The Impact of Long Range Atmospheric Transport from Out-of-Basin Sources of PBTs on the Great Lakes Basin and Implications for Lake Superior

S. Venkatesh, J. Ma, A. P. Dastoor, S. L. Gong, Y-F. Li and C. Yang

Environment Canada, Toronto, ON M3H 5T4 Canada
Outline

- Regional transport of PBTs (Toxaphene, HCB)
  - Impacts on Lake Superior
- Global Transport of PBTs (Lindane, Mercury)
- Climate fluctuations and air concentrations of PBTs over the GLs
Atmospheric Transport Models for PBTs

- **Canadian Model for Environmental Transport of Organochlorine Pesticides (CanMETOP)**
- **Global/Regional Atmospheric Heavy Metals Model (GRAHM)**

## Model Description

<table>
<thead>
<tr>
<th></th>
<th>CanMETOP</th>
<th>GRAHM</th>
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</thead>
<tbody>
<tr>
<td>Atmosphere model</td>
<td>3-D Eulerian transport</td>
<td>3-D Eulerian transport</td>
</tr>
<tr>
<td>Soil model</td>
<td>Fugacity/mass balance</td>
<td>No</td>
</tr>
<tr>
<td>Horizontal resolution</td>
<td>24/35 km, 1°×1° lat/lon</td>
<td>1°×1° lat/lon</td>
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<tr>
<td>Vertical resolution</td>
<td>Surface-11000 m</td>
<td>Surface-15000 m</td>
</tr>
<tr>
<td>Atmospheric chemistry</td>
<td>No</td>
<td>Gas and aqueous phase</td>
</tr>
</tbody>
</table>

A schematic view of multi-compartment PBT models
Regional transport of PBTs

Persistent
Bio-accumulative
Toxic
Episodic long-range atmospheric transport of toxaphene from the southeast US to the Great Lakes.
Soil residues of toxaphene in the US in 2000 (tonnes/cell, 1 cell = 24 km × 24 km)
CanMETOP Modeled Daily air concentration (pg m$^{-3}$) and wet deposition (kg day$^{-1}$) of Toxaphene over Lake Superior for September 1-15, 2000.
Cross-section/vertical profile of air concentration indicating northward transport of toxaphene
Soil residue (tonnes cell\(^{-1}\)) of toxaphene in 2000

Modeled contribution of toxaphene sources to annually averaged daily air concentration over Lake Superior in 2000
Modeled contribution of toxaphene sources to annually averaged wet deposition over the Great Lakes in 2000
Annual air/land release of HCB (kg yr\(^{-1}\)) in the US (Source: USEPA TRI emission inventory) and annual soil residue in 2001 of HCB in the US from historical pesticides application.
Modeled contribution of HCB sources to annually averaged daily air concentration of HCB in 2001 over Lake Superior.

Source strength and proximity play a key role in contributing to the budget of HCB over the lake.
Global transport of PBTs
Lindane

Global soil residues in 2005

1 cell = $1^\circ \times 1^\circ$ lat/lon

(Tonnes/cell)
CanMETOP modeled lindane daily air concentration (pg m$^{-3}$) at 3000 m height for 2005 (animation)
Trans-Pacific transport

Atmospheric Transport of Lindane (pg m$^{-3}$) from May 23–30, 2005 at 3000 m height
Global CanMETOP modeled lindane deposition flux to the Great Lakes in 2005, (Note units of g/season)
Model simulations of the Impact of lindane emissions from the Canadian Prairie provinces on the Great Lakes in 1998

Modeled annual total loading (dry dep + wet dep + net gas flux, kg yr\(^{-1}\)) to the Great Lakes. (See inset for Annual loading (kg yr\(^{-1}\)) due to net gas exchange)

Modeled annual (5/1/1998-4/30/1999) \(\gamma\)-HCH dry, wet and total depositions

Elemental Mercury Mixing Ratios at 400mb with Asia only emissions.

Saturday April 17 2004 at 02:00Z
Annual average contributions to the Great Lakes from 1995 Anthropogenic emissions of Mercury

- Deposition
- Air burden
- Sur. Conc.

Legend:
- Canada
- USA
- Europe
- Asia
- Others
Climate fluctuations and air concentrations of PBTs
Surface air temperature (SAT) anomaly in North America associated with 8 strong El Niño episodes in November to March from 1948 to 2002.

Averaged SAT anomaly in winters during 1990s at IADN master stations
Eagle Harbor (EGH) at Lake Superior

- Winter: $R^2 = 0.25$
- Spring: $R^2 = 0.51$
- Summer: $R^2 = 0.06$
- Fall: $R^2 = 0.09$

Point Petre (PPT) at Lake Ontario

- Winter: $R^2 = 0.02$
- Spring: $R^2 = 0.01$
- Summer: $R^2 = 0.02$
- Fall: $R^2 = 0.00$
Thank you