Atmosphere-Land Dynamics of Mercury in a Forest Landscape of the Adirondack Region of New York

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Outline

- Background and site description
- Forms of Hg in the atmosphere
- Hg inputs – wet deposition and throughfall
- Foliar Hg
- Soil Hg emissions
- Stream losses and mass balance
Huntington Wildlife Forest
Newcomb, NY

- MDN monitoring NY20 station
- U.S. EPA CASTNET
- Latitude: 43.9731
- Longitude: -74.2231
- Elevation: 500m
Deciduous throughfall & Emission

Wet deposition

Coniferous throughfall & Emission

Ambient air
Arbutus Lake Watershed-352 ha
Atmospheric Hg

- **Sampling Method**
  - June 2006 ~ May 2007
  - Tekran automated Hg species system
    (Tekran model 2537A, 1130, and 1135)

- **Analytical Method**
  - CVAFS
## Overall Concentrations

<table>
<thead>
<tr>
<th></th>
<th>GEM (ng/m³)</th>
<th>RGM (pg/m³)</th>
<th>HgP (pg/m³)</th>
<th>RGM/TGM (%)</th>
<th>HgP/PM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.39</td>
<td>1.77</td>
<td>3.22</td>
<td>0.12</td>
<td>0.22</td>
</tr>
<tr>
<td>S. E.</td>
<td>0.01</td>
<td>0.04</td>
<td>0.07</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Median</td>
<td>1.31</td>
<td>1.19</td>
<td>2.35</td>
<td>0.09</td>
<td>0.17</td>
</tr>
<tr>
<td>S.D.</td>
<td>0.36</td>
<td>2.20</td>
<td>3.73</td>
<td>0.15</td>
<td>0.22</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.51</td>
<td>&lt; MDL</td>
<td>&lt; MDL</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>2.52</td>
<td>45.44</td>
<td>53.98</td>
<td>3.45</td>
<td>3.02</td>
</tr>
<tr>
<td>N</td>
<td>3147</td>
<td>3136</td>
<td>3137</td>
<td>3147</td>
<td>3147</td>
</tr>
</tbody>
</table>
Monthly Variations of Hg

- Highest in winter and summer
- Lowest in fall
Diurnal Patterns

- **Forest Canopy**
  - Photoreaction
  - Air-foliar exchange
  - Hg emission from the forest floor
- **Warm seasons (all species)**
  - Significant diurnal patterns
- **Winter**
  - Weak diurnal patterns
Wet Deposition & Throughfall
**Hg Concentrations**

- **Leaf-on**
  - Throughfall > precipitation
  - 2 times higher (slope=0.53)

- **Leaf-off**
  - Throughfall > precipitation
  - Slightly higher (slope=0.86)

- **Precipitation quantity**
  - Throughfall 80% precipitation

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The graph shows the comparison of mercury concentrations in throughfall and precipitation under leaf-on and leaf-off conditions. The equations for the linear regression models are:

- Leaf-off:
  - $Y = 0.53X + 1.15$, $R^2 = 0.45$

- Leaf-on:
  - $Y = 0.86X + 0.05$, $R^2 = 0.92$

The data points indicate that throughfall mercury concentrations are generally higher than those in precipitation, with a notably stronger correlation under leaf-on conditions.
Leaf Tissue

- **THg increase**
  - ~10x increase
  - Beech > Birch, Maple

- **Understory beech**
  - 42% higher

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**Yellow Birch**

- THg (ng g⁻¹)
- 0 to 80
- r²=0.90
- 0.22 ng/(g·day)

**Sugar Maple**

- THg (ng g⁻¹)
- 0 to 80
- r²=0.80
- 0.23 ng/(g·day)

**Am. Beech**

- THg (ng g⁻¹)
- 0 to 80
- r²=0.90
- 0.35 ng/(g·day)

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(a)

(b)

(c)
Soil Evasion

Dynamic Flux Chamber

DFC operation system for measuring Hg emission flux from soils
Leaf-off Periods

- Diurnal pattern
- Highly dependent on solar radiation and air temperature
- Most soil Hg is Hg\(^{2+}\). How is Hg reduced?
Leaf – off

- $F = Hg$ Emission Flux
- $R_S = $ Solar Radiation
- $T_A = $ Air Temp.
- $a = 0.0068$, $b = 0.075$, $c = 0.169$

Leaf – on

- $F = Hg$ Emission Flux
- $T_A = $ Air Temp.
- $a'' = 0.108$, $b'' = 0.0718$, $c'' = 8.14E-10$
Yearly Estimation

- Assuming
  - Zero emissions during snow cover
  - Zero emissions during rain events between 8 AM and 8 PM.
  - Leaf-on period is from May to Oct.

Cumulative estimated Hg emission flux is 6.3 $\mu$g m$^{-2}$ year$^{-1}$
Stream Flux

- Discharge driven flux
- "New" vs. "Old" Hg
- Limited particulate contribution (~25%)
- Wetlands are important in the supply of Hg species
Conclusions

- Concentrations of atmospheric Hg species are dynamic at this remote forest site.
- Hg inputs and soil emissions are important pathways.
  - Litterfall is the most important input.
  - Throughfall $\approx$ emissions.
- High flow events result in elevated Hg loss.
- Soil and lake are net sinks of Hg inputs.