Primary Biological Aerosol Particles: an important part of the global organic aerosol budget?

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FIRST... SOME INTRODUCTIONS

Bonne Ford, graduate student

Gena Renninger, graduate student

Kateryna Lapina, postdoc
Jaenicke [2005] suggests may be as large a source as dust/sea salt (1000s Tg/yr)
Elbert et al. [2007] suggest emission of fungal spores ~ 50 Tg/yr
CURRENT SOURCE ESTIMATES FOR ORGANIC AEROSOL (Tg/yr)

WITHOUT PBAP

PBAP estimates ~1000 Tg/yr would swamp all other sources of organic aerosol. Fungal spores emissions equivalent to biomass burning?

Biomass Burning, 50

SOA, 30

Biofuels, 8

Fossil Fuel, 11

WITH PBAP?

PBAP, 1000

Biomass Burning, 50

SOA, 30

Biofuels, 8

Fossil Fuel, 11

Budget #'s from GEOS-Chem [Park et al., 2003; Henze et al., 2008]
PBAP ACROSS THE SIZE RANGE?

May also make important contribution to fine mode aerosol

Dominates the coarse mode (pollens, debris…)

From Andi Andreae (unpublished data)
GEOS-CHEM SIMULATION OF FUNGAL SPORE PBAP

I. Identify tracer to test simulation: Mannitol is a *unique* tracer for fungal spores [Bauer et al., 2008; Elbert et al., 2007]

\[ 1 \text{ pg mannitol} = 38 \text{ pg OM}^* \]

II. First-guess: constant emissions from Elbert et al. [2007], with 20% in fine mode

III. Optimize emissions: Test meteorological drivers to reproduce observed variability

VAST improvement for fine PBAP: capture variability, unbiased simulation
MODEST improvement for coarse PBAP: relatively unbiased, but other drivers?
WHERE ARE FUNGAL SPORES AN IMPORTANT SOURCE OF ORGANIC AEROSOL?

a) PBAP (fungal spore) Emissions
b) Contribution of PBAP to Surface OA (fine)

c) Surface PBAP Concentrations: fine
d) Surface PBAP Concentrations: coarse

Generally contribute ~10% to fine mode surface OA, but > 30% in tropics
WHEN ARE FUNGAL SPORES AN IMPORTANT SOURCE OF ORGANIC AEROSOL?

Pronounced seasonality in extratropics (corresponding to vegetation cover), peaking in late-summer/fall as in measurements.

unpublished data, Hanna Manninen

GEOS-Chem simulation

unpublished data, Hanna Manninen

[Ho et al., 2005]

[Hyytiala, 2008]

[Ho et al., 2005]

[Sousa et al., 2008]
CONCLUSION

Fungal spores make a modest, but regionally important contribution to organic carbon aerosol budget. More observations needed to test… What about other PBAP types?

Next up: implications for CCN (using GLOMAP model…)

[Heald and Spracklen, GRL, in press]
EXTRAS
PBAP: PRESENT-THROUGHOUT THE YEAR, IN URBAN AND RURAL LOCATIONS

Mainz, Germany (1990-1998)

Particles > 0.2 μm, stained with protein dye

No clear seasonality: multiple PBAP sources

PBAP # fraction = 5-50%

Lake Baikal, Russia (1996-1997)

[Jaenicke, 2005]
MANNITOL: A UNIQUE TRACER FOR Fungal Spores

1 spore contains 1.7 pg mannitol [Elbert et al., 2007; Bauer et al., 2008]

Organic matter:
33 pg/spore [Bauer et al., 2008] OR 65 pg/spore [Elbert et al., 2008]

CONVERSION: [OM] = 38[mannitol]

Average sugar alcohol content at different sites in Vienna

Comparing measured mannitol w/ concentrations estimated from spore counts

[Bauer et al., 2008]
WHAT DRIVES MANNITOL/FUNGAL SPORE EMISSION?

Potential meteorological/phenological drivers [Jones and Harrison, 2004]:
Temperature, radiation, wind speeds, surface wetness, precipitation, leaf area index (LAI), RH, water vapour concentrations and boundary layer depths

BEST drivers are LAI and water vapour concentrations.

CAUTION: not necessarily causal!
ANY INDICATION OF PBAP IN AMAZE-08?

Field site: close to Manaus, Brazil (in Amazonia), Feb-Mar

No obvious indication of an important sub-micron PBAP in the “pristine” Amazon... Our ~ 30% contribution (to PM$_{2.5}$) would be consistent with measurement uncertainty.

NEED: (1) more ambient measurements of mannitol/spores (2) Better time series of measurements to resolve diurnal cycle

**PRELIMINARY** AMS obs: Scot Martin, Qi Chen (Harvard). Jose Jimenez, Delphine Farmer (CU Boulder)
### Fine Mode (PM2.5) Measurements (DJF, MAM, JJA, SON): Total (independent)

<table>
<thead>
<tr>
<th>Reference</th>
<th>Mean Concentration (ng/m³)</th>
<th>Concentration range</th>
<th>Location</th>
<th>Time</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claeys et al., 2004</td>
<td>9.4 (day)</td>
<td>8.4 (night)</td>
<td>LBA-CLaire, Balbina, Amazonas (1°55'S, 59°24'W)</td>
<td>July 25-28 2001</td>
<td>&lt; 2.5</td>
</tr>
<tr>
<td>Decesari et al., 2006</td>
<td>21.9 (dry, n=51)</td>
<td>20.2 (transition, n=20) 18 (wet, n=7)</td>
<td>LBA-SMOCC, FNS, Rondonia (10°45'S, 62°21'W, 315m asl)</td>
<td>Sept-Nov, 2002</td>
<td>Fine</td>
</tr>
<tr>
<td>Graham et al., 2002</td>
<td>26.3 (FNS n=9)</td>
<td>22.3 (RBj, n=12)</td>
<td>Amazon, FNS (10°45'S, 62°21'W)</td>
<td>October 1-29, 1999</td>
<td>Fine</td>
</tr>
<tr>
<td>Graham et al., 2003b</td>
<td>15.2 (n=6)</td>
<td></td>
<td>LBA-CLaire, Balbina, Amazonas (1°55'S, 59°24'W)</td>
<td>July 19-28 2001</td>
<td>Fine</td>
</tr>
<tr>
<td>Ion et al., 2005</td>
<td>5.3 (n=63), 10.1 (n=27, day) 2.3 (n=28, night)</td>
<td>0.62-29 1.28-29 0.62-12</td>
<td>K-puszta, Hungary (46°580’N, 19°33’ E, 136 asl)</td>
<td>4 June-10 July 2003</td>
<td>Fine</td>
</tr>
<tr>
<td>Kourtchev et al., 2005</td>
<td>1.94 (n=3, summer)</td>
<td>0.69 (n=2, fall)</td>
<td>Hyytiälä, Finland (61°51’N, 24°17’E, 170m asl)</td>
<td>July 24-Aug 6, 2004</td>
<td>PM1</td>
</tr>
<tr>
<td>Kourtchev et al., 2005, poster (from Elbert)</td>
<td>10.7</td>
<td>5.4-26</td>
<td>Julich, Germany (50.93N, 6.37E)</td>
<td>Summer</td>
<td>PM2.5</td>
</tr>
<tr>
<td>Yttri et al., 2007</td>
<td>1.6</td>
<td>0-4.2</td>
<td>Helsfyr, Oslo (59°56’N, 10°44'E),</td>
<td>Sept 9-Oct 3, 2002</td>
<td>PM2.5</td>
</tr>
<tr>
<td>Yttri et al., 2007</td>
<td>2</td>
<td>0.81-4.3</td>
<td>Sofienberg Park, Oslo (59°56’N, 10°44'E)</td>
<td>Nov 21-Dec 14, 2002</td>
<td>PM2.5</td>
</tr>
<tr>
<td>Yttri et al., 2007</td>
<td>2.8</td>
<td>2.0</td>
<td>Elverum (60°53’N, 11°34’ E)</td>
<td>Jan 30-Mar 15, 2002</td>
<td>PM2.5</td>
</tr>
<tr>
<td>Yttri et al., 2007</td>
<td></td>
<td>2.0</td>
<td></td>
<td>May 22-Jun 28, 2002</td>
<td>PM2.5</td>
</tr>
<tr>
<td>Yttri et al., 2007</td>
<td>0.27</td>
<td>0-0.87</td>
<td>Birkenes (58°23’N, 8°15’E)</td>
<td>Entire 2002</td>
<td>PM2.5</td>
</tr>
</tbody>
</table>

**N=12**  
**MEAN=8.5**
CORRELATION OF MANNITOL W/ METEOROLOGICAL VARIABLES

Graphs showing correlations between Mannitol concentration and various meteorological variables.

- Mannitol concentration vs. LAI [cm²/cm²]:
  - R: 0.56
- Mannitol concentration vs. H₂O, lev=1 [ppm]:
  - R: 0.89
- Surface temperature vs. Solar Radiation at Ground [W/m²]:
  - R: 0.75
  - R: 0.67
- Precipitation [mm/day] vs. Solar Radiation at Ground [W/m²]:
  - R: 0.67
  - R: 0.66
- H₂O concentration vs. Solar Radiation at Ground [W/m²]:
  - R: 0.82
  - R: 0.90