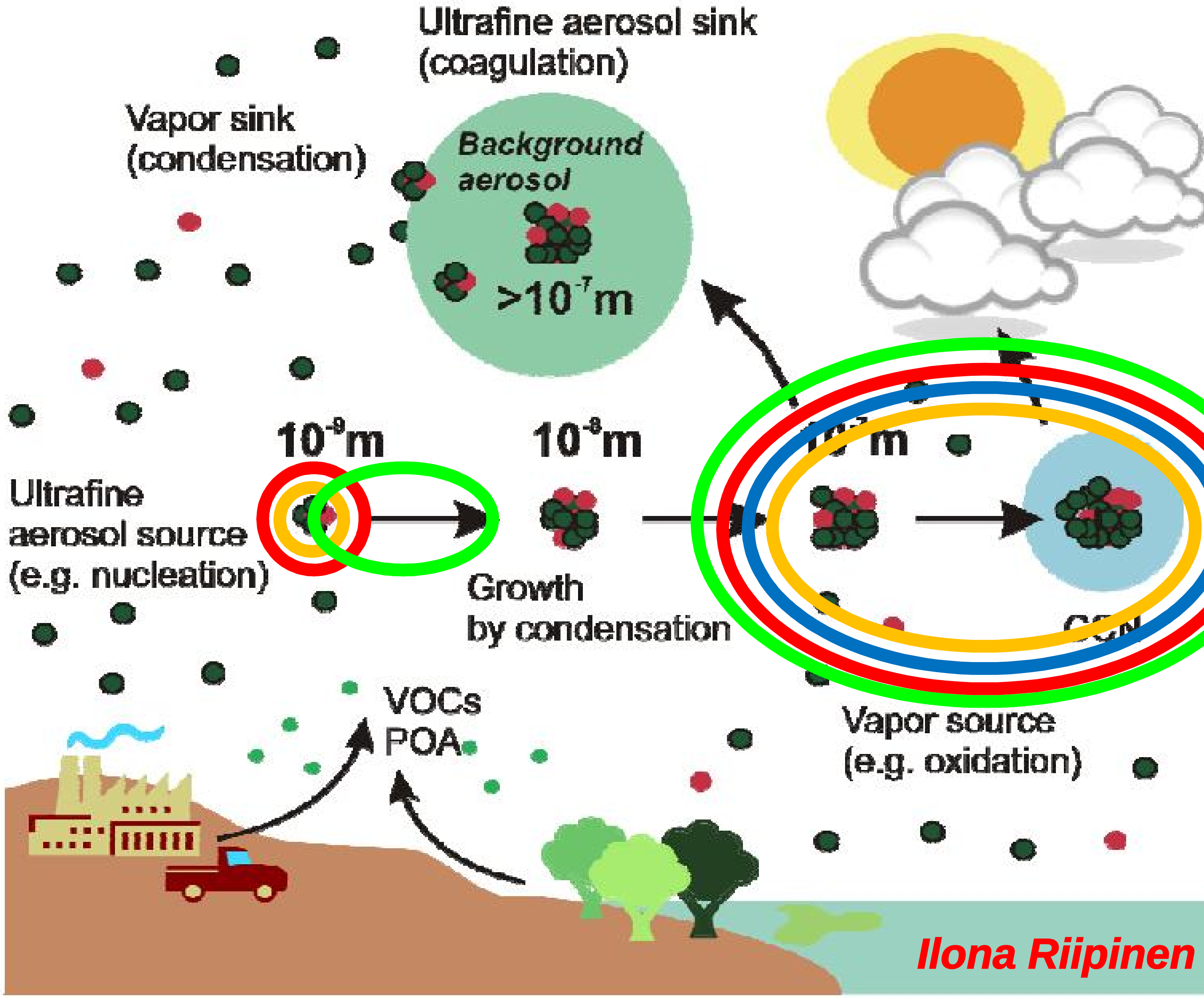


Figure 6: A mass spectrum of ambient air from one 2-Hz saved spectrum (24 September 2017, 18:48:34 UTC) at m/Q = 105 Th. With a mass resolving power m/Δm = 12,000, 5 peaks were resolved in the deconvolution. The same mass spectrum was then down-sampled to lower resolving powers of 5,500 and 1,200.

< ppt → ppt → ppb (ppm)

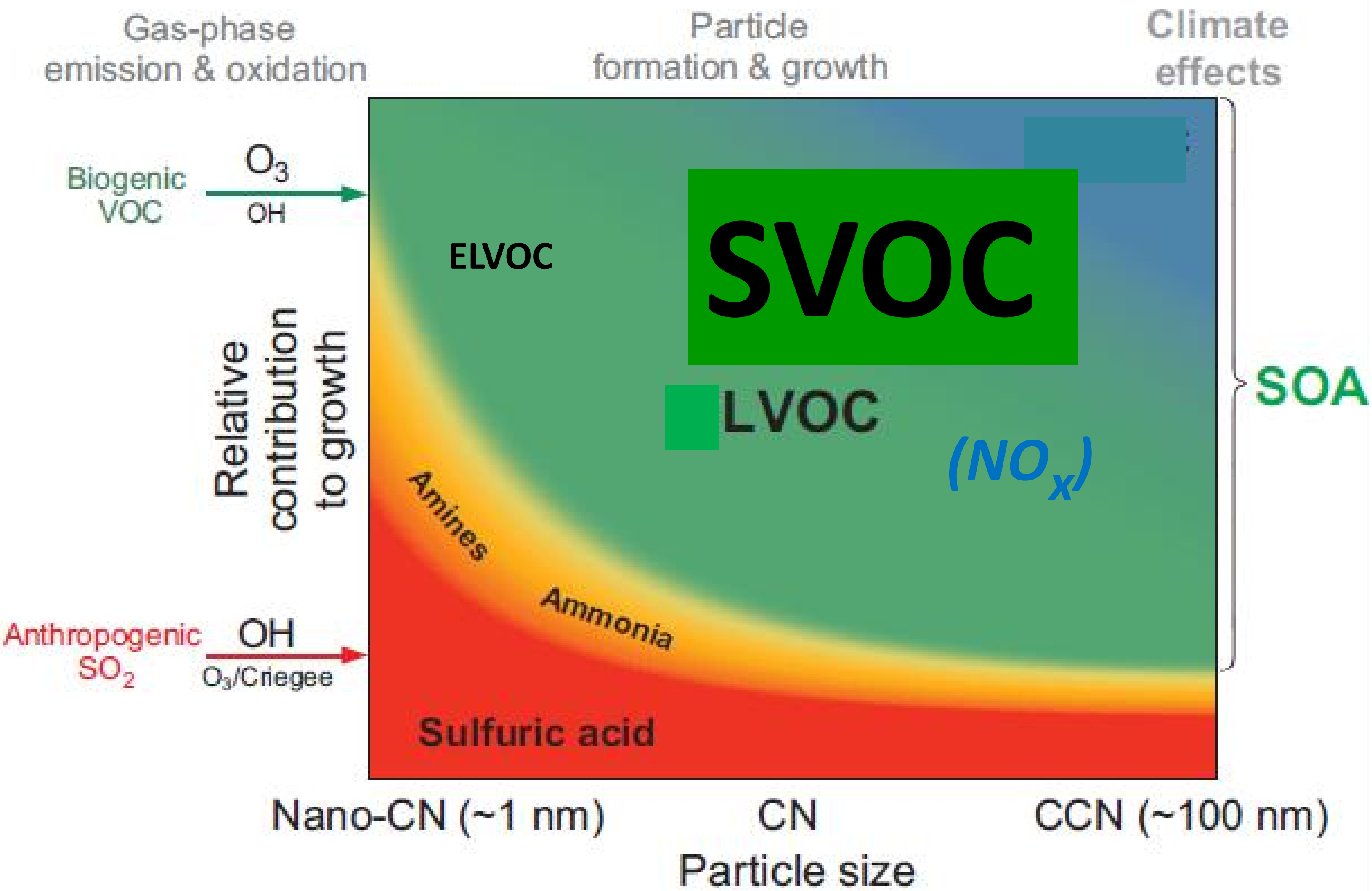


LETTER

doi:10.1038/nature13032

A large source of low-volatility secondary organic aerosol

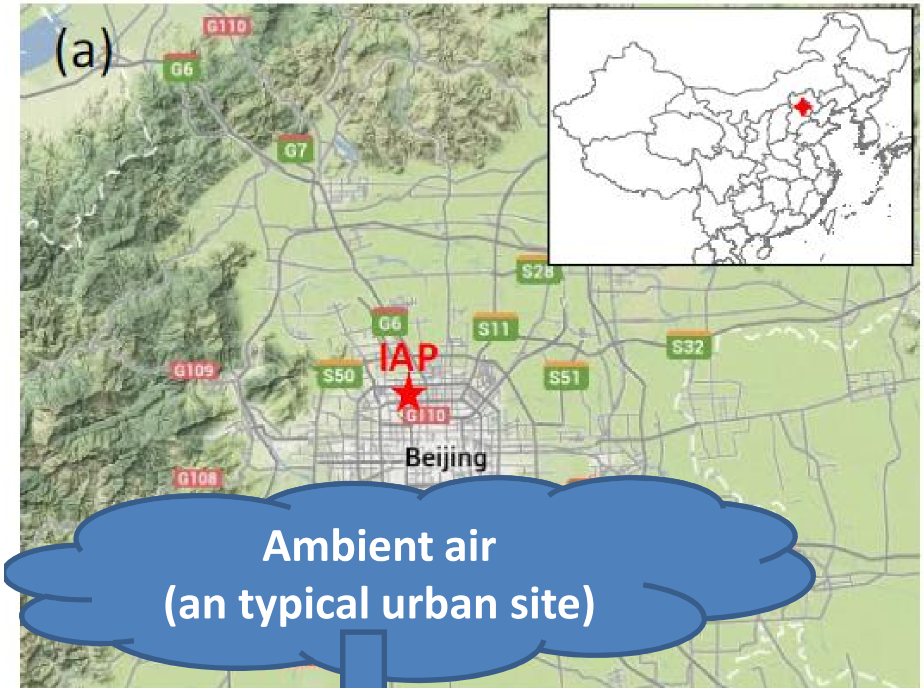
Mikael Ehn[1,2], Joel A. Thornton[2,3], Einhard Kleist[4], Mikko Sipilä[2], Heikki Junninen[2], Iida Pullinen[1], Monika Springer[1], Florian Rubach[1], Ralf Tillmann[1], Ben Lee[3], Felipe Lopez-Hilfiker[3], Stefanie Andres[1], Ismail-Hakki Acir[1], Matti Rissanen[2], Tuija Jokinen[2,5], Siegfried Schobesberger[2], Juha Kangasluoma[2], Jenni Kontkanen[2], Tuomo Nieminen[2,6], Theo Kurtén[7], Lasse B. Nielsen[8], Solvejg Jørgensen[8], Henrik G. Kjaergaard[8], Manjula Canagaratna[9], Miikka Dal Maso[10], Torsten Berndt[5], Tuukka Petäjä[2], Andreas Wahner[1], Veli-Matti Kerminen[2], Markku Kulmala[2], Douglas R. Worsnop[2,9], Jürgen Wildt[4] & Thomas F. Mentel[1]



Inter-comparisons of four aerosol mass spectrometers during the summer time of 2018 in an urban site, Beijing, China

Jian Zhao, Yao He, Weiqi Xu, Yele Sun

Instrument setups



On the rooftop of a two-story building (~ 8 m above ground) in IAP (39º58’28’’ N, 116º22’16’’ E; 49 m.a.s.l.),CAS, Beijing, China

Ambient air
(an typical urban site)

$PM_{2.5}$ URG cyclones

Nafion Driers

(for each instrument)

Room 1

PM_1 len, HR-ToF-AMS, **standard vaporizer**

CDCE (~0.5);
RIE_{SO4}=1.37;
RIE_{NH4}=4.3;

Room 2

PM_1 len, Q-ACSM, **standard vaporizer**

CDCE (~0.5);
RIE_{SO4}=0.84;
RIE_{NH4}=1.45;

Room 3

$PM_{2.5}$ len, ToF-ACSM1, **capture vaporizer**

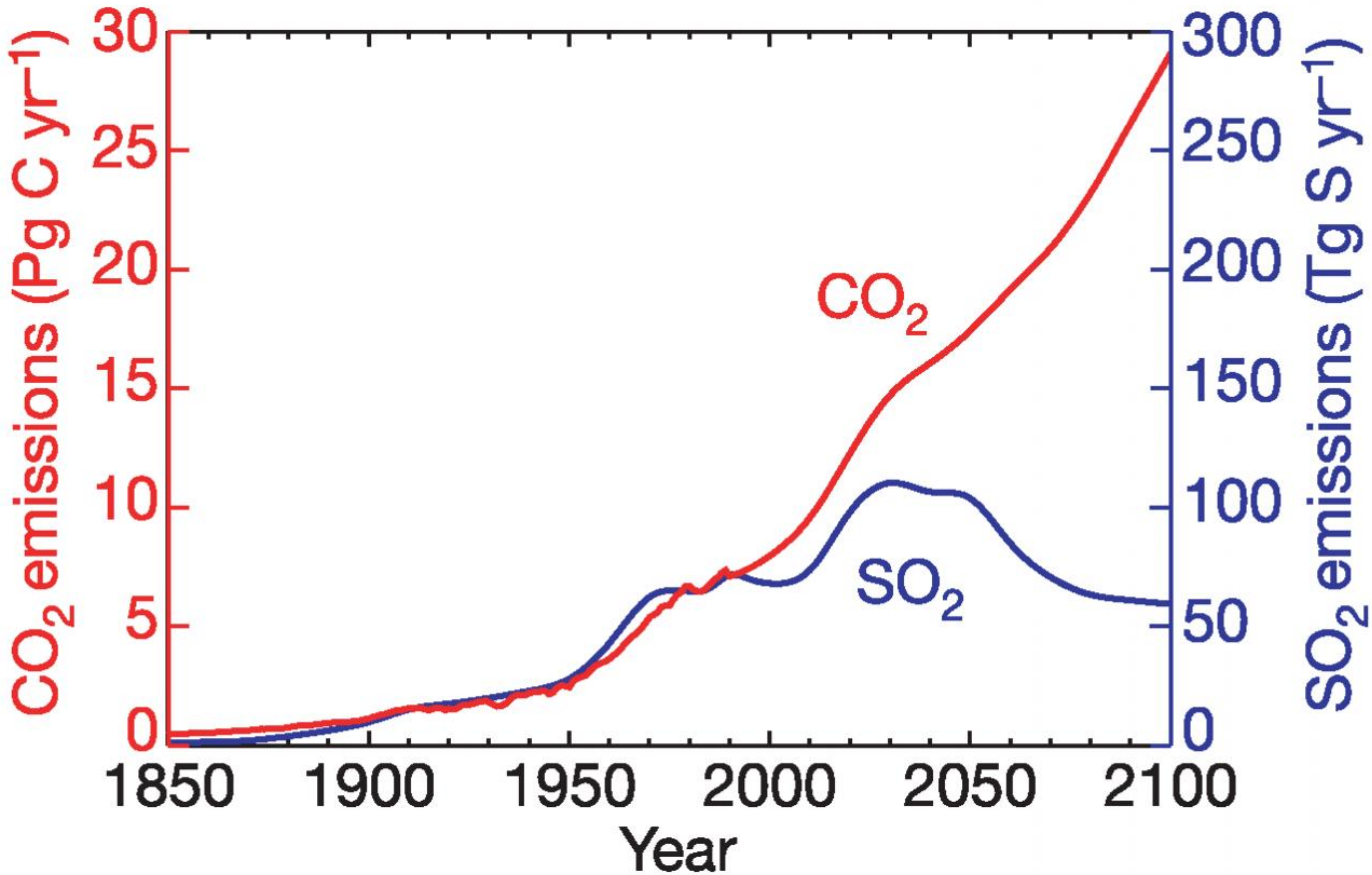
CE=1;
RIE_{SO4}=1.09;
RIE_{NH4}=3.06;

$PM_{2.5}$ len, ToF-ACSM2, **capture vaporizer**

CE=1;
RIE_{SO4}=1.02;
RIE_{NH4}=3.08;

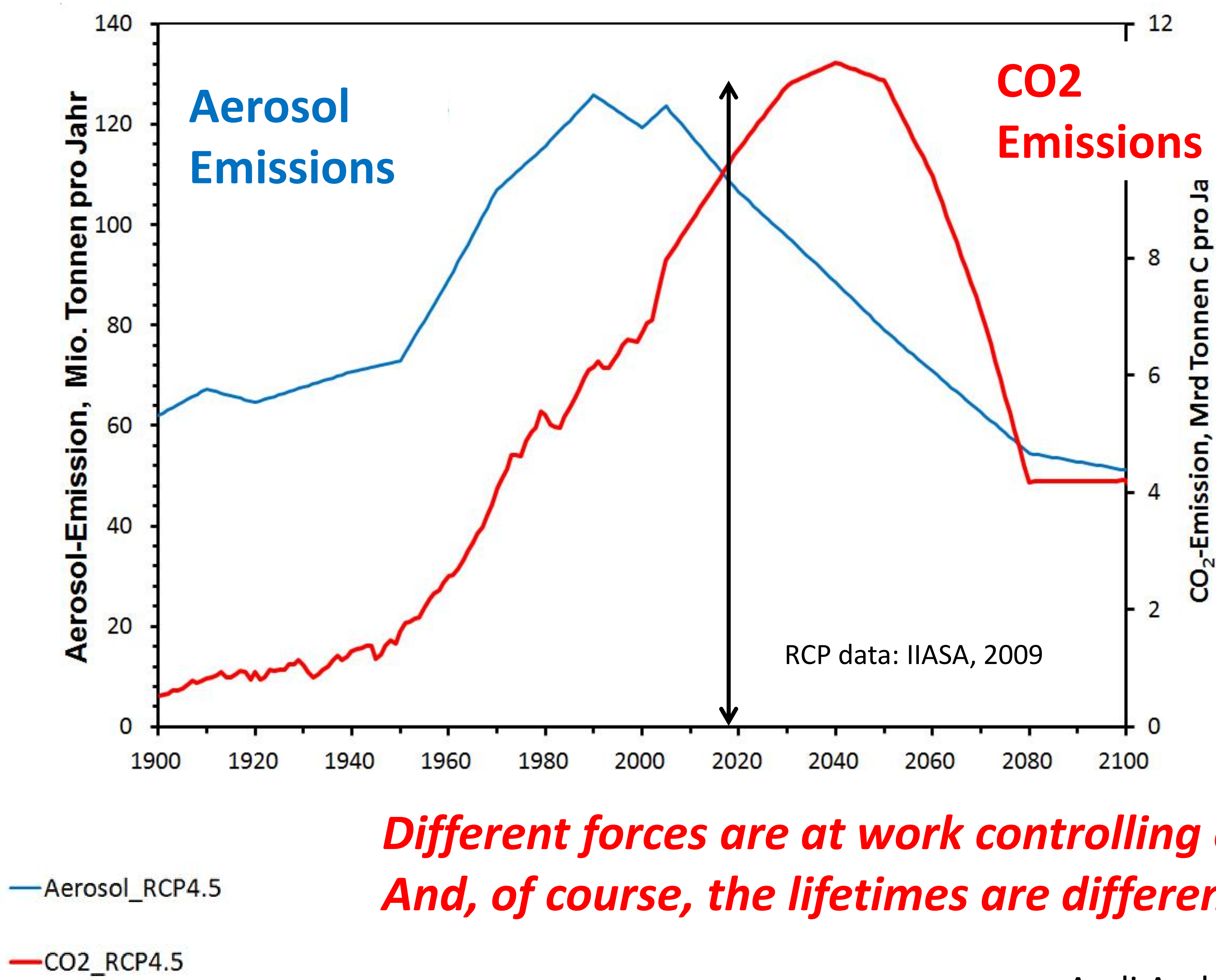
(Sun et al., ACP, 2015)

Andreae et al., Nature, 2005



Erwartete Entwicklung: kühlende Effekte durch Sulfataerosole nehmen in Zukunft eher ab,
(wegen der Gesundheitseffekte durch Feinstaub müssen die Aerosolbelastungen verringert werden),
Gleichzeitig nehmen die erwärmenden Effekte durch steigende GHG-Emissionen zu.
→ Deutliche Verschärfung des Klimawandels zu erwarten.

Why must GHG and Aerosols diverge?



Different forces are at work controlling emissions.
And, of course, the lifetimes are different!

Andi Andreae, MPI Mainz


There are more people living inside
this circle than outside of it.

Submicron Aerosol at a Receptor Site in New Delhi: Interpreting Sources and Their Origin.

SAHIL BHANDARI, Shahzad Gani, Dongyu S. Wang, Kanan Patel, Sarah Seraj, Joshua Apte, Lea Hildebrandt Ruiz, *University Of Texas At Austin*

Prashant Soni, Zainab Arub, Gazala Habib, *Indian Institute of Technology Delhi*

09/06/2018

Smog envelops buildings on the outskirts of the Indian capital New Delhi in November, 2014. Credit Roberto Schmidt/Agence France-Presse — Getty Images

“Aerodyne (MS) Product Line”

ACSM
ToF-ACSM
Mini-AMS
HR-ToF-AMS
LToF-AMS

PM2.5 Lens, ePToF, Capture Vaporizer, ADQ
SP- Module
Thermo-denuder
Aerosol Dryer / Sampling System
PAM Flow Reactor

APi-TOF IMR (I-), NO3- Module, EESI-ToF
IMS-ToF
GC-ToF TAG Module

Vocus-PTR-ToF