Reducing Uncertainties in Modeling Atmospheric Mercury

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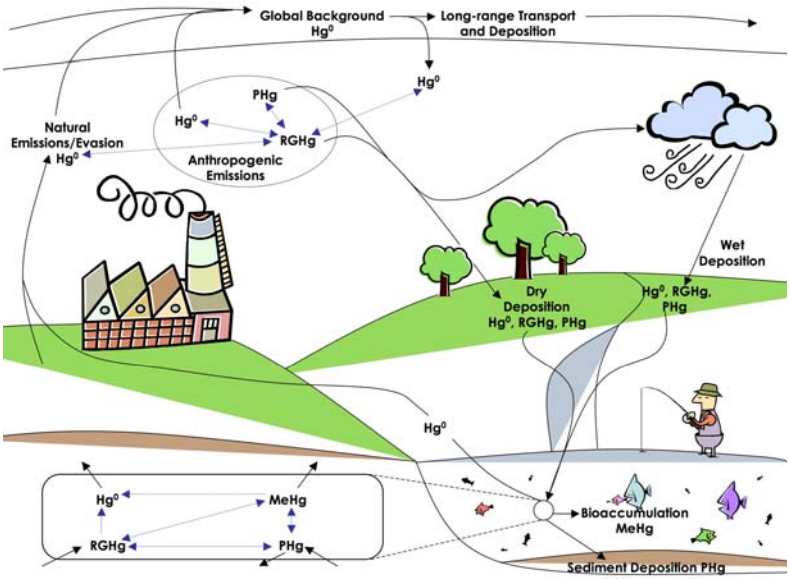
Mercury Basics

Three **different** atmospheric mercury species

- **Elemental Gaseous Mercury (Hg^0)** - stays in atmosphere for 1-1.5 years, global pollutant from global sources
- **Reactive Gaseous Mercury (RGHg)** - stays in atmosphere for a few days, highly reactive
- **Particulate Mercury (PHg)** - stays in atmosphere for about a week, removed by precipitation

Mercury Basics



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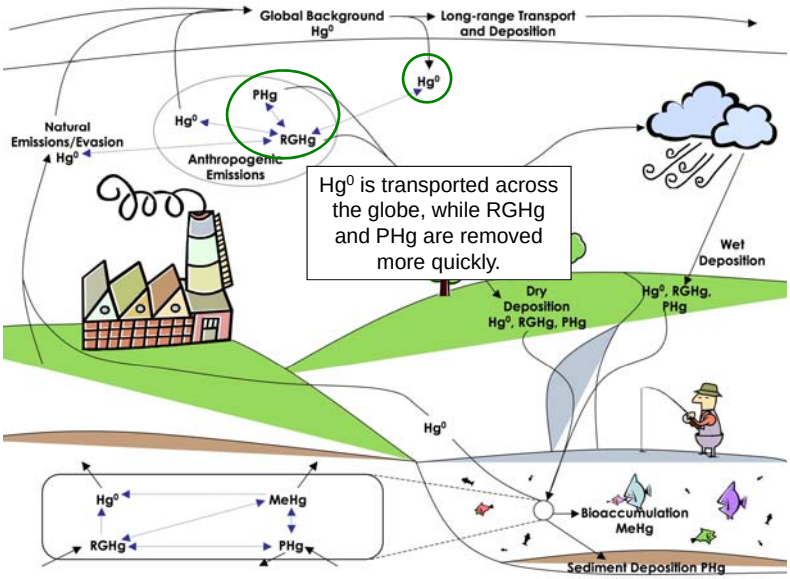

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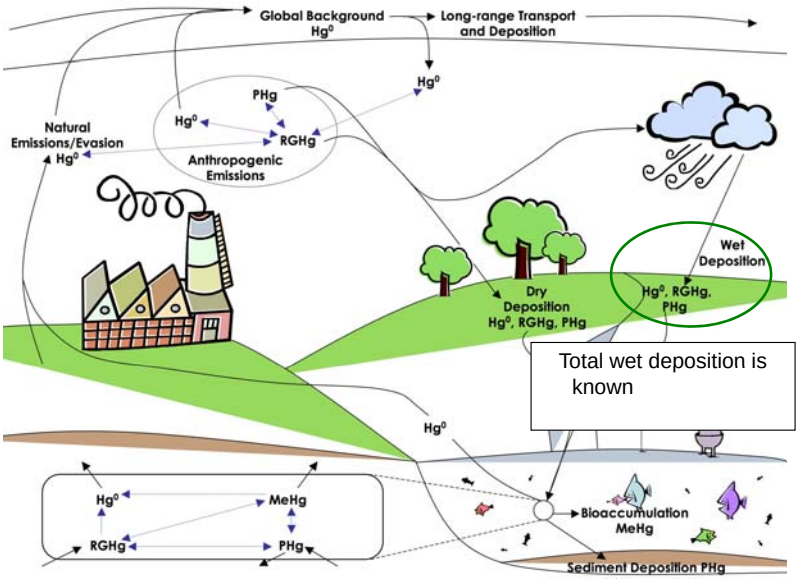
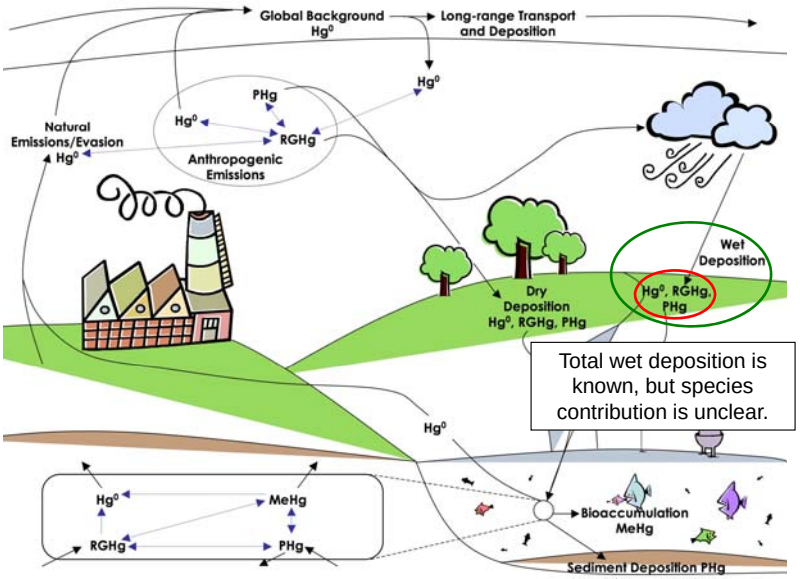


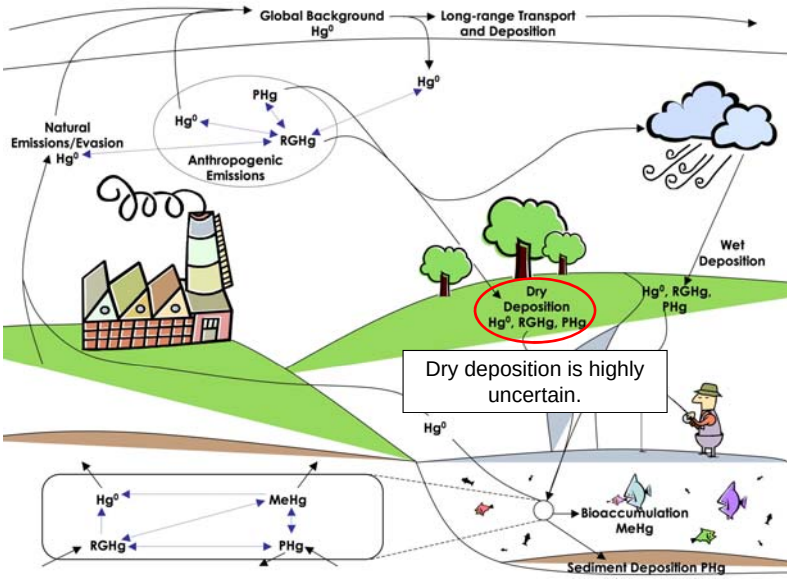
Total wet deposition is known

Mercury Basics



Total wet deposition is known, but species contribution is unclear.

Mercury Basics



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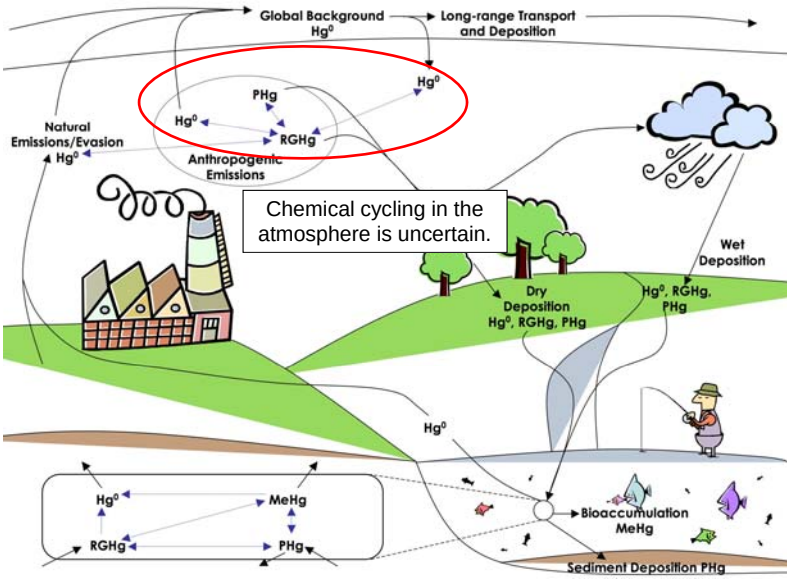
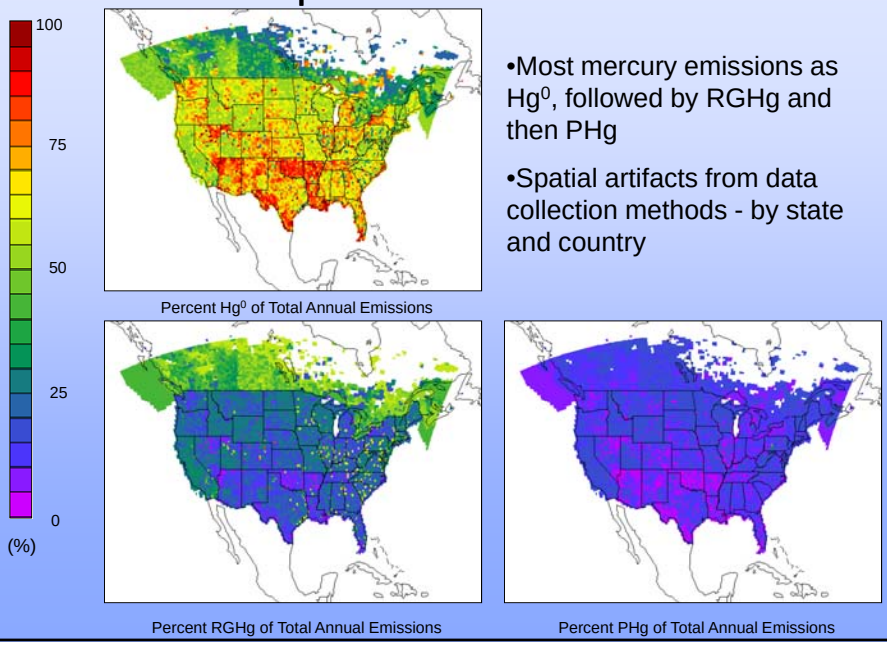
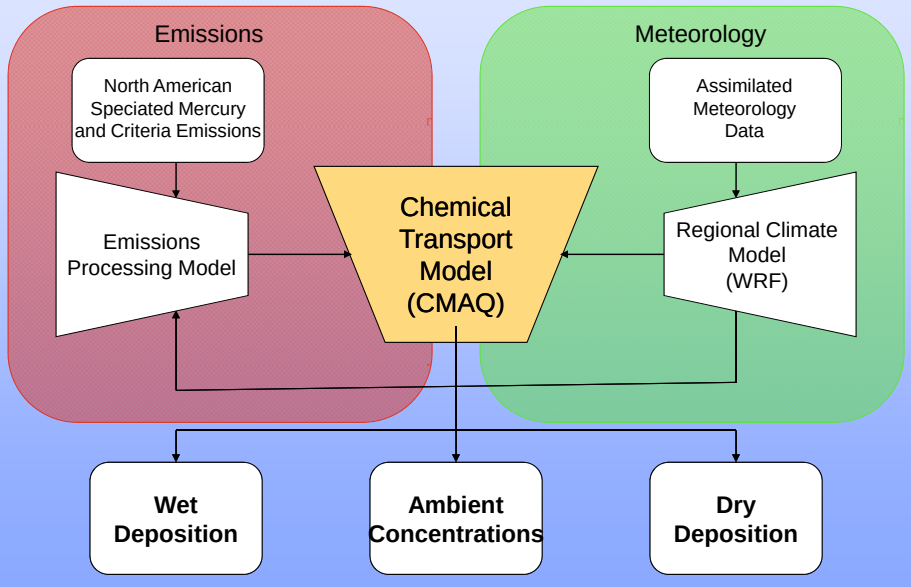


Species Contribution



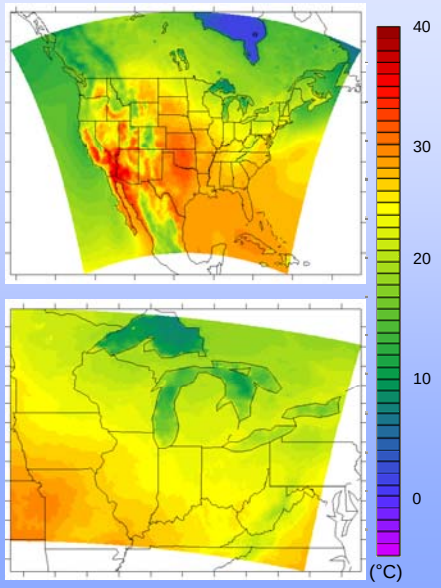
- Most mercury emissions as Hg^0, followed by RGHg and then PHg
- Spatial artifacts from data collection methods - by state and country

Modeling Systems



Model Grid & Resolution

- Full-year run from January 2003 to January 2004
- U.S. domain with 36 km x 36 km resolution
- Great Lakes region with 12 km x 12 km resolution
- 30 vertical layers in WRF, 15 vertical layers in CMAQ
- CB05 chemistry and aerosol module 4, with mercury

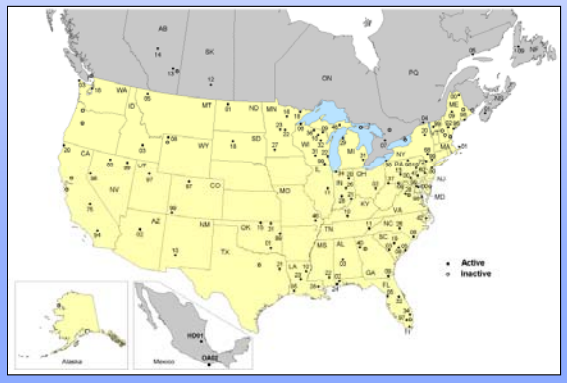


Average Temperature for July 2003

Wet Deposition

Mercury Deposition Network (MDN)

- Weekly unspeciated total mercury wet deposition
- CMAQ generally under-predicts wet deposition (Bullock and Brehme, 2002; Gbor et al., 2007; Bullock et al., 2009; Lin et al., 2007)

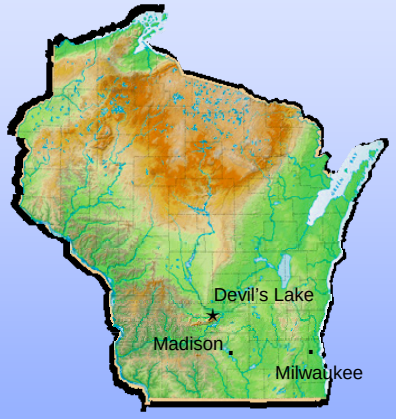


General agreement across models, mechanisms and inputs.

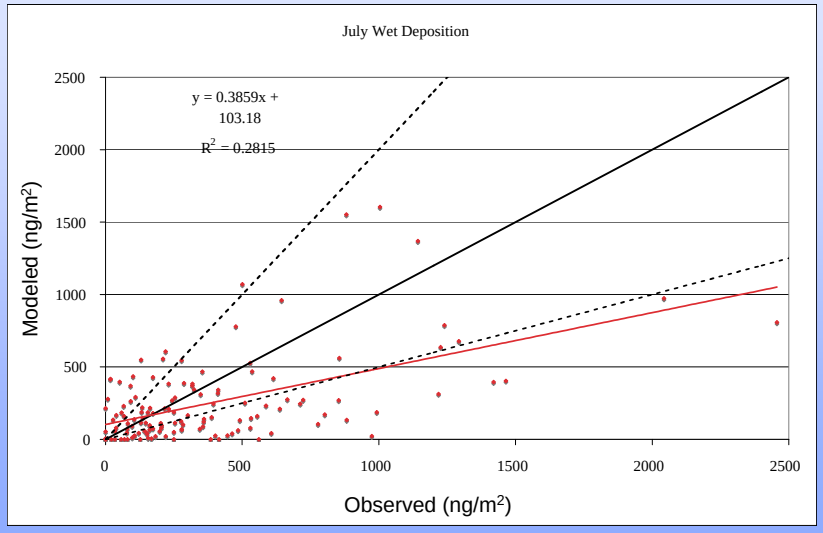
Accuracy or imitation?

Ambient Concentrations

- Episodic and/or unspeciated (Sillman et al., 2007; Burke et al., 1995)
- CMAQ captures total mercury concentrations (e.g. Lin and Tao, 2007)
- Comparison with speciated surface concentrations every two hours at Devil's Lake (rural) and Milwaukee (urban) for 2003 and 2004 collected by Jamie Schauer and Andy Rutter



Wet Deposition in the Great Lakes



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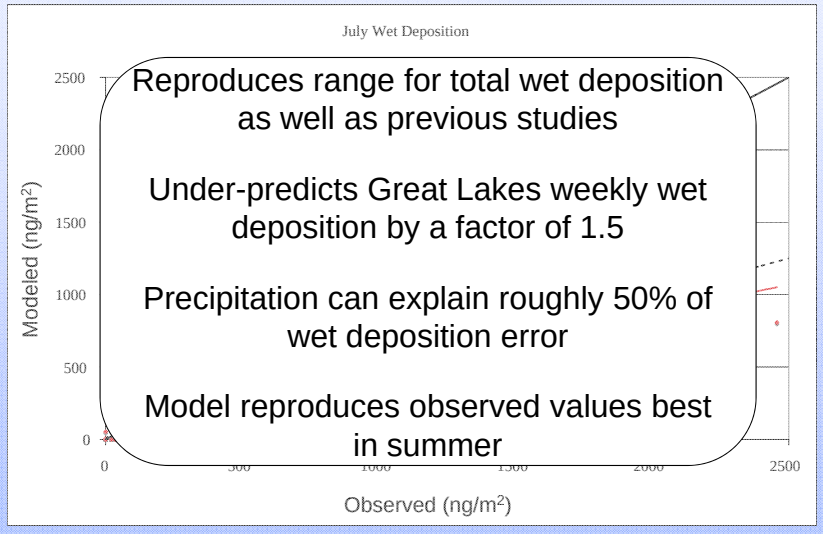


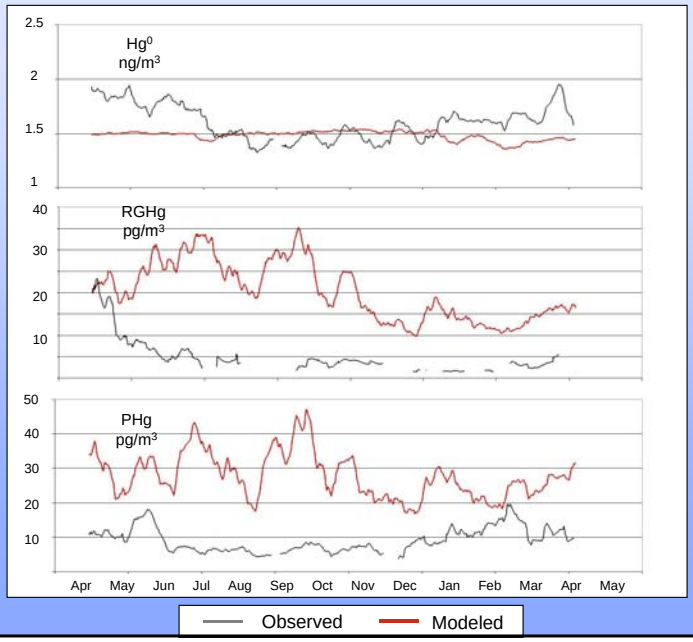
Reproduces range for total wet deposition as well as previous studies

Under-predicts Great Lakes weekly wet deposition by a factor of 1.5

Precipitation can explain roughly 50% of wet deposition error

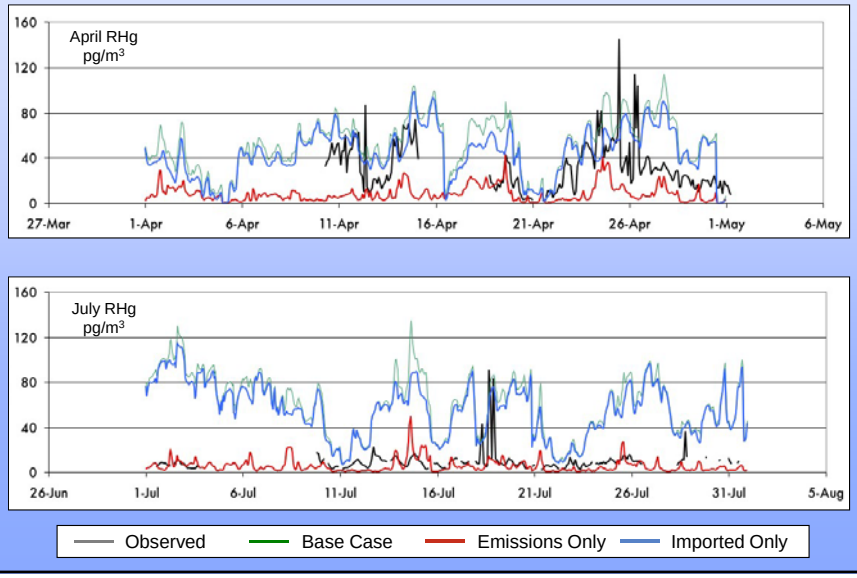
Model reproduces observed values best in summer

Ambient Surface Concentration - Rural

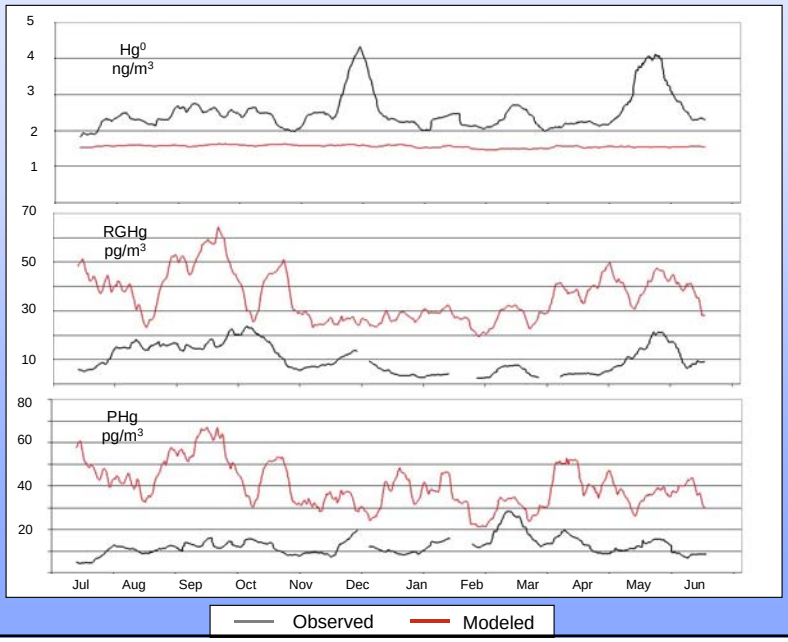


Ambient Surface Concentration - Rural

Imported or Emitted?



Ambient Surface Concentration - Urban



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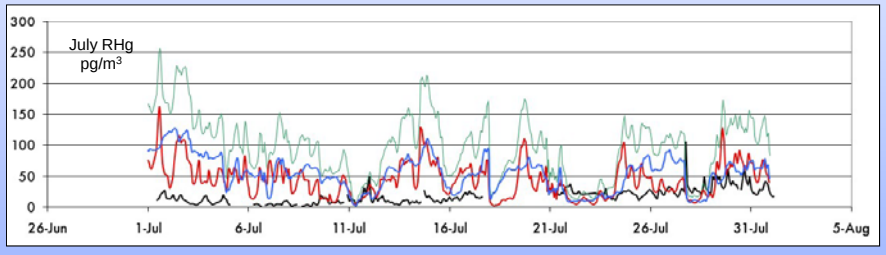
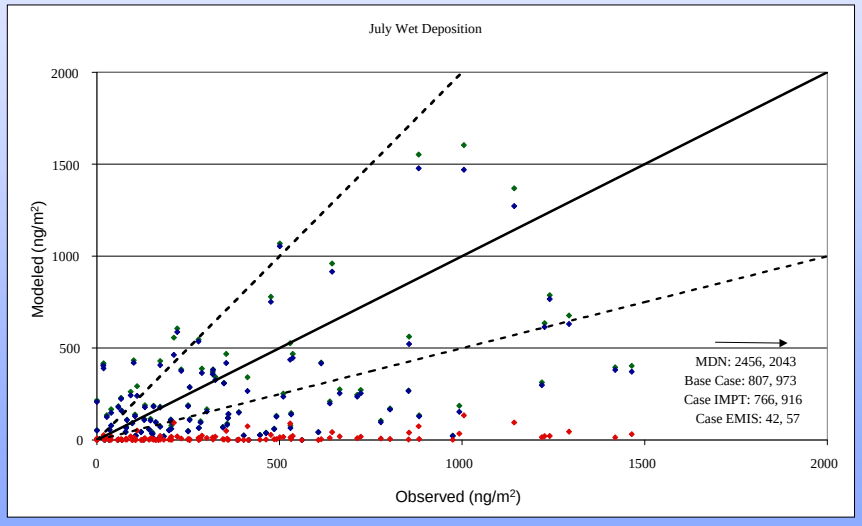


Observed Base Case Emissions Only Imported Only

Wet Deposition

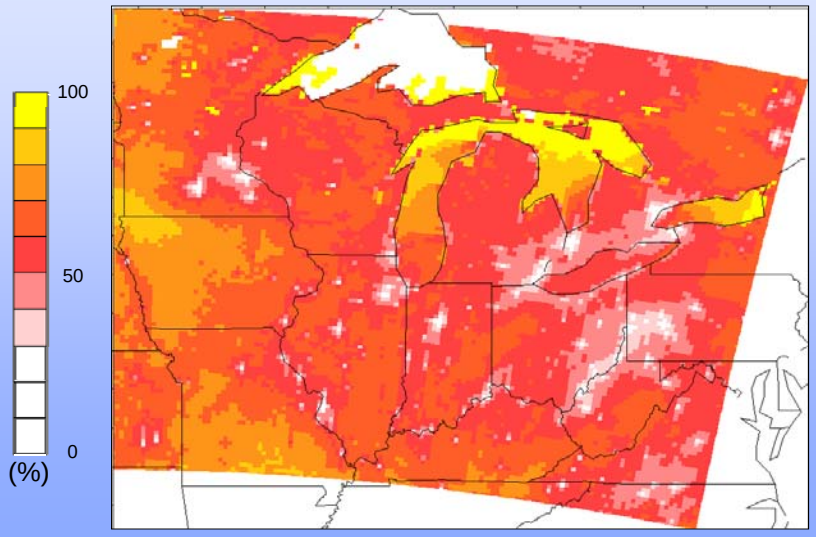
Imported or Emitted?



Base Case Emissions Only Imported Only

Dry Deposition

Imported or Emitted?



Imported RHg Percent Contribution to Total July Dry Deposition

Major Uncertainties…

- Over-prediction at surface for reactive mercury concentrations driven by local chemical production from Hg^0

  RHg production is too high

- RGHg plumes do not reach rural sites

  Dry deposition removal likely too fast

- Wet deposition values agree, but are based on erroneous chemistry

  “Tuned” wet deposition, not model accuracy

Research Needs

Speciated concentration monitors

Further laboratory study for mercury chemistry and dry deposition

Speciated reporting for wet deposition

Laboratory and field measurements for dry deposition data

Thank you!

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