Biogenic VOC - organic aerosol - EMEP

David Simpson\(^{(1,2)}\)

1. EMEP MSC-W, Norwegian Meteorological Institute, Oslo, Norway
2. Chalmers University of Technology, Gothenburg, Sweden
EMEP: European Monitoring and Evaluation Programme

**CLRTAP:** Convention on Long Range Transboundary Air Pollution

- Adopted 1979
- 51 Parties
- Eight Protocols

  EMEP, 1984
  Last one: Göteborg, 1999

- EMEP contributes modelling and measurements to policy bodies
- e.g. to EU NEC Directives + CAFE

powerdot :-)
Does BVOC Matter?

\[ \Delta \text{DMax-}O_3, \]

No-isoprene:

DMax-\(O_3\),

Base:
Does isoprene matter?
OA: Subject=Horrendous!

Some issues:

- Which precursors? (Isoprene, terpenes, aromatics ..)
- 1000s of compounds, mainly unknown.
- Gas-phase? Aqueous-phase? Particle-phase?
- Thermodynamics/Volatility
- Aging
- Artifact-rich observations!

See e.g. Donahue et al., Atmos. Environ., 2009, Hallquist et al., ACP, 2009
Source-Apportionment

- **Tracers:**
  - $^{14}$C $\Rightarrow$ modern/fossil
  - cellulose/%WNA $\Rightarrow$ plant matter, ...
  - sugars/alcohols $\Rightarrow$ fungi, ...
  - OC/EC $\Rightarrow$ primary emissions
  - levoglucosan $\Rightarrow$ biomass-burning

- Some ‘traps’, e.g. some modern $^{14}$C could be from cooking oils, ’hot’-carbon, etc.

- All factors very uncertain!

- ”Statistical” solution -LHS

(e.g. Gelencsér et al., JGR, 2007, Szidat et al., ACP, 2009, Yttri et al., ACP 2009, 2011)
Nordic source apportionment: 1

Summer ($PM_{10}$):

Yttri et al., ACP, 2011
Nordic source apportionment: 2

Long-term:

Genberg et al, ACP, 2011
Source-apportionment in Europe shows:

- Summer OM dominated by BSOA
- Winter OM dominated by biomass-burning

This is both good (simple!)
Source-apportionment in Europe shows:

- Summer OM dominated by BSOA
- Winter OM dominated by biomass-burning

This is both good (simple!)

and bad!

- These are the hardest emission sources to pin down
Do models have the answer?
Do models have the answer?

.... any answer you want!!

c.f. Bergström et al., ACPD, 2012
Belief in models?

The basic rule:
Belief in models?

The basic rule:

Garbage in ⇒ Garbage out:

powerdot :-)

Toulouse GEIA June 2012
Belief in models?

The basic rule:

Garbage in \(\Rightarrow\) \(\Rightarrow\) Garbage out:

SOA twist:

Garbage in the middle!
## BVOC Uncertainties

### Emission Factors, monoterpenes:

<table>
<thead>
<tr>
<th></th>
<th>$\mu$g g$^{-1}$h$^{-1}$</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway spruce</td>
<td>3.0</td>
<td>Simpson et al., 1999, Schurgers et al., 2009</td>
</tr>
<tr>
<td></td>
<td>$\sim$1</td>
<td>Janson et al., Hakola et al., 2003</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>Stewart et al., 2003</td>
</tr>
<tr>
<td></td>
<td>3.52</td>
<td>Smiatek &amp; Steinbrecher, 2006</td>
</tr>
<tr>
<td>Beech</td>
<td>0.0</td>
<td>Simpson et al., 1999, Guenther et al., 1995</td>
</tr>
<tr>
<td></td>
<td>15.0</td>
<td>Smiatek &amp; Steinbrecher, 2006</td>
</tr>
<tr>
<td></td>
<td>21.14</td>
<td>Steinbrecher et al., 2009</td>
</tr>
<tr>
<td></td>
<td>10.0</td>
<td>Schurgers et al., 2009</td>
</tr>
</tbody>
</table>
Comparison, Swedish BVOC Emissions

1) Isoprene

<table>
<thead>
<tr>
<th>Species</th>
<th>Cover</th>
<th>Emis. Factor (EF)</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ug/g/h</td>
<td>Cover × EF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S99</td>
<td>S99</td>
</tr>
<tr>
<td>Betula</td>
<td>13%</td>
<td>0.1</td>
<td>1</td>
</tr>
<tr>
<td>Fagus</td>
<td>1%</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>Picea abies</td>
<td>39%</td>
<td>1.0</td>
<td>40</td>
</tr>
<tr>
<td>Pinus sylv.</td>
<td>41%</td>
<td>0.1</td>
<td>4</td>
</tr>
<tr>
<td>Populus trem.</td>
<td>2%</td>
<td>60.0</td>
<td>120</td>
</tr>
<tr>
<td>Quercus unspec</td>
<td>1%</td>
<td>60.0</td>
<td>60</td>
</tr>
<tr>
<td>Other broadleaf</td>
<td>3%</td>
<td>1.0</td>
<td>3</td>
</tr>
</tbody>
</table>

Notes: EF applies at 30 C, full sunlight
S99 = Simpson et al., 1999
Isoprene emitters: single species do matter

Keenan et al., ACP, 2009
Emission factors versus Emissions

powerdot :-)

Toulouse GEIA June 2012
Isoprene emitters: single species do matter

Keenan et al., ACP, 2009
Emission factors versus Emissions

Refs Q. Robur:
- Isidorov et al., 1985
- Steinbrecher et al., 1993
- Possel et al., 2004
## BVOC Emissions

### Estimates of Emissions, Finland:

<table>
<thead>
<tr>
<th>Study</th>
<th>Isoprene (Gg/yr)</th>
<th>Monoterpenes (Gg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guenther et al. 1995</td>
<td>240</td>
<td>400</td>
</tr>
<tr>
<td>Simpson et al. 1999</td>
<td>39</td>
<td>160</td>
</tr>
<tr>
<td>Lindfors et al. 2000</td>
<td>21</td>
<td>160</td>
</tr>
<tr>
<td>Guenther et al. 2006</td>
<td>160</td>
<td>-</td>
</tr>
<tr>
<td>Tarvainen et al. 2007</td>
<td>15</td>
<td>110</td>
</tr>
</tbody>
</table>

(Rinne et al., 2009)

Further problems with seasonal variation (few winter measurements!), spatial variation, and methodological differences (e.g. EC versus gradient, enclosure).
EMEP BVOC emissions

2011 update - significant changes in methodology
2011 update - significant changes in methodology

- ICP/JRC forest maps, 115 species - Köble & Seufert (2001)
- Emission factors per species, updated from Simpson et al. (1999) with NATAIR, Keenan et al. (2009), Rinne et al. (2009), Schurgers et al. (2009), ...
EMEP BVOC emissions

2011 update - significant changes in methodology

- ICP/JRC forest maps, 115 species - Köble & Seufert (2001)
- + Emission factors per species, updated from Simpson et al. (1999) with NATAIR, Keenan et al. (2009), Rinne et al. (2009), Schurgers et al. (2009), ...
- aggregated into EMEP 16 land-cover categories,
- Preserved G95-style T and PAR functions
- Simple LAI scaling
For example, Isoprene emissions potentials (ug/m2/h), EMEP DF (temperate/boreal deciduous forest):
EMEP versus MEGAN
In general, MEGAN BVOC $\gg$ EMEP BVOC.
(Difficult to understand.)
• BVOC are important for O$_3$, SOA
• Despite this, few BVOC flux data are available
• Isoprene inventories change little - too few new data! (Illusion-phase, see Arneth et al., ACP, 2008)
• Still little known about OVOC
• SOA science still ’in infancy’; essential to pin-down BVOC inputs
• Measure BVOC emissions (+concentrations, products) !!