Regional OC/SOA and EMEP
- Background for NMR project

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Outline:

- Where do we start?
- What do the models suggest?
- What do SOA models have in common with string theory?
- What do the measurements tell us?
- The NMR project
EMEP models

- ACID model - Simple chemistry - PMx mass
- OZONE model - full photochemistry - PMx mass
- AERO model - Simple chemistry - aerosol dynamics
Where do we start?

Basic EMEP models include primary OC (POC) and EC.

These consistently underpredict OC:
Where do we start?

- Basic EMEP models include primary OC (POC) and EC

These consistently underpredict OC:

- Could it be SOA?
But ....

We also underestimate EC!

![Graph showing EC 1999 data]

- Obs. mean = 1.85
- Model mean = 0.33
- Correlation = 0.69
But ....

We also underestimate EC!

The first major problem is then to reconcile emissions of primary EC with measured values
The EMEP SOA model

- Emissions characterised as:
  - ‘Oil’: Fossil-fuel combustion emissions
  - ‘Wood’: Residential combustion
- Existing and Secondary OC as:
  - ASOA: Anthropogenic SOA (from aromatics)
  - BSOA: Biogenic SOA (from terpenes)
  - BGND: Background OC (mixture oil/wood type)
- Gas/Particle partitioning (Pankow-type approach - see Andersson-Sköld and Simpson, 2001)

NOTE: the ‘wood’ category is clearly a gross exaggeration, but the aim here is to look at seasonal cycles rather than absolute levels.
EMEP SOA Model:

Results: Annual Average OC, year 2001 (ug/m3)
BVOC Contribution

Results: Contribution of BVOC to OC (%)
AVOC Contribution

Results: Contribution of AVOC to OC (%)

![Map showing the contribution of AVOC to OC (%)]
Seasonal Variation:

K-Puzsta, Hungary:

Note: The BGND contribution is held fixed in the model.
Model results suggest:

- A summer maxima in SOA caused by biogenics
- Anthropogenic contributions have winter maxima, but are much smaller
- Maximum OC location coincides with maximum BSOA, in Northern Europe
State of SOA Modelling

- Model theories change every year!
- Over last 10 years we have seen:
  - Fixed-yield theories
  - Need to exceed $P_{sat}$
  - Gas-Particle partitioning ($\alpha$-K) - successful for smog-chambers
- Possible reactions within the aerosol invalidate most current theories!
- Increasing evidence for polymerisation and other reactions within aerosol
String theory?

What do SOA models have in common with string theory?

- Easy for modellers to produce 'pretty plots' and numbers for SOA
String theory?

What do SOA models have in common with string theory?

- Easy for modellers to produce ’pretty plots’ and numbers for SOA
- But impossible to prove them wrong - there are insufficient measurements!
Measurements?

Sources of Data:

- NILU EC/OC Campaign, 2002-2003 - 24h sample of EC/OC once per week
- Austrian AUPHEP sites - daily EC/OC
- CARBOSOL (EU Project) - weekly EC/OC

Investigation only just started - focus on OC/EC ratios
Seasonal variation?

Comment: winter concentrations similar to summer
Seasonal variation?

Comment: winter concentrations ≥ summer
**OC/EC, Austria AU02**

AUPHEP site - Daily data:

**Station AU2, Summer**
- Fitted Slope: 1.8
- Corr: 0.66

**Station AU2, Winter**
- Fitted Slope: 1.6
- Corr: 0.83

**Station AU2, All months**
- Fitted Slope: 1.7
- Corr: 0.79

**NOTE:** slope very similar in all seasons, but scatter larger in summer.
OC/EC, Austria AT02

NILU EC/OC site - 24h data, once per week: (Illmitz)

NOTE: slope much larger than from AUPHEP site. Why?! (Different methods?)
OC/EC, Italy

NILU EC/OC site - 24h data, once per week: (Belogna)

NOTE: slope very similar in all seasons.
OC/EC, Netherlands

NILU EC/OC site - 24h data, once per week: (Kollumerward)

NOTE: slope very different! Why?
OC/EC, Sweden

NILU EC/OC site - 24h data, once per week: (Aspvreten)

Station SE 12, Summer
Fitted Slope: 9.1
Corr: 0.97

Station SE 12, Winter
Fitted Slope: 3.9
Corr: 0.96

Station SE 12, All months
Fitted Slope: 5.0
Corr: 0.81

NOTE: slope very different! Why?
## Summary of OC/EC

OC/EC Ratios from NILU Campaign:
(Sorted by increasing summer-winter ratio, given in last column)

<table>
<thead>
<tr>
<th></th>
<th>Summer (S)</th>
<th>Winter (W)</th>
<th>All months</th>
<th>Ratio W/S</th>
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<tr>
<td>Belgium</td>
<td>1.9</td>
<td>2.4</td>
<td>2.2</td>
<td>0.79</td>
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<td>5.2</td>
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<td>4.4</td>
<td>3.7</td>
<td>3.8</td>
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<td>2.3</td>
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<td>4.0</td>
<td>5.5</td>
<td>2.7</td>
</tr>
</tbody>
</table>
Comments on OC/EC

- For many sites there is hardly any difference in summer/winter OC/EC ratios
- Sites in warmer locations show small differences, e.g. AT, IT, PT - this does not directly support ideas of a large biogenic contribution
- Greatest differences in "cold" regions? Why?
  - Greater biogenic SOA in Northern Europe?
  - More primary biogenic OC in Northern Europe?
  - Greater condensation?
  - Artefacts in remote regions? (e.g. absorption on quartz filters?)
NMR Project

- Model predictions of summertime maxima in OC, due to BSOA, are not consistent with measurements at many sites.
- SOA modelling is very immature.
- Neither measurements nor modelling are currently good enough to explain OC levels.
Aims to use both:

- Look for correlations between measured OC and:
  - Modelled primary EC and/or OC from different sources
    - e.g. fossil-fuel, wood, forest-fires
  - Modelled SOA from different sources
    - e.g. ASOA, BSOA
  - Modelled fields of precursors
    - e.g. AVOC (aromatics), BVOC (terpenes)

- i.e. a semi-empirical approach