Overview of the particulate matter composition in various regions of Switzerland

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Outline

• Measurement principle of the Aerosol mass spectrometer
• Markers in mass spectra for source attribution
• Overview of the results concerning aerosol composition (PM1) (mostly nitrate (NO₃), ammonium (NH₄), sulfate (SO₄), black carbon (BC), some chloride and organic mass (OM) at monitoring sites
• Discussion of OM sources using mass spectral markers
• First results from recent mobile measurements
• Conclusions
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: organic aerosol mass spectra

- **Urban**
  - Diesel Fuel Laboratory
  - Lubricating Oil Laboratory
  - Diesel Exhaust Aerosol
  - Traffic Dominated Urban Aerosol

- **Non-Urban**
  - Langley Rural
  - Sumas Semi Rural
  - Jungfraujoch High Alpine
  - Jeju Island Marine

McFiggans, Alfarras et al., Faraday Discussions, 2005
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)
Mass fragment markers for different sources

Original proposition (Alfarra et al., 2004):
- \textbf{m/z 44} (mostly \( \text{CO}_2^+ \)) indicative for secondary organic aerosols (SOA)
- \textbf{m/z 57} (mostly \( \text{C}_4\text{H}_9^+ \)) indicative for organic mass of traffic exhaust

New findings (Alfarra et al., 2007)
- \textbf{m/z 60} (mostly \( \text{C}_2\text{O}_2\text{H}_4^+ \)) indicative for \textit{biomass burning} (e.g. domestic wood burning)
  - wood burning may also contribute to m/z44, and to m/z57
  - in most cases: m/z57 from traffic is dominating (m/z 57 major peak); wood burning contribution might be taken into account in simple estimations
  - the attribution of m/z44 must be done carefully if biomass burning sources are present
Locations with AMS Measurements

- Zürich (July/August and January)
- Reiden (February)
- Roveredo (March, December)
- Härkingen (May)
- Payerne (June, January)
- Massongex (December)
- JFJ (Winter, Summer)
- Riviera (June)
- Milano (June)
- Rhine valley (February)
- Mobile measurements

2006
Average composition in Zürich in summer and winter

Zürich (July)

- Black Carbon: 13%
- Organic mass: 60%
- Nitrate: 7%
- Sulfate: 13%
- Ammonium: 7%

Zürich (January)

- Black Carbon: 14%
- Organic mass: 32%
- Nitrate: 15%
- Sulfate: 27%
- Ammonium: 11%
### Average compositions in winter

#### Zürich (January)
- **Black Carbon**
- **Organic mass**
- **Nitrate**
- **Sulfate**
- **Ammonium**
- **Chloride**

#### Roveredo (December)

#### Massongex (December)

#### Payerne (January)

#### Reiden (February)
Simple estimations of wood burning and traffic contributions using marker/OM concentration ratios

<table>
<thead>
<tr>
<th>Station (summer/winter)</th>
<th>Wood burning</th>
<th>traffic</th>
<th>Rest (mostly SOA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roveredo (Dec)</td>
<td>95%</td>
<td>5%</td>
<td>0%</td>
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<tr>
<td>Roveredo (March)</td>
<td>47%</td>
<td>11%</td>
<td>42%</td>
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<tr>
<td>Zürich (Jan)</td>
<td>29%</td>
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<td>57%</td>
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<td>Reiden (Feb)</td>
<td>32%</td>
<td>12%</td>
<td>56%</td>
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<tr>
<td>Massongex (Dec)</td>
<td>36%</td>
<td>12%</td>
<td>52%</td>
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<tr>
<td>Payerne (Jan)</td>
<td>32%</td>
<td>11%</td>
<td>57%</td>
</tr>
<tr>
<td>Zürich (July)</td>
<td>14%</td>
<td>14%</td>
<td>72%</td>
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<tr>
<td>Härkingen(May)</td>
<td>11%</td>
<td>20%</td>
<td>69%</td>
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<tr>
<td>Payerne (July)</td>
<td>10%</td>
<td>10%</td>
<td>80%</td>
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</table>
Average diurnal cycle of chloride and organic mass in Massongex

\[
\text{Organics}
\]

\[
\text{Chloride}
\]

\[
\text{NH}_3 + \text{HCl} \rightarrow \text{NH}_4\text{Cl}
\]
PSI mobile laboratory
Estimation of wood burning contribution to OM as a function of location
Average composition in the Rhine valley compared to Zürich and Reiden
Poster by Chirico, Weimer et al.

In Rhine valley relatively more EC and OM
Wood burning contribution Rhinevalley: 14-21%; Reiden/Zürich : 29-32%
Traffic contribution: Rhinevalley: 20-41%; Reiden/Zürich : 12-14%
Mobile measurements in Milano
Mobile measurements in Milano

[Graph showing mass concentration over time for different components: Chl, NH4, SO4, NO3, Org, EC.]

Milano
27. June 2007
Average composition of aerosol in Milano in the morning of June 27, 2007

**Milano**
20.7 °C
06:08:00 - 10:28:00

**Relative intensity**

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**Estimation of OM contributions:**
Traffic: 64%
Wood burning: 4%
Conclusions

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

- Markers can be used to some extent to estimate sources for OM (wood burning, traffic, secondary organic aerosol). Better are sophisticated source apportionment methods (see next talk).

- Ammonium nitrate is very important in winter. The contribution of ammonium sulfate was highest in Zürich

- 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. During the mobile measurements in the Rhine valley and especially in Milano, very high concentrations of EC and traffic contributions were found