

# Atmospheric Mercury Deposition Impacts of Future Electric Power Generation

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Presentation at

## **Mercury in the Great Lakes Region**

*Sponsored by the Commission for Environmental Cooperation's  
Environment, Economy and Trade and Pollutants and Health Programs  
in cooperation with the Binational Toxic Strategy*

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**\* This presentation was developed for discussion purposes. The opinions, views or other information contained herein do not necessarily reflect the views of the CEC, Canada, Mexico or the United States.**

# Outline

- **Emissions Scenarios**
- **“Receptors” Studied**
- **Atmospheric Modeling**
- **Results**

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## U.S. Mercury Emissions *Scenarios*

<b>Area sources</b> (residential fuel combustion, mobile sources...)	<b>Point sources</b> other than coal-fired electricity generation (smelters, incinerators...)	<b>Coal-fired electricity generation</b>
<b>1996 data</b> <b>(U.S. EPA)</b>	<b>1996 data</b> <b>(U.S. EPA)</b>	<b><i>Current:</i></b> <b>1999 data</b> <b>(U.S. EPA)</b>

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		<b><i>Future:</i></b> <b>2020 Projected Baseline</b> <b>(U.S. EPA)</b>

**U.S. 2020 *baseline inventory* for mercury emissions from coal-fired power plants:**

- estimated emissions from U.S. facilities if no new regulatory limitations were imposed beyond existing programs to cap and trade emissions of *sulfur dioxide* and *nitrogen oxides*.
- generating capacity estimated based on economic and demographic factors

## U.S. Mercury Emissions *Scenarios*

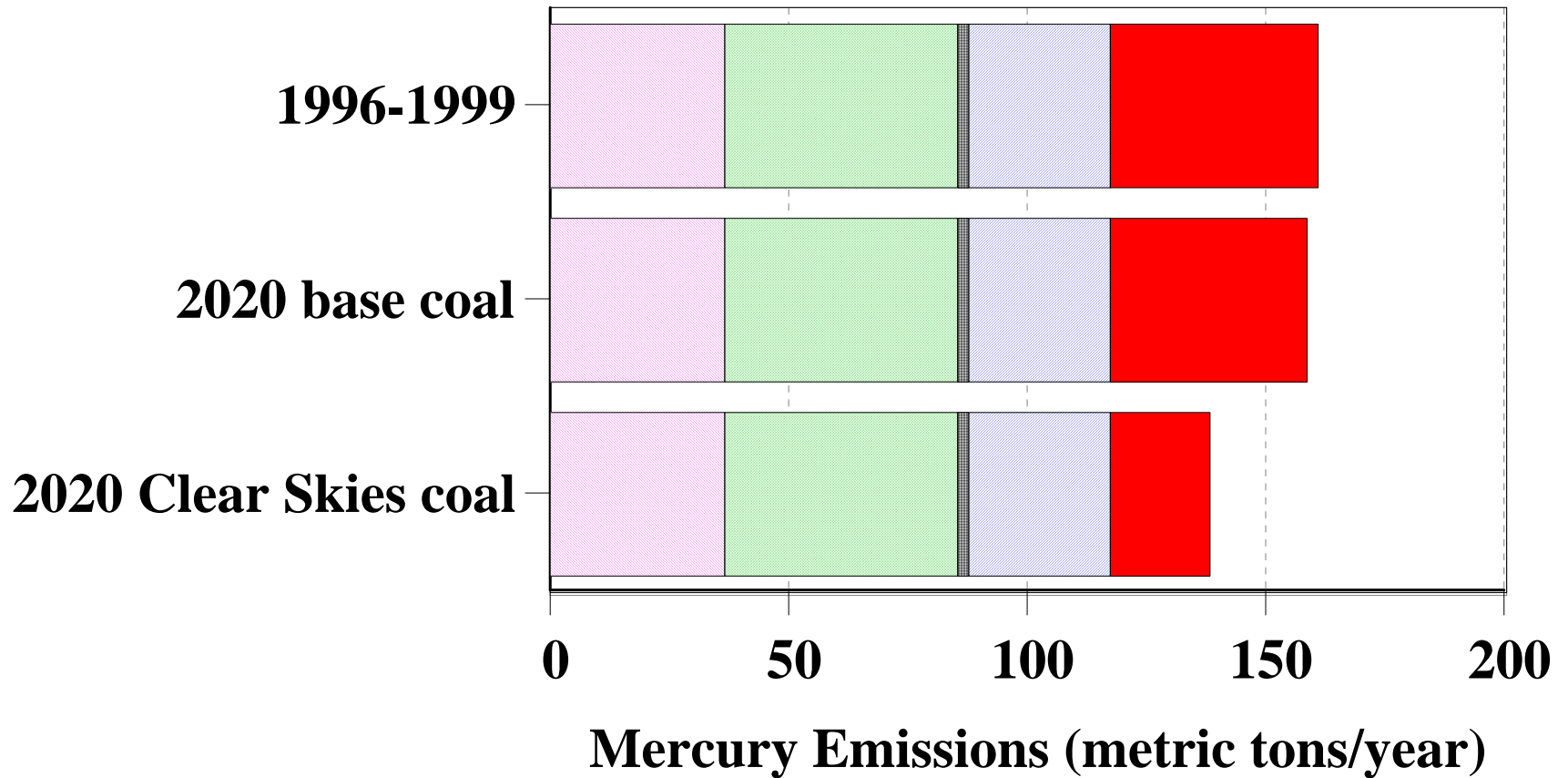
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<b>1996 data</b> <b>(U.S. EPA)</b>	<b>1996 data</b> <b>(U.S. EPA)</b>	<i>“Current”:</i> <b>1999 data</b> <b>(U.S. EPA)</b>
		<i>Future:</i> <b>2020 Projected Baseline</b> <b>(U.S. EPA)</b>
		<i>Future:</i> <b>2020 Clear Skies</b> <b>(U.S. EPA)</b>

## **U.S. 2020 *Clear Skies* inventory for mercury emissions from coal-fired power plants:**

- Projected emissions in 2020 from U.S. facilities if the proposed *Clear Skies* legislation is adopted and implemented.
- Presumptive cap of 14 metric tons of mercury emissions in 2018 versus the base 1999 U.S. emissions of about 43 metric tons.
- In the 2020 *Clear Skies* scenario used here [supplied by the EPA], the total mercury emissions are actually 21 metric tons due to provisions in the proposed legislation allowing “banking” of early excess emission reductions that can be used later under a trading program.



# U.S. Mercury Emissions



- other fuel combustion
- incineration
- metals
- manufacturing and other
- coal-fired electricity generation

## Canadian Mercury Emissions *Scenarios*

<b>Area sources</b> (residential fuel combustion...)	<b>Point sources</b> other than coal-fired electricity generation (smelters, incinerators...)	<b>Coal-fired electricity generation</b>
<b>1995 data from Environment Canada</b>	<b>2000 NPRI data used to update 1995 data from Environment Canada</b>	<b><i>Current:</i></b> <b>2000 NPRI</b>

## Canadian Mercury Emissions *Scenarios*

<b>Area sources</b> (residential fuel combustion...)	<b>Point sources</b> other than coal-fired electricity generation (smelters, incinerators...)	<b>Coal-fired electricity generation</b>
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		<b><i>Future:</i></b> <b>National Energy Board 2020 “Supply Push”</b>

**Canadian National Energy Board 2020 *Supply Push scenario* for coal combustion at coal-fired power plants:**

- technology advances slowly
- limited action with respect to the environment.

## Canadian Mercury Emissions *Scenarios*

<b>Area sources</b> (residential fuel combustion...)	<b>Point sources</b> other than coal-fired electricity generation (smelters, incinerators...)	<b>Coal-fired electricity generation</b>
<b>1995 data from Environment Canada</b>	<b>2000 NPRI data used to update 1995 data from Environment Canada</b>	<i>Current:</i> <b>2000 NPRI</b>
		<i>Future:</i> <b>National Energy Board 2020 “Supply Push”</b>
		<i>Future:</i> <b>National Energy Board 2020 “Techno-Vert”</b>

**Canadian NEB 2020 *Techno-Vert* scenario for coal combustion at coal-fired power plants:**

- technology advances rapidly
- broad action with respect to the environment, including preference for environmentally-friendly products and cleaner-burning fuels.

## For both Canadian 2020 scenarios:

- the same *emissions factors*

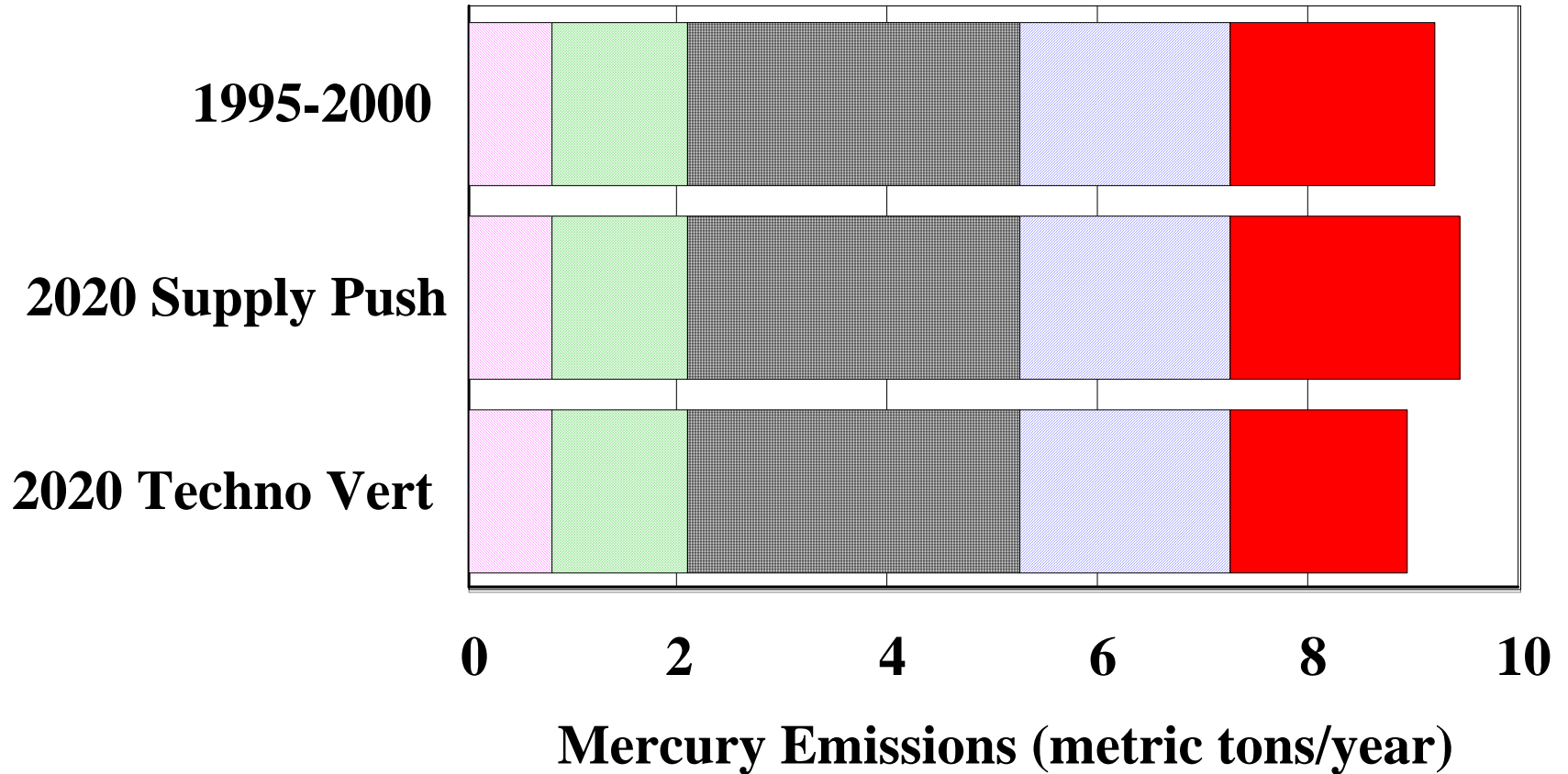
(amount of mercury emitted per ton of coal burned)

- and the same *speciation profile*

[fraction of emissions as Hg(II), Hg(0), and Hg(p)]

...as the current emissions inventory

# Canadian Mercury Emissions



- other fuel combustion
- incineration
- metals
- manufacturing and other
- coal-fired electricity generation







# Current and Projected Power Plant Mercury Emissions






## Canada and the United States

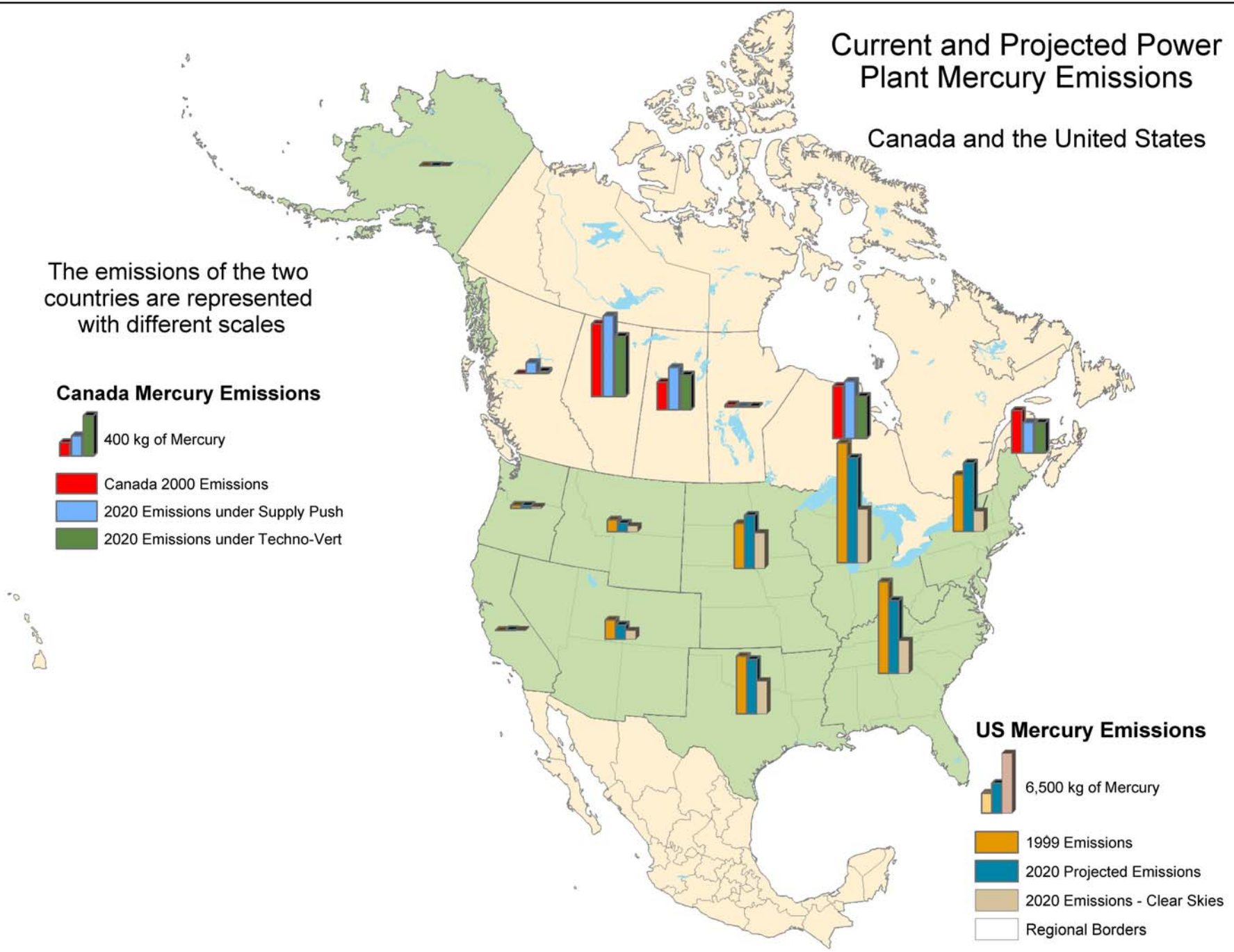
The emissions of the two countries are represented with different scales

### Canada Mercury Emissions

-  400 kg of Mercury
-  Canada 2000 Emissions
-  2020 Emissions under Supply Push
-  2020 Emissions under Techno-Vert

### US Mercury Emissions

-  6,500 kg of Mercury
-  1999 Emissions
-  2020 Projected Emissions
-  2020 Emissions - Clear Skies
-  Regional Borders



## The U.S. and Canadian Future Scenarios used in this analysis are not really comparable...

- ...the 2020 U.S. *Clear Skies* scenario envisions enhanced pollution control (e.g., scrubbers) at some coal-fired power plants,
- ...but additional pollution control is not considered in *these* particular 2020 Canadian scenarios.

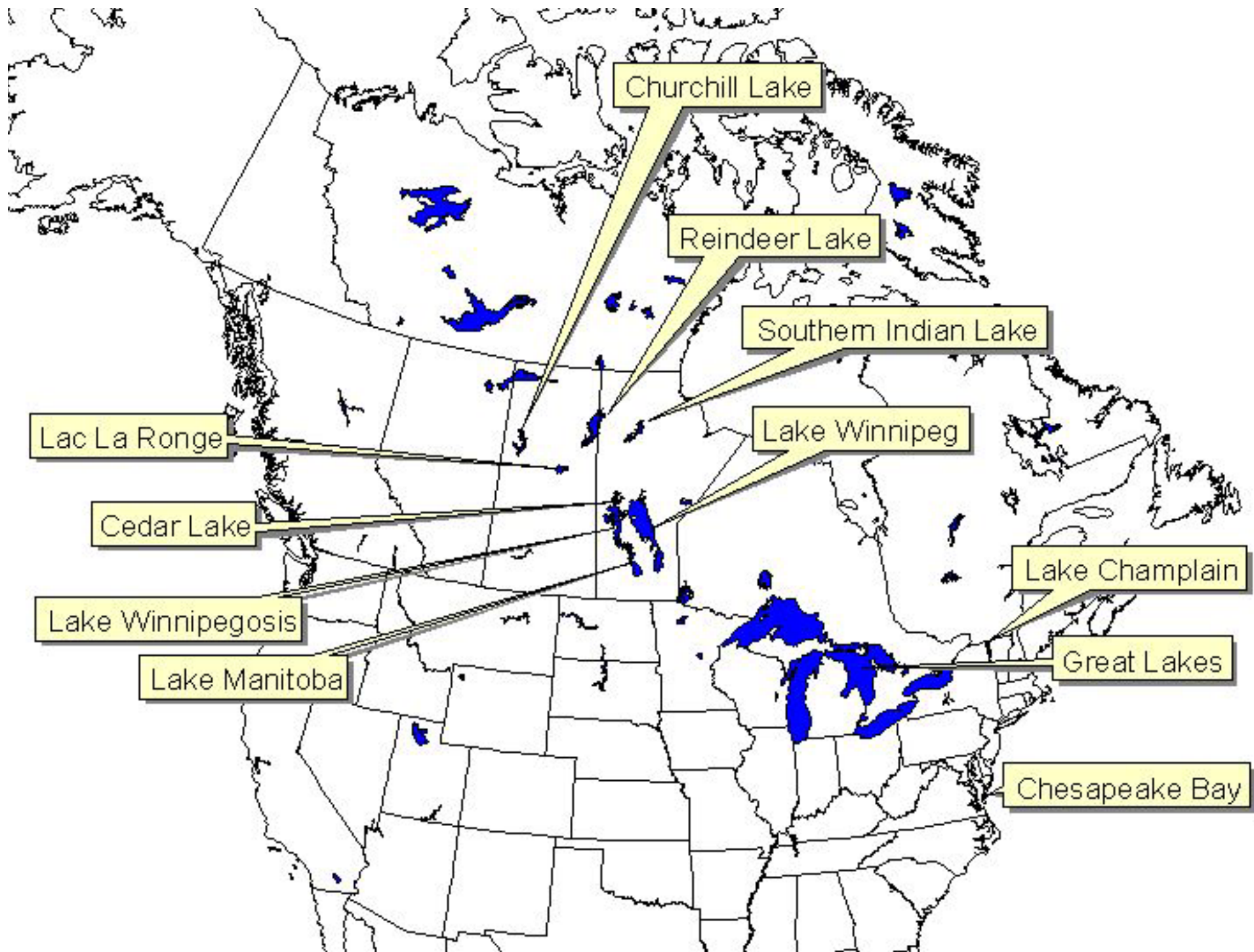
# Outline

■ Emissions Scenarios

■ **“Receptors” Studied**

■ Atmospheric Modeling

■ Results



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*Modeling  
methodology  
described in a  
forthcoming  
publication:*

## **Modeling the Atmospheric Transport and Deposition of Mercury to the Great Lakes**

Accepted for Publication by *Environmental Research*,  
for the special issue of the journal devoted to papers from the  
*Workshop on An Ecosystem Approach to the Health Effects of Mercury  
in the Great Lakes Basin*, Windsor, Ontario, Feb 2003.

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# Three “kinds” of atmospheric mercury:

- **Elemental mercury – Hg<sup>0</sup>**

*Minimal local and regional deposition*

- **Reactive Gaseous Mercury (RGM) – Hg(II)**

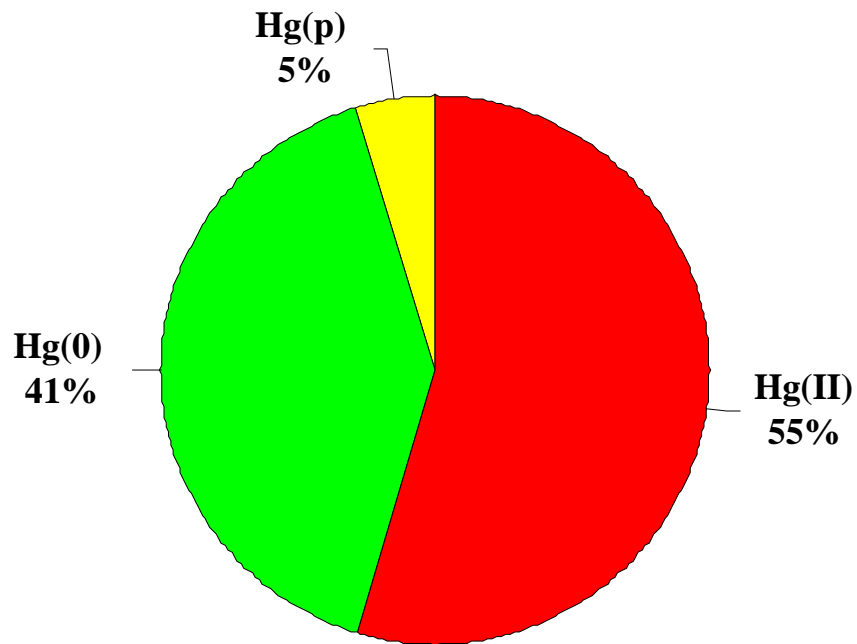
*Enhanced local and regional deposition*

- **Particulate Mercury – Hg(p)**

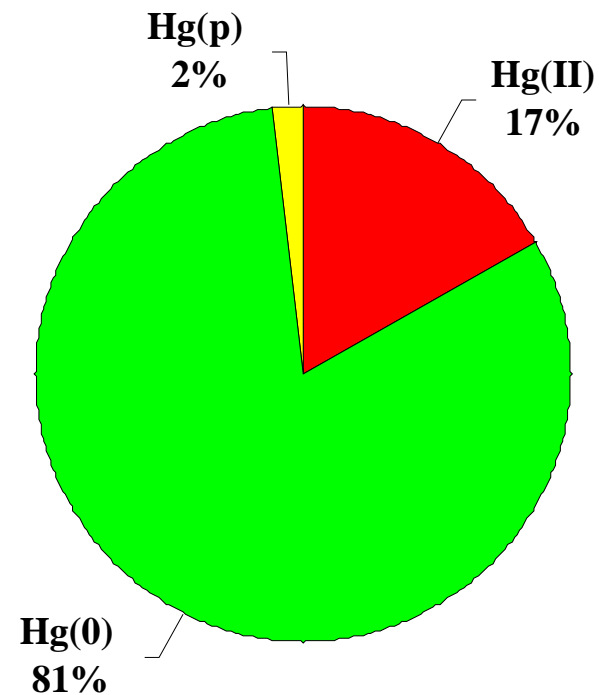
*Moderate local and regional deposition*

# Typical Speciation Profiles of Mercury Emissions From Coal-Fired Electricity Generation Facilities

*Without Wet Scrubber*



*With Wet Scrubber*



(and similar difference with dry scrubbers)

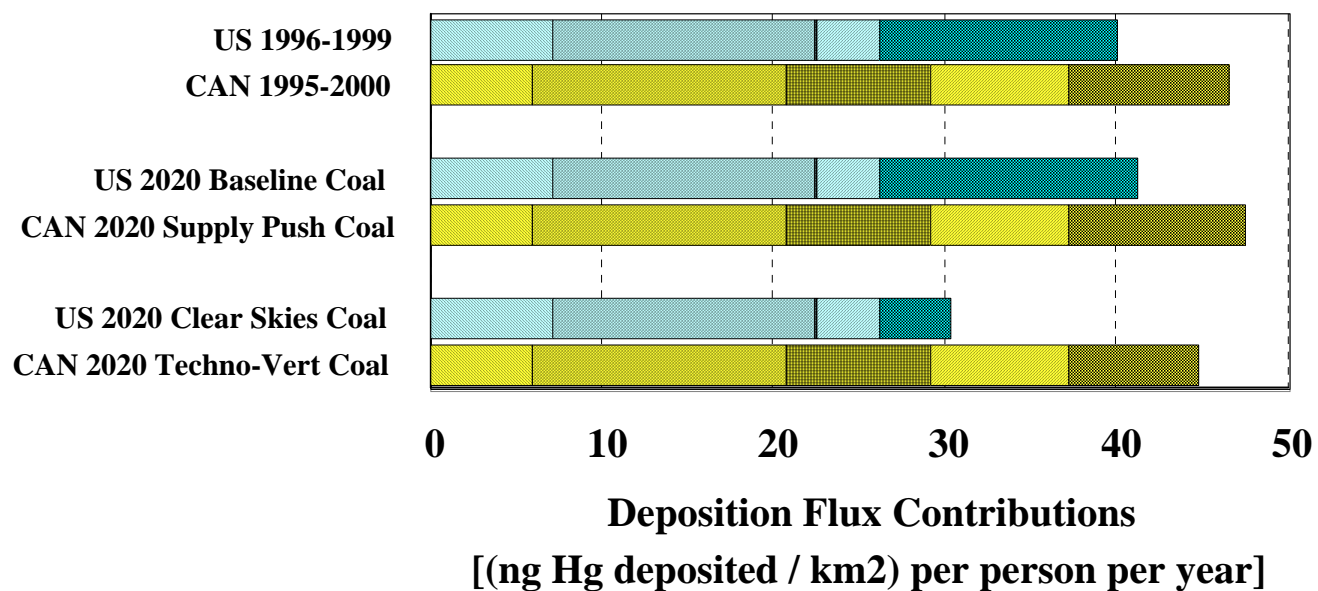


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# *Mercury Emissions from Coal-Fired Electricity Generation are not the only emissions impacting these receptors...*

**Per Capita Contributions to Lake Ontario from All Source Categories**

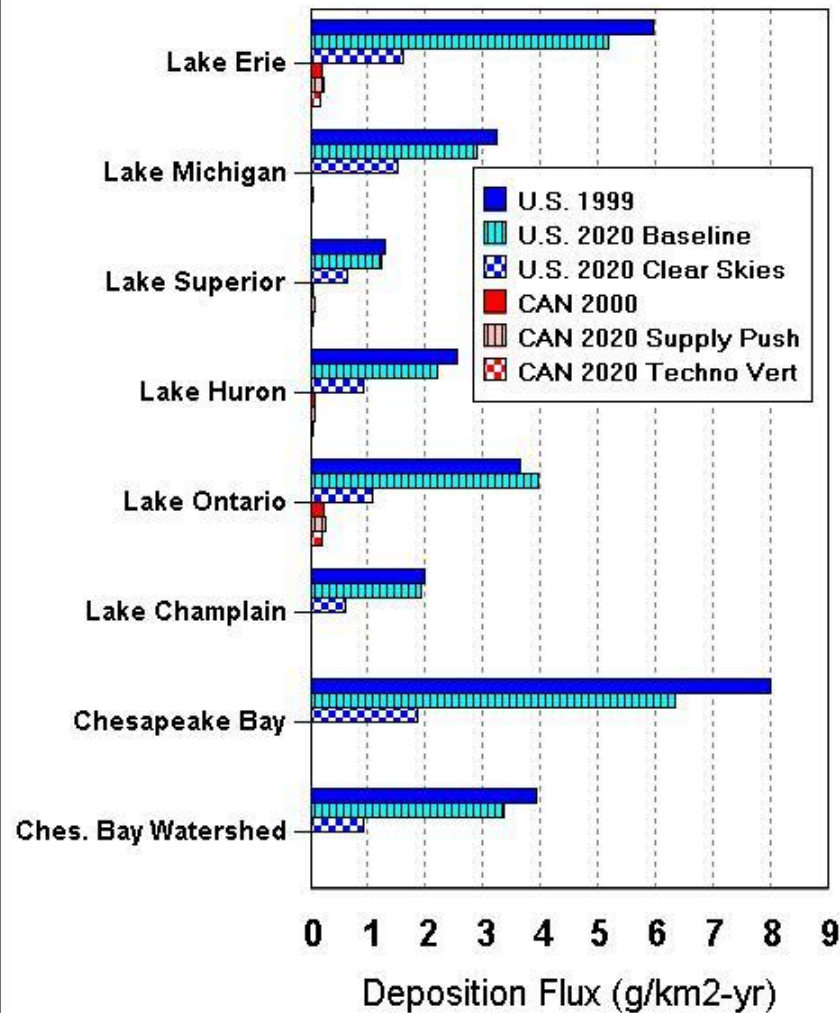


- other fuel combustion
- manufacturing and other
- incineration
- coal-fired electricity generation
- metals

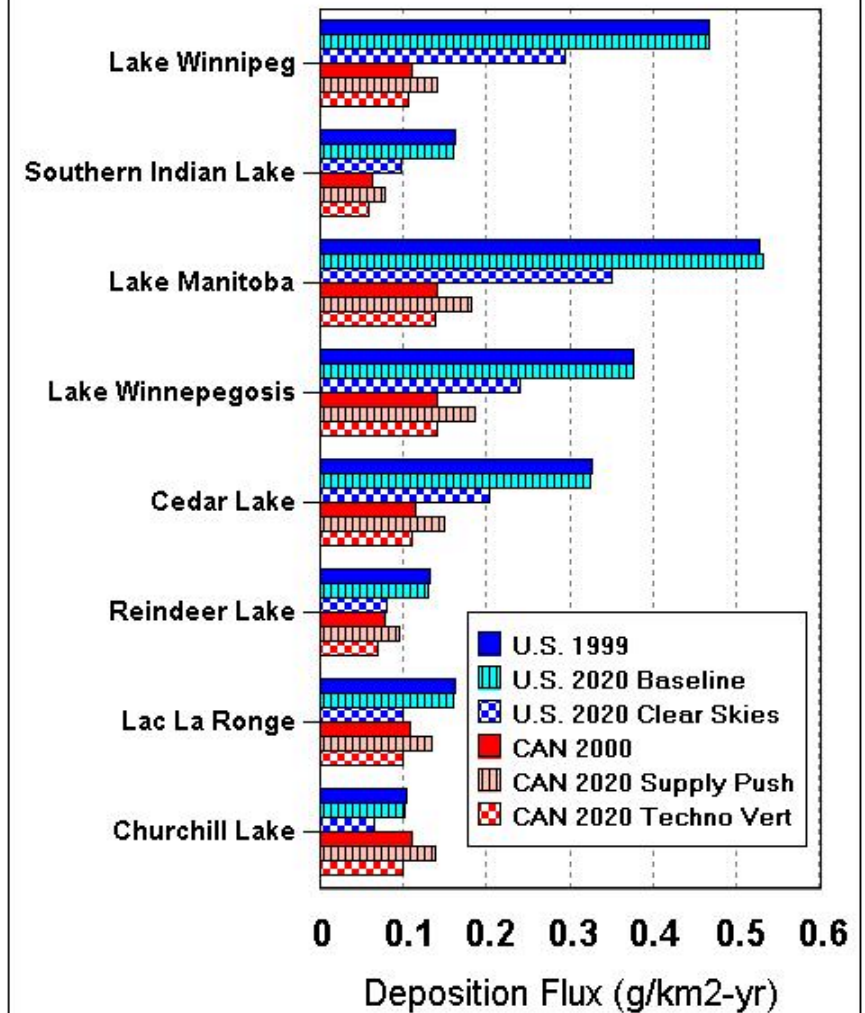
U.S. data shown with "blue" shading; Canadian data shown with "yellow" shading.  
The only category with emissions changes in 2020 is "coal-fired electricity generation";  
all other source categories were held constant at their "current" baseline

# The receptors fell into two groups:

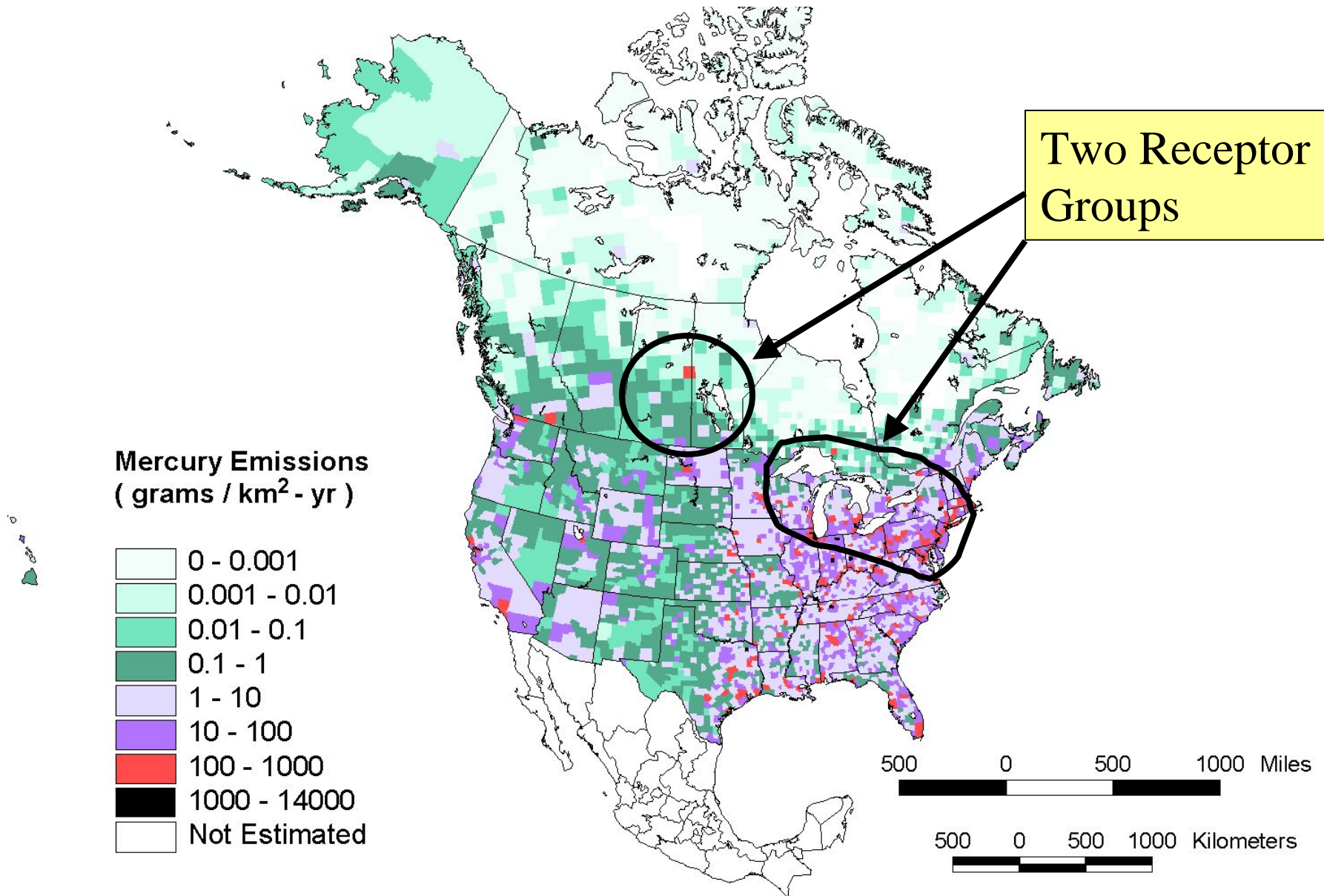
**Figure 5. Deposition Flux from Coal-Fired Electricity Generation to "U.S. influenced" receptors**



**Figure 6. Deposition Flux from Coal-Fired Electricity Generation to "Canada & U.S. influenced" receptors**

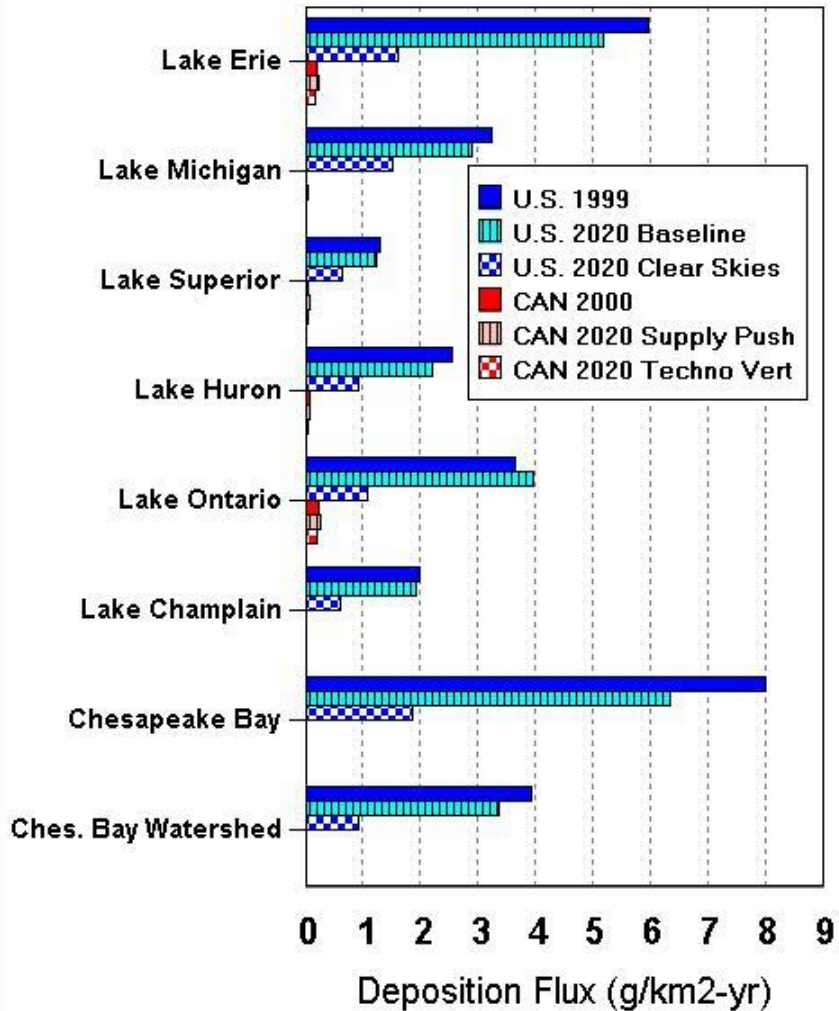


# Anthropogenic Mercury Emissions from Sources in the U.S. and Canada (~1995-1996)

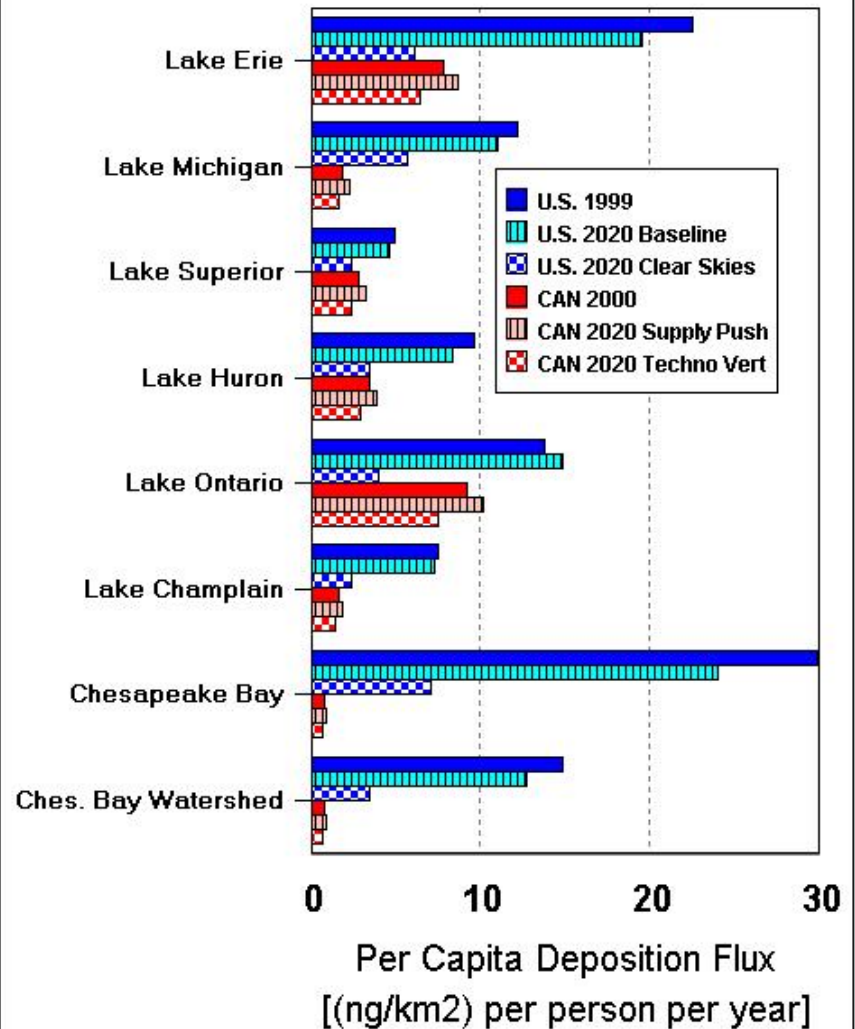


*Even on a per-capita basis, U.S. emissions appear to be more important for the first group...*

**Figure 5. Deposition Flux from Coal-Fired Electricity Generation to "U.S. influenced" receptors**

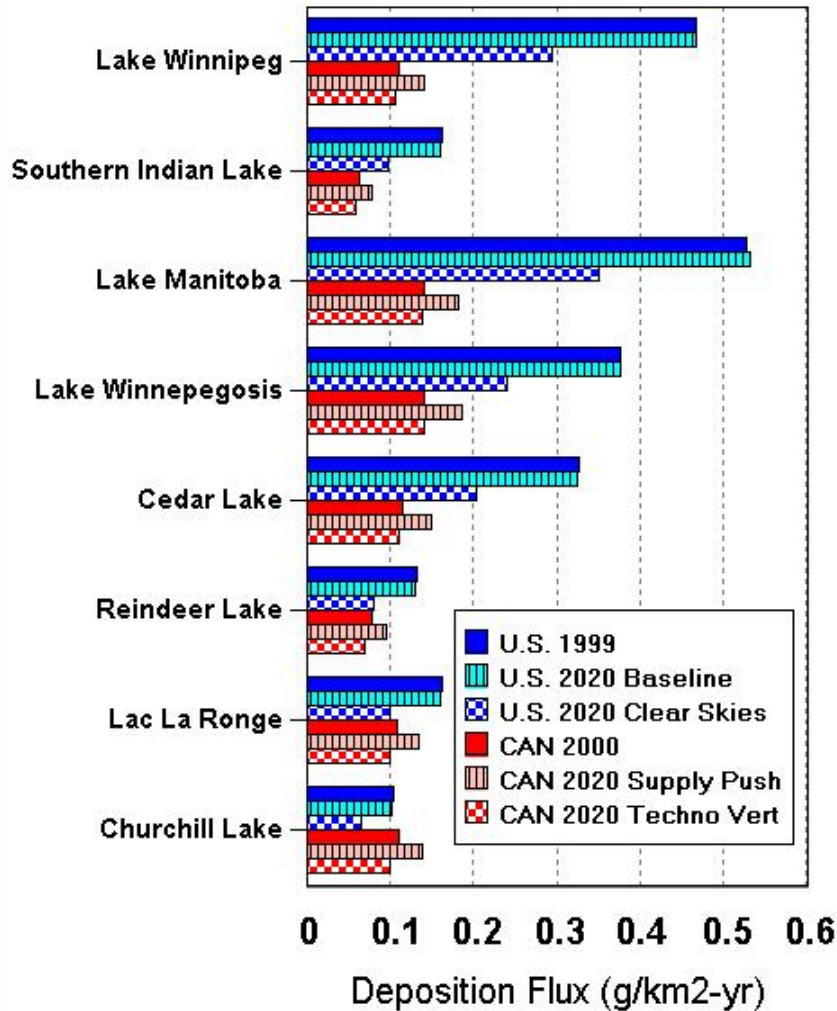


**Figure 7. Per Capita Deposition Flux from Coal-Fired Electricity Generation to "U.S. influenced" receptors**

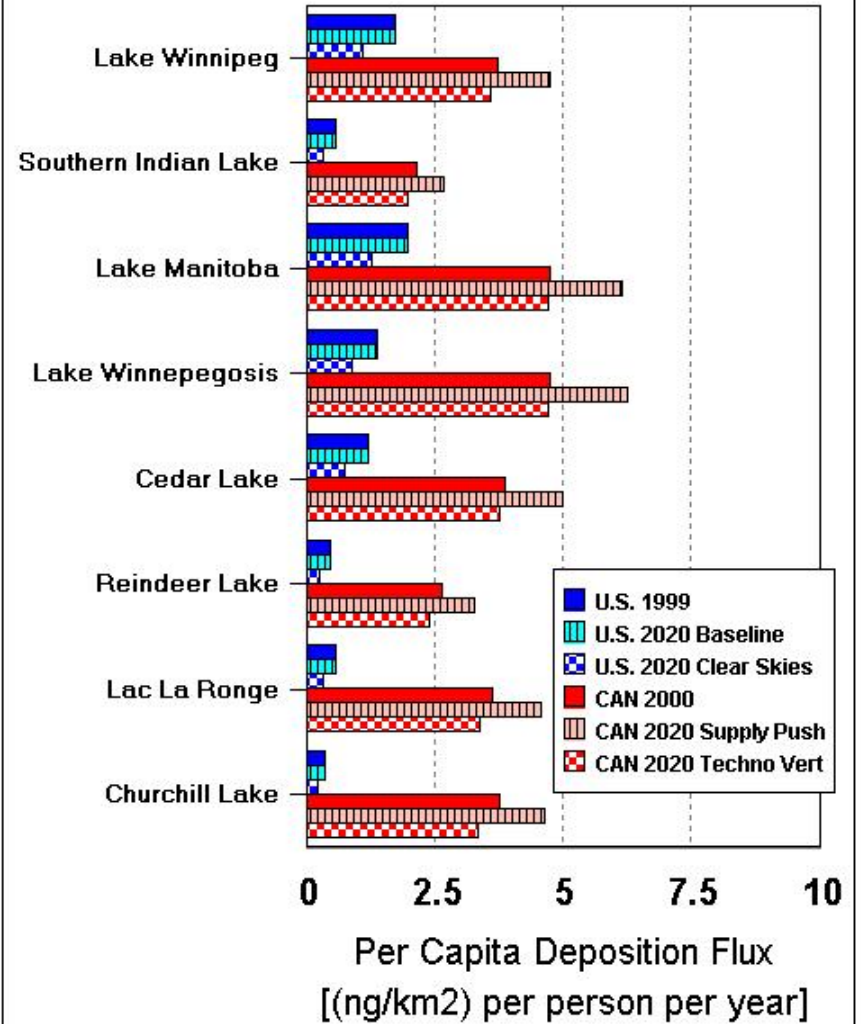


*However, on a per-capita basis, Canadian emissions appear to be more important for the second group...*

**Figure 6. Deposition Flux from Coal-Fired Electricity Generation to "Canada & U.S. influenced" receptors**



**Figure 8. Per Capita Deposition Flux from Coal-Fired Electricity Generation to "Canada and U.S. influenced" receptors**



## Some Limitations of this Study...

- U.S. and Canadian anthropogenic emissions *only*  
[ignoring natural emissions and global sources]
- *Uncertainties in emissions inventories,  
and in fate and transport modeling*
- **Future U.S. & Canadian scenarios not really comparable;  
many other scenarios that could be considered, including  
some with much deeper reductions in mercury emissions**

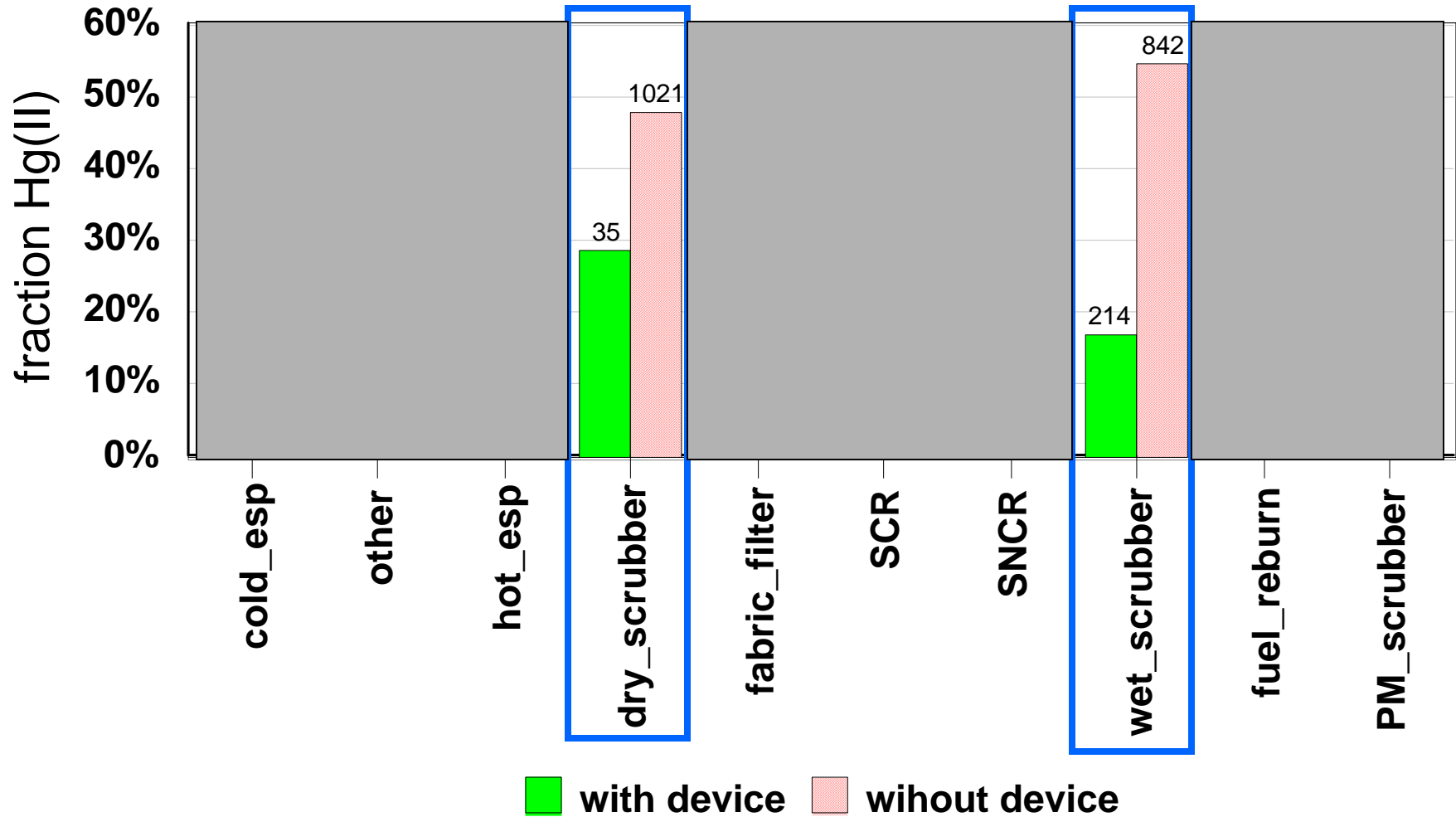
# Summary and Conclusions

- Deposition impact of *current* and *future* U.S. and Canadian mercury emissions examined with an atmospheric fate and transport model
- Receptors fell into two groups:
  - (1) Influenced primarily by the U.S.; *larger total flux*
  - (2) Influenced by the U.S. and Canada; *smaller total flux*
- Coal-fired power plants not the only contributors to atmospheric mercury deposition in the receptors studied
- Emissions from coal-fired power plants contribute significantly to deposition to all the receptors, and changes in the amounts and/or speciation profile of these emissions will result in changes in deposition.



# **Extra Slides**

**Hg(II) fraction vs. air pollution control device for Hg(II) ("RGM")  
for mercury emissions from U.S. coal-fired electricity generation**



numbers above bars are the number of records