

Simulating the Atmospheric Fate and Transport of Mercury using the NOAA HYSPLIT Model

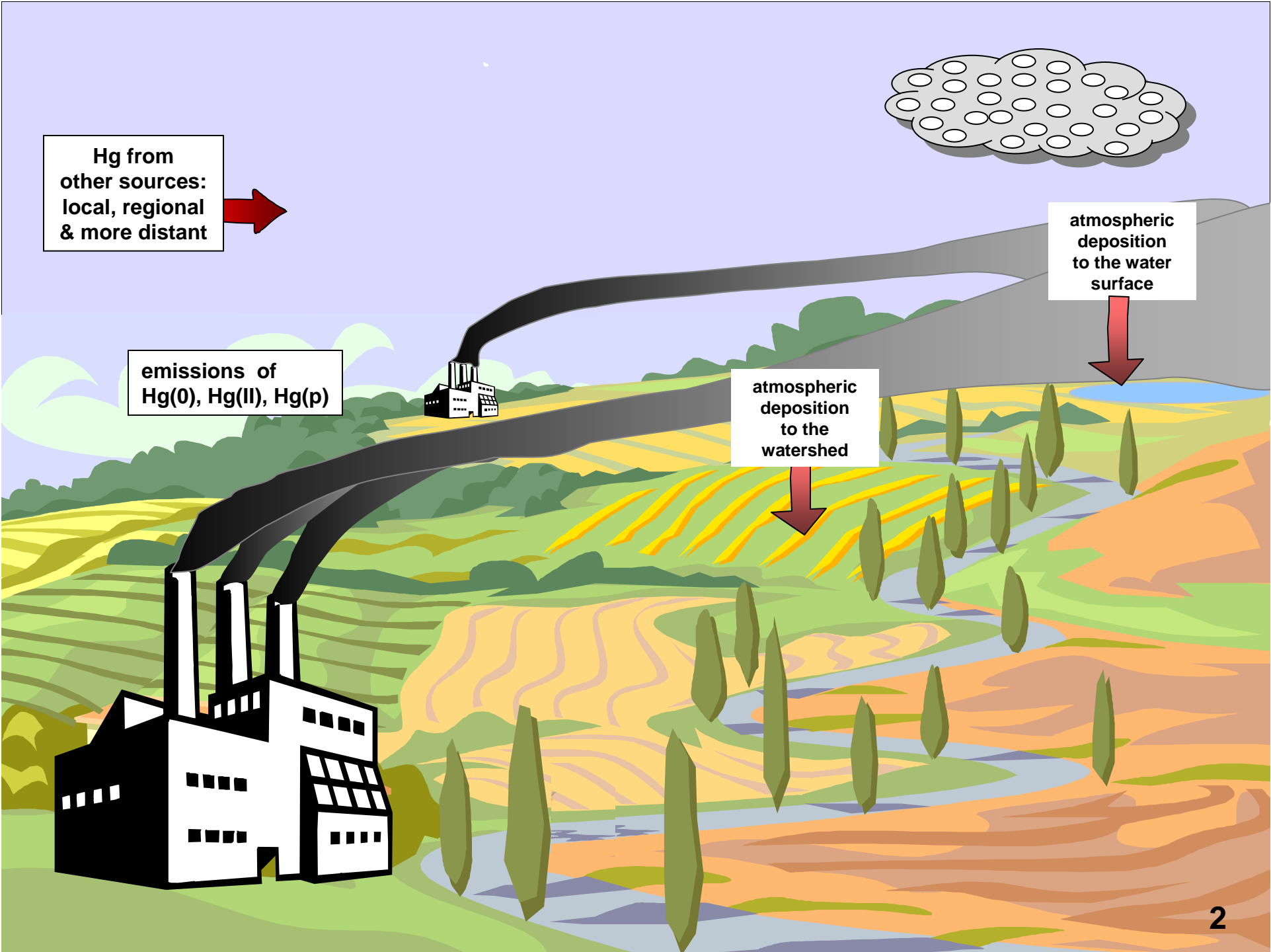


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<http://www.arl.noaa.gov/ss/transport/cohen.html>



Presentation S-1614 at Mercury 2006
Conference on Mercury as a Global Pollutant
Session S-EM-1: Bridging the Gap Between
Empirical Data and Multi-Media Modeling, August 8, 2006



Hg from other sources: local, regional & more distant

emissions of Hg(0), Hg(II), Hg(p)

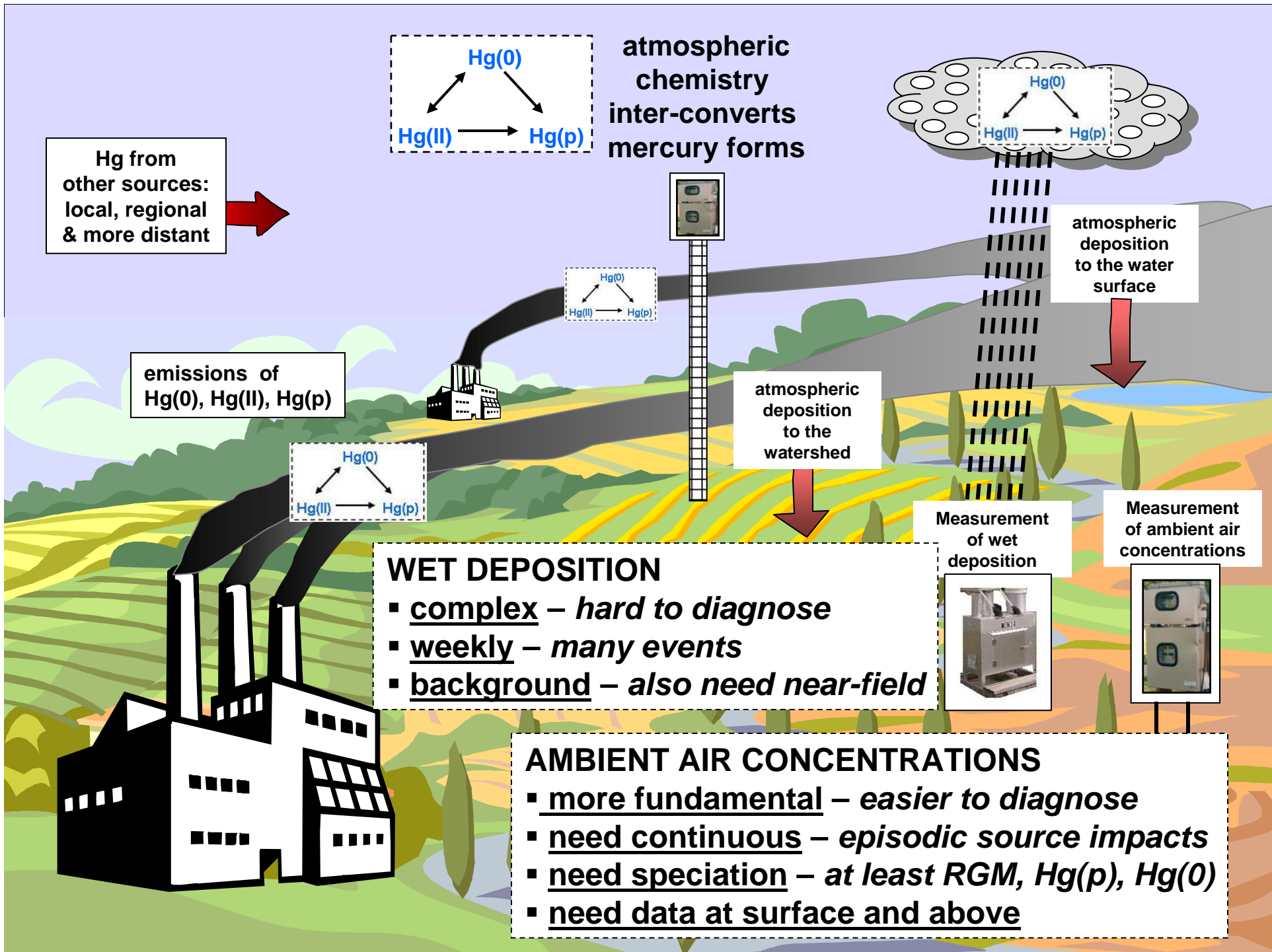
atmospheric deposition to the watershed

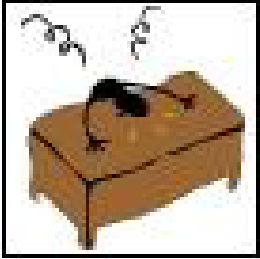
atmospheric deposition to the water surface

- ❑ ***policy development*** requires:
 - **source-attribution (*source-receptor* info)**
 - **estimated impacts of alternative future scenarios**

- ❑ **estimation of *source-attribution & future impacts*** requires atmospheric models

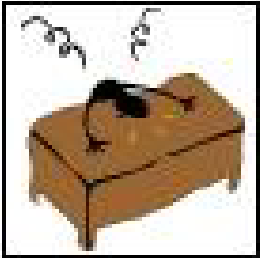
- ❑ ***atmospheric models*** require:
 - **knowledge of atmospheric chemistry & fate**
 - **emissions data**
 - **ambient data for “ground-truthing”**





speciated ambient concentration data is scarce

- *few measurement sites at ground level*
- *very few measurements aloft*



therefore, atmospheric mercury models have not really been comprehensively evaluated yet

- *we don't really know how good or bad they are*

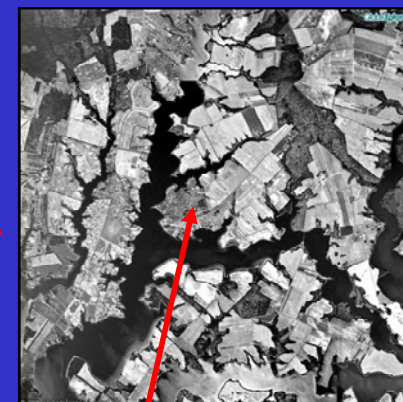
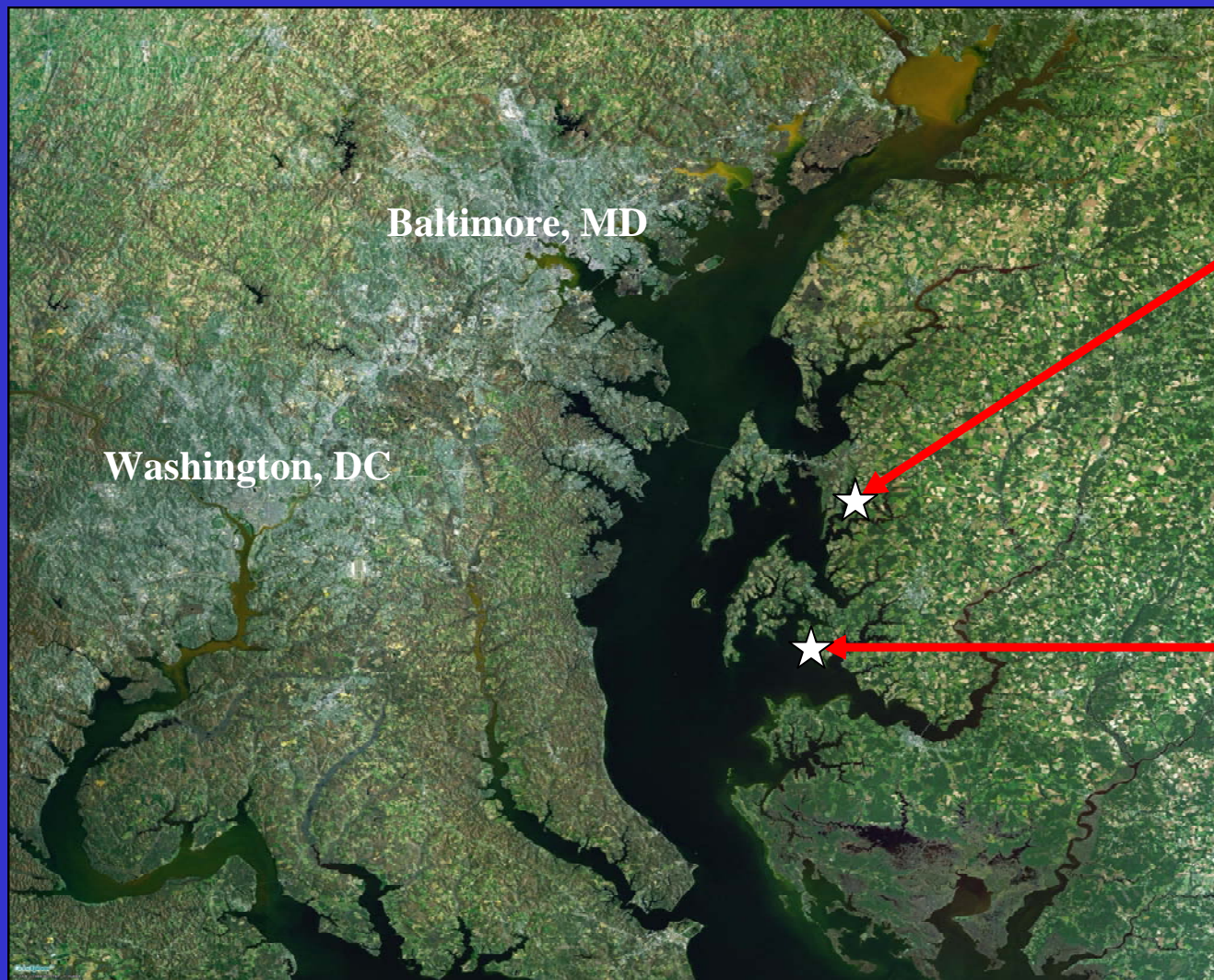


collaboration between measurement and modeling community is key

- *measurers need modelers to help interpret data*
- *modelers need measurements to evaluate models*

**NOAA measurements of
ambient concentrations
of speciated
atmospheric mercury
at Oxford Maryland,
June-Aug 2004**

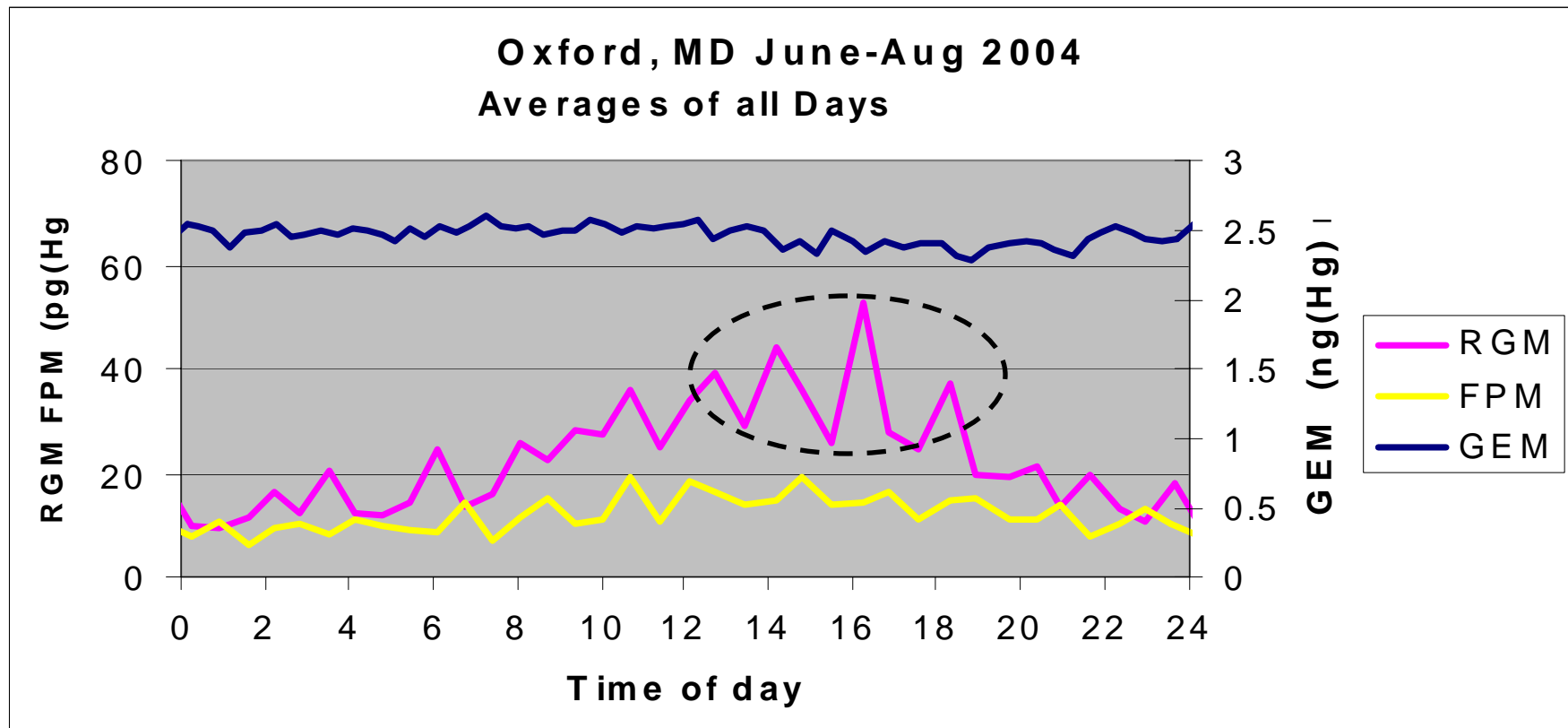
Summer 2004 NOAA ARL Hg Measurement Sites



Wye Research and
Education Center
(38.9131EN, 76.1525EW)



Cooperative Oxford Lab
(38.678EN, 76.173EW)



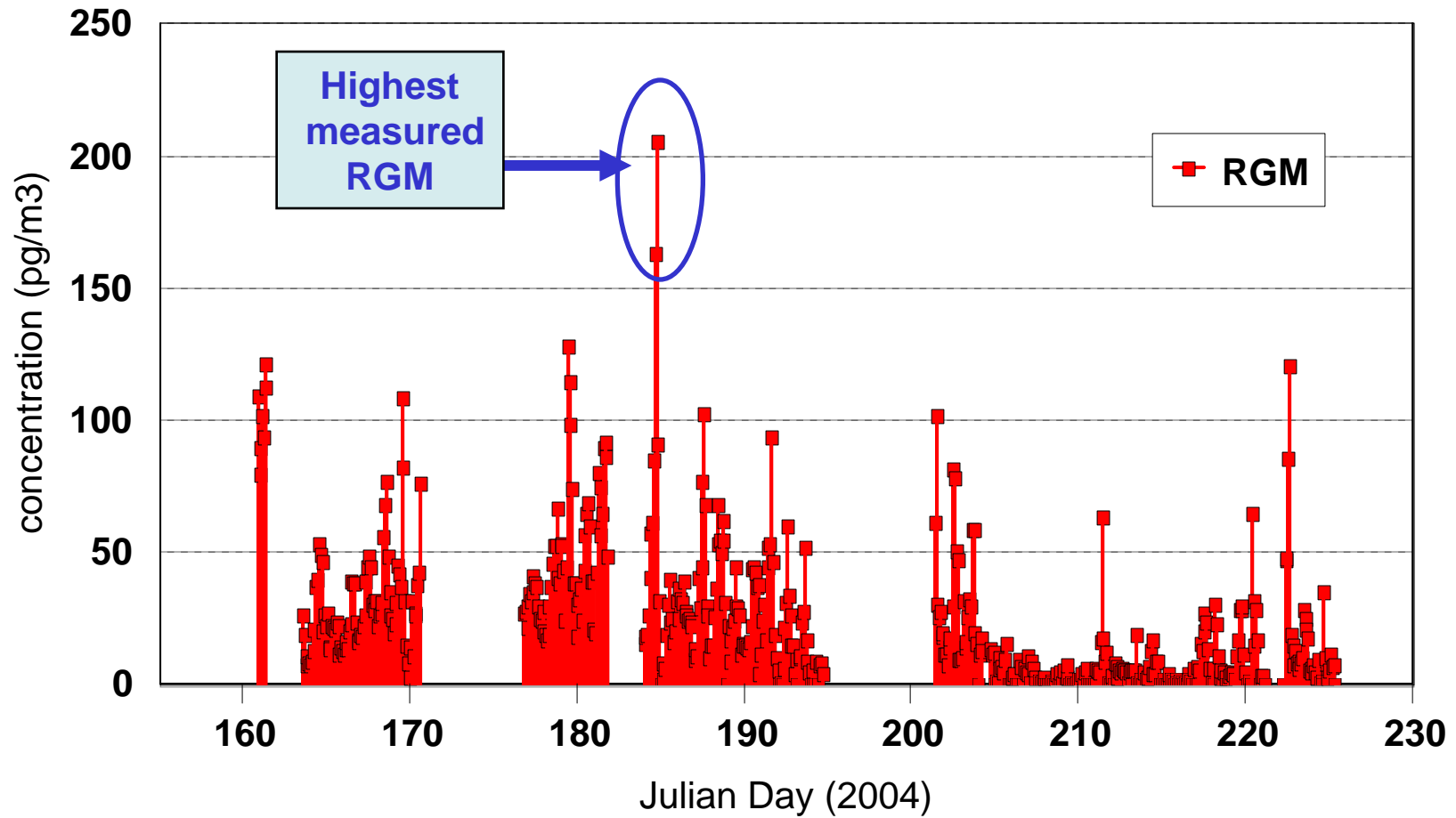
peak of RGM in afternoon

- to what extent due to atmospheric **chemistry**, i.e., in-situ production of RGM in atmosphere, through oxidation of Hg(0)?*
- to what extent due to atmospheric **mixing**, i.e.,*
 - *Night: boundary layer very shallow, RGM quickly depleted via deposition;*
 - *Day: boundary layer thicker, “continuous” supply of RGM mixed down to surface*

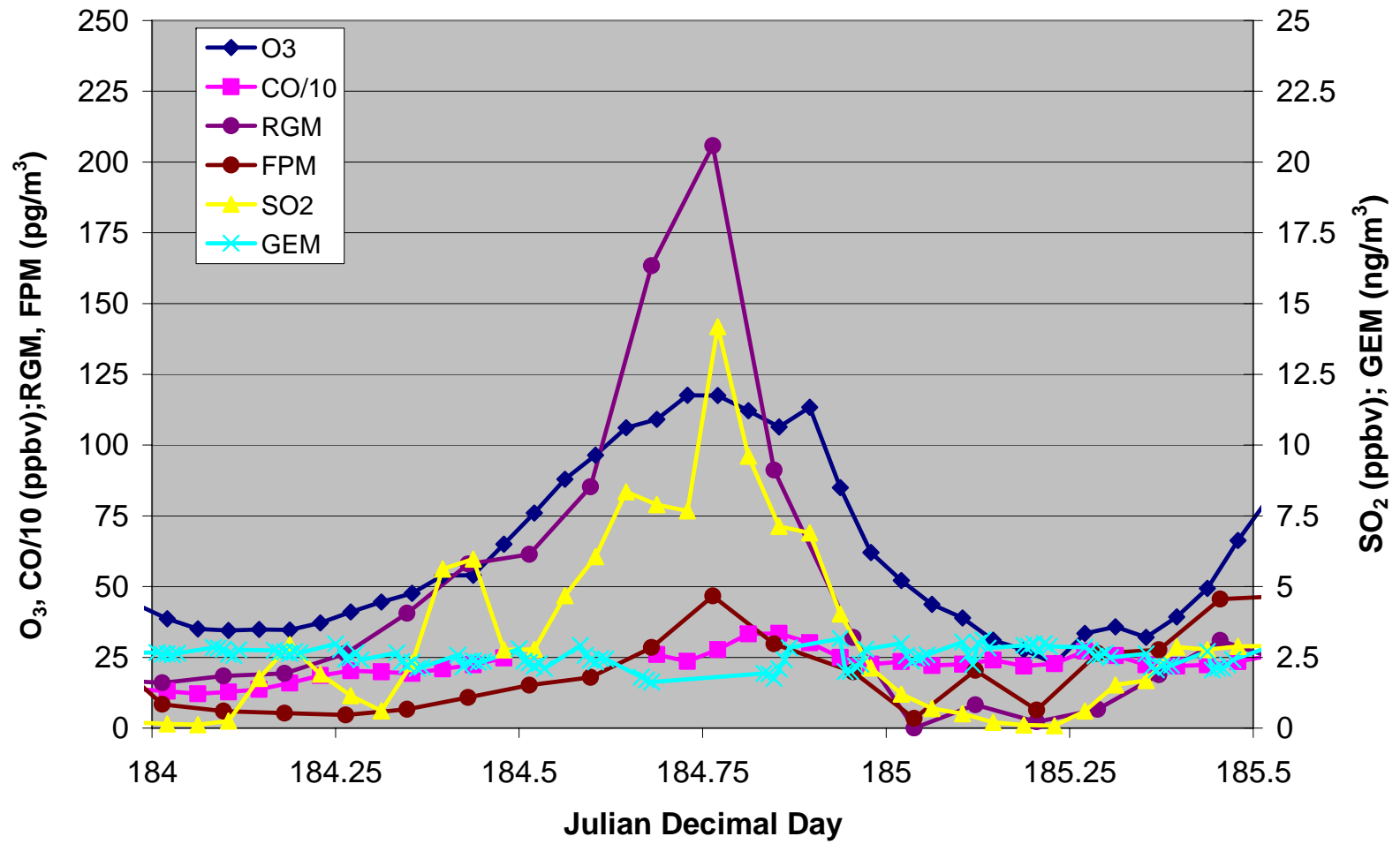
peak of RGM in afternoon

❑ *to what extent due to local, regional, or more distant sources?*

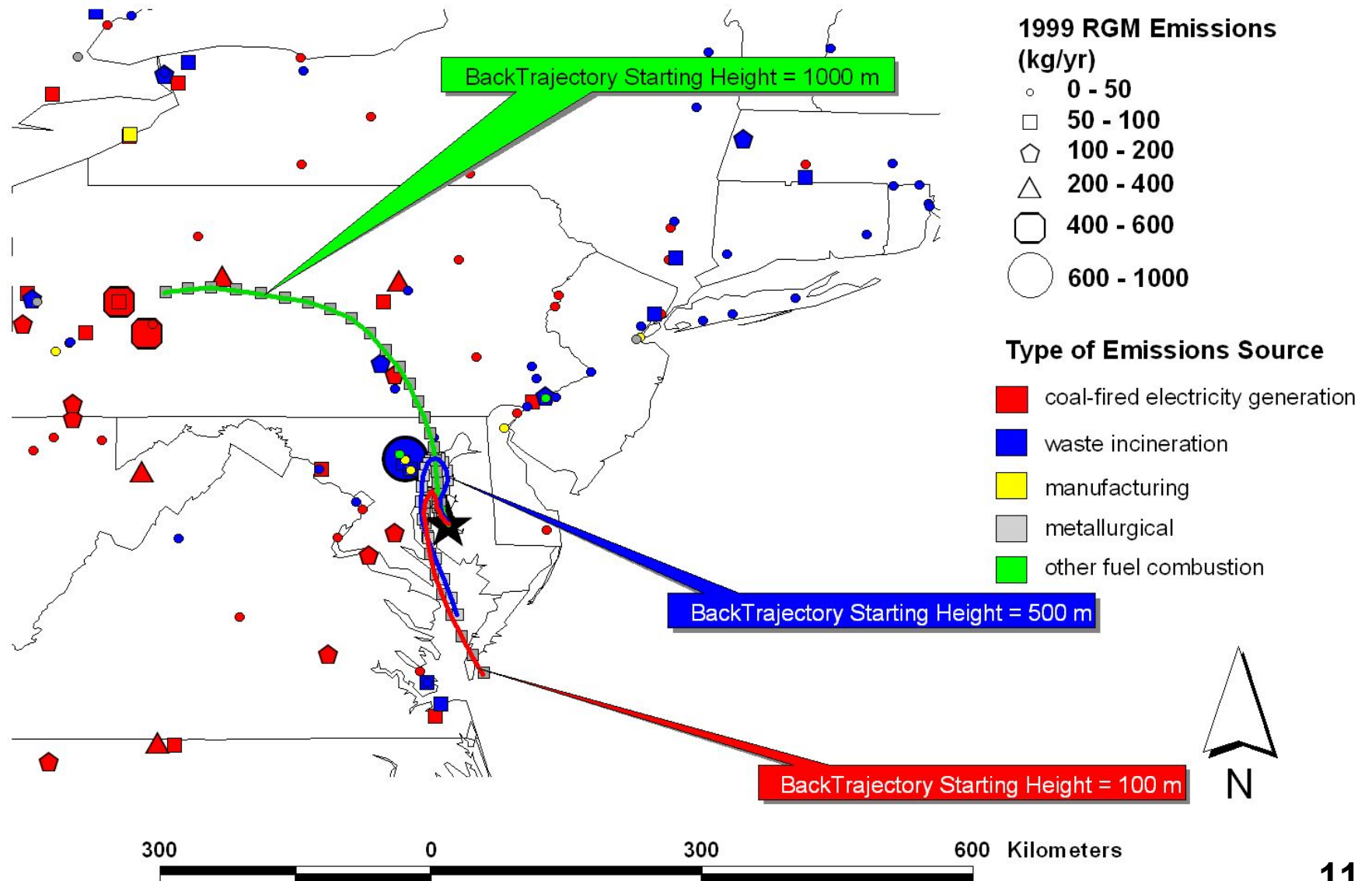
Measured Atmospheric Concentrations at Oxford MD, Summer 2004



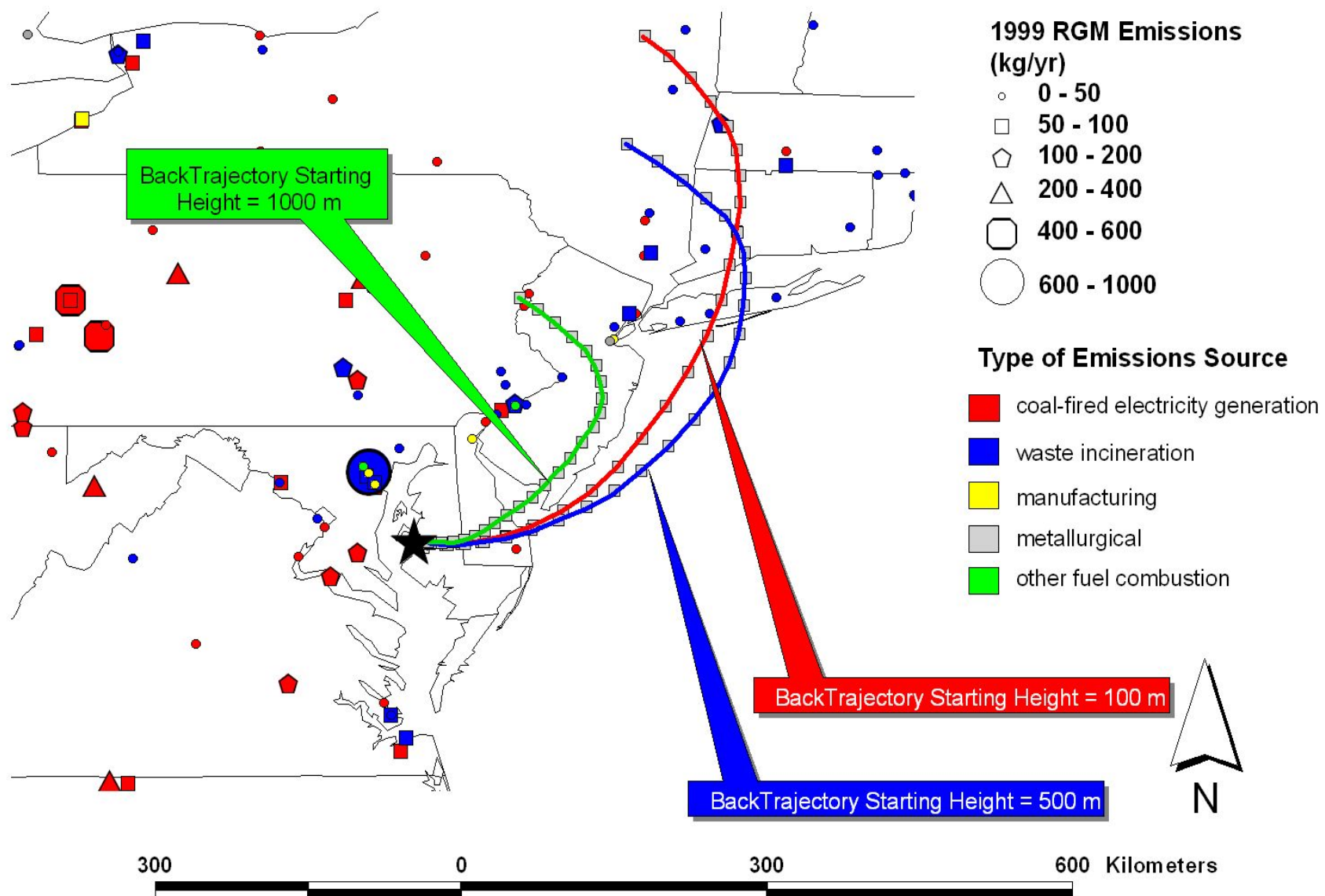
Concentrations Measured at Oxford, MD



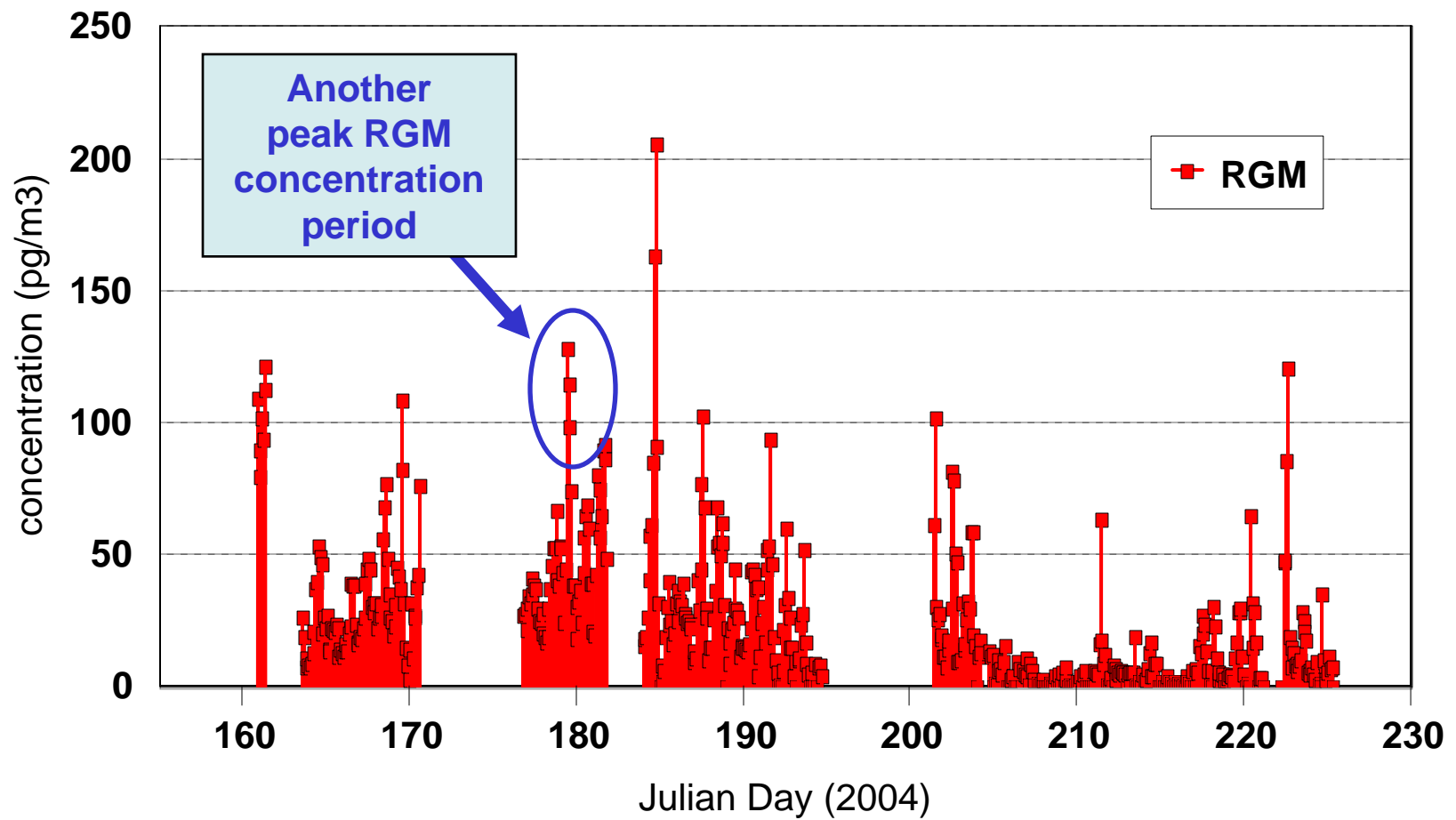
Oxford July 2, 2004 Peak Concentration in RGM



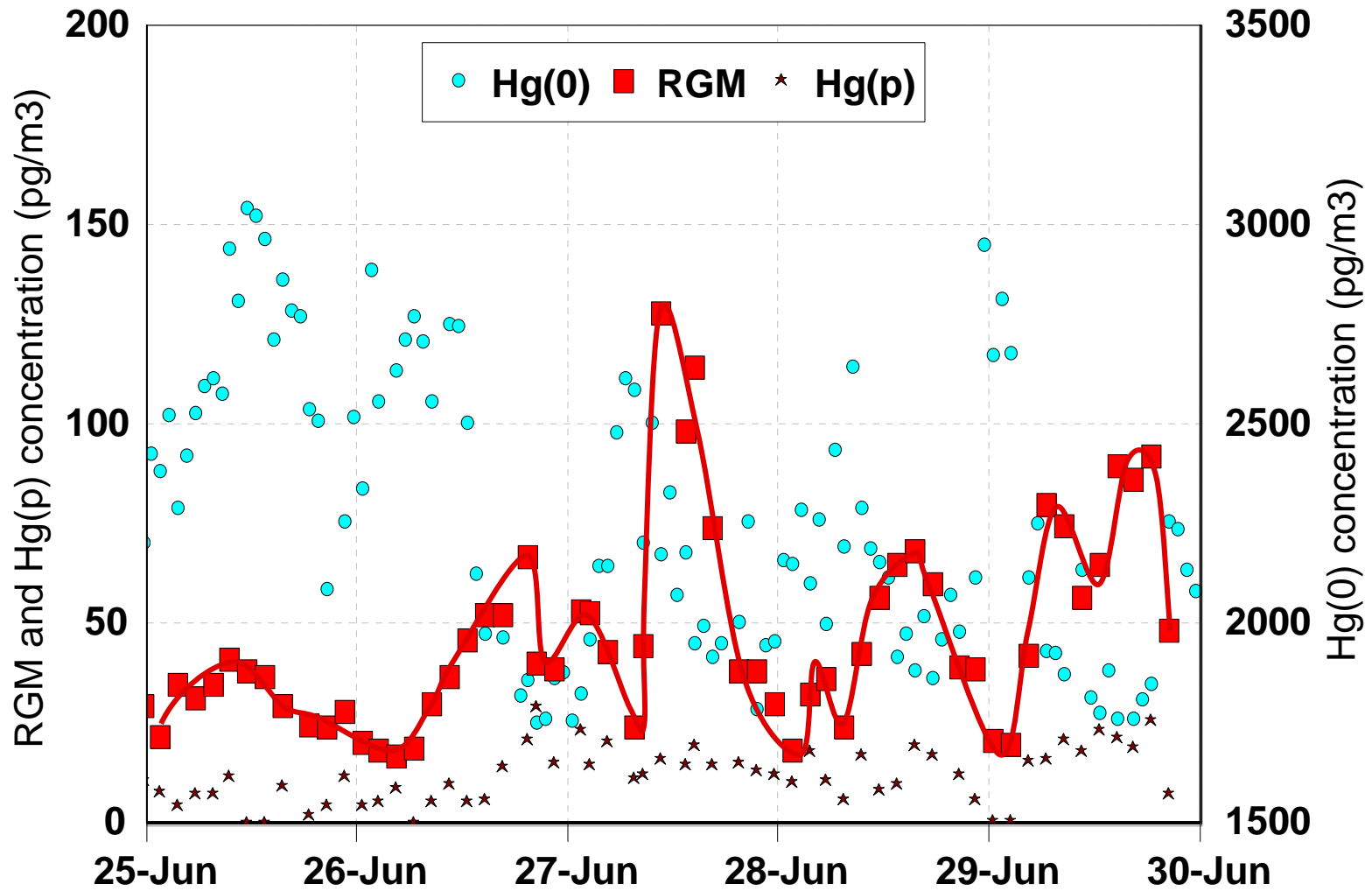
Oxford July 3, 2004 -- one day after Peak Concentration in RGM



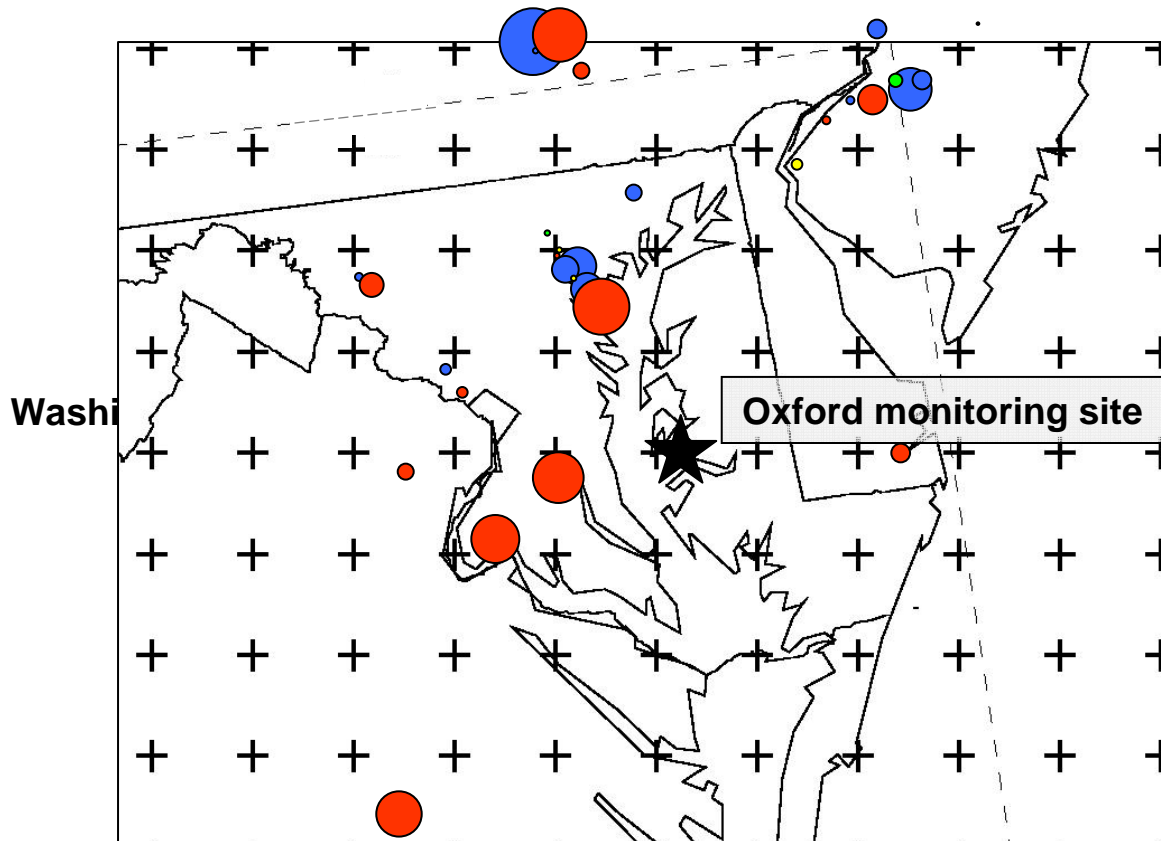
Measured Atmospheric Concentrations at Oxford MD, Summer 2004



Measured Atmospheric Hg Concentrations at Oxford, MD, June 25-30, 2004



NOAA EDAS 40km meteorological data grid in the vicinity of the Oxford monitoring site

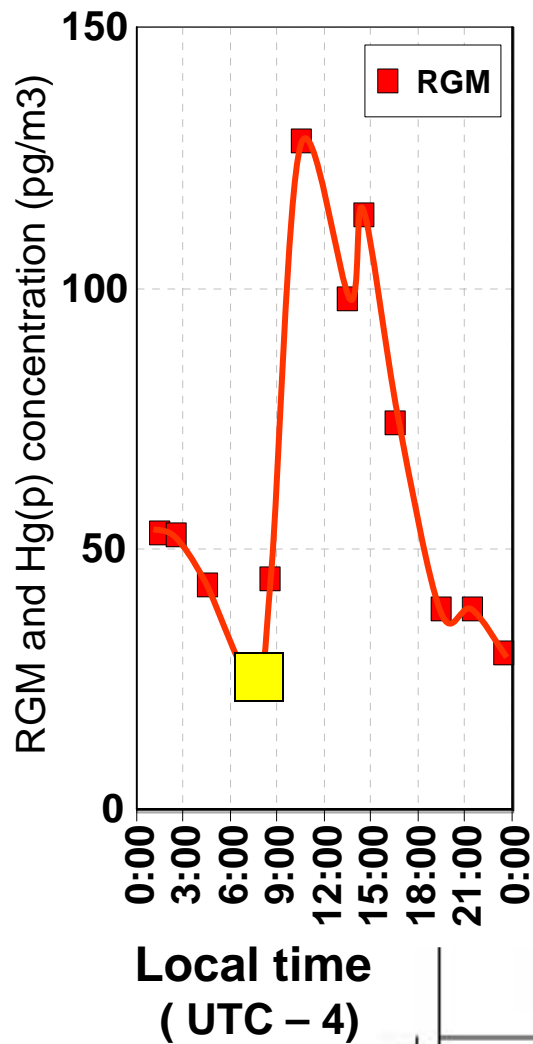


symbol color indicates type of mercury source

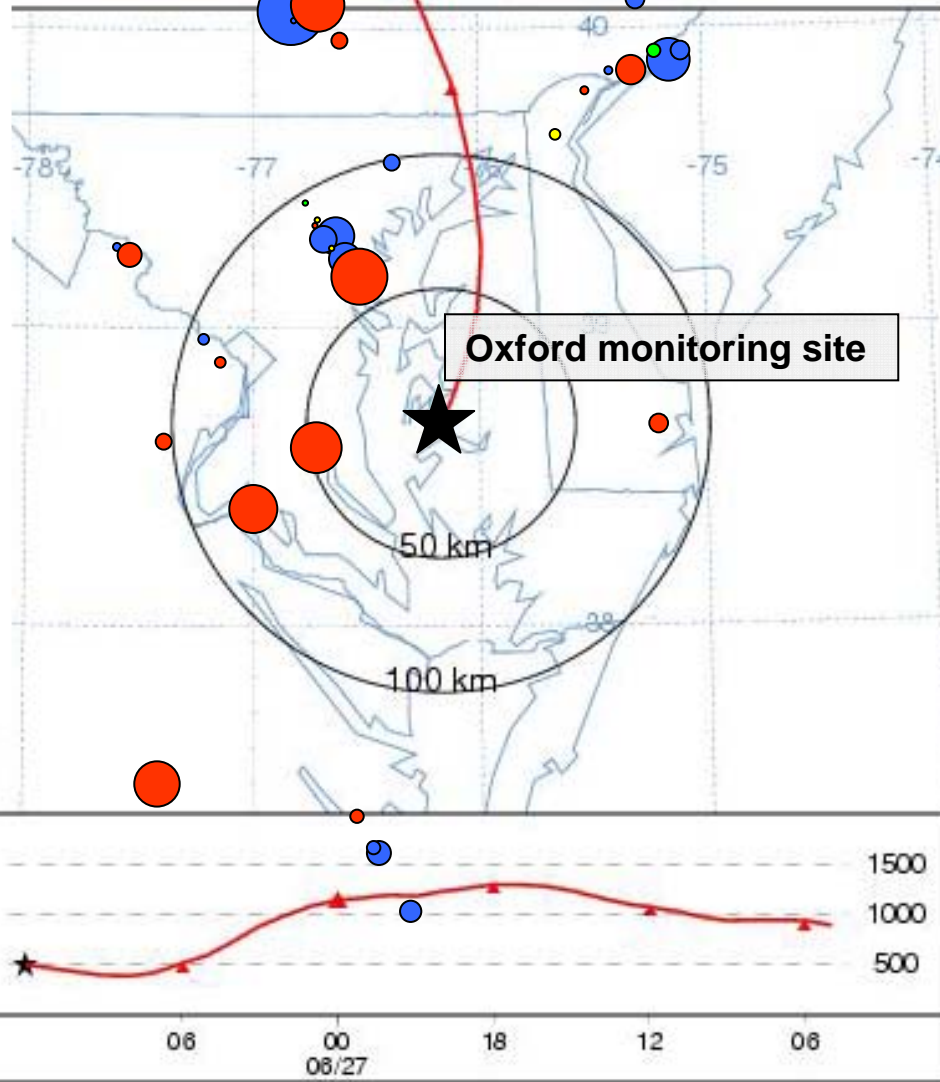
- coal-fired power plant
- waste incinerator
- manufacturing and other
- other fuel combustion

symbol size is proportional to 1999 Hg(II) emissions rate

- 150 kg/yr
- 100 kg/yr
- 50 kg/yr



NOAA HYSPLIT MODEL
 Backward trajectory ending at 12 UTC 27 Jun 04
 EDAS Meteorological Data

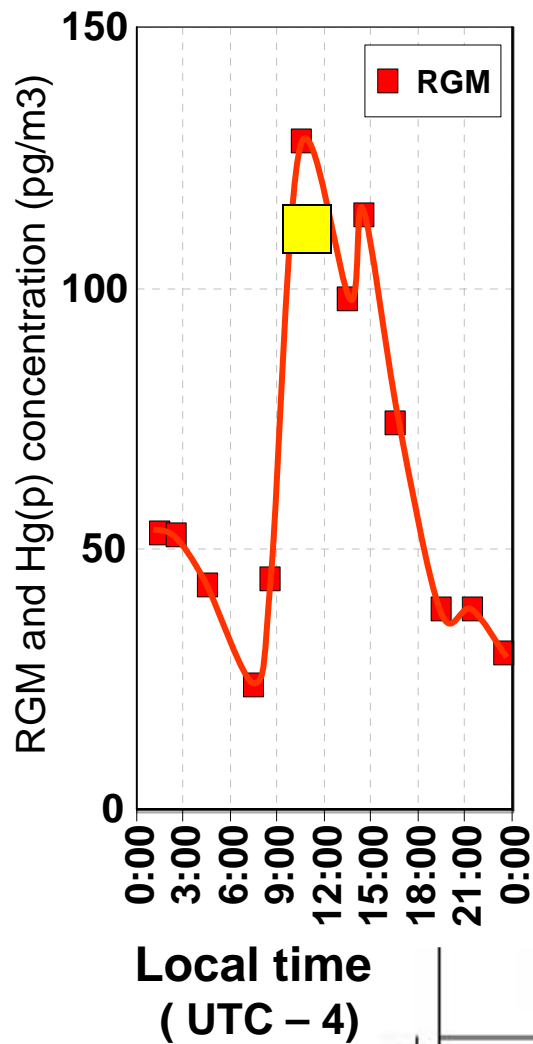


symbol color indicates type of mercury source

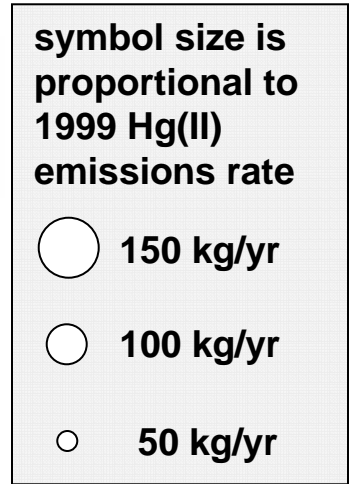
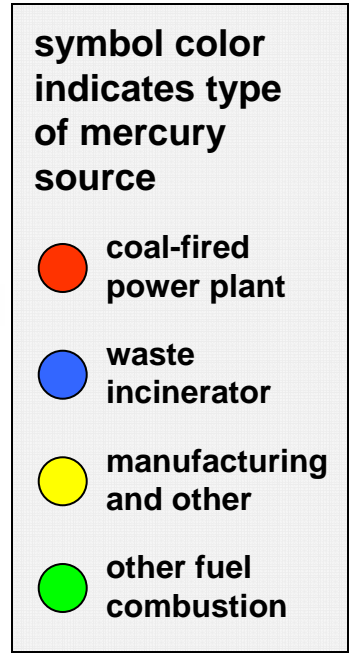
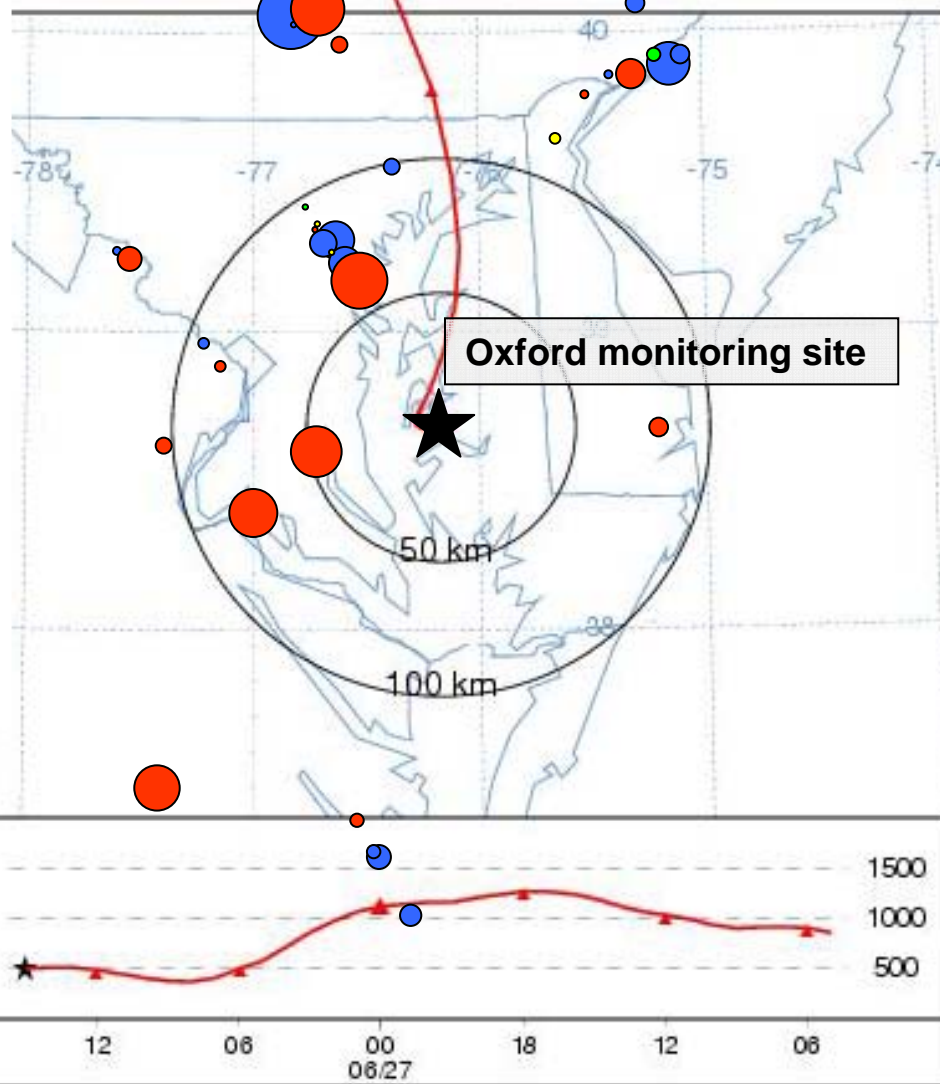
- coal-fired power plant
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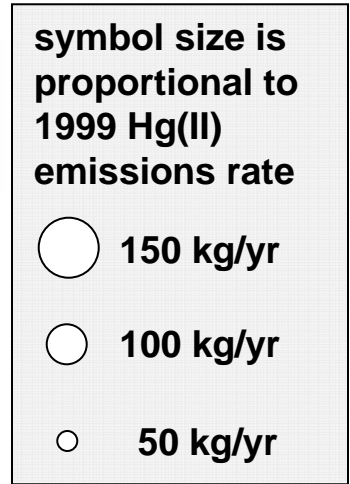
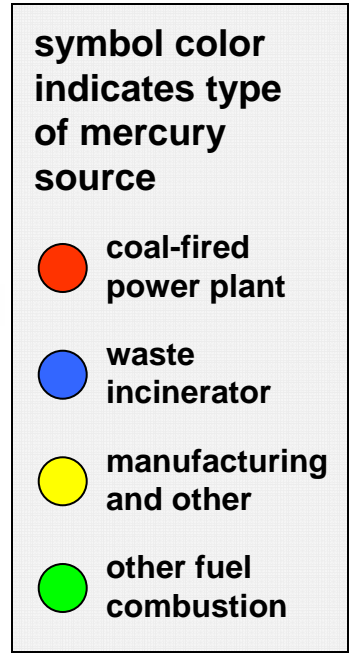
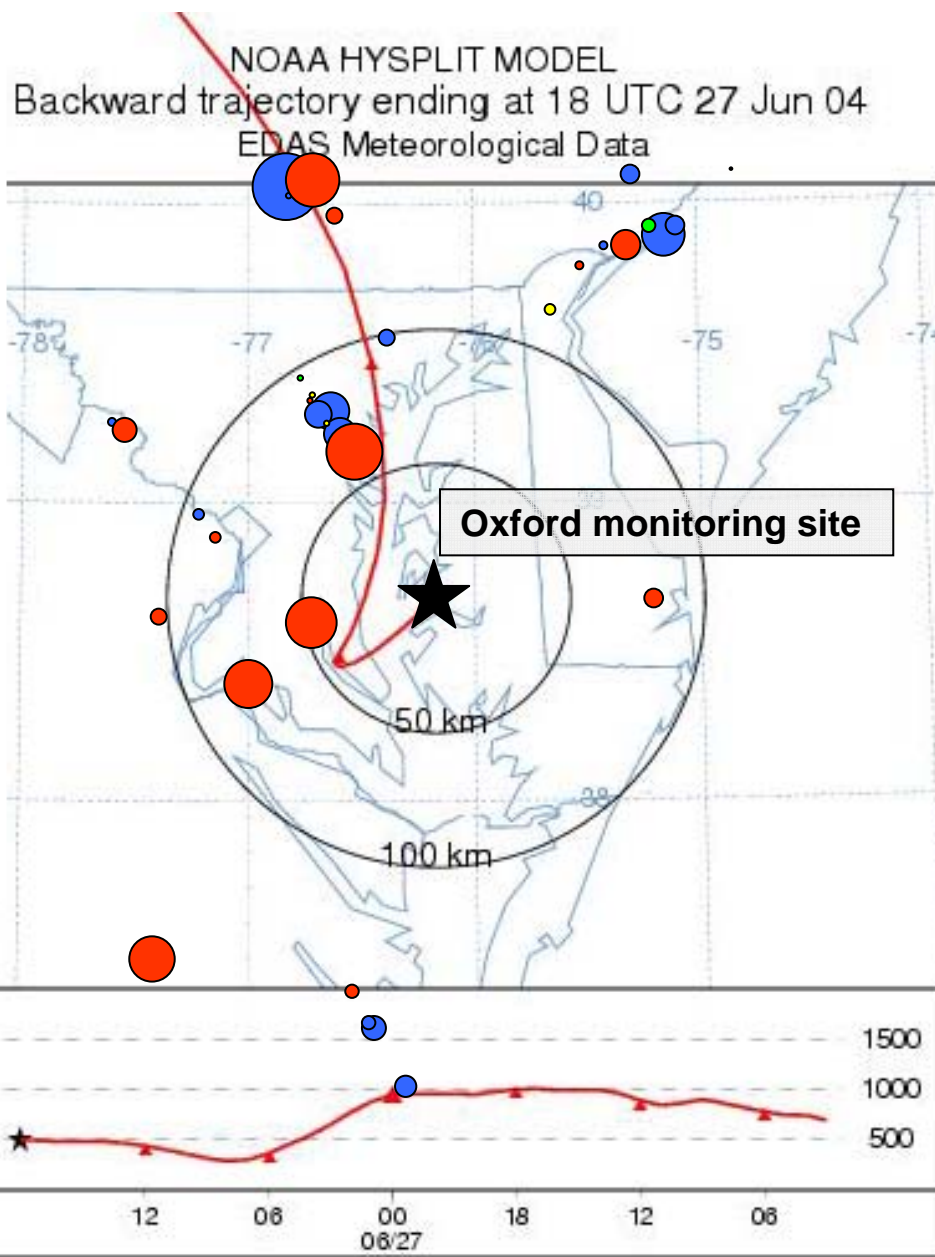
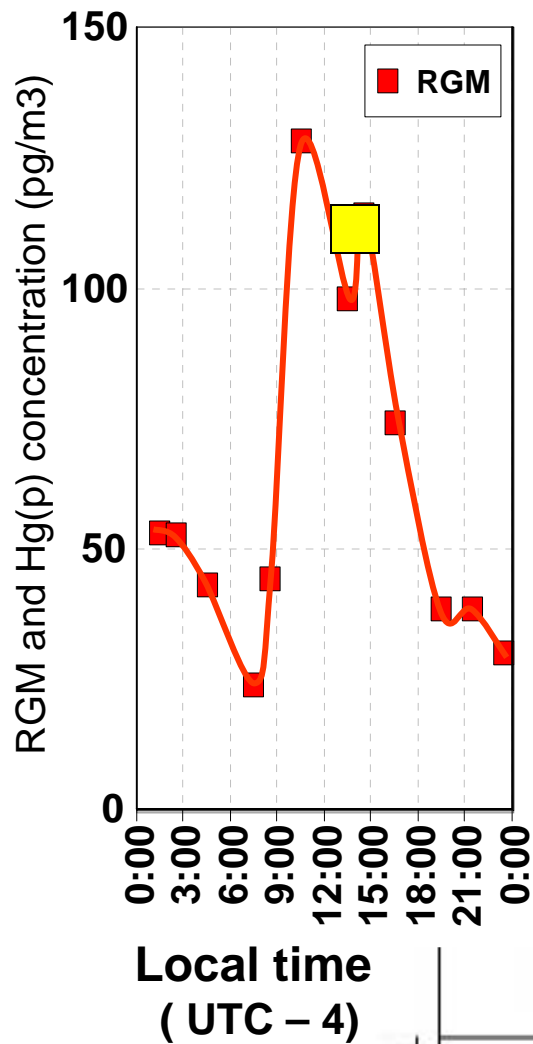
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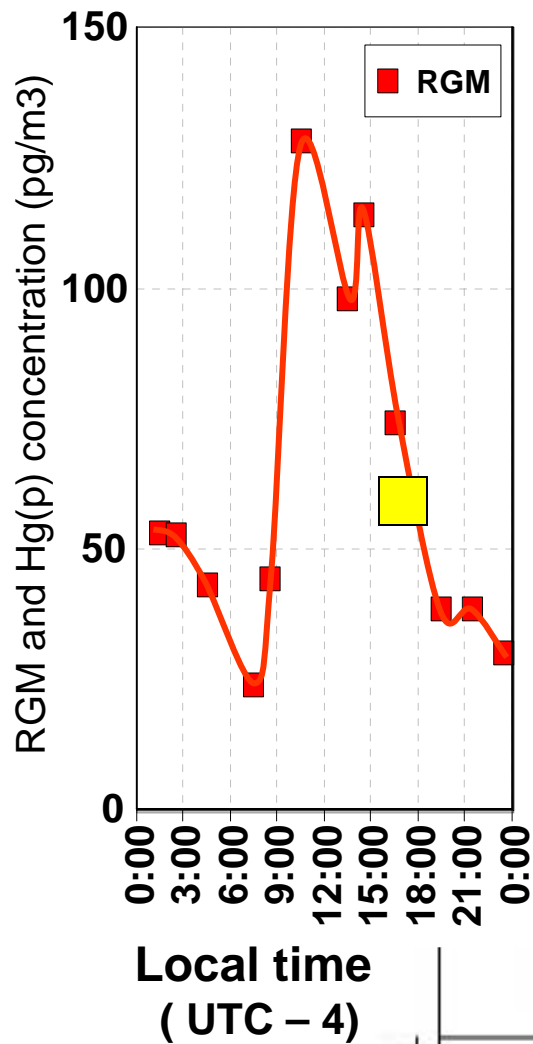
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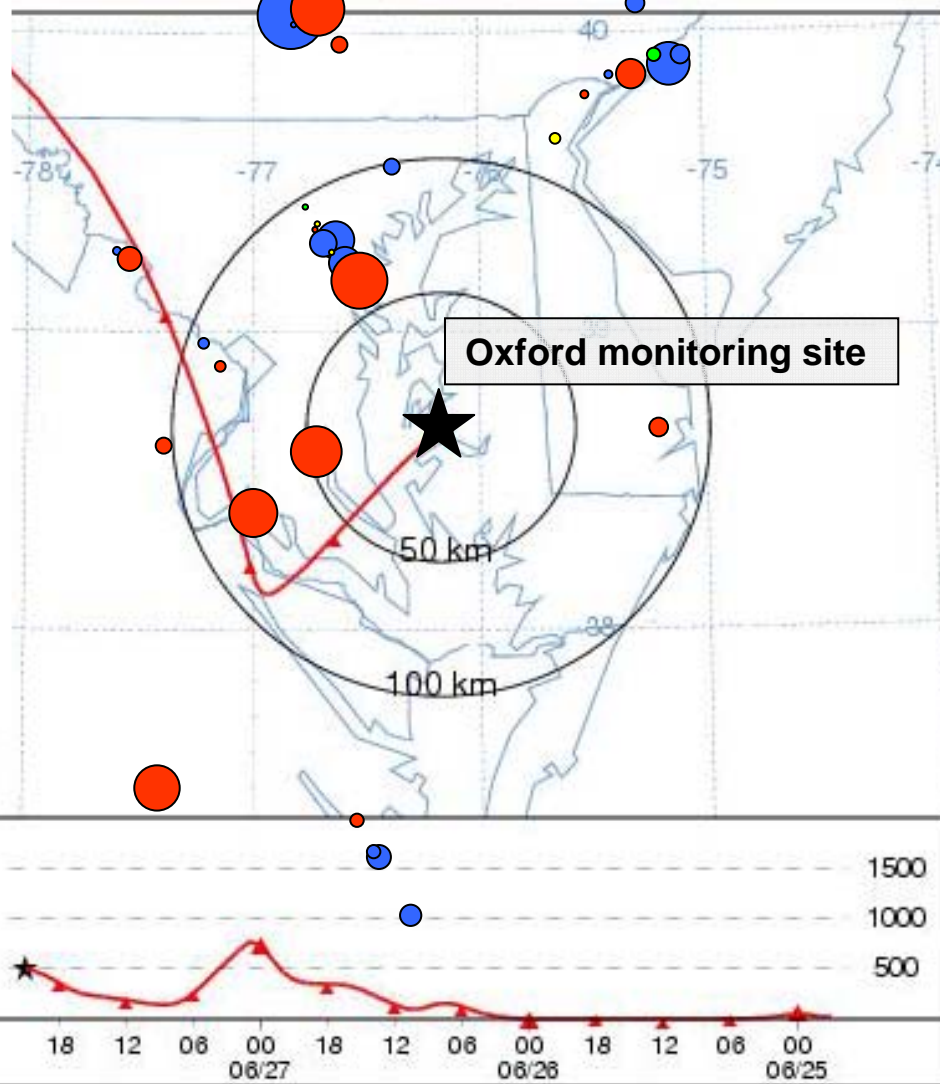
NOAA HYSPLIT MODEL
 Backward trajectory ending at 15 UTC 27 Jun 04
 EDAS Meteorological Data







NOAA HYSPLIT MODEL
 Backward trajectory ending at 21 UTC 27 Jun 04
 EDAS Meteorological Data

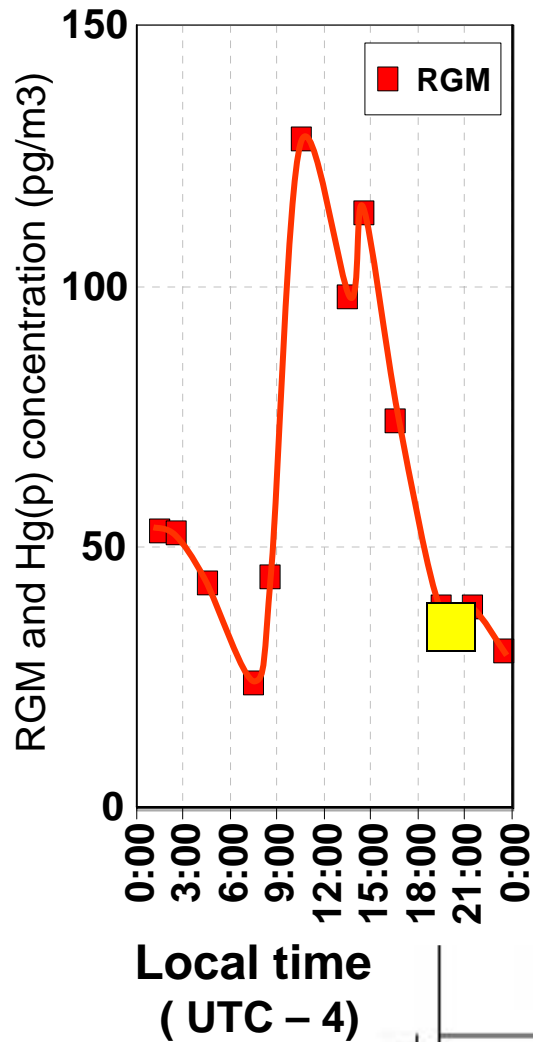


symbol color indicates type of mercury source

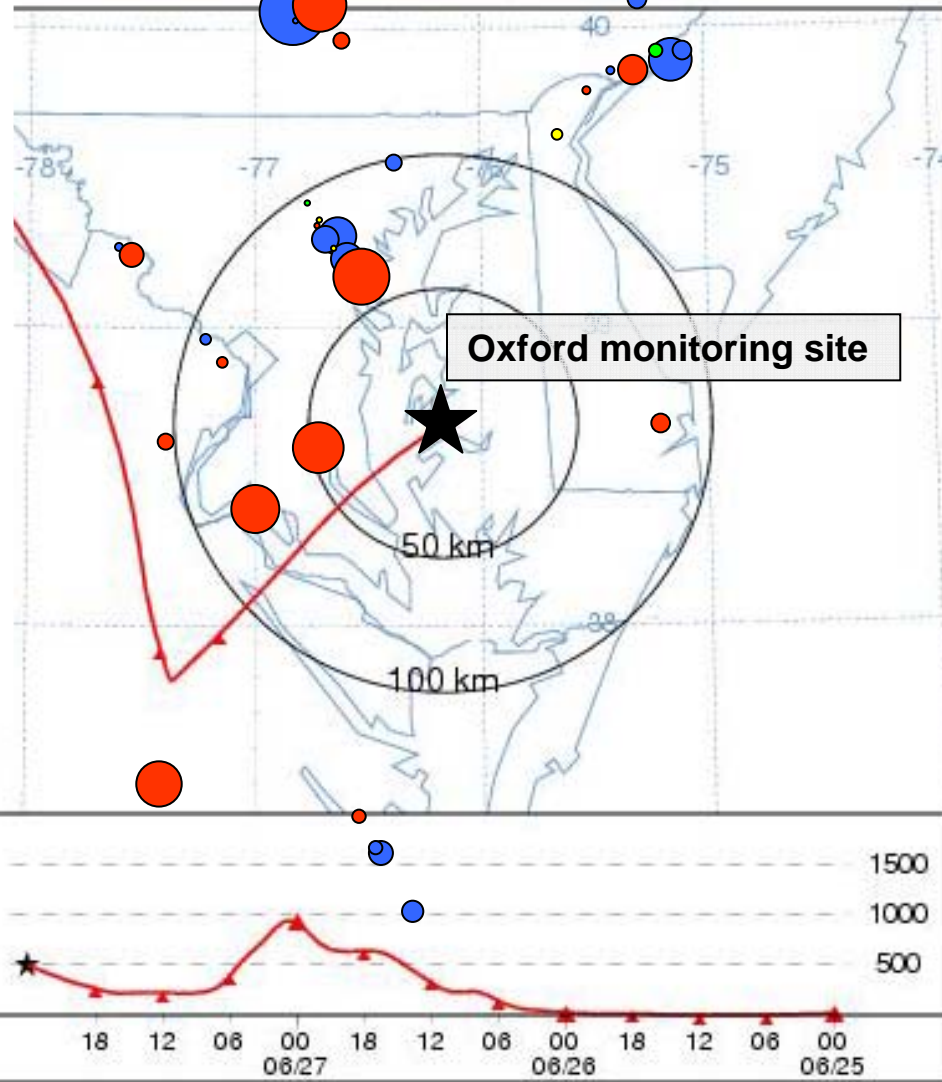
- coal-fired power plant
- waste incinerator
- manufacturing and other
- other fuel combustion

symbol size is proportional to 1999 Hg(II) emissions rate

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NOAA HYSPLIT MODEL
 Backward trajectory ending at 00 UTC 28 Jun 04
 EDAS Meteorological Data

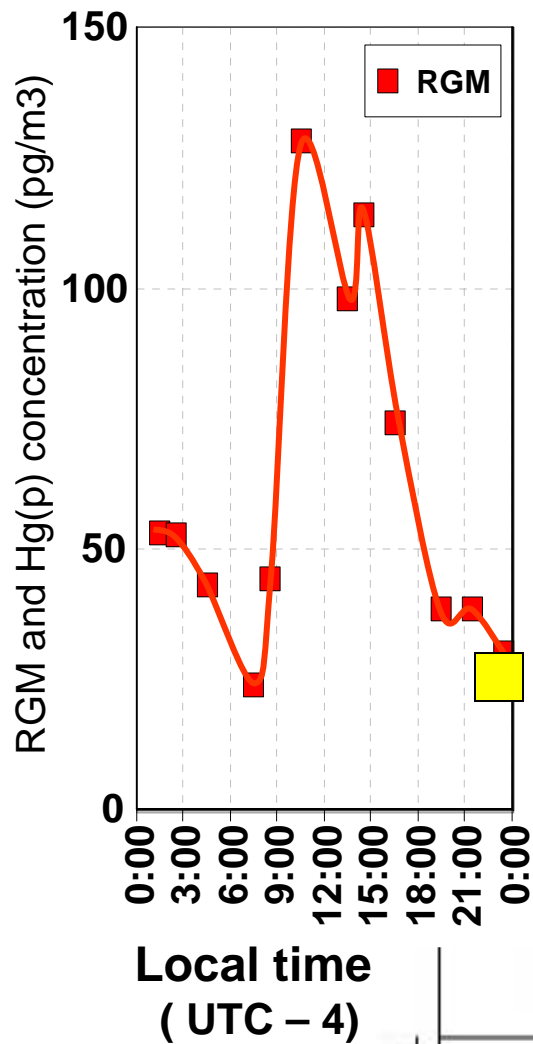


symbol color indicates type of mercury source

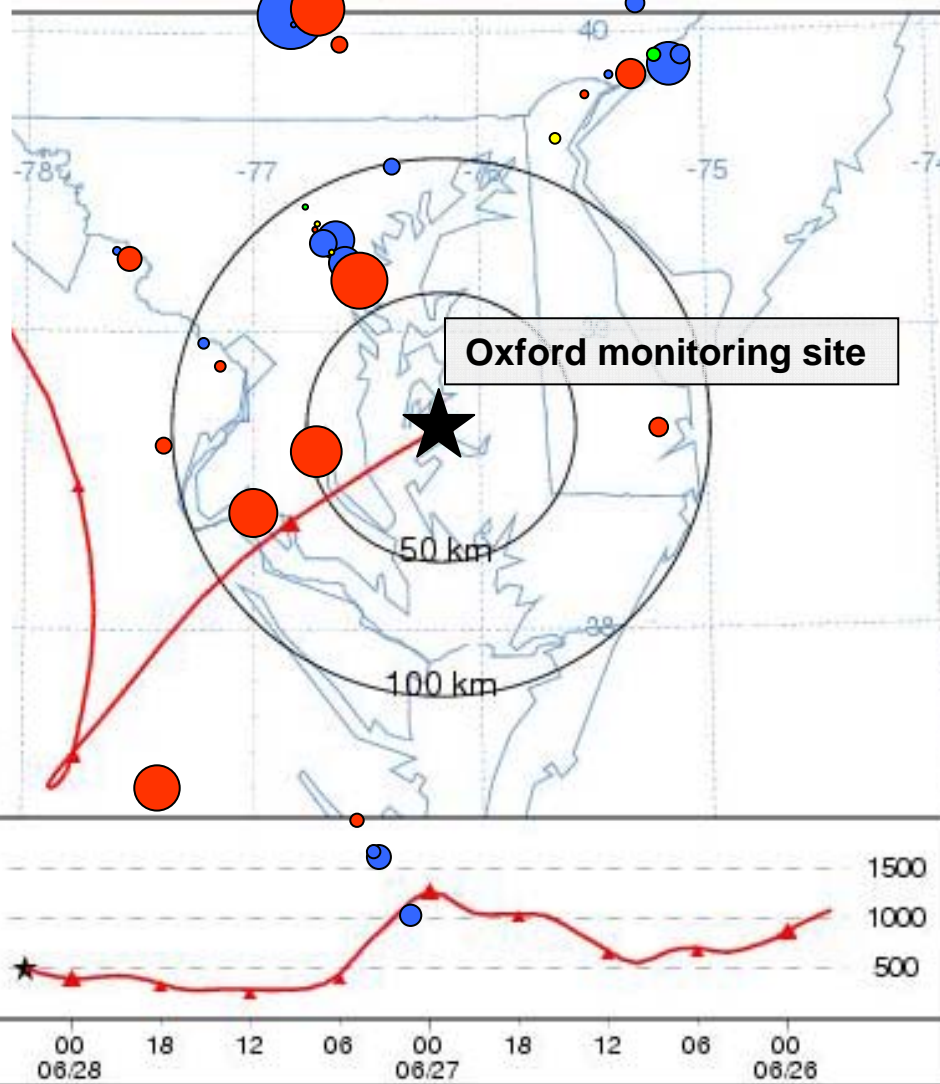
- coal-fired power plant
- waste incinerator
- manufacturing and other
- other fuel combustion

symbol size is proportional to 1999 Hg(II) emissions rate

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- 50 kg/yr



NOAA HYSPLIT MODEL
 Backward trajectory ending at 03 UTC 28 Jun 04
 EDAS Meteorological Data

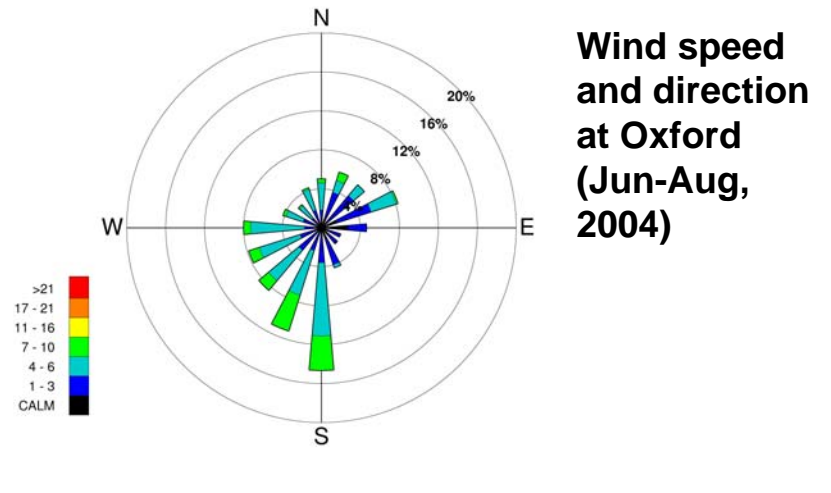
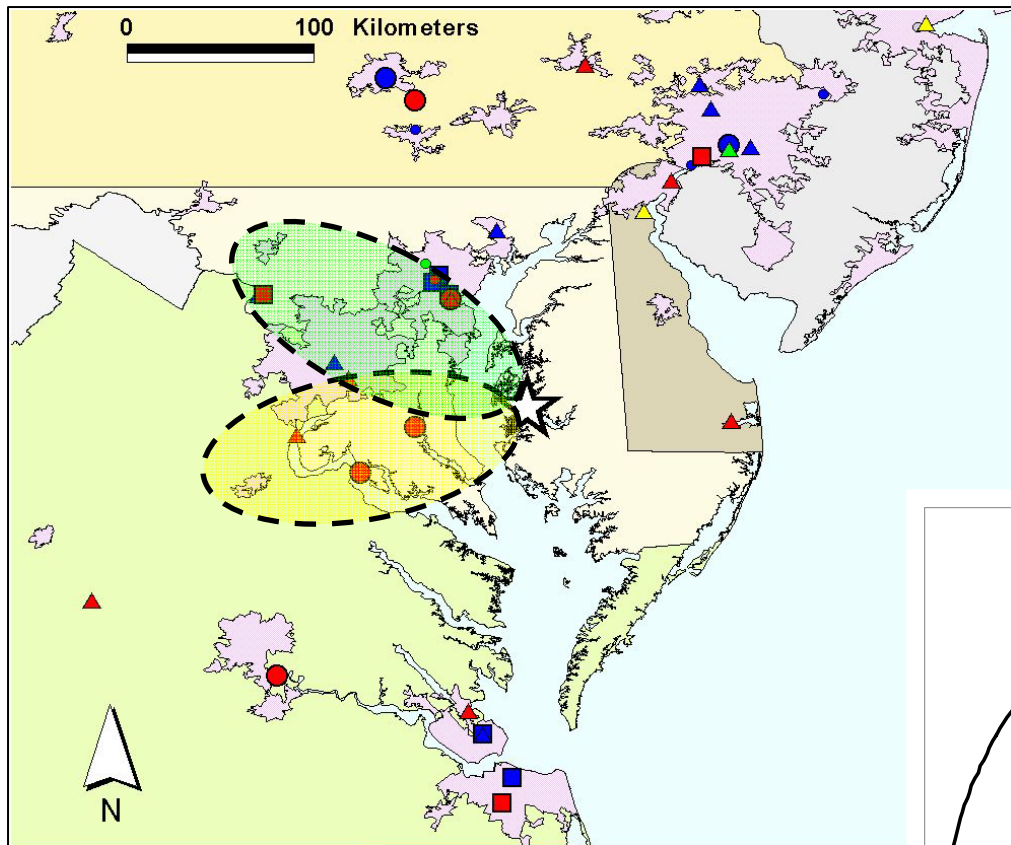


symbol color indicates type of mercury source

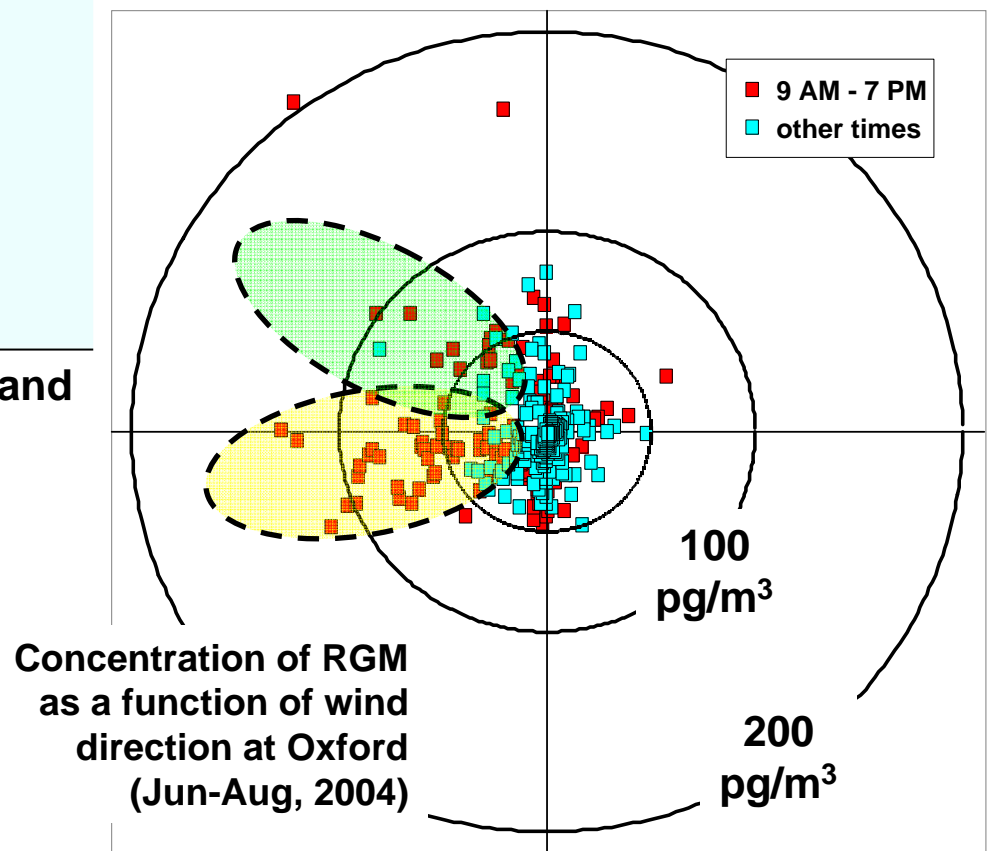
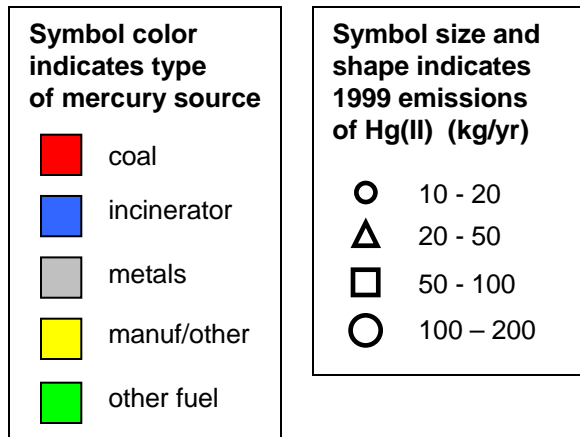
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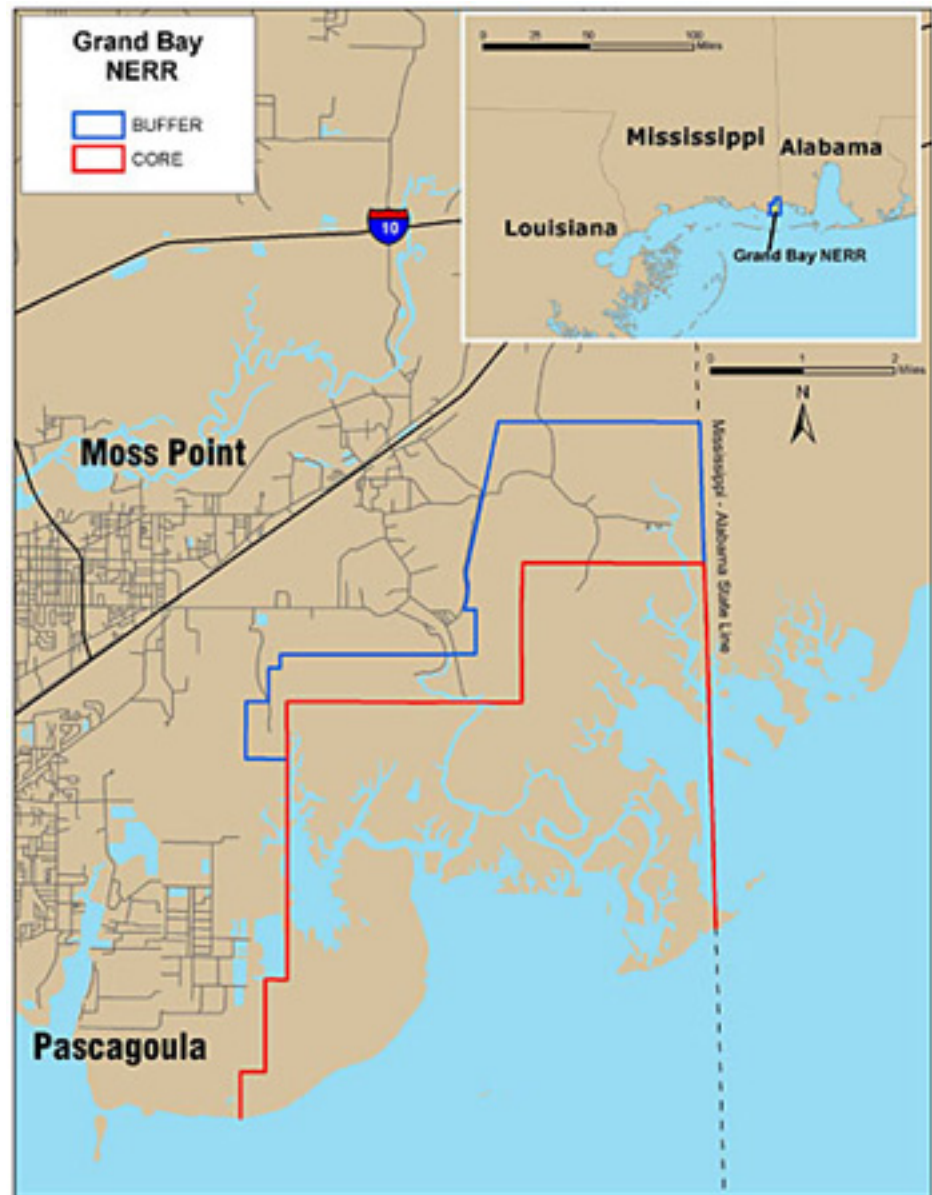


1999 RGM emissions near Oxford, Maryland

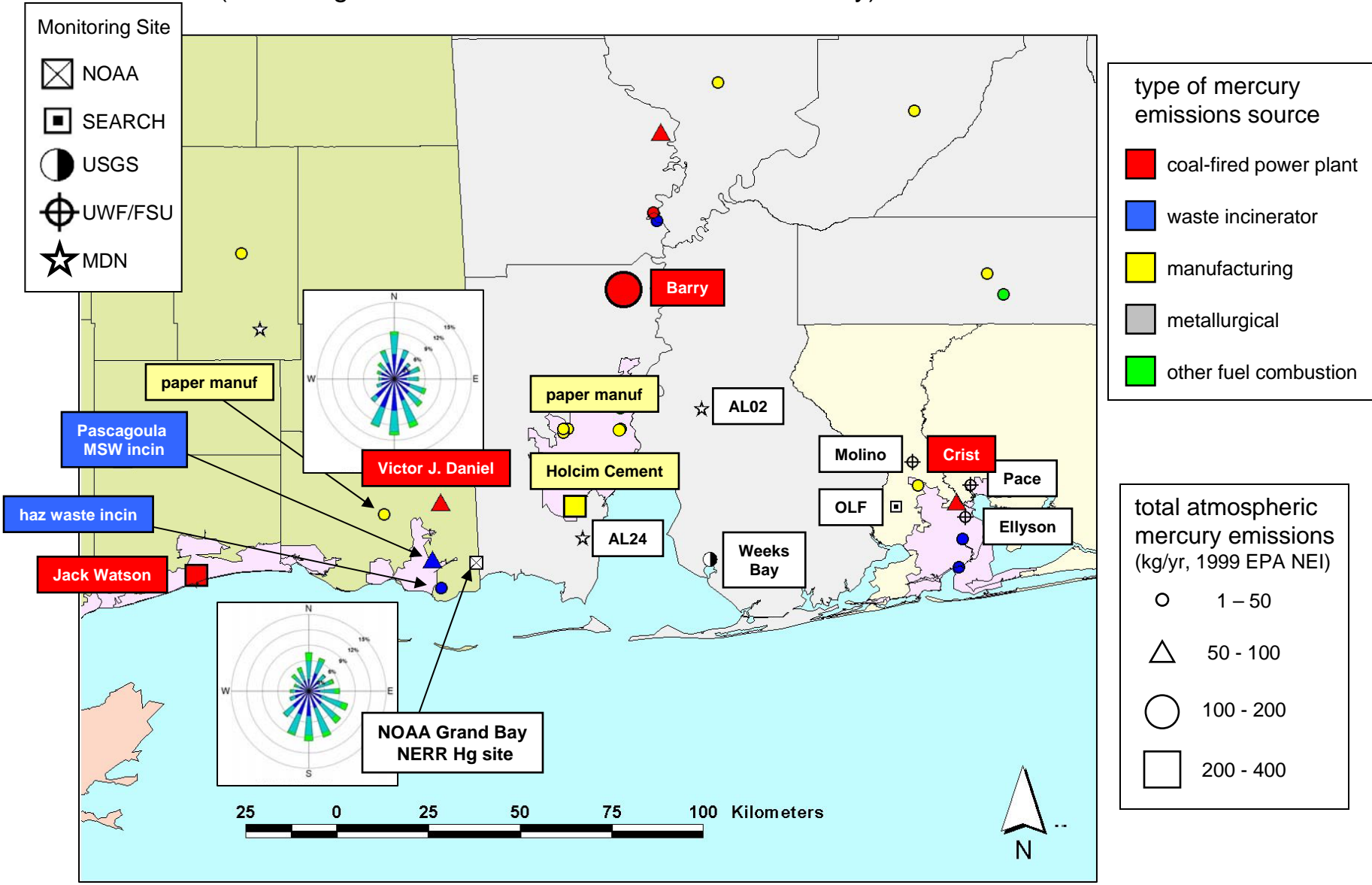


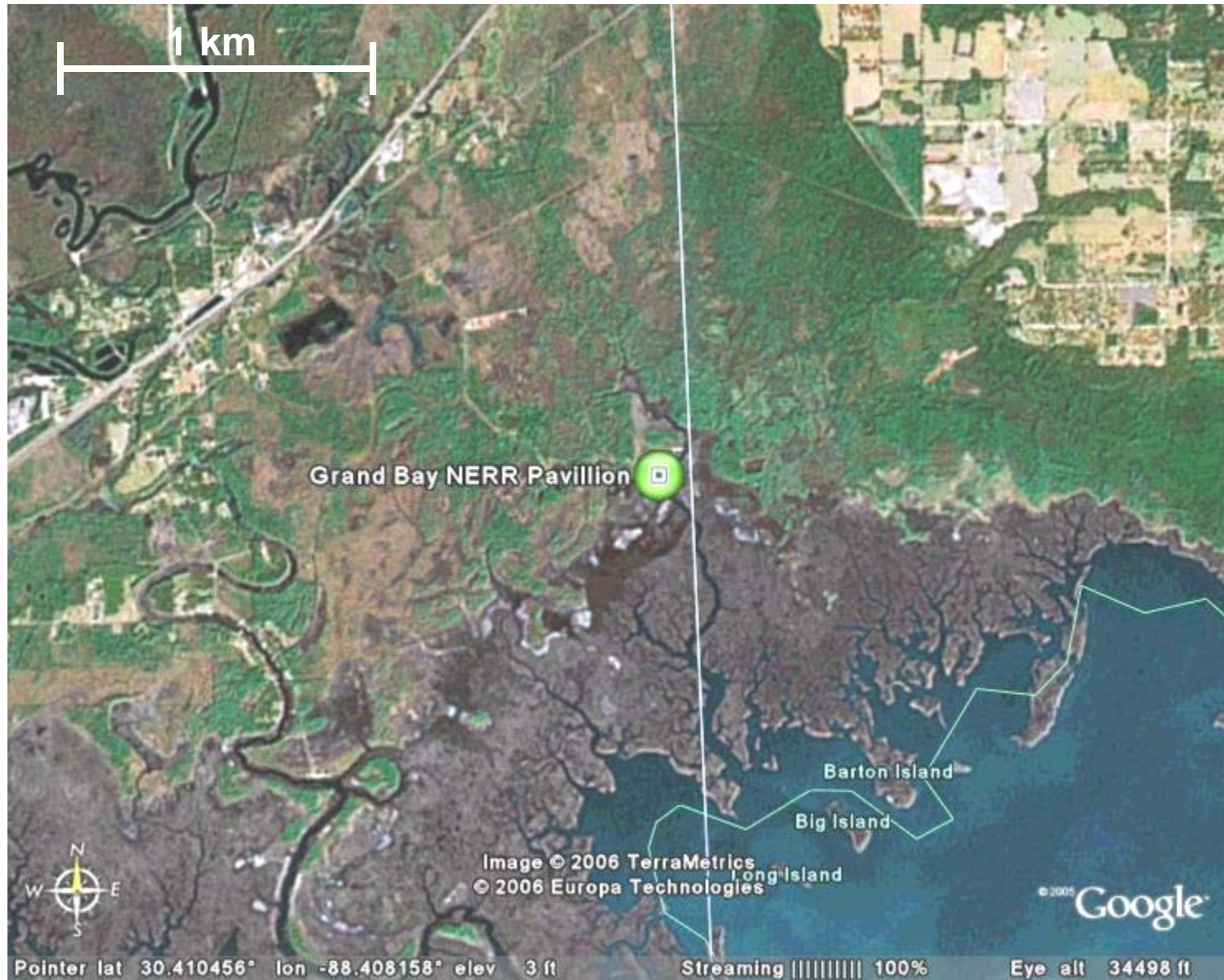
NOAA measurements of ambient concentrations of speciated atmospheric mercury at the Grand Bay National Estuarine Research Reserve, Mississippi

to begin Fall 2006



Location of the new NOAA Grand Bay NERR Atmospheric Mercury monitoring site, other atmospheric Hg monitoring sites, and major Hg point sources in the region (according to the EPA 1999 NEI emissions inventory)





1 km

Grand Bay NERR Pavillion

Barton Island

Big Island

Long Island

Image © 2006 TerraMetrics
© 2006 Europa Technologies

© 2005 Google

Pointer lat 30.410456° lon -88.408158° elev 3 ft

Streaming | 100%

Eye alt 34498 ft

U.S. Fish and Wildlife Service Pavilion at Grand Bay NERR

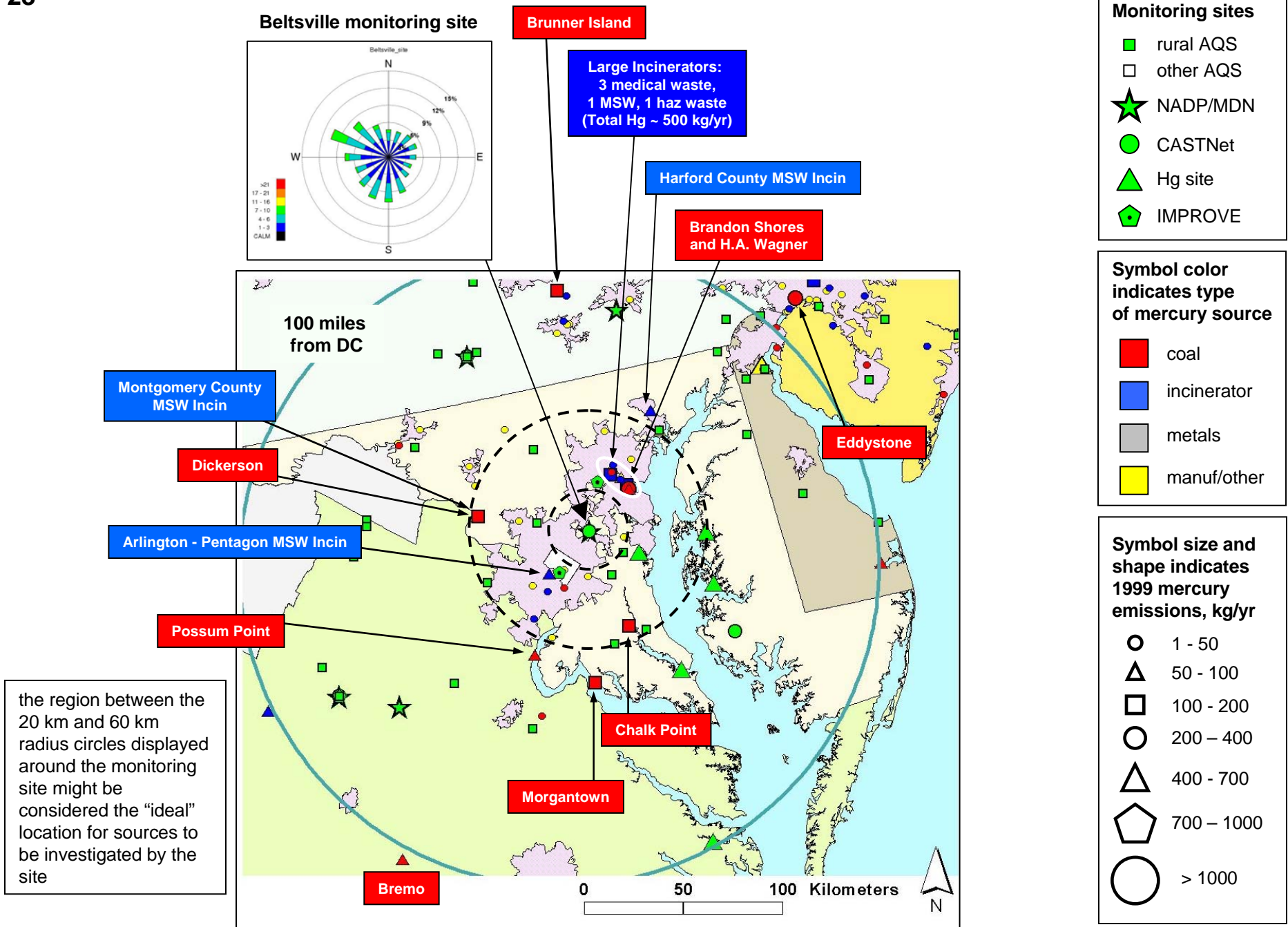


View looking south and west from the U.S. Fish and Wildlife Service Pavilion at Grand Bay NERR

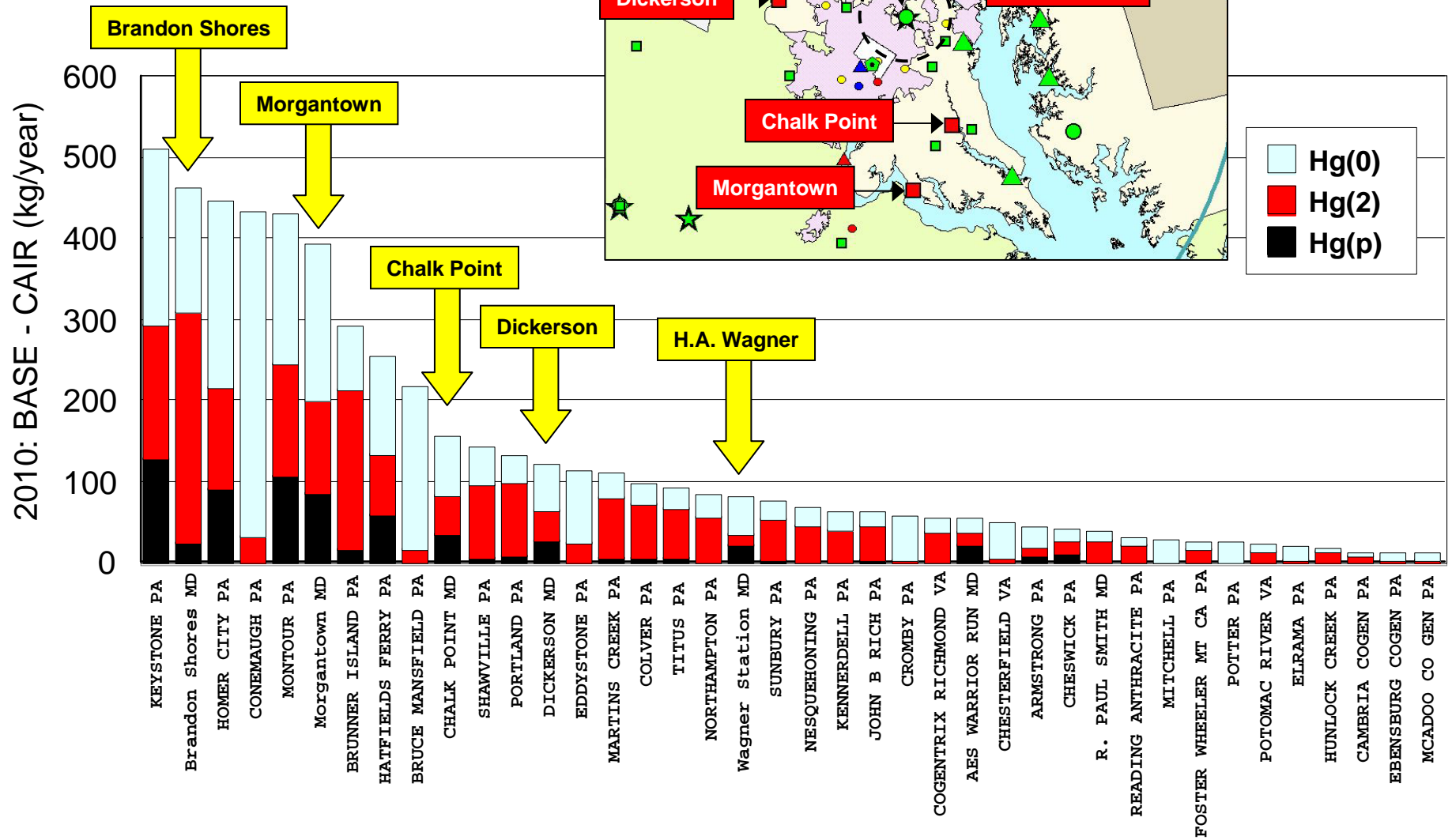


**EPA-NOAA
measurements of
ambient concentrations
of speciated
atmospheric mercury
at Beltsville Maryland**

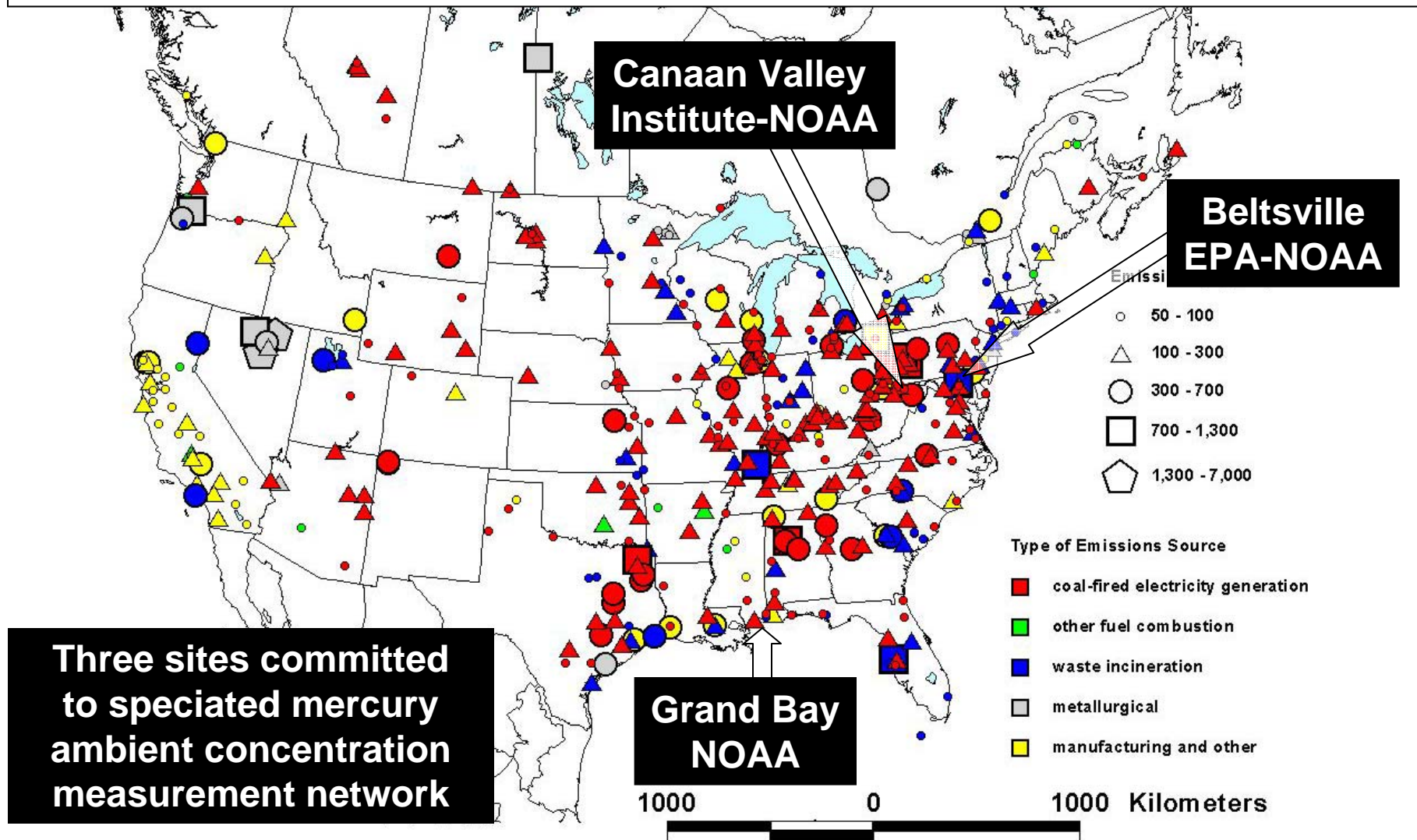
to begin Fall-Winter 2006



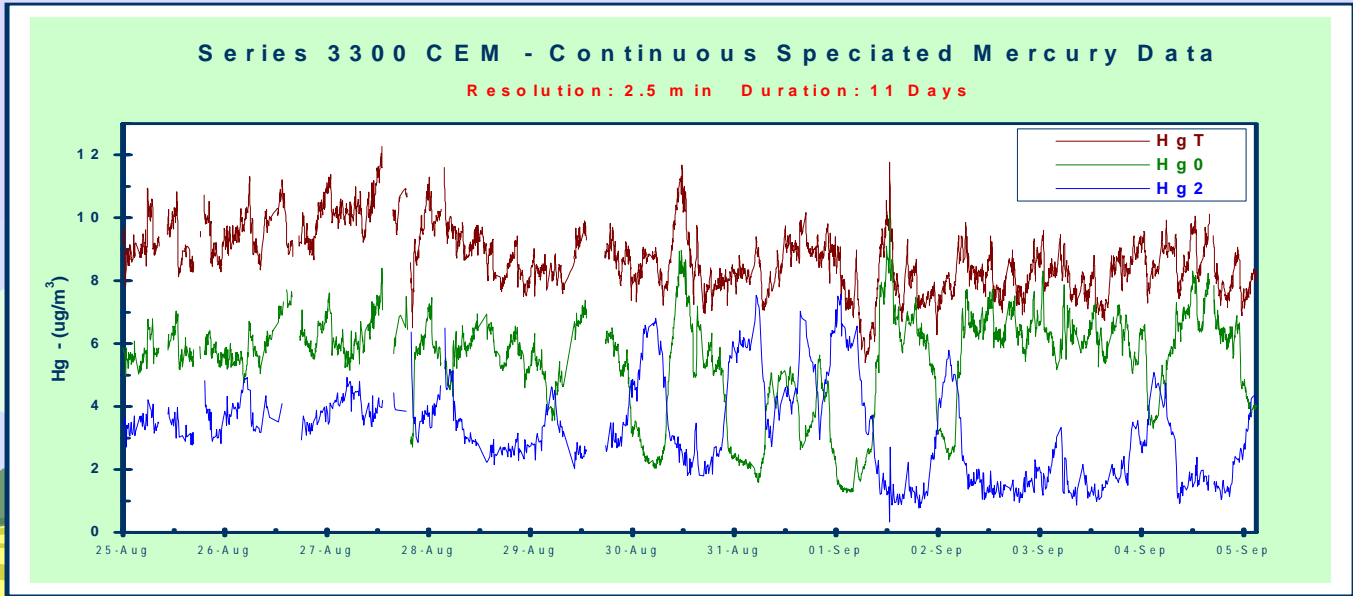
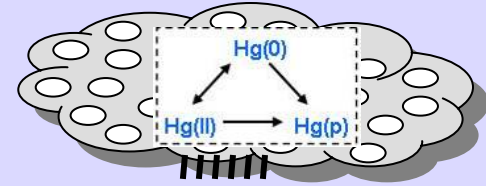
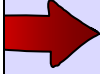
Coal-fired power plants in MD, VA, PA, and DE with the largest projected differences between 2010 base and 2010 Clean Air Interstate Rule (CAIR) emissions



Largest sources of total mercury emissions to the air in the U.S. and Canada, based on the U.S. EPA 1999 National Emissions Inventory and 1995-2000 data from Environment Canada



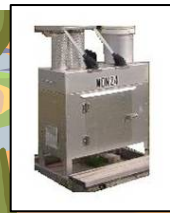
Hg from other sources: local, regional & more distant



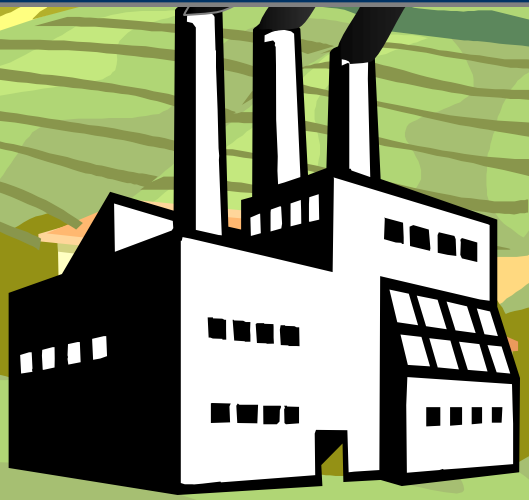
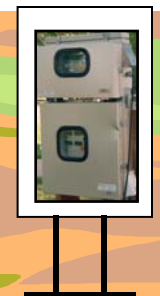
atmospheric deposition to the water surface



Measurement of wet deposition

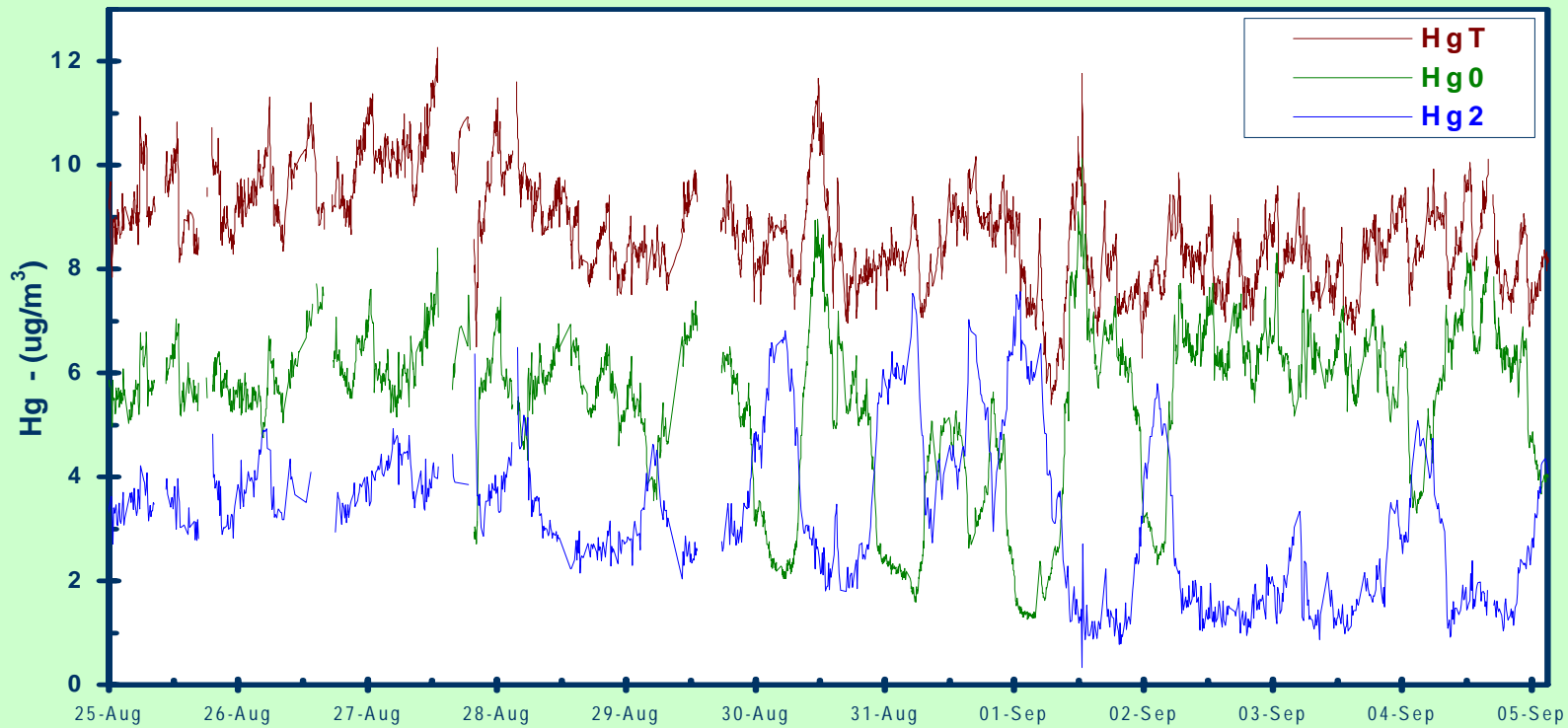


Measurement of ambient air concentrations



Series 3300 CEM - Continuous Speciated Mercury Data

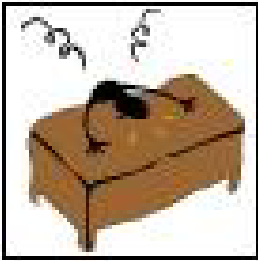
Resolution: 2.5 min Duration: 11 Days



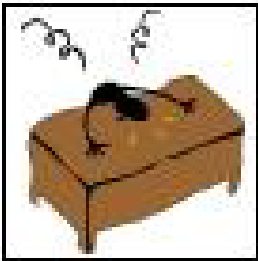
***Thanks to Marty Keller, Senior Applications Engineer,
Tekran Instruments Corporation, for providing this graph!***

Temporal Problems with Emissions Inventories

Variations on time scales of minutes to hours

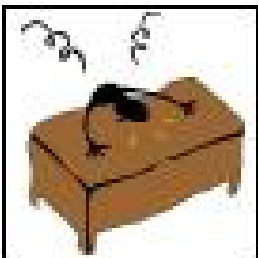


- *CEM's needed – and not just on coal-fired power plants*
- *CEM's must be speciated or of little use in developing critical source-receptor information*
- *Clean Air Mercury Rule only requires ~weekly total-Hg measurements, for purposes of trading*



We don't have information about major events

- *e.g., maintenance or permanent closures, installation of new pollution control devices, process changes*
- *Therefore, difficult to interpret trends in ambient data*



Long delay before inventories released

- *2002 inventory is being released this year in U.S.; till now, the latest available inventory was for 1999*
- *How can we use new measurement data?*

Overall Budget of Power Plant

$$1000 \text{ MW} \times \$0.10/\text{kw-hr} \\ = \$1,000,000,000 \text{ per year}$$

Speciation Continuous Emissions Monitor (CEM):

~\$200,000 to purchase/install

Amortize over 4 yrs: ~\$50,000/yr

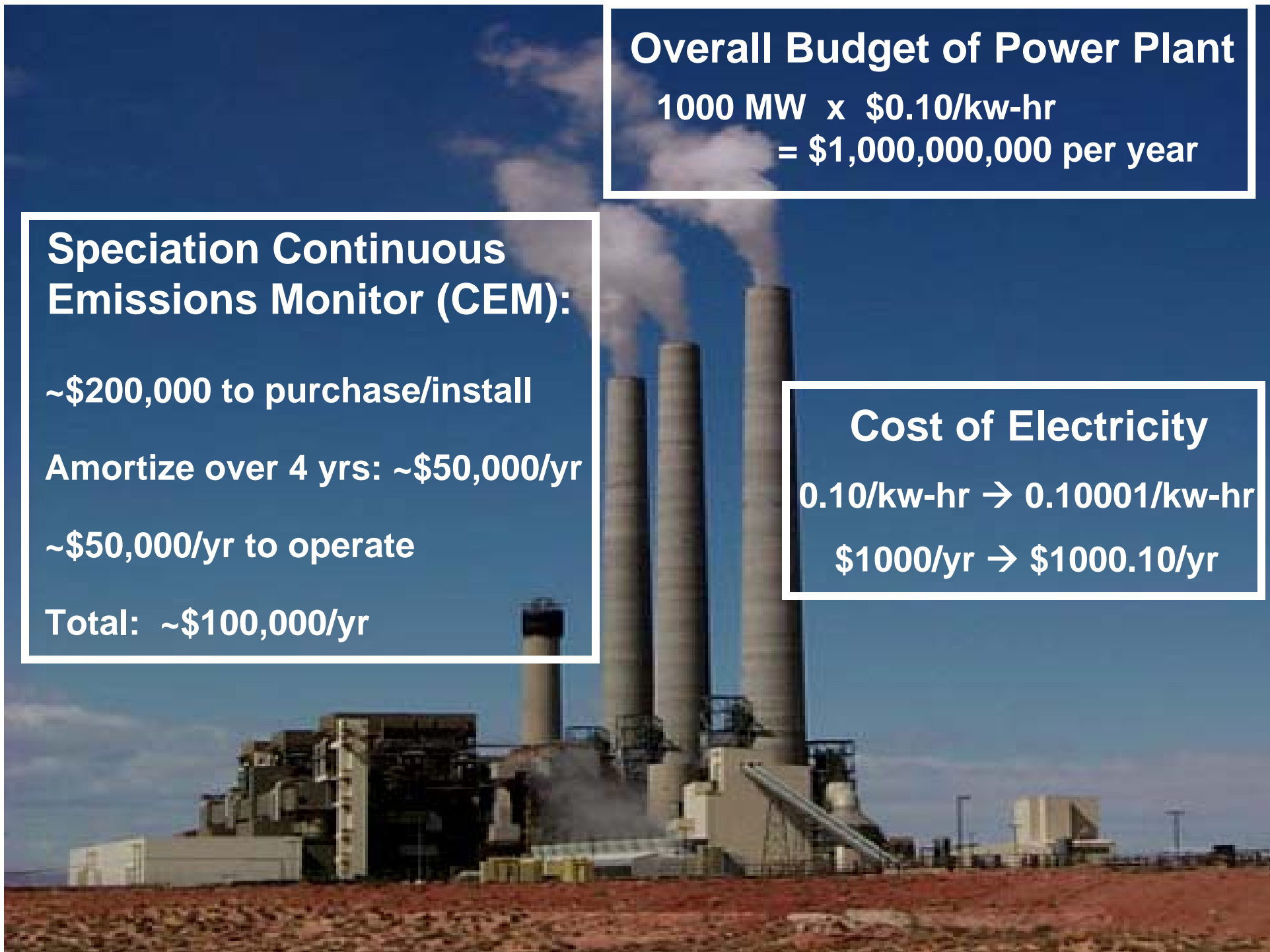
~\$50,000/yr to operate

Total: ~\$100,000/yr

Cost of Electricity

0.10/kw-hr \rightarrow 0.10001/kw-hr

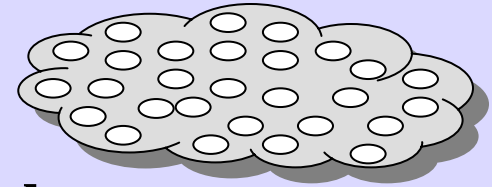
\$1000/yr \rightarrow \$1000.10/yr



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): *collaboration on multimedia Hg modeling*
- ❑ David Schmeltz, Gary Lear, John Schakenbach, Scott Hedges, Rey Forte (EPA): *collaboration on Hg models and /measurements, including new EPA-NOAA Hg monitoring site at Beltsville, MD.*
- ❑ 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*

Thanks!



For more information on this research:

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

