Fine and ultrafine particle measurements in Switzerland at various stations and on different roads

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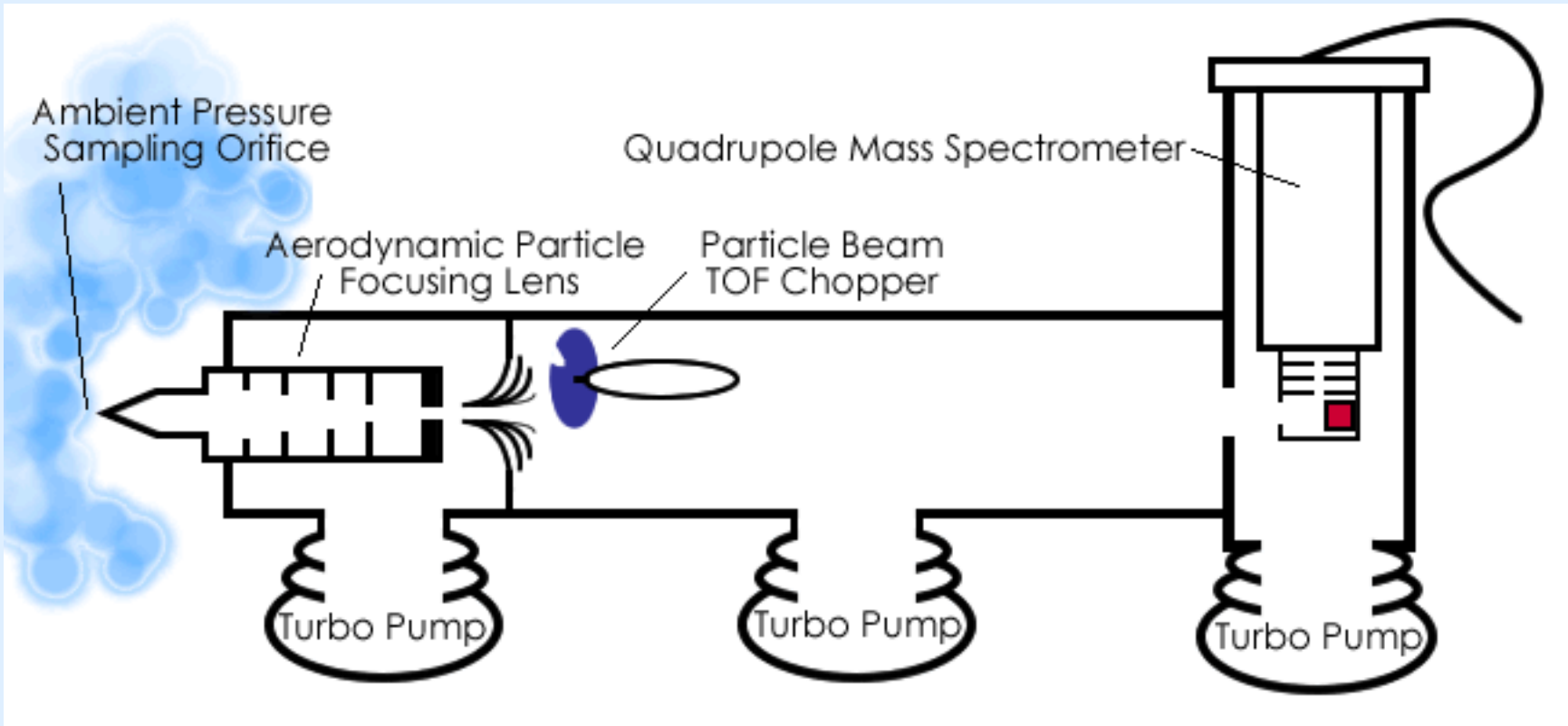
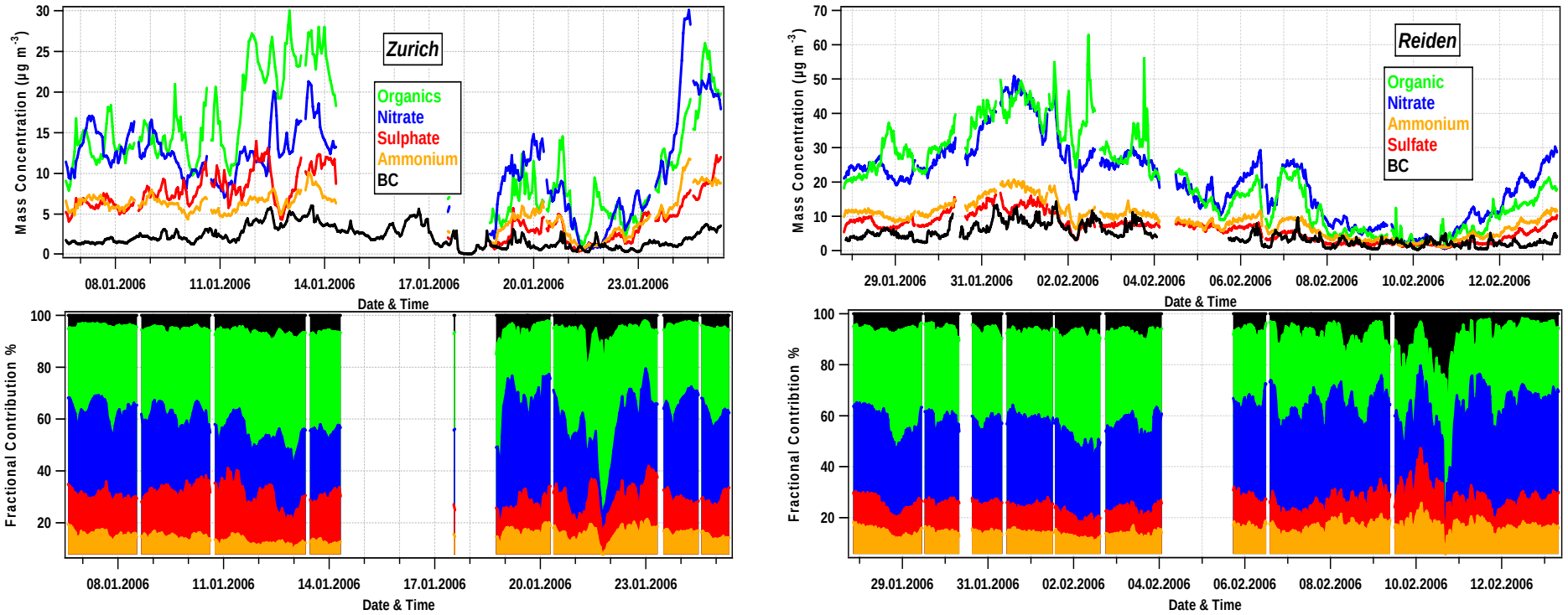
Outline

- Source apportionment using aerosol mass spectrometry and ^{14}C- analyses at various stations : Focus Alpine valley and Zurich in Switzerland
- Mobile measurements including Fast mobility particle sizer and aerosol mass spectrometry measurements
- Conclusions concerning contribution of secondary inorganics and organics, wood burning and traffic to PM1, elemental carbon, ultrafine particle number

The Aerodyne aerosol mass spectrometer

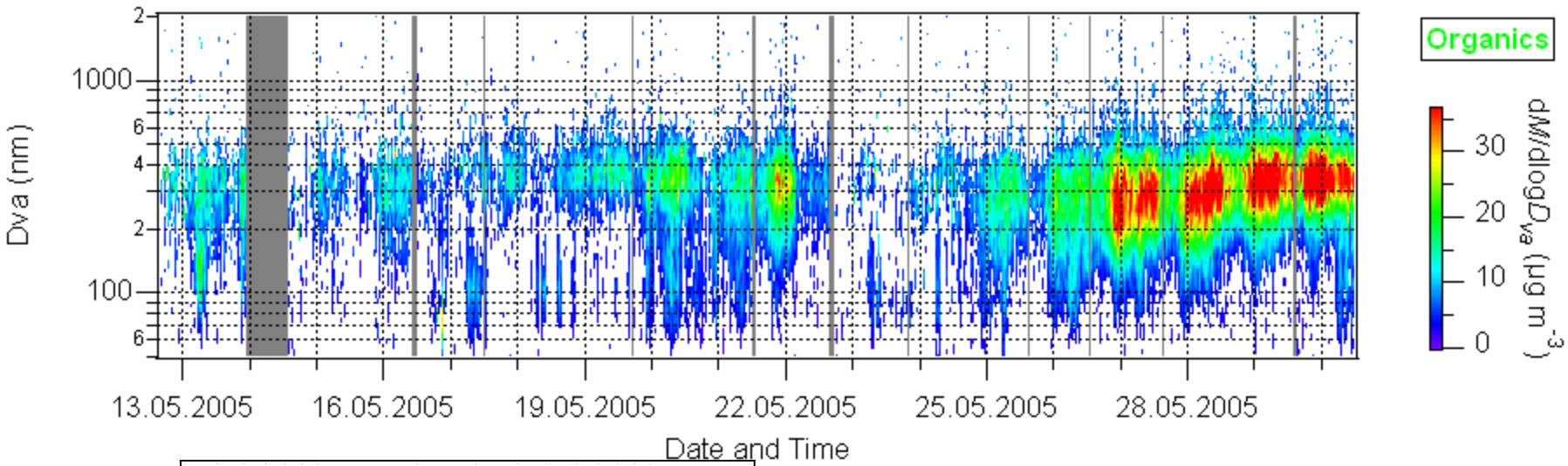


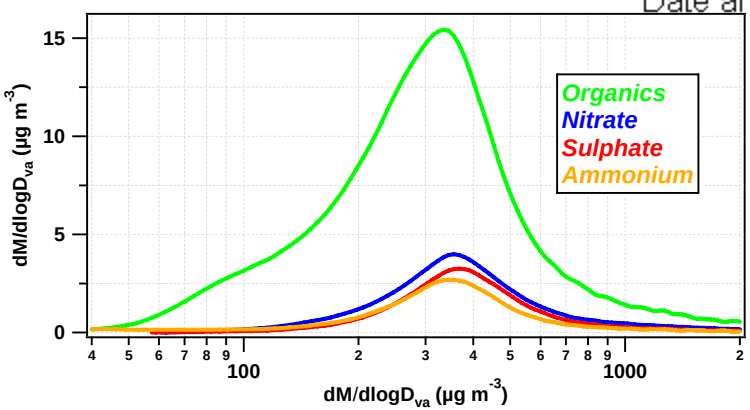
Example of Aerosol mass spectrometer measurements together with some black carbon measurements by an Aethalometer



Time resolution: minutes down to 6 seconds at low detection limits

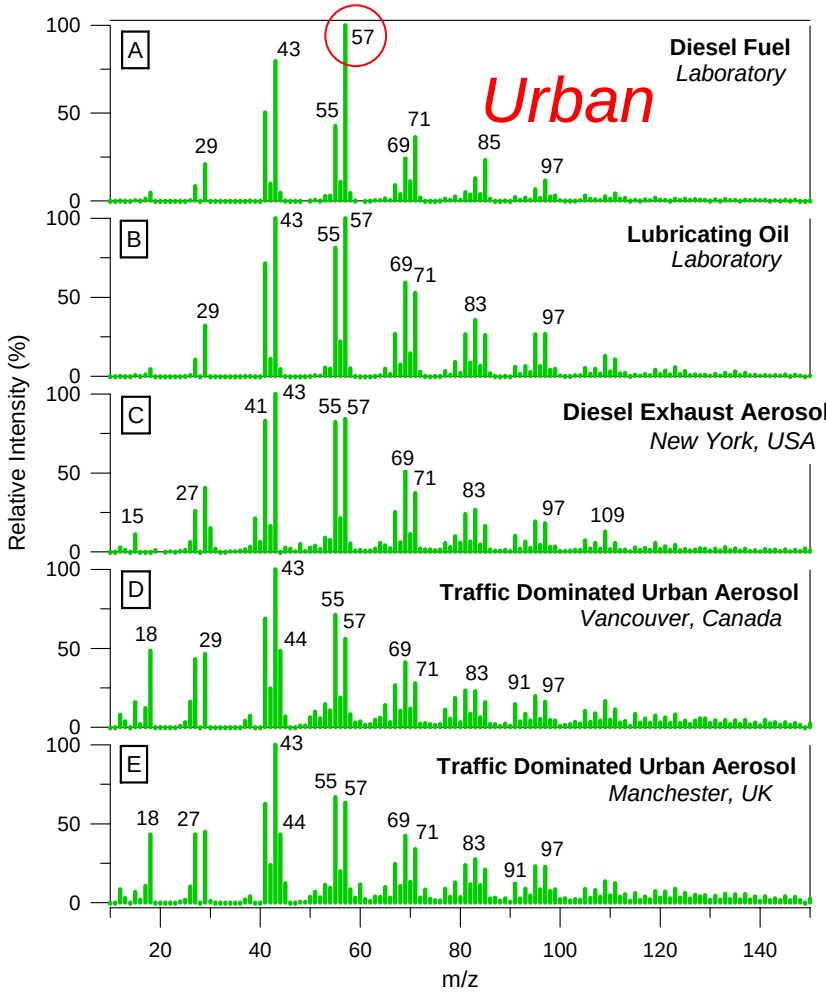
Aerodyne aerosol mass spectrometer output: size distribution

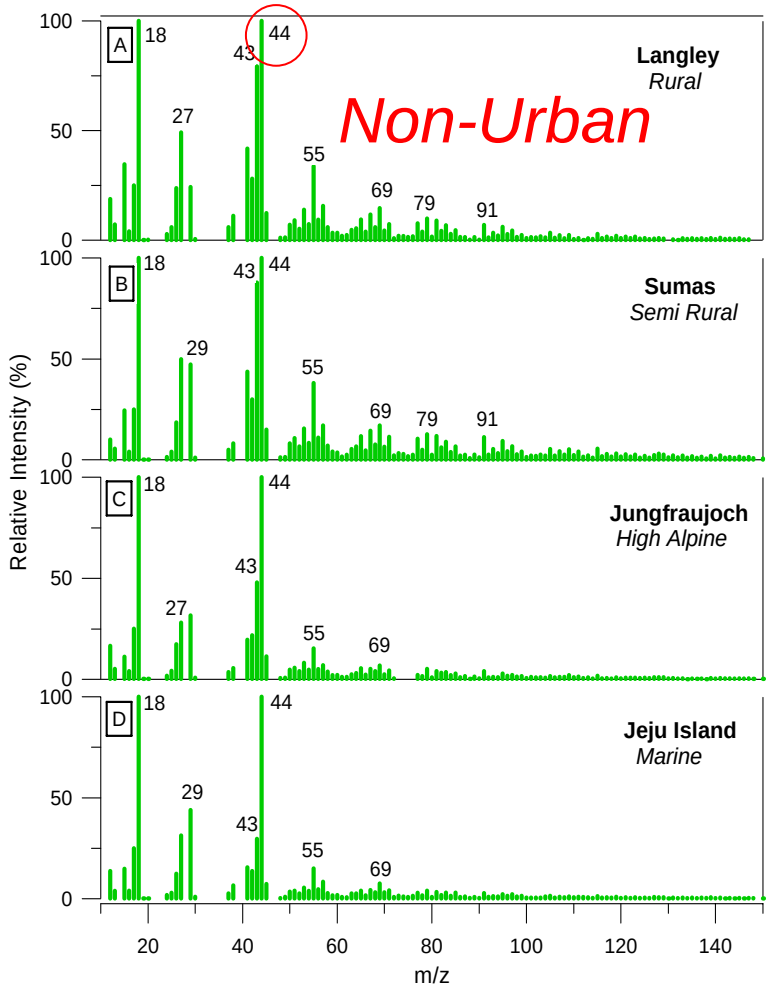




- Aerosol mass size distributions

Aerodyne aerosol mass spectrometer output: organic aerosol mass spectra





McFiggans, Alfarra et al., Faraday Discussions, 2005

2007

Aerosol mass spectra of wood burning particles

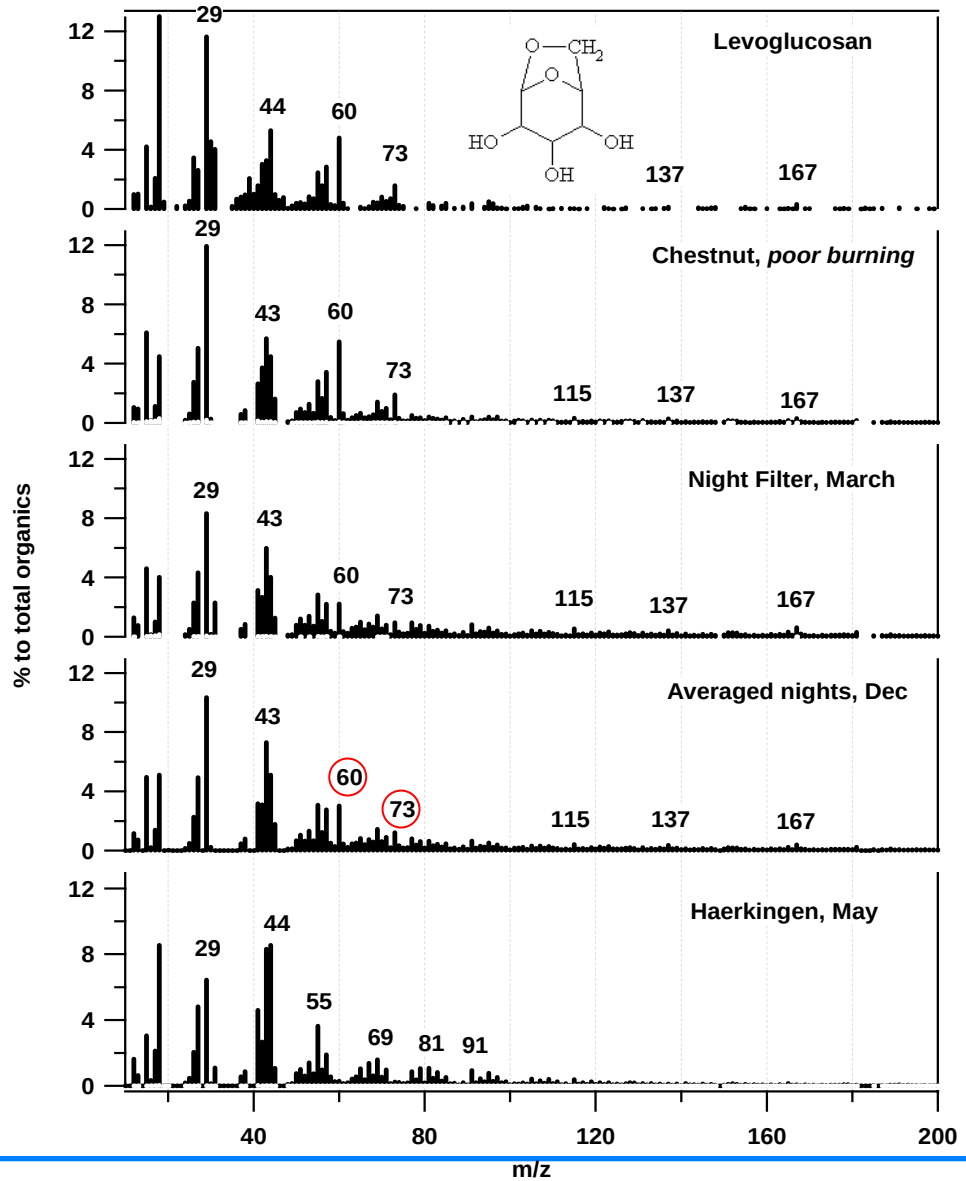
Levoglucosan

Wood burner (emissions) chestnut, very inefficient burning

Night period in Roveredo in March, more than 80% of OC non-fossil

Average in Roveredo over the whole December

Mass spectra from a Motorway site in May

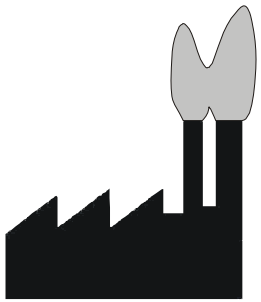


Alfarra et al. ES&T (2007)

2007

Simplified source apportionment by $^{14}C/^{12}C$

Anthropogenic Emissions



^{14}C decayed

Biogenic Emissions

^{14}C modern

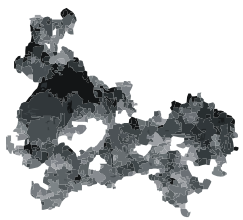
Flux $F_a = \mathrm{d}m_a/\mathrm{d}t$

$f_M = 0$

Flux $F_b = \mathrm{d}m_b/\mathrm{d}t$

$f_M = 1$

Carbonaceous aerosol



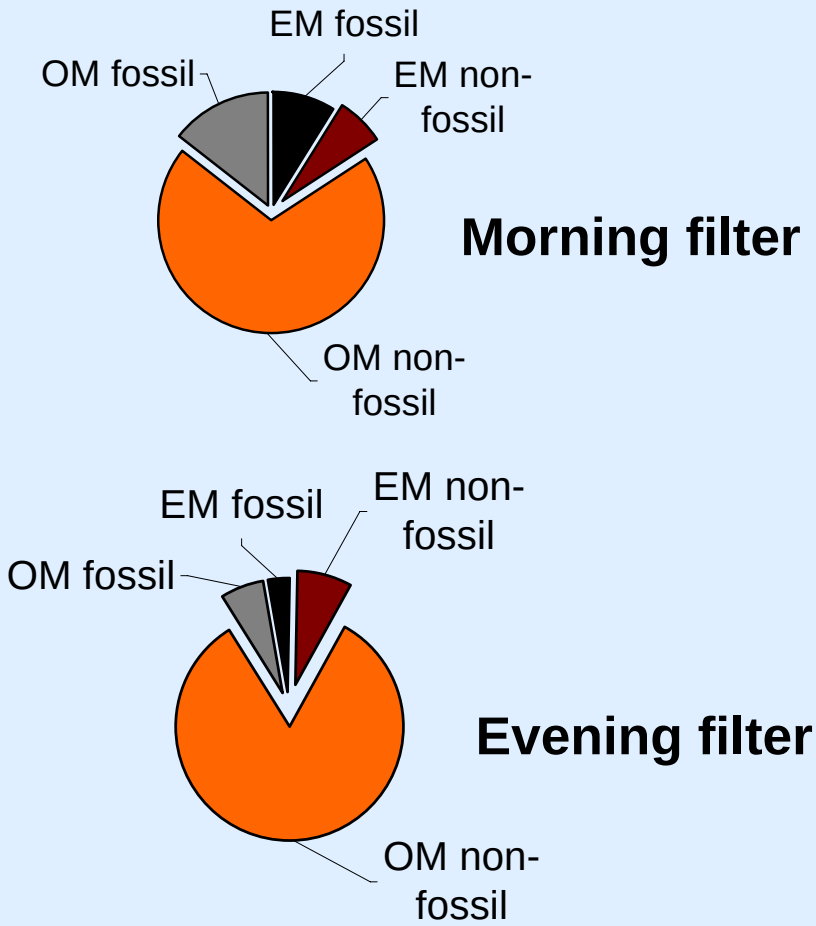
$$f_M = \frac{F_b}{F_a + F_b}$$

Non-fossil fraction: $f_M = (^{14}C/^{12}C_{Sample}) / (^{14}C/^{12}C)_{Current\ Biomass}$

Szidat et al., several papers from 2004-2007, e.g. JGR 2006, GRL 2007

2007

Fossil and non-fossil carbon in the particulate matter in Roveredo winter



Szidat et al., GRL, 2007

Positive Matrix Factorization (PMF): Bilinear unmixing (Advanced factor analysis)

Mass peaks j: *1…m*

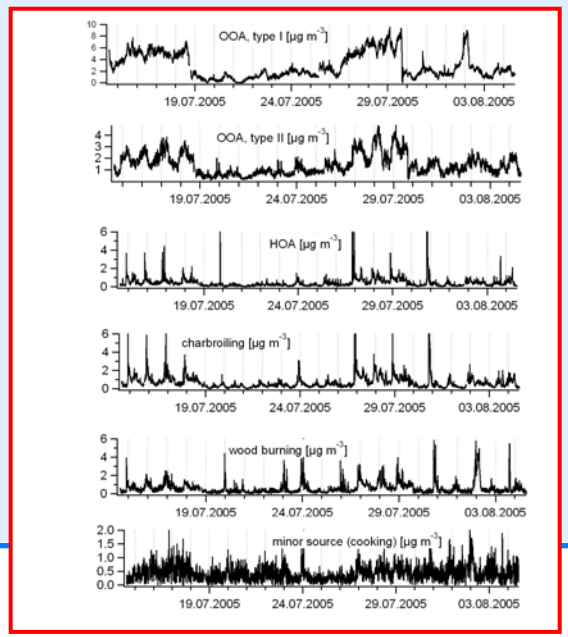
samples in time i: *1…n*

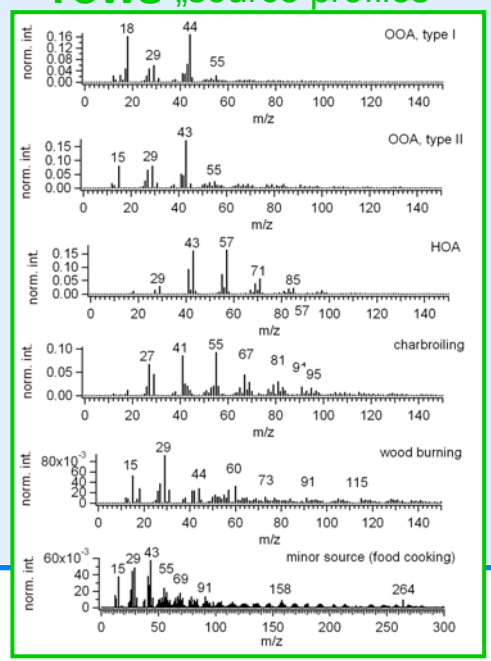
X {n x m} = **G** {n x p} × **F** {p x m} + **E** {n x m}

number of factors/ reduced dimensions

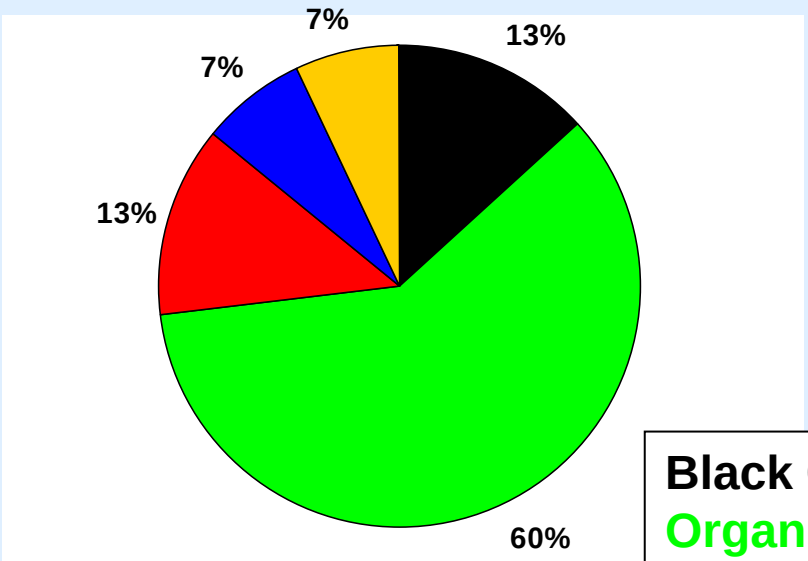
rows „source profiles“

columns „source strengths“





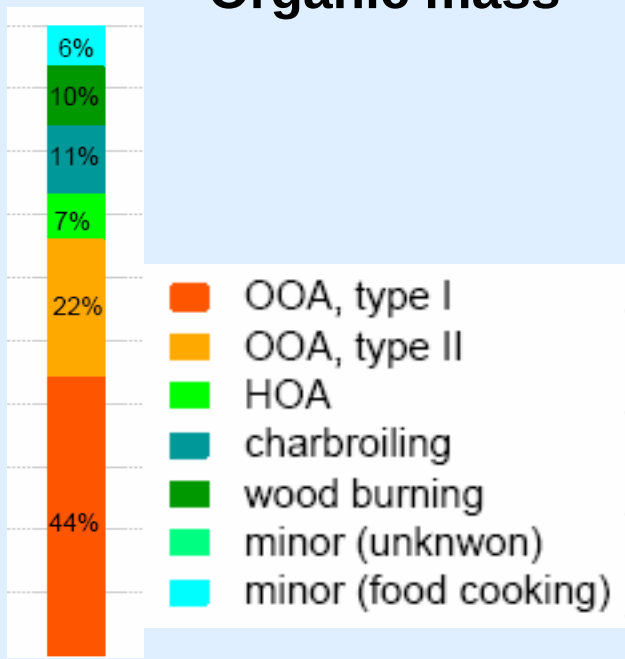
Chemical composition in Zürich summer and Positive Matrix Factorization of the organic matter



Zürich (July)

Black Carbon
Organic mass
Nitrate
Sulfate
Ammonium

Organic mass



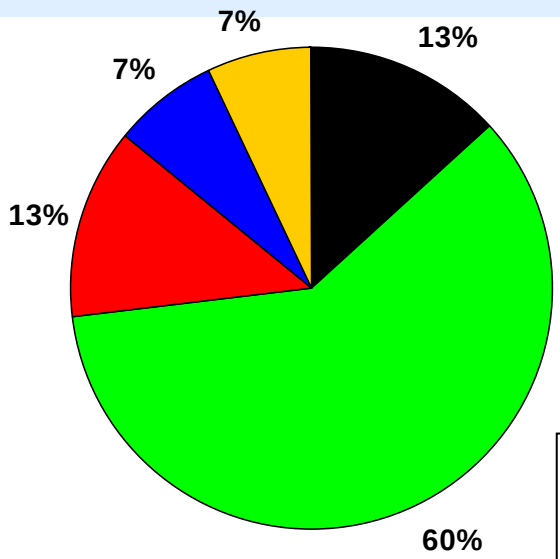
OOA: Secondary organic aerosol

HOA: mostly traffic

Lanz et al., ACP (2007)

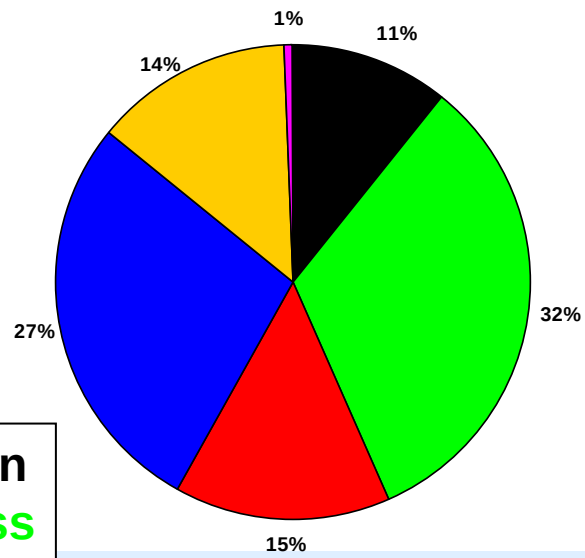
2007

Average composition in Zürich in summer and winter



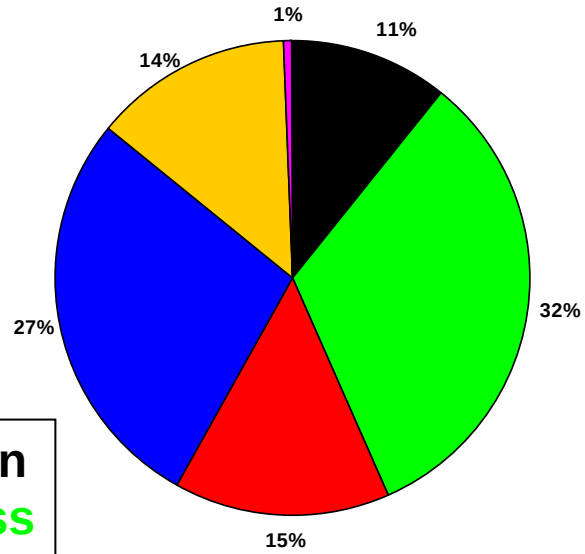
Zürich (July)

Black Carbon
Organic mass
Nitrate
Sulfate
Ammonium



Zürich (January)

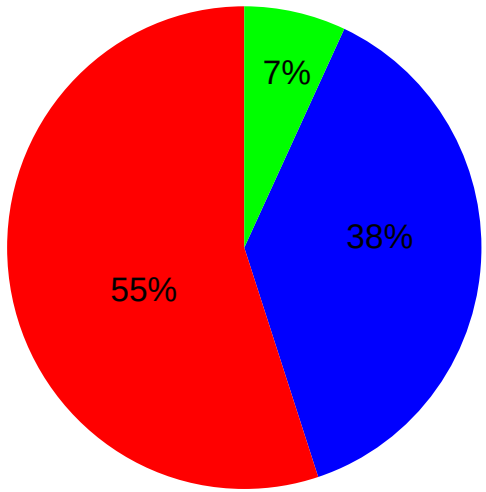
Composition of PM1 in Zürich winter and Similar method as PMF (with constrained traffic organic factor) of OM



Zürich (January)

Black Carbon
Organic mass
Nitrate
Sulfate
Ammonium

Organic matter



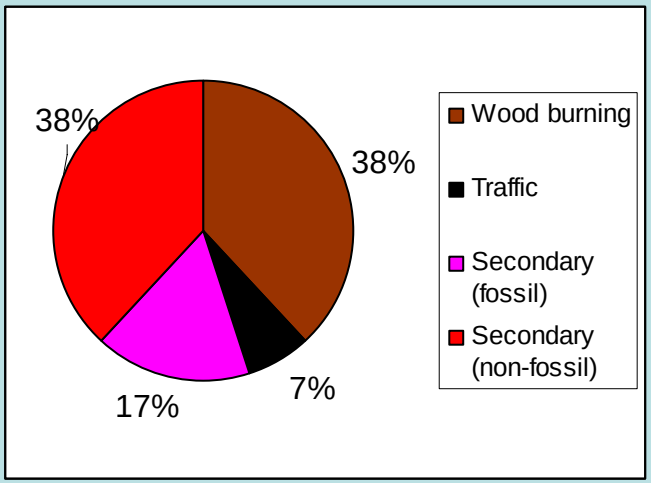
Wood burning
Secondary organics
traffic

Lanz et al., accepted in ES&T

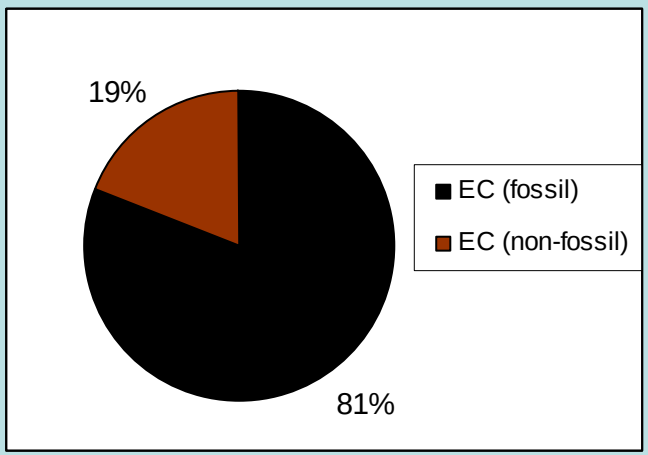
2007

Carbon apportionment using ^{14}C analysis
Estimation of fossil and non-fossil SOA contribution

OM



EC



Use of AMS analysis :

- wood burning 38%

- HOA 7%

Assumptions :

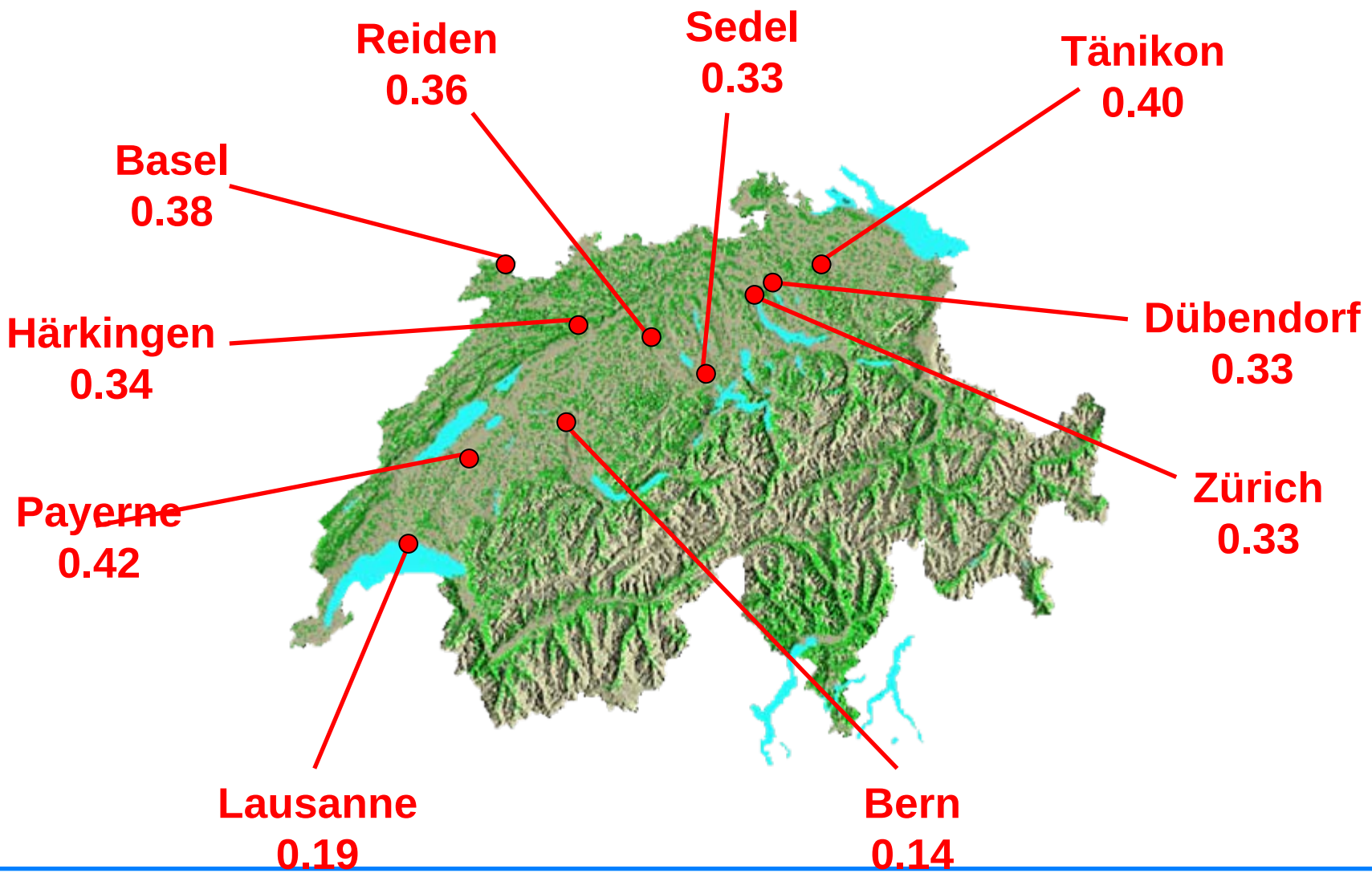
- only SOA, HOA and wood burning present

- OM/OC=2 for wood burning and SOA and OM/OC=1.2 for HOA

Lanz et al., accepted in ES&T

2007

$EC_{biomass}/EC_{tot}$: Spatial distribution on 29.01.2006



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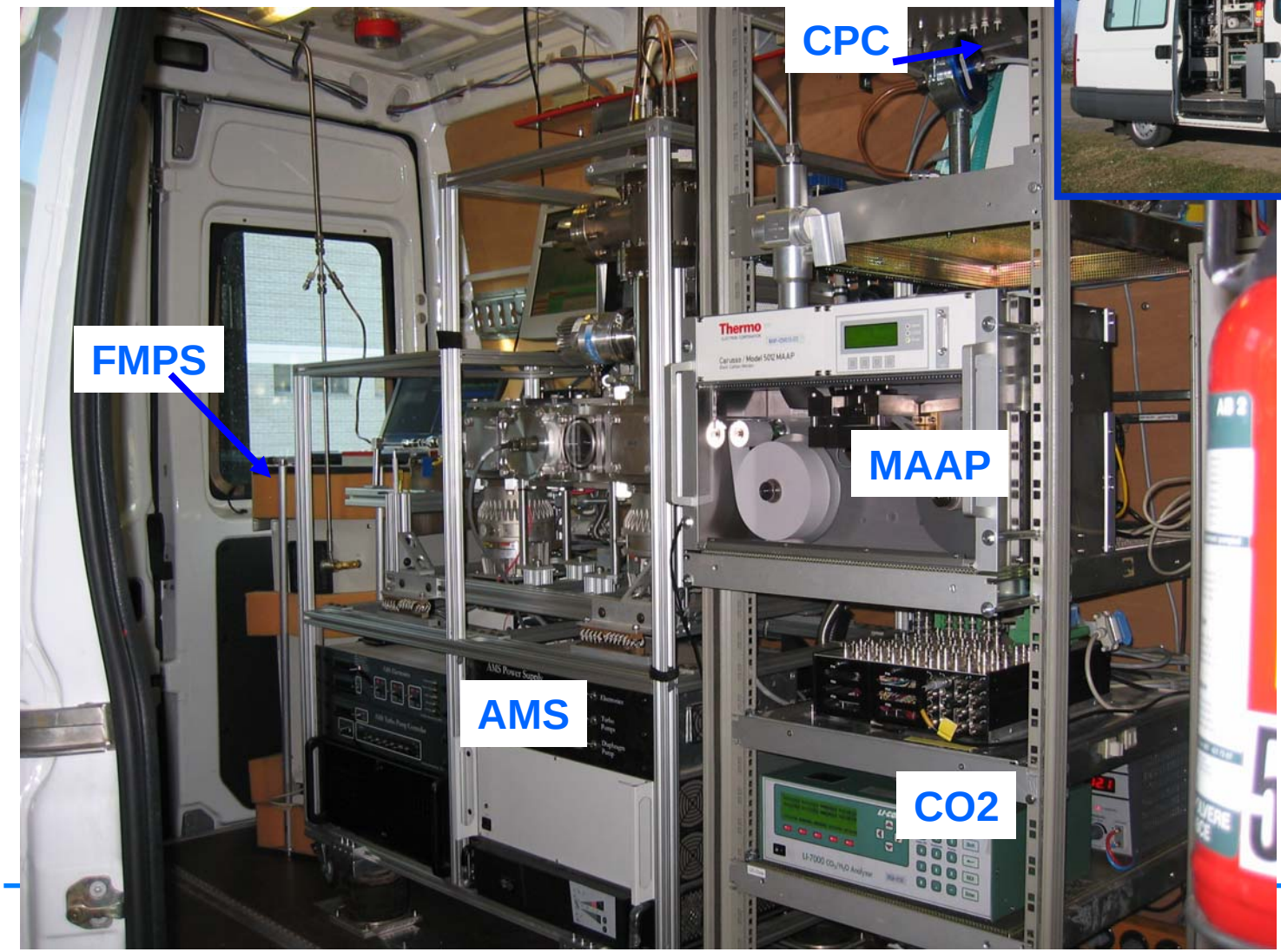
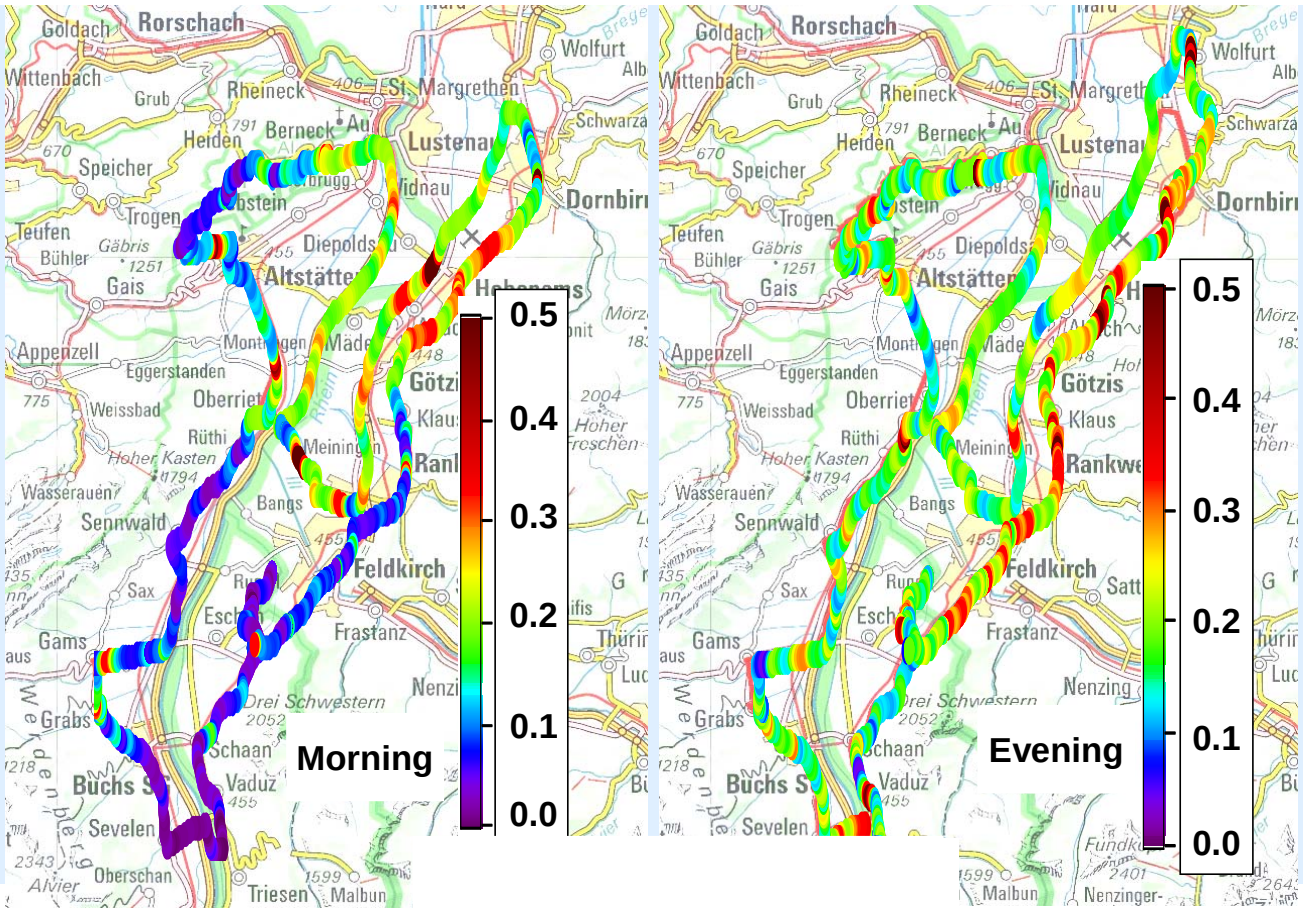
PSI

LABOR FÜR ATMOSPHÄREN-CHEMIE

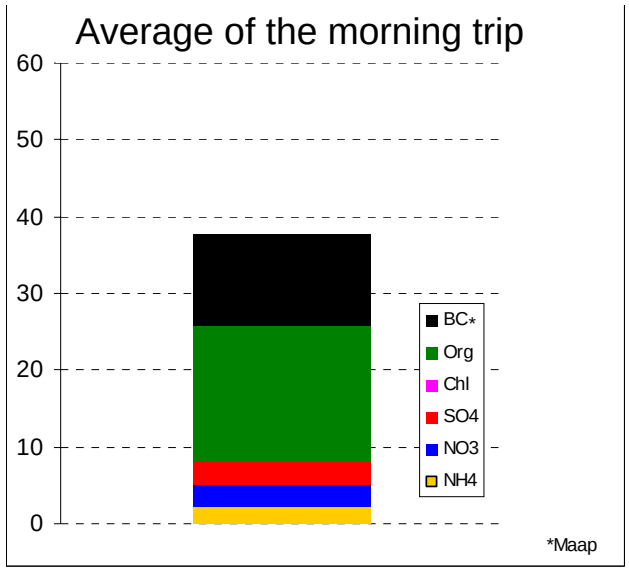
The PSI mobile laboratory

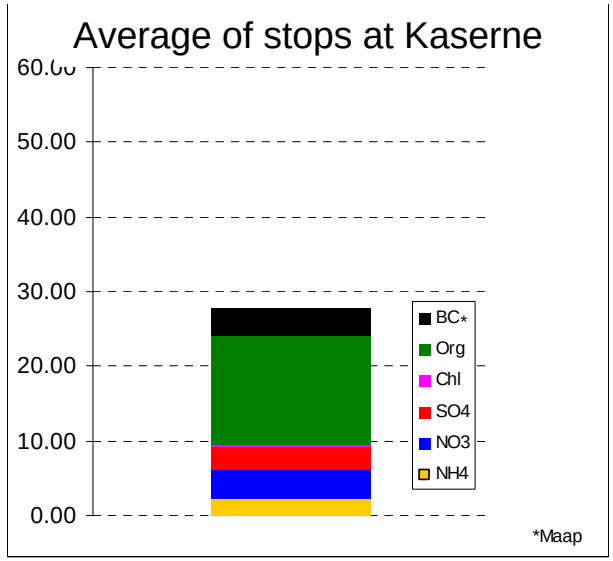


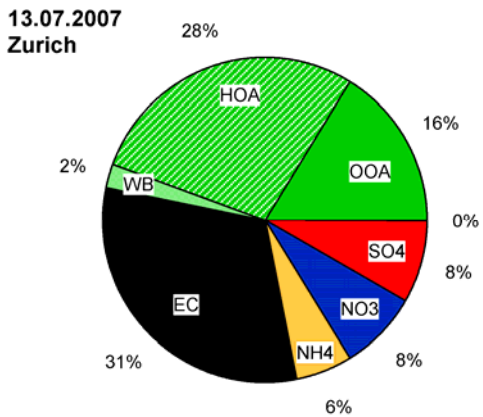
Estimation of wood burning contribution to OM as a function of location

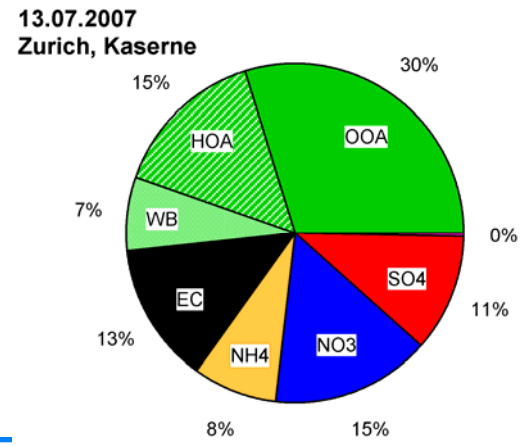


Difference between urban background and average in the city on the street









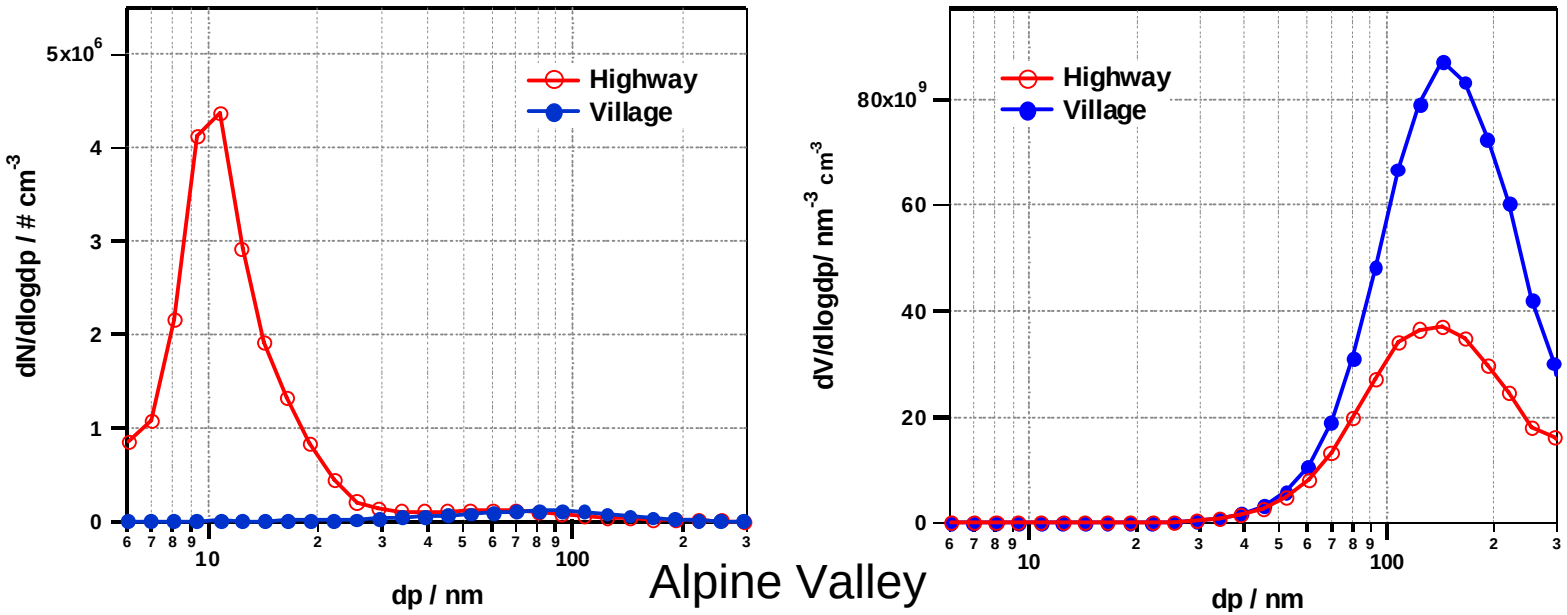
WB: wood burning

HOA: mostly traffic

OOA: secondary

A factor of two less BC and HOA at the urban background

Aerosol size distribution (5.6-560 nm) in an Alpine valley



Alpine Valley
Riviera 2005 Winter

- **Consistent picture : Nanoparticle concentrations <30 nanometers very high on highway**
- **In villages : much lower nanoparticle concentrations, in case of high wood burning contribution, higher volume concentration**

Conclusions

• The Aerosol mass spectrometer is a powerful tool for the analysis of aerosol composition. Mobile measurements allow for new possibilities.

• The organic aerosol mass spectra can be used for source apportionment

• Ammonium nitrate is very important in winter.

• In summer, secondary organic aerosols are very important. But also in winter is the contribution typically 50% (except in some Alpine valleys)

• Wood burning is in winter always an important source

• The traffic contribution to OM at the monitoring stations was not very high. First results indicates that the average traffic contribution to EC and OM on various streets in Zürich is around a factor of 2 higher than at urban background.

• The Elemental carbon and the particle number (especially the nanoparticle number) is mostly due to traffic. Very high ultrafine particle concentrations are found on the highway.