PAUL SCHERRER INSTITUT PSI LABOR FÜR ATMOSPHÄREN-CHEMIE

EMPA Materials Science & Technology

Source apportionment of submicron organic aerosol at an urban background site in Zürich

11th ETH-Conference on Combustion Generated Nanoparticles

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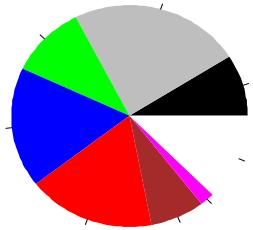
Overview

- Introduction: Atmospheric aerosols



- Methods: Receptor modeling

$$\mathbf{x}_i = \mathbf{C}\mathbf{S}_i + \mathbf{E}_i$$

- Results: Zürich-Kaserne

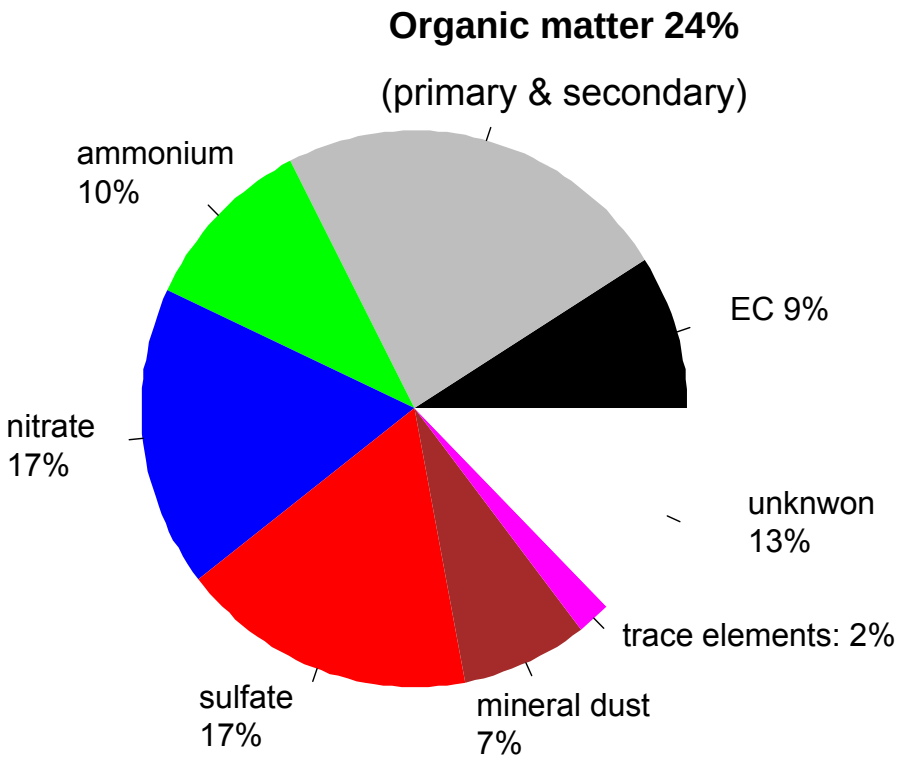
- Conclusions

Atmospheric (organic) aerosols

- Impact on health (climate, ecosystems, visibility, ….)

Atmospheric (organic) aerosols

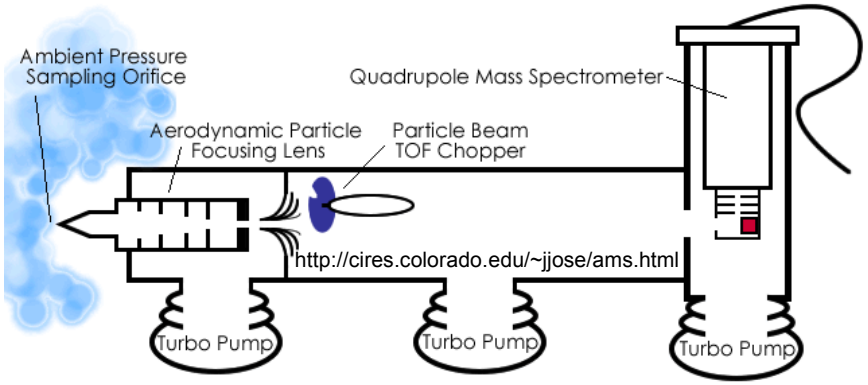
- Impact on health (climate, ecosystems, visibility, ….)
- Composition:



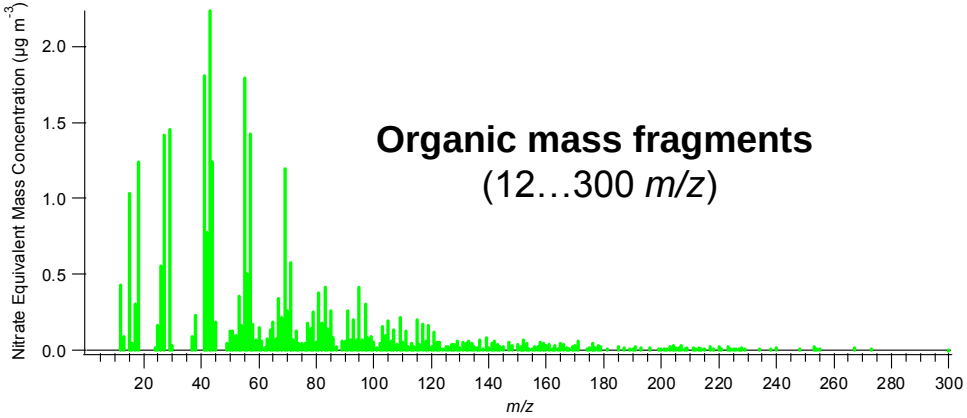
$PM_{2.5}$ (Zürich-Kaserne; Hueglin et al., 2005)

Aerosol measurements

- Aersol mass spectrometer (Q-AMS, Aerodyne Inc.)



- Non-refractory, submicron (~PM_1) aerosol
- Online, (semi-)quantitative
- High time-resolution (sec - minutes)



Receptor modeling

- **Receptor models** (linear mixing models)

$$\mathbf{x}_i = \mathbf{C}\mathbf{S}_i + \mathbf{E}_i$$

$\mathbf{X}_i$: multivariate observation (m-vector)	***measured AMS spectrum (270 dimensional)***
C: loadings (m x p-matrix), C ≥ 0	***aerosol source profile (270 x p-matrix)***
$\mathbf{S}_i$: scores (p-vector), S ≥ 0	***p latent aerosol source activities***

- No assumptions about source distributions
- Optional: meteorology/source composition

- Types

CMB - chemical mass balance: *chemical signature of sources known*

PMF - positive matrix factorization: " " " " *unknown*

Receptor modeling II

reconstructed data matrix

$$\hat{X} = CS$$

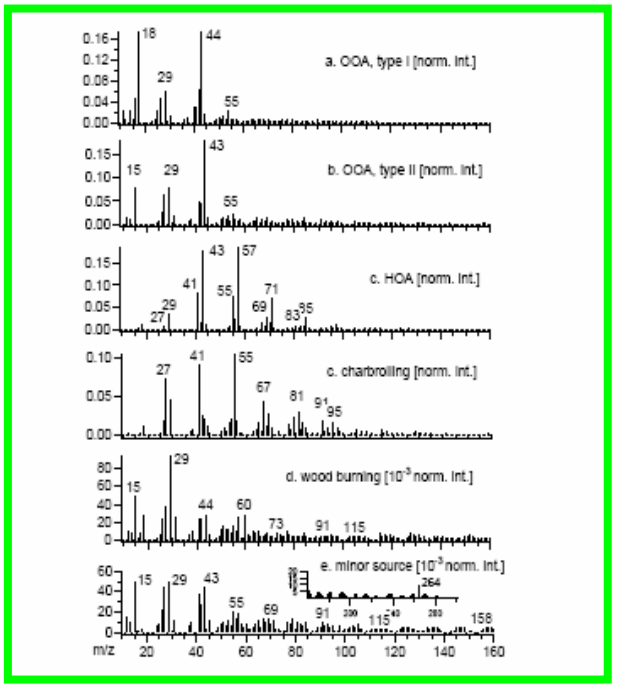
measured data matrix (X)

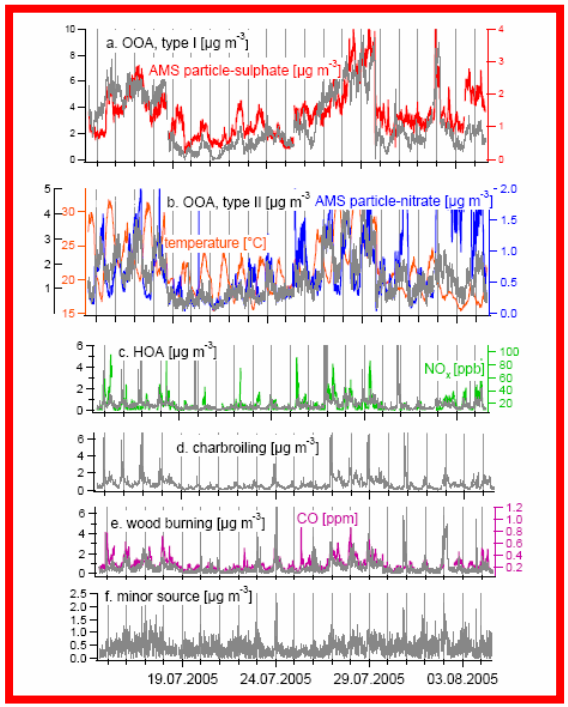
$$X - \hat{X} = E$$

modeled source profiles

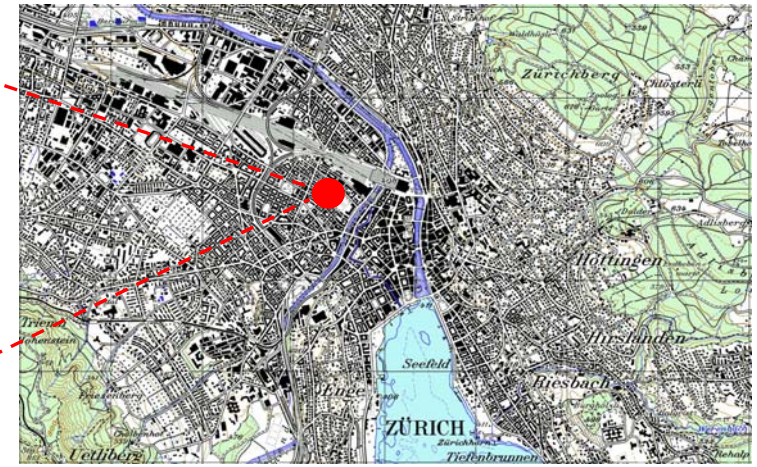
modeled time series of source activities

factors/sources





AMS sampling site: Zürich, urban background



Urban background site (Zürich-Kaerne)
Public backyard

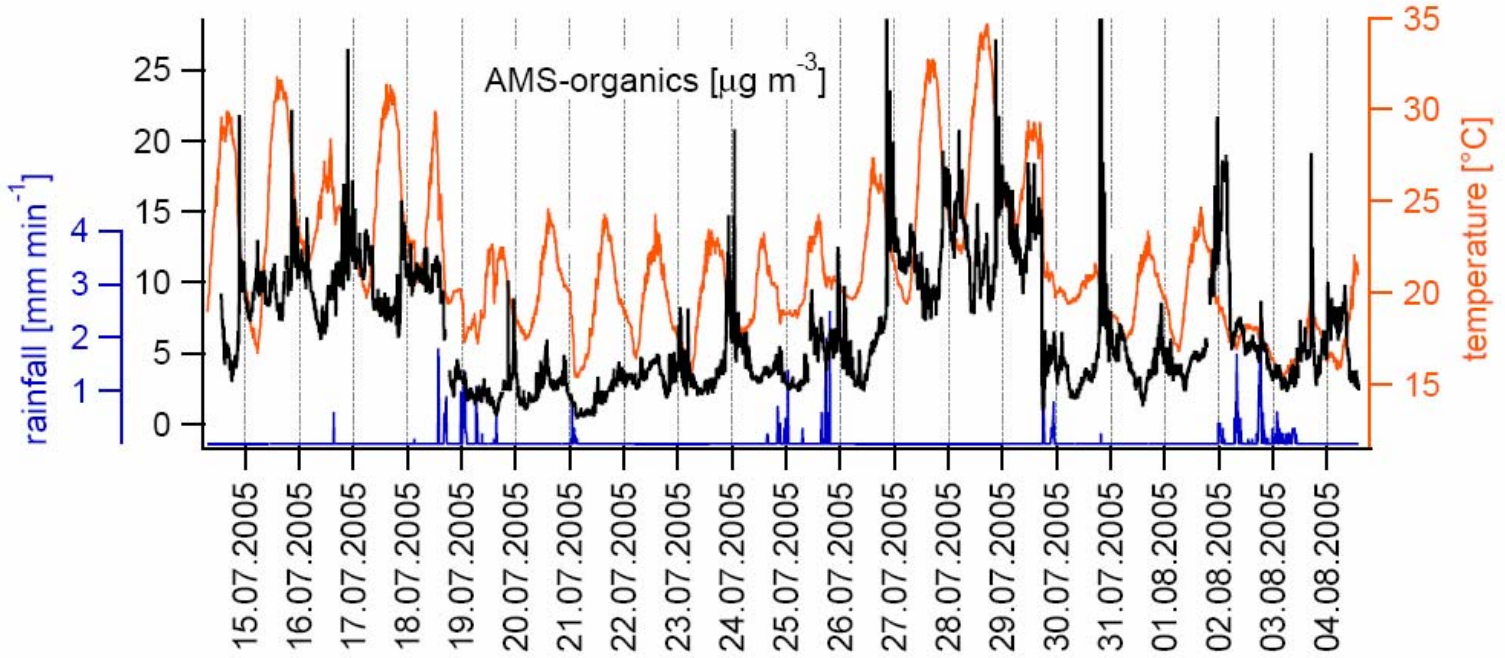
500 meters from Zurich main station
1 mile from lakeside

Site of the Swiss National Air Pollution Monitoring Network (NABEL; www.empa.ch/nabel)

<u>Ancillary data to validate math. model:</u>
- meteo (radiation, wind direction, temperature…)
- gas-phase (CO, NO_x, O_3, SO_2, VOCs, …)
- aerosol (PM_{10}, OC, EC)

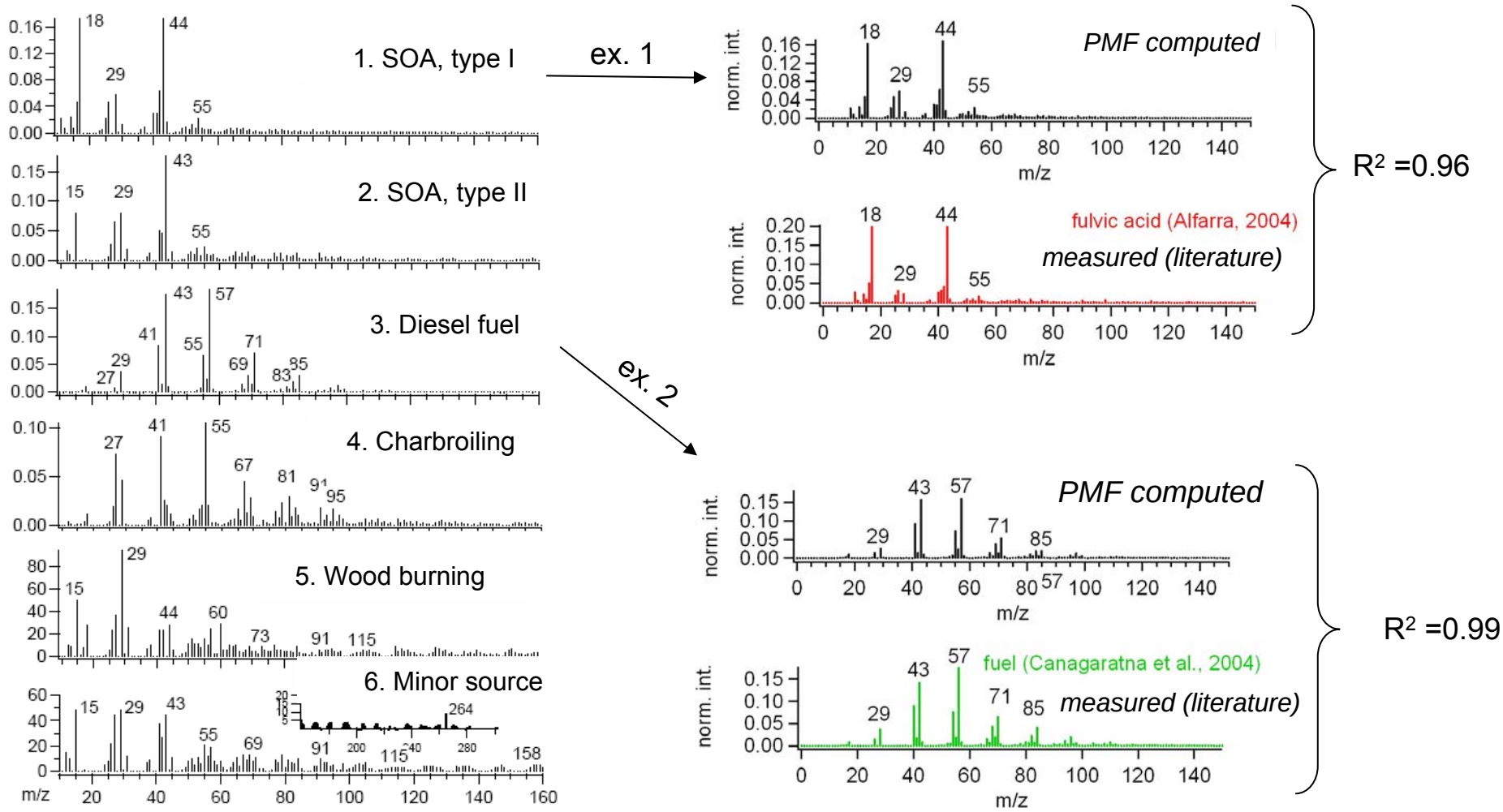
Zürich, Summer 2005

- 14 July – 4 August 2005
- **Photochemical episodes** („summer smog“)
- Positive matrix factorization (PMF)
  (Lanz et al., 2007, Atmos. Chem. Phys.)



Zürich, Summer 2005

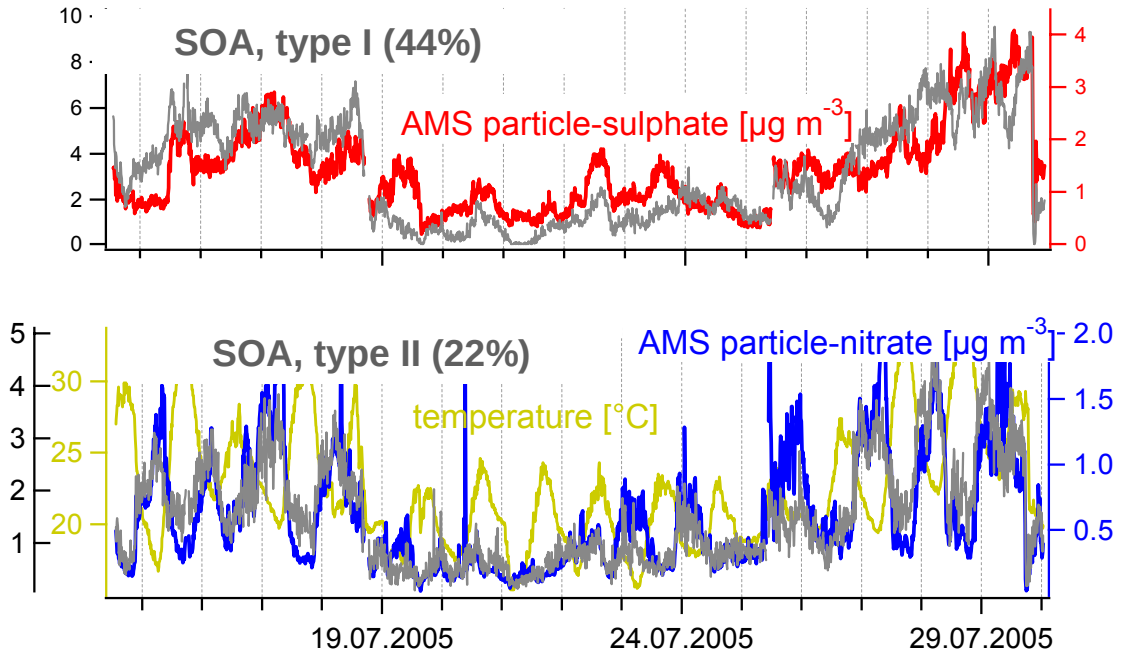
Source profiles (C matrix): Verification by independently measured AMS profiles



Zürich, Summer 2005

Source contributions: **66%** of submicron AMS-organics are **SOA**

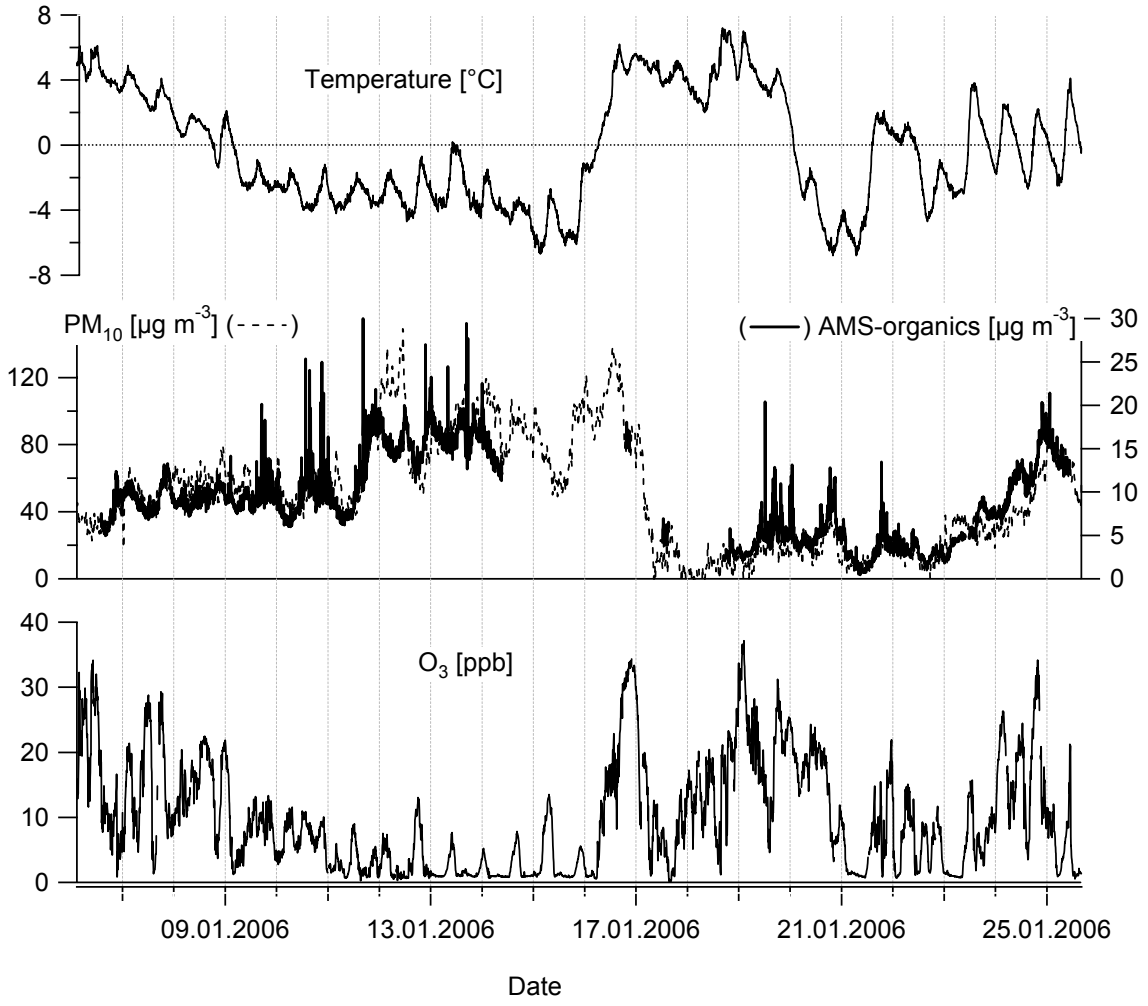
SOA = secondary organic aerosols (i.e. formed by gas-to-particle reactions in the atmosphere)



POA (=primary organic aerosols) account for **34%** and can directly be attributed to sources (10% wood burning, 7% fuel combustion, 13% charbroiling, <4% food cooking)

Zürich, Winter 2006

- 6 to 23 January 2006
- **Temperature inversions** („winter smog“)
- Hybrid model: CMB x PMF (Lanz et al., ES&T, in review)



Zürich, Winter 2006

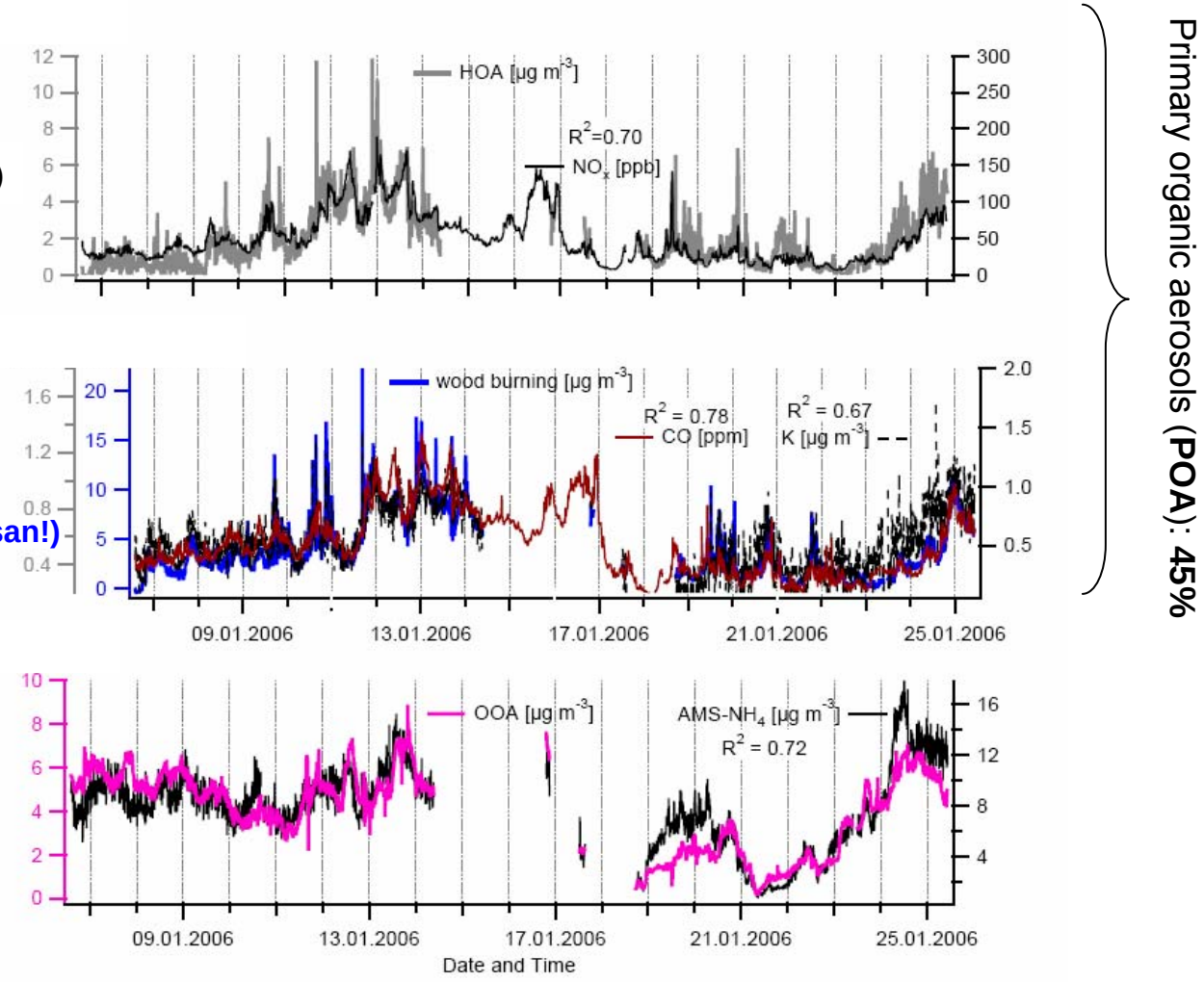
Source contributions:

a. Fuel combustion (7%)

b. Wood burning (38%)

(emission rel. levoglucosan!)

c. **SOA (55%)**

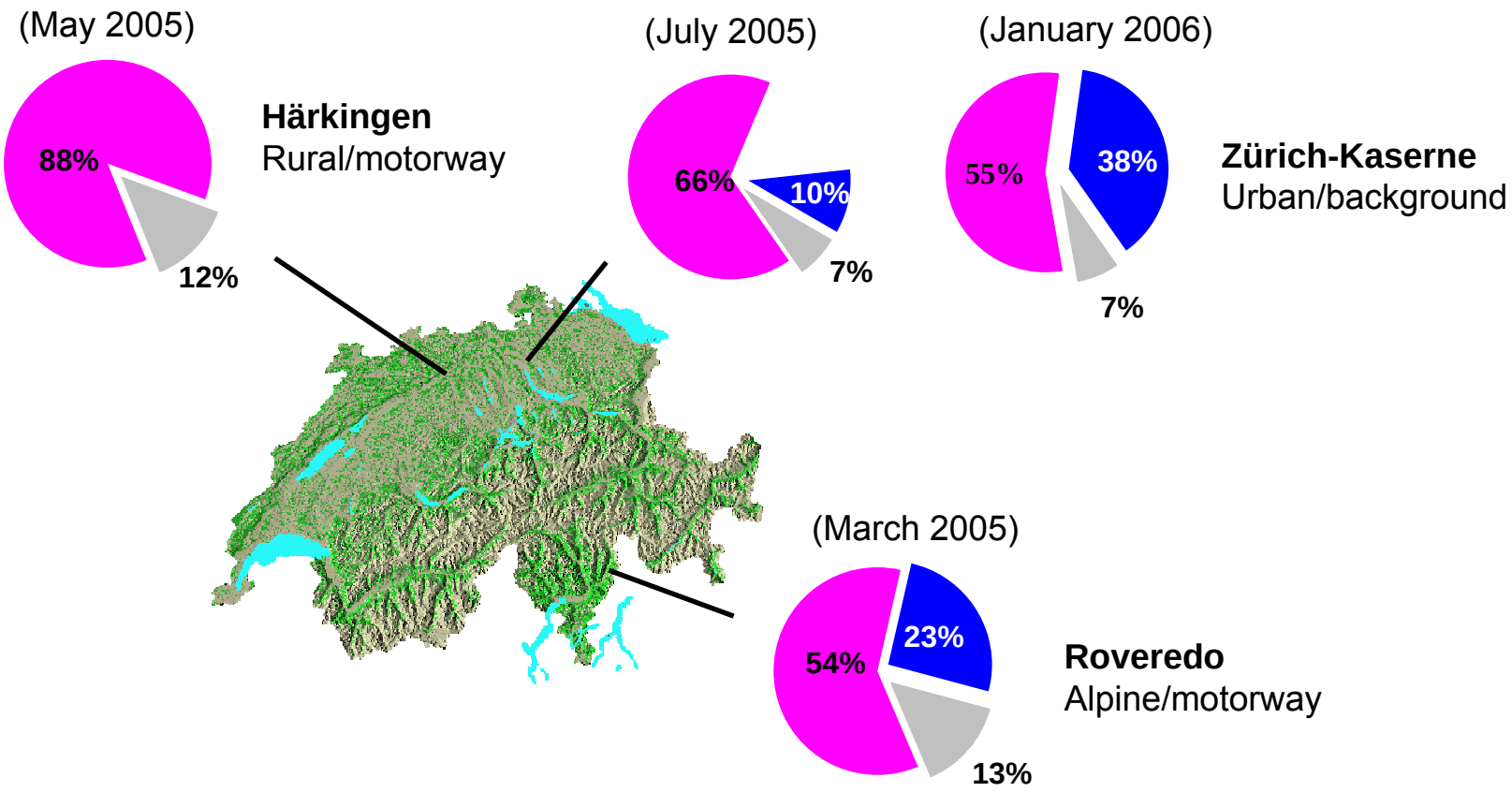


Primary organic aerosols (**POA**): **45%**

Diesel combustion

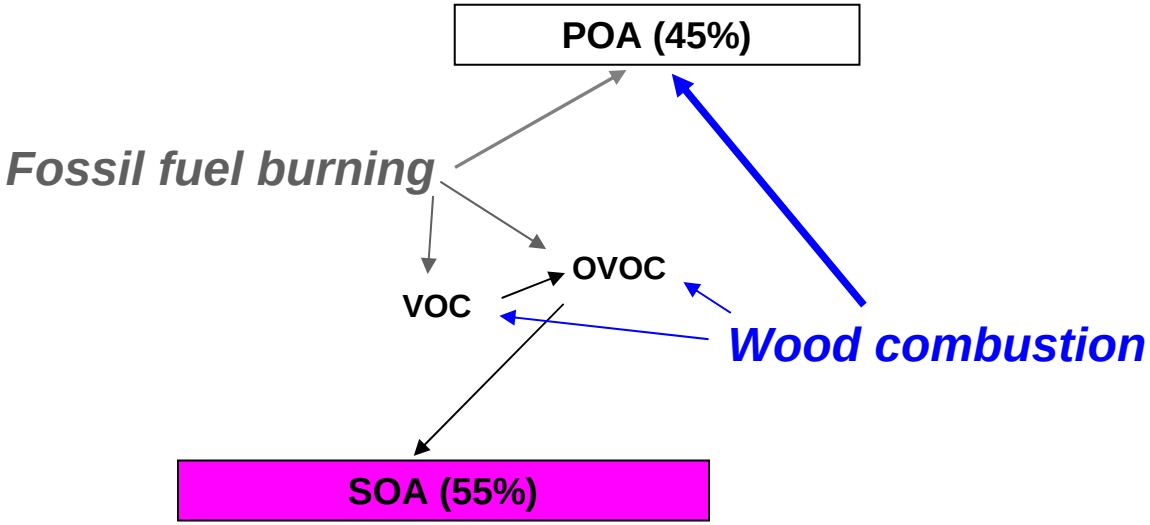
Wood burning aerosol

Secondary organic aerosol



Source apportionment of SOA

- Apportionment of SOA to emission sources: winter 2006



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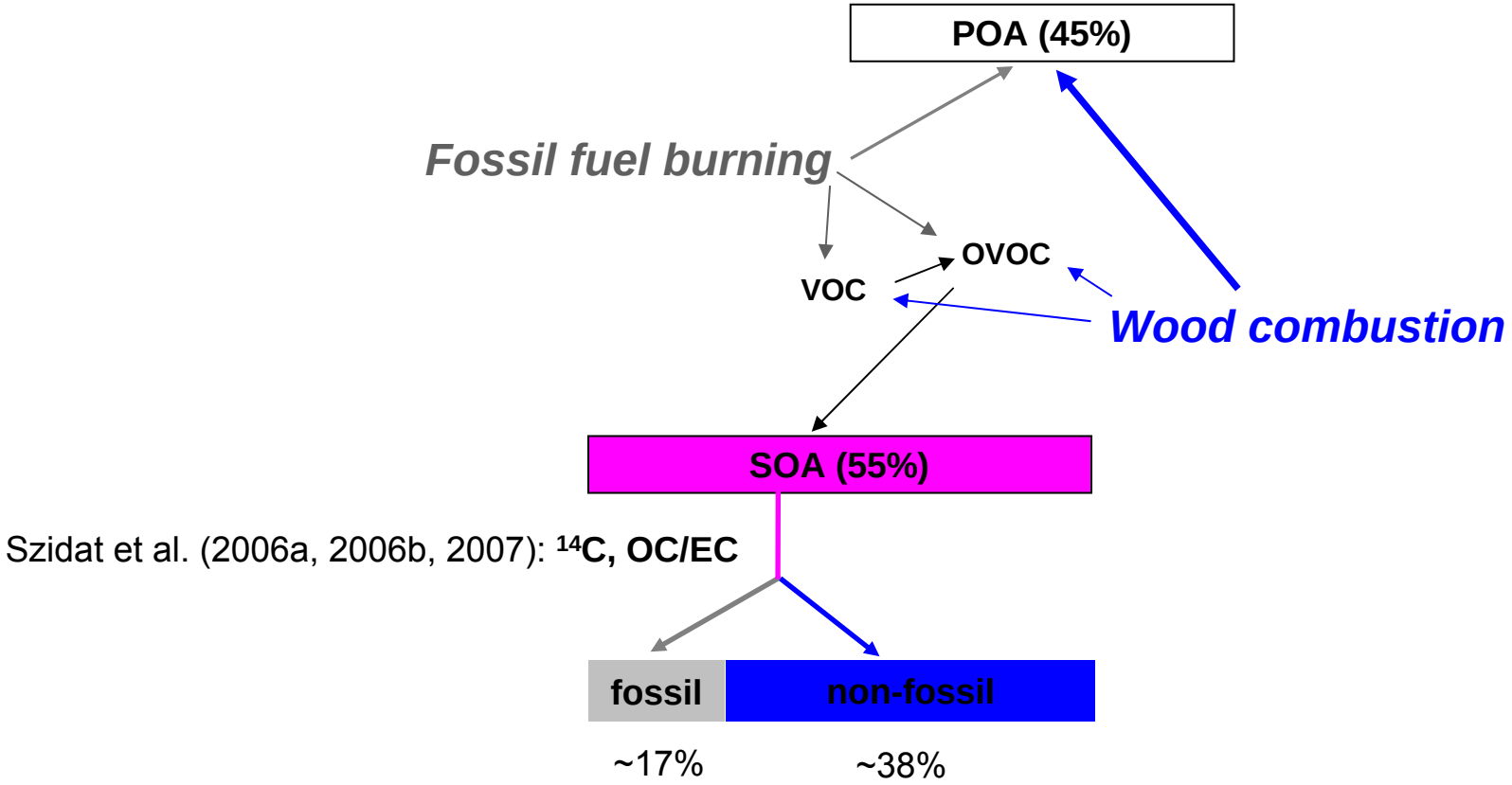

Szidat et al. (2006a, 2006b, 2007): **^{14}C, OC/EC**

Conclusions

- Ambient (AMS) organic aerosols can be attributed to sources by linear mixing models (PMF).

- **SOA** accounted for **50-90%** of the organic aerosol

  SOA is dominant both in **summer** (photochemistry) and in **winter** (accumulation, low temperatures)

- **POA** accounted for **10-50%** of organic aerosol

  Residential areas/winter: POA dominated by **wood burning**

- ^{14}C measurements give further insights into **SOA source attribution** (fossil/non-fossil) (Winter 2006):

  Fuel combustion contributes more to SOA (17%) than POA (7%)
  Wood burning contributes equally to SOA (38%) and POA (38%)

Thanks to

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