

# Atmospheric Mercury Panel

- ❑ **Mark Cohen** (NOAA):  
*Modeling atmospheric fate/transport of mercury*
  
- ❑ **Tom Holsen** (Clarkson University):  
*Lake Ontario Atmospheric Deposition Study (LOADS)*
  
- ❑ **Pierrette Blanchard** (Environment Canada):  
*Canadian atmospheric mercury measurements*
  
- ❑ **Open discussion**

# Atmospheric Fate and Transport of Mercury



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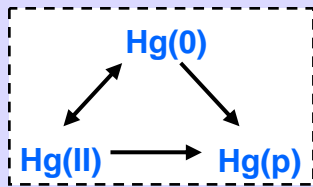
***<http://www.arl.noaa.gov/ss/transport/cohen.html>***



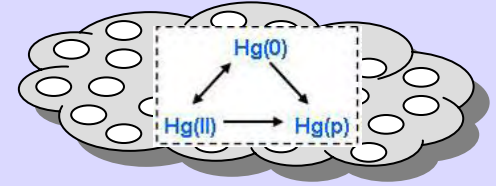
**Lake Ontario Contaminant Monitoring & Research Workshop**  
**Planning for the 2008 Cooperative Monitoring Year**  
**- Contaminants Component -**  
**Grand Island Holiday Inn, Grand Island, New York**  
**March 27 & 28, 2007**

## MANY THANKS TO:

- ❑ Gary Foley, J. David Mobley, Elsie Sunderland, Chris Knightes (EPA); Panos Georgopolous and Sheng-Wei Wang (EOSHI Rutgers Univ); John McDonald (IJC): *funding and collaboration on multimedia Hg modeling*
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- ❑ David Ruple, Mark Woodrey (Grand Bay NERR), Susan White , Gary Matlock, Russell Callender, Jawed Hameedi (NOAA), and Durwin Carter (U.S. Fish and Wildlife Service): *collaboration at NOAA Grand Bay NERR atmospheric monitoring site*
- ❑ Anne Pope and colleagues (EPA): *U.S. mercury emissions inventory*
- ❑ David Niemi, Dominique Ratte, Marc Deslauriers (Environment Canada): *Canadian mercury emissions inventory data*
- ❑ Mark Castro (Univ. Md, Frostburg), Fabien Laurier (Univ Md Ches Biol Lab), Rob Mason (Univ CT), Laurier Poissant (Envr Can): *ambient Hg data for model evaluation*
- ❑ Roland Draxler, Glenn Rolph, Rick Artz (NOAA): *HYSPLIT model and met data*
- ❑ Steve Brooks, Winston Luke, Paul Kelley (NOAA) : *ambient Hg data*

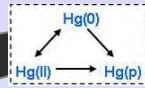
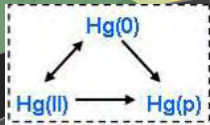


atmospheric  
chemistry  
inter-converts  
mercury forms



Hg from  
other sources:  
local, regional  
& more distant

emissions of  
 $\text{Hg}(0)$ ,  $\text{Hg}(\text{II})$ ,  $\text{Hg}(\text{p})$



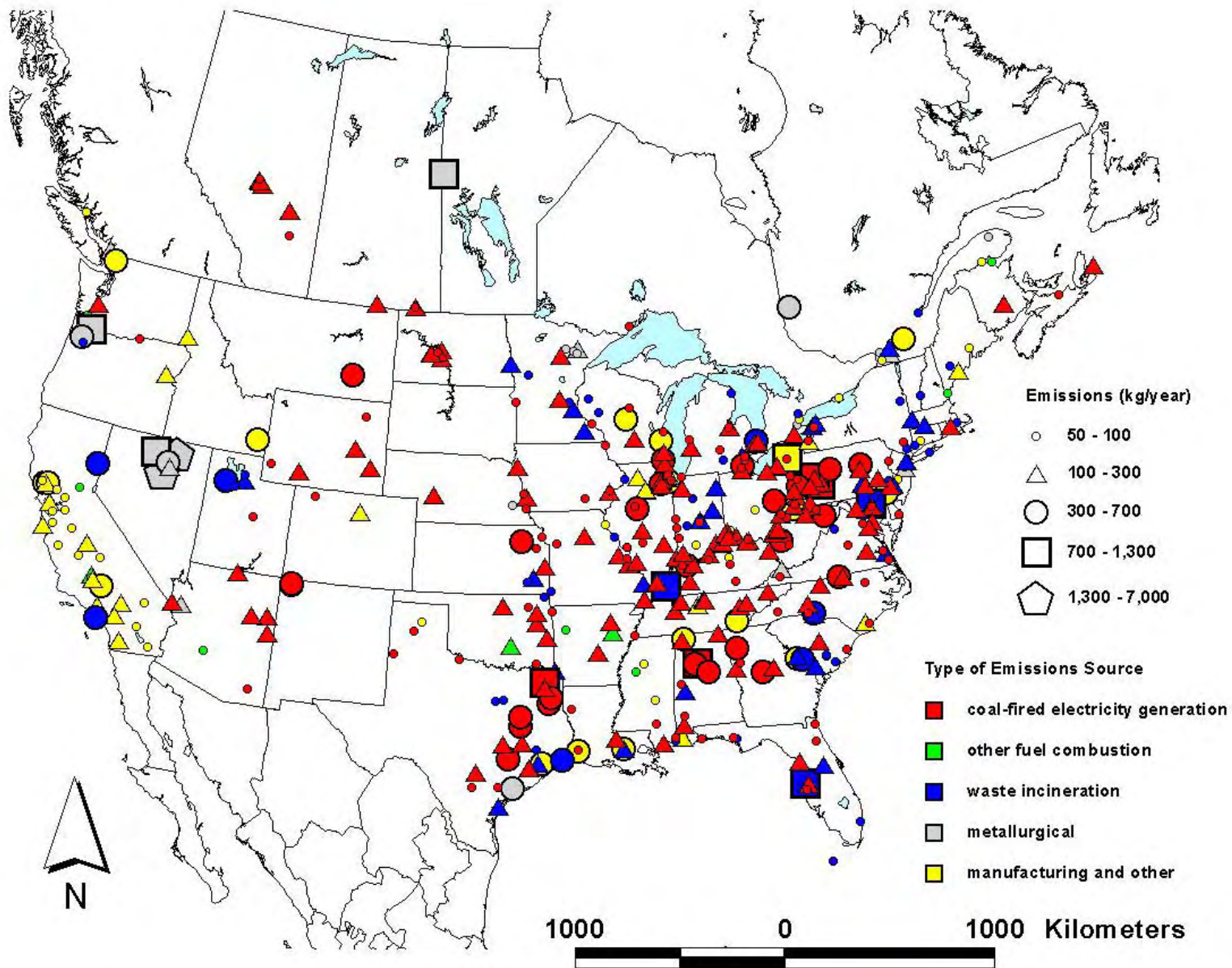
Surface  
exchange with  
the watershed

Surface  
exchange with  
the lake

# Objectives and Rationale of Atmospheric Modeling in Conjunction with Great Lake Multi-Compartment Mercury Modeling Project

- ❑ Estimate *deposition amount* of different mercury species and/or forms to different regions of Lake Ontario lake surface and watershed, for use in ecological assessment and modeling
  - dry deposition generally estimated with models
  - modeling can help fill in spatial gaps between measurement sites
  - modeling can help estimate deposition for other times
    - past
    - future (for different emissions scenarios)
  
- ❑ Estimate *source attribution* for deposition of different mercury species and/or forms to different regions of Lake Ontario lake surface and watershed, including estimation of the relative importance of:
  - different source regions (local, regional, national, continental, global)
  - different jurisdictions (different states and provinces)
  - anthropogenic vs. natural emissions
  - different anthropogenic source types (power plants, waste incin., etc)

# Largest mercury sources in U.S. and Canadian air emissions inventories (~1999-2000)



Source of emissions data: U.S. EPA and Environment Canada

***Some preliminary results for the  
atmospheric deposition impact of  
U.S. and Canadian anthropogenic mercury  
air emissions sources on Lake Ontario***

# Largest modeled atmospheric deposition contributors to Lake Ontario based on 1999-2000 emissions

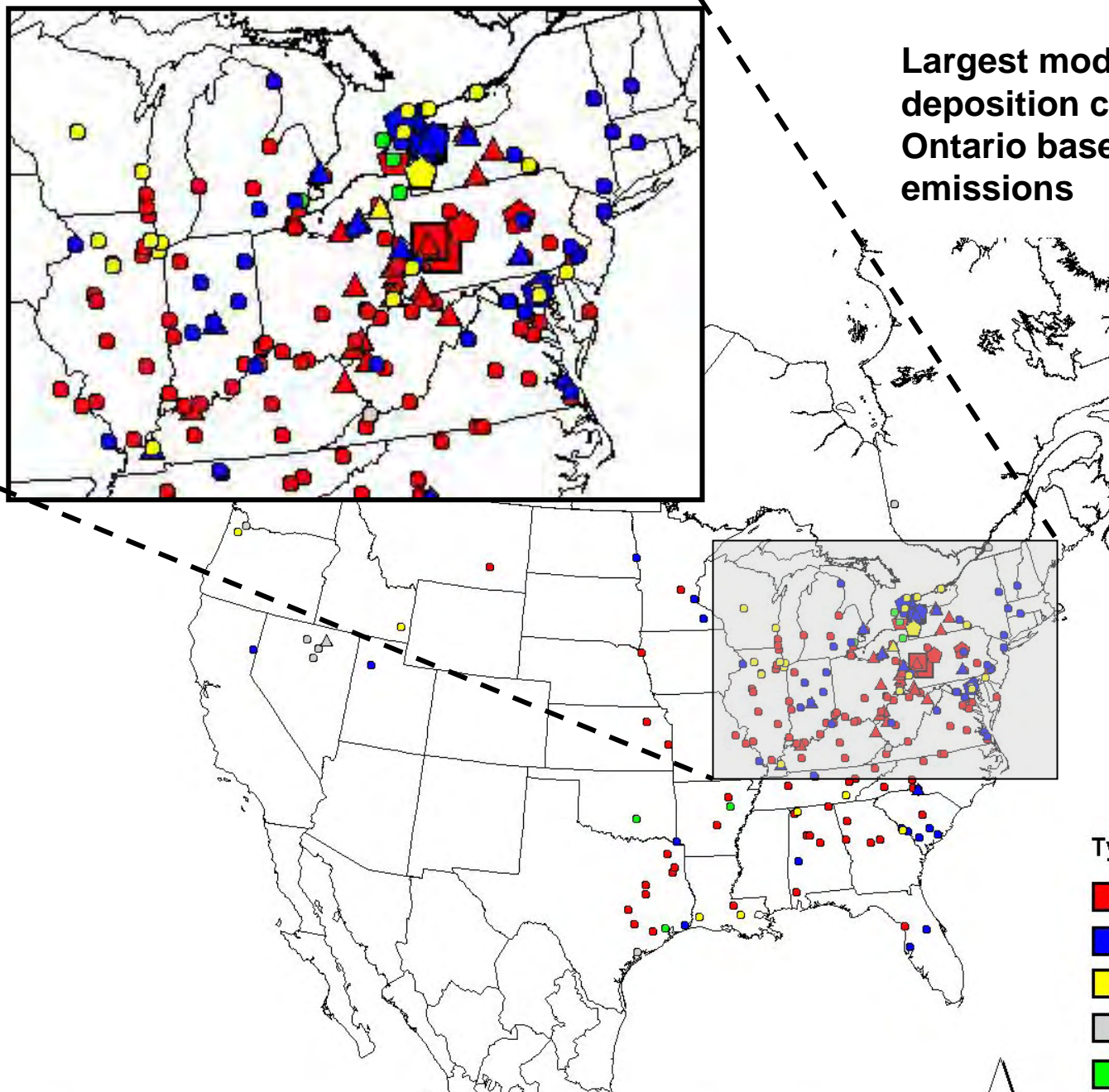
Fraction of total modeled deposition contributed by a particular source

- 0.1 - 0.3 %
- △ 0.3 - 1 %
- ◡ 1 - 3 %
- 3 - 10 %
- ◻ 10 - 30 %

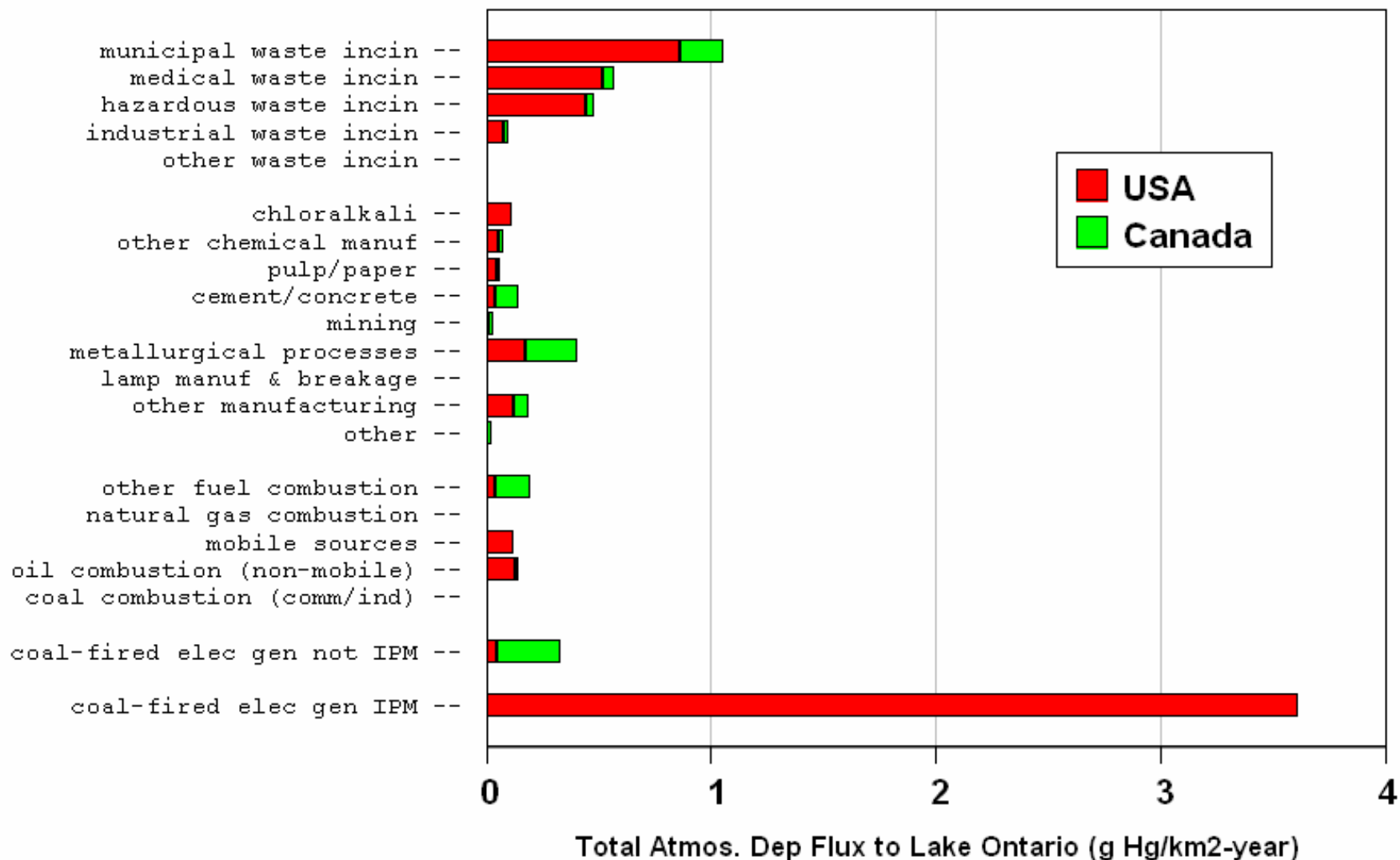
Type of Emission Source

- coal-fired electricity generation
- waste incineration
- manufacturing
- metallurgical
- other fuel combustion

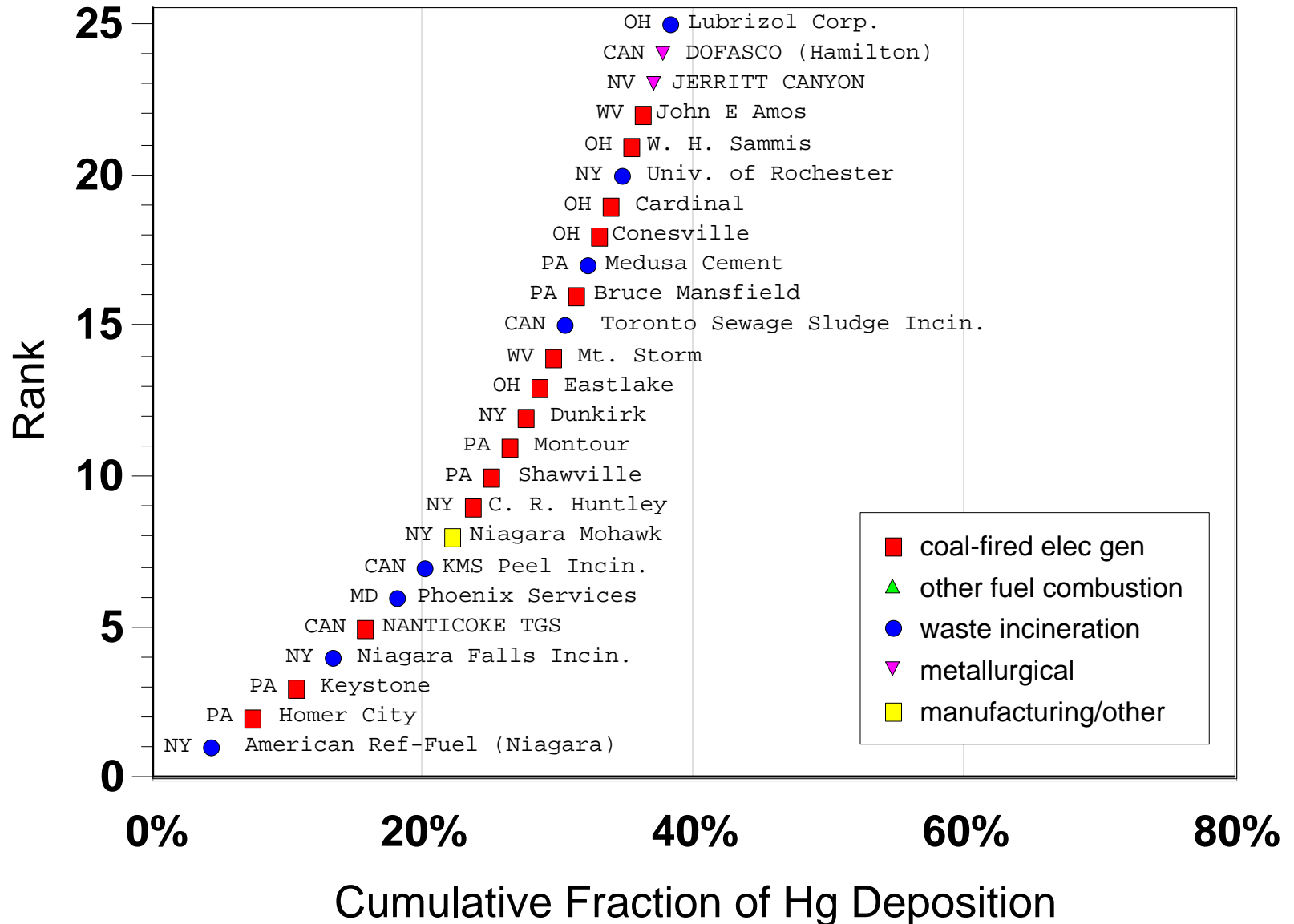
1000 0 1000 2000 Kilometers



# Modeled atmospheric mercury deposition to Lake Ontario from U.S. and Canadian source sectors based on 1999-2000 emissions

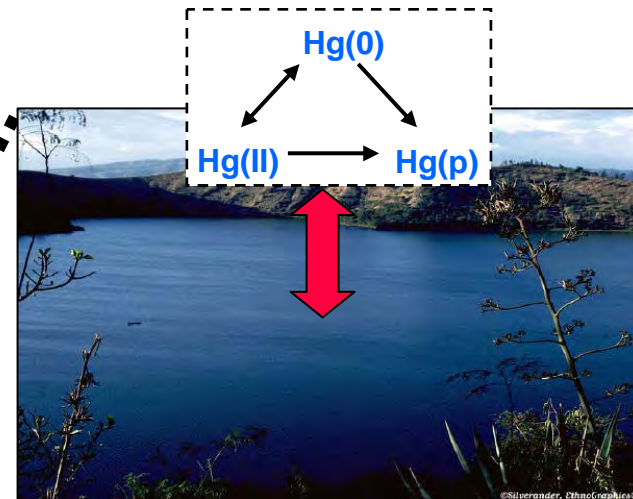
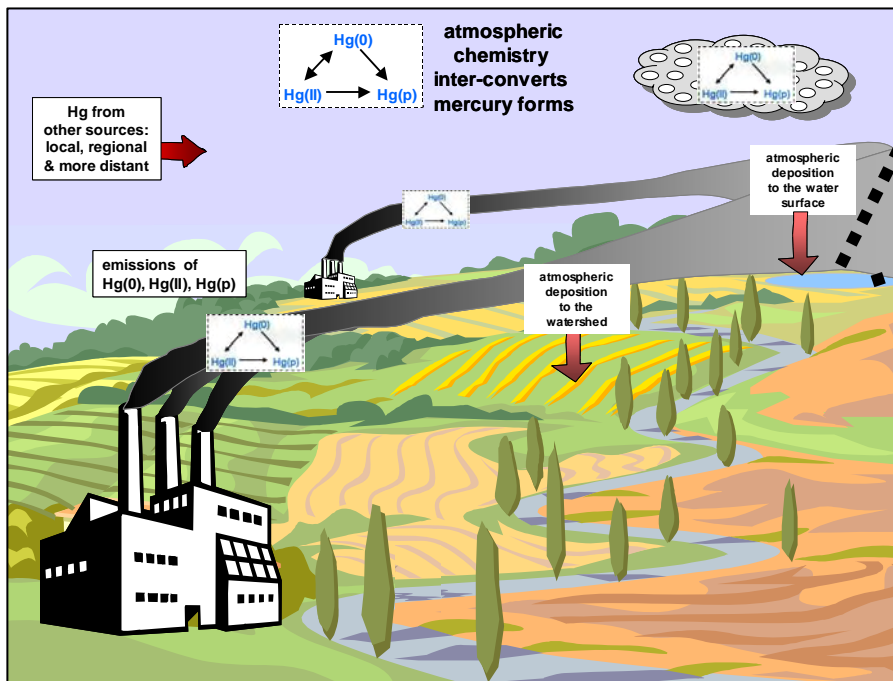


# Top 25 Contributors to 1999 Hg Deposition Directly to Lake Ontario



***Many uncertainties in these earlier results...***

***How to refine modeling and link with other models in a multi-media framework?***

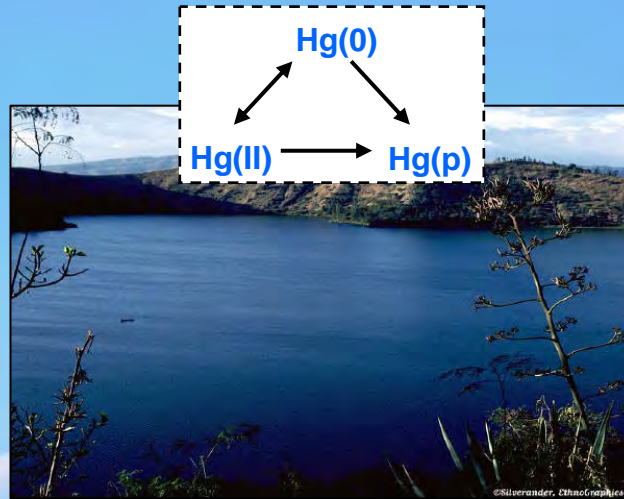


For Lake Ontario:

How to link the atmospheric model and the aquatic fate/cycling model?

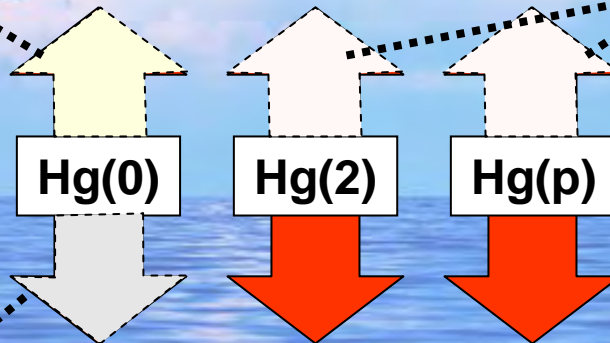
Surface exchange of Hg(0) from Lake Ontario *may* not have large impact on overall atmospheric Hg fate-transport (?)

It may turn out that dynamic, *run-time* linkage between lake and atmosphere is not critical for Hg (?) (we will see...)

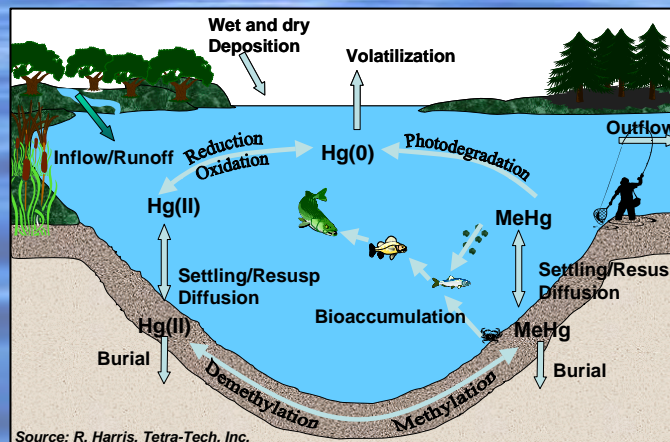


**Air-Water Interface**  
 – at the boundary between the atmospheric model (over the lake) and the lake fate and cycling model

Upward Flux of Hg(2) and Hg(p) is probably small



The precise specification of surface exchange of Hg(0) *may* not have large impact on methyl-mercury production (???)



### *Inputs to Model*

meteorology

emissions

*For model evaluation, emissions and meteorology must be for the same time period as ambient measurement data*

### *Atmospheric Mercury Model*

atmospheric chemistry

wet deposition

phase partitioning

surface exchange

### *Model Evaluation*

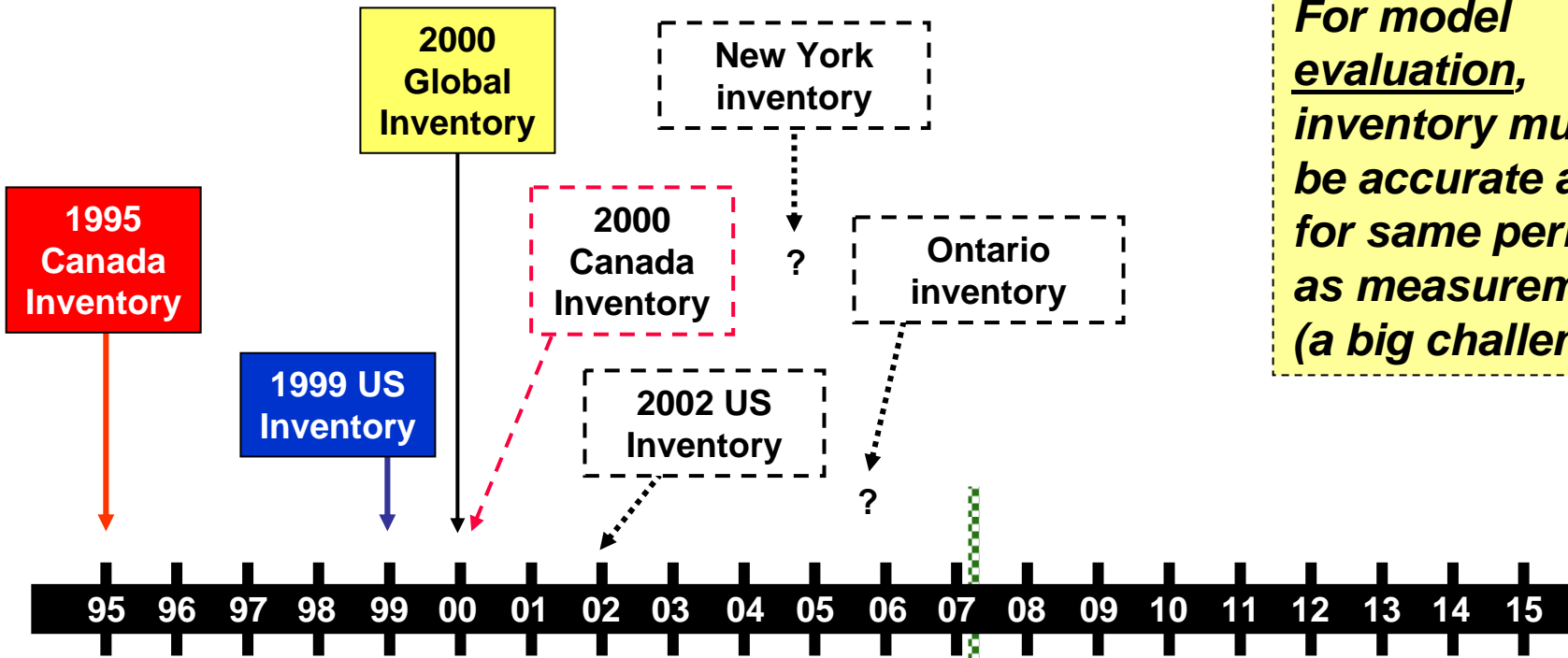
Wet deposition data

Speciated ambient concentration data

### *Model Outputs*

Wet and dry deposition of different mercury species to lake and watershed

Source attribution information for deposition

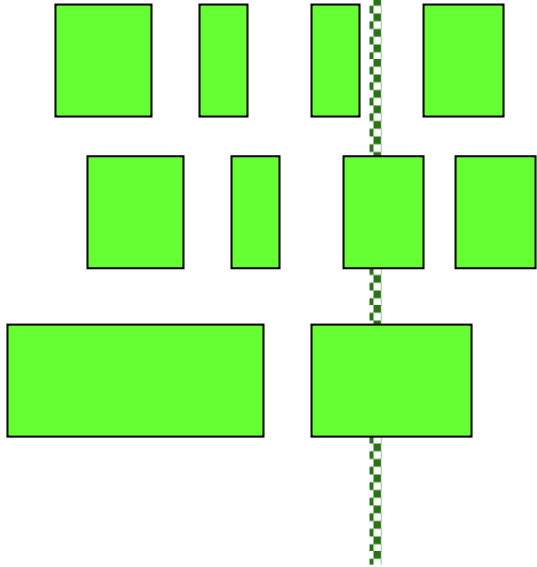


***For model evaluation, inventory must be accurate and for same period as measurements (a big challenge!)***

speciated atmospheric Hg measurements at site x

speciated atmospheric Hg measurements at site y

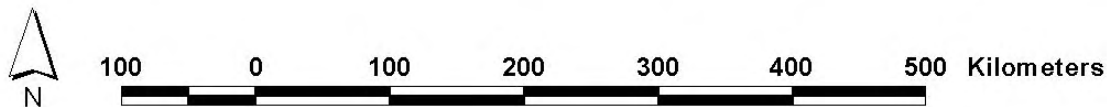
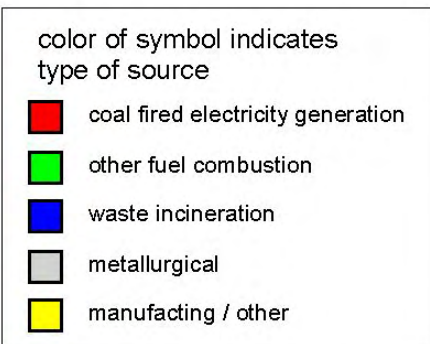
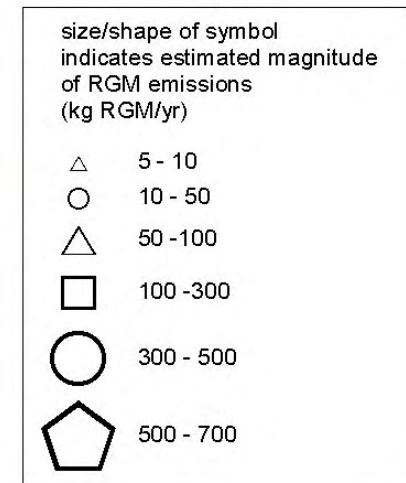
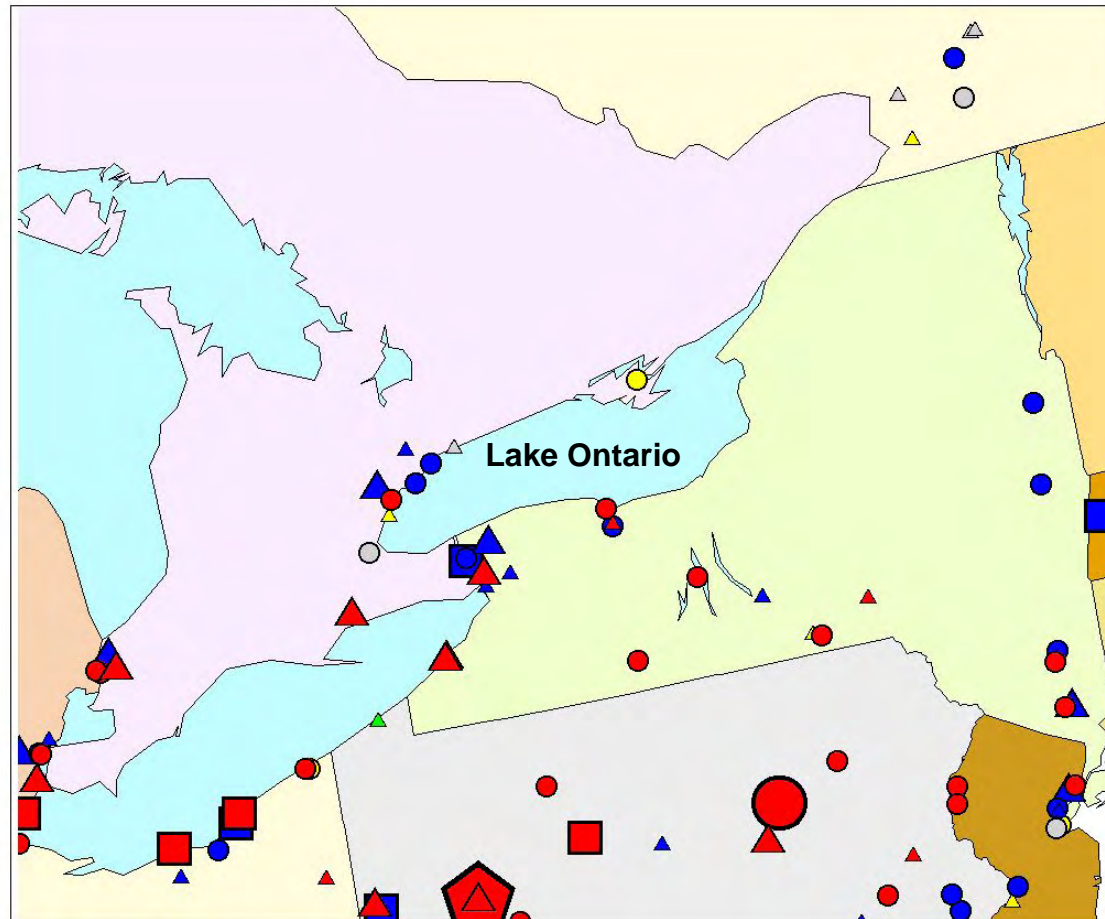
speciated atmospheric Hg measurements at site z



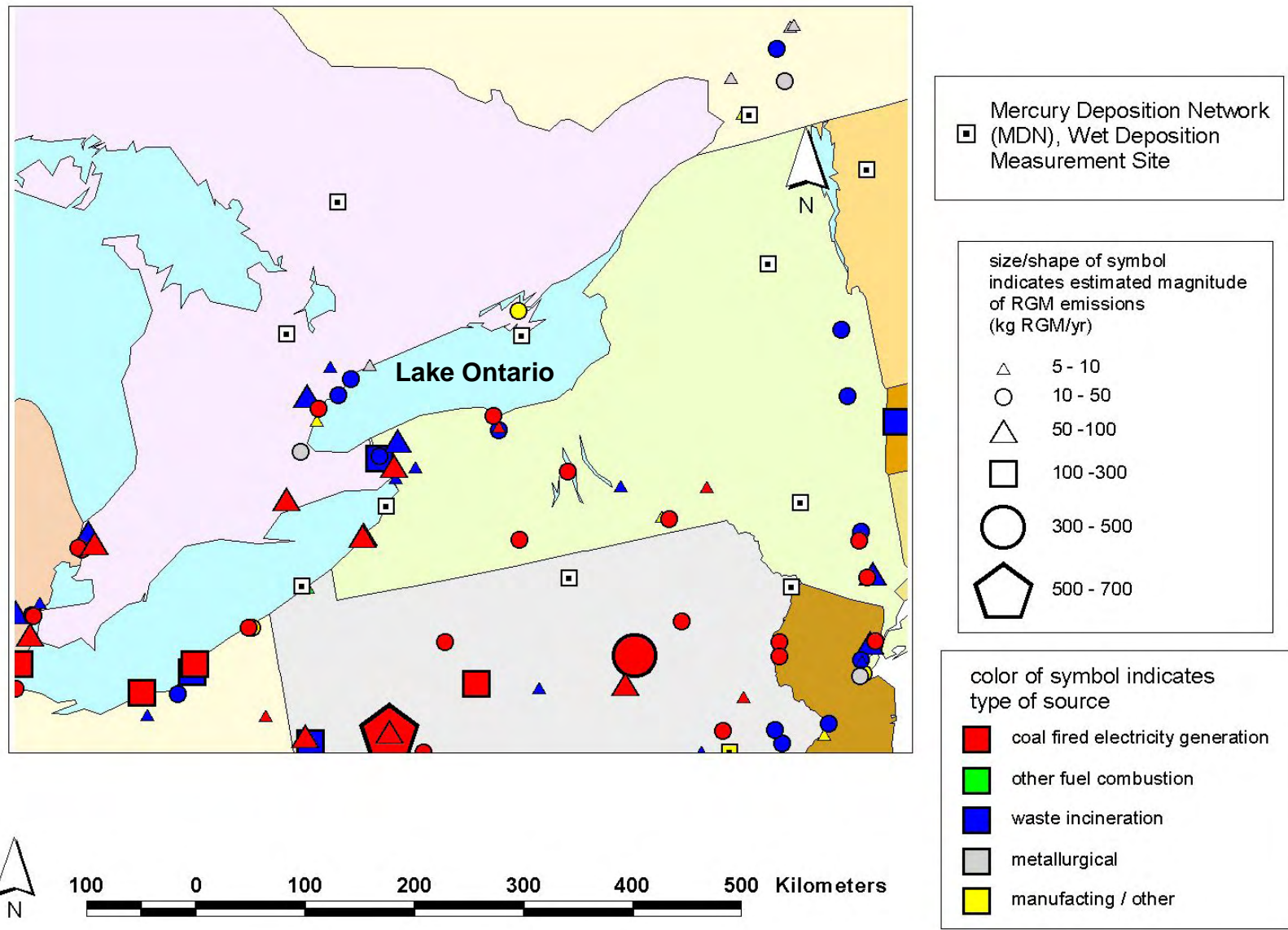
Hypothetical – just for illustration purposes

# RGM emissions (~1999) in the Lake Ontario region

***“RGM” = Reactive Gaseous Mercury, the form of atmospheric mercury most readily deposited***

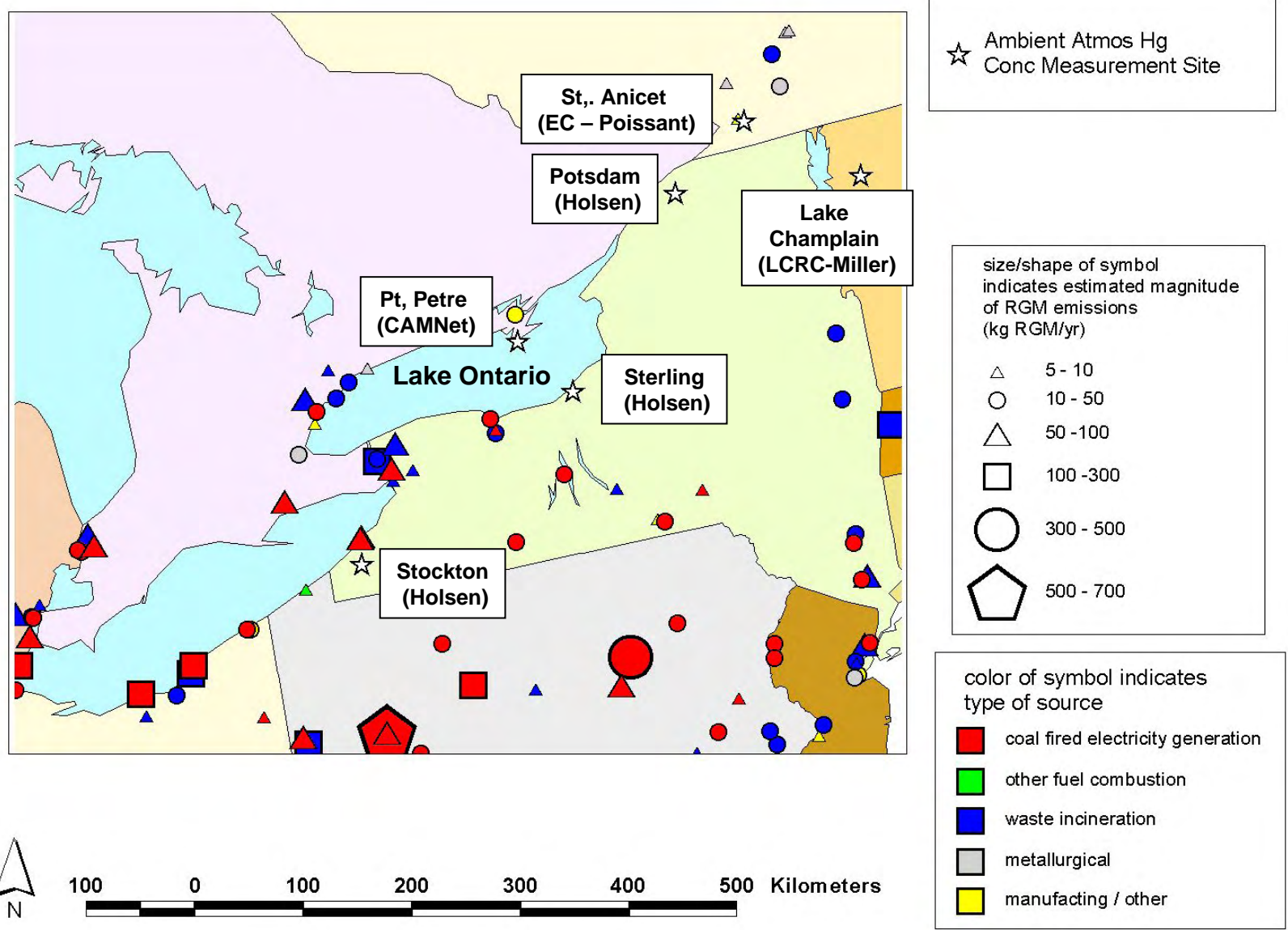


# RGM emissions (~1999) in the Lake Ontario region, and Mercury Deposition Network (MDN) sites



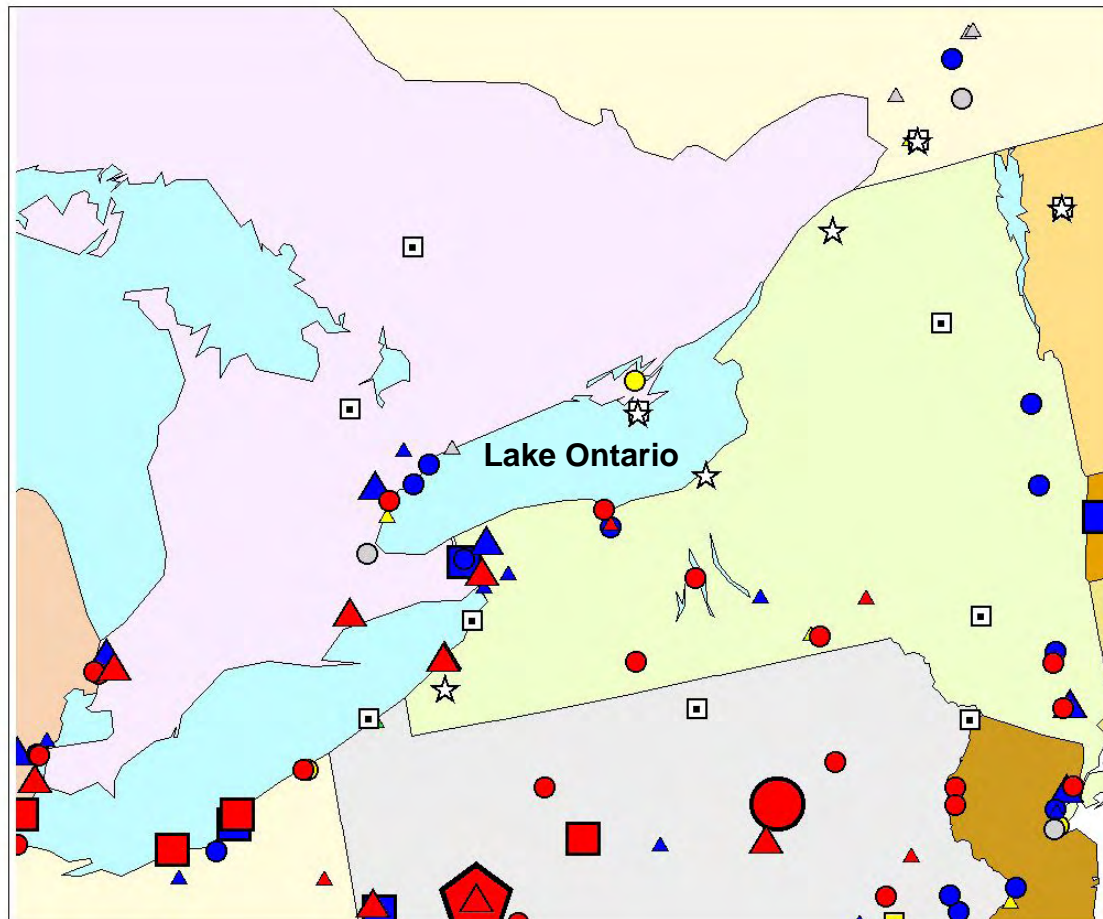
Source of emissions data: U.S. EPA and Environment Canada

# RGM emissions (~1999) in the Lake Ontario region, and (some of the) sites where speciated concentrations of atmospheric Hg have been measured



Source of emissions data: U.S. EPA and Environment Canada

# RGM emissions (~1999) in the Lake Ontario region, along with MDN and ambient concentration sites



- ☆ Ambient Atmos Hg Conc Measurement Site
- ▣ Mercury Deposition Network (MDN), Wet Deposition Measurement Site

size/shape of symbol indicates estimated magnitude of RGM emissions (kg RGM/yr)

- △ 5 - 10
- 10 - 50
- △ 50 - 100
- 100 - 300
- 300 - 500
- ⬠ 500 - 700

color of symbol indicates type of source

- coal fired electricity generation
- other fuel combustion
- waste incineration
- metallurgical
- manufacturing / other

Atmospheric models can potentially provide valuable deposition and source-attribution information.

But... models have not been adequately evaluated, so we don't really know very well how good or bad they are...

... air pollution model or error pollution model?

### **Challenges / critical data needs for model evaluation:**

#### **Ambient Monitoring Data**

- speciated ambient concentrations  
(need RGM and Hg(p), not just total gaseous mercury)
- wet deposition

#### **Emissions inventories**

- complete
- "accurate"
- speciated
- up-to-date (or at least for the same period as measurements)
- temporal resolution better than annual (e.g., shut-downs, etc)

**Thanks!**