Atmospheric Mercury Trends

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O_3, SO_2, NOy, SO_4^{-2} Aerosols and CO

PAR/Solar Radiation

PM2.5 and PM10 (quantity and chemistry: IMPROVE)

OC/EC

Meteorology (WS, WD, RASS)

Wet Deposition (Total Mercury)

Mercury in Ambient Air: GOM, PBM2.5, and GEM

Question

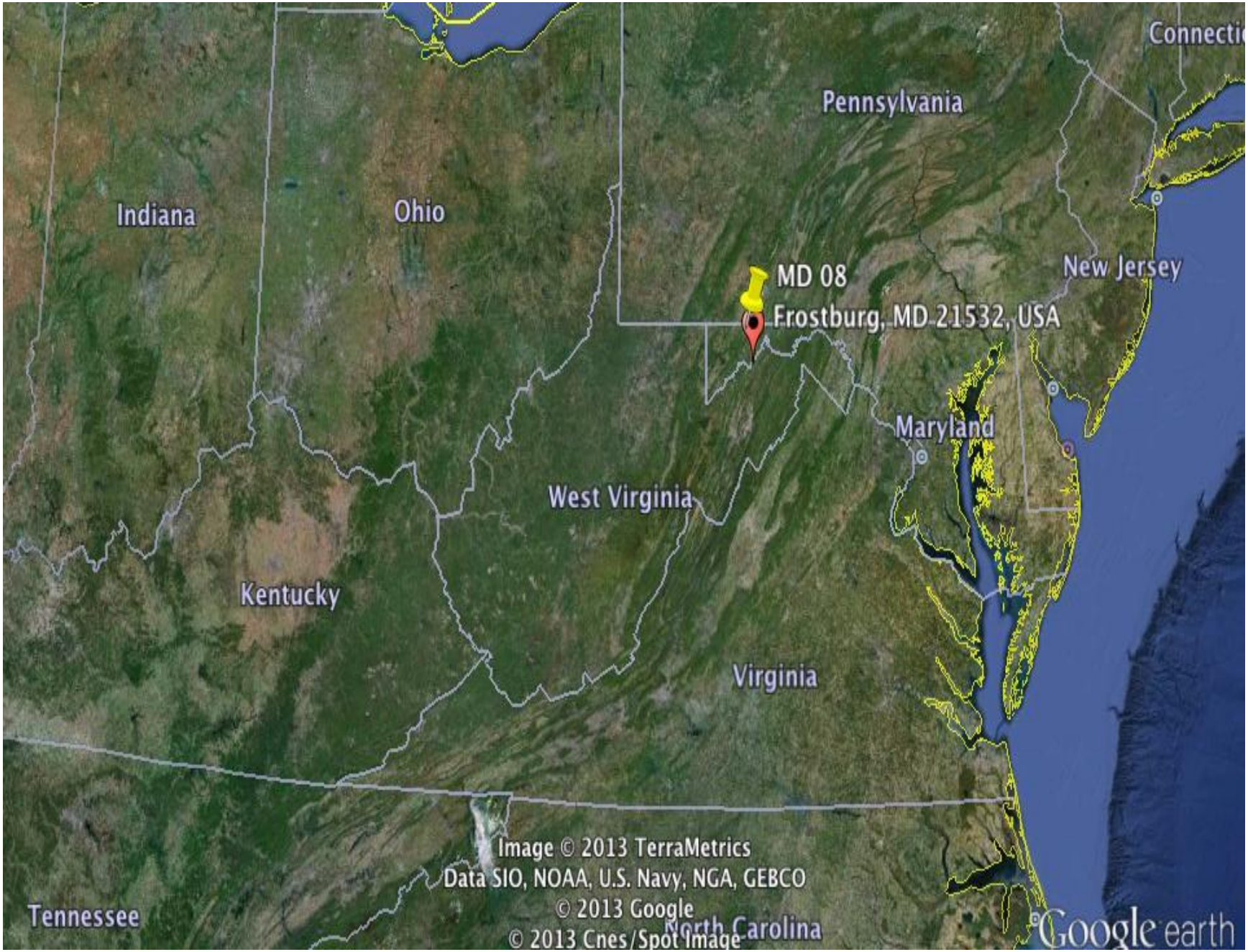
Have reductions in mercury emissions from US power plants lowered wet and dry deposition of mercury compounds?

---Note, I am using ambient air concentrations as a surrogate for dry deposition.---

Approach

Examine Power Plant Emission Trends (EPA's Toxic Release Inventory, TRI).

Compare emission patterns with measurements of wet deposition and ambient air concentrations of mercury compounds (surrogate for dry deposition).


Connecti
Pennsylvania
Indiana
Ohio
MD 08
Frostburg, MD 21532, USA
New Jersey
Maryland
West Virginia
Kentucky
Virginia
Tennessee
North Carolina
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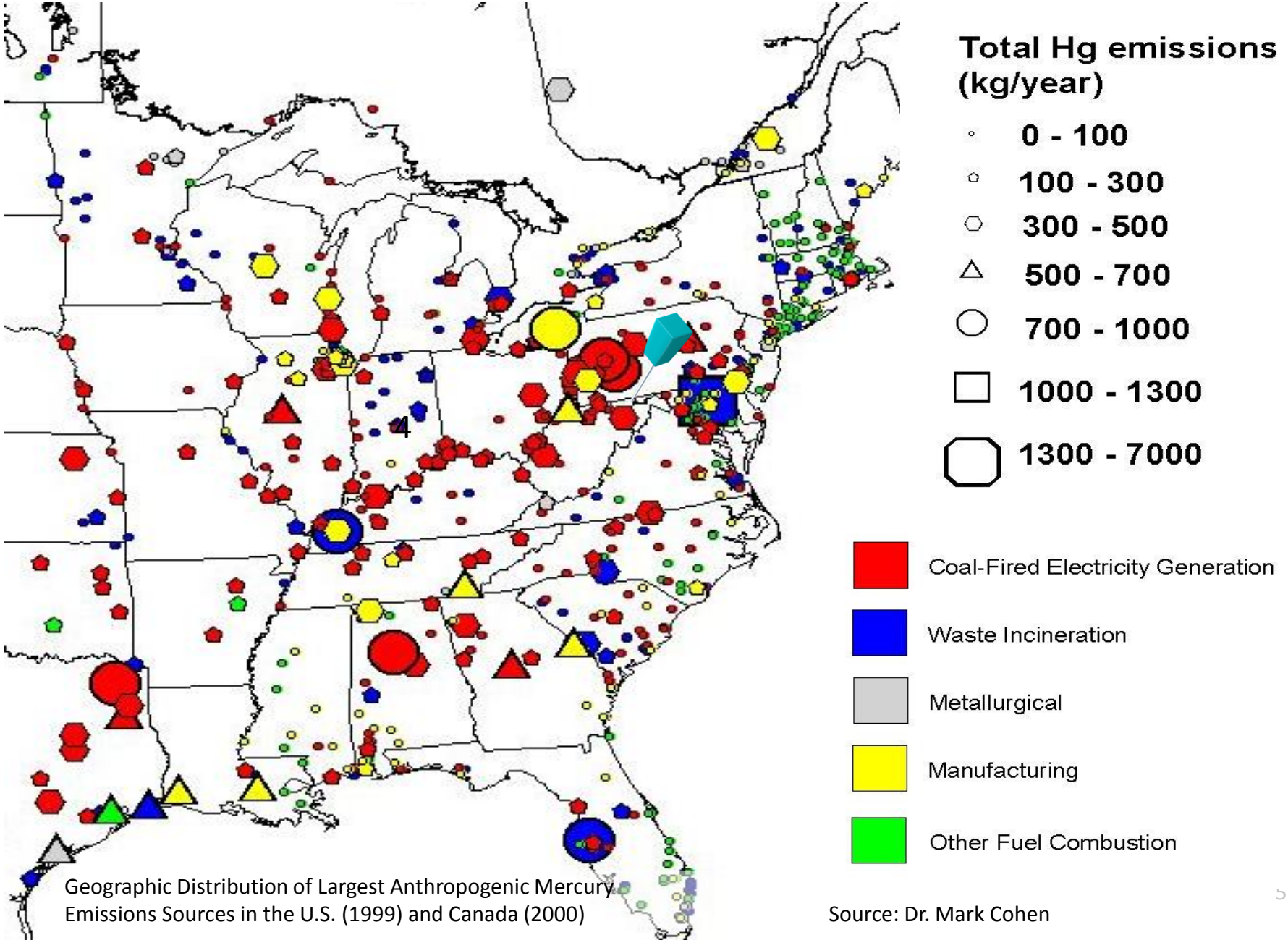
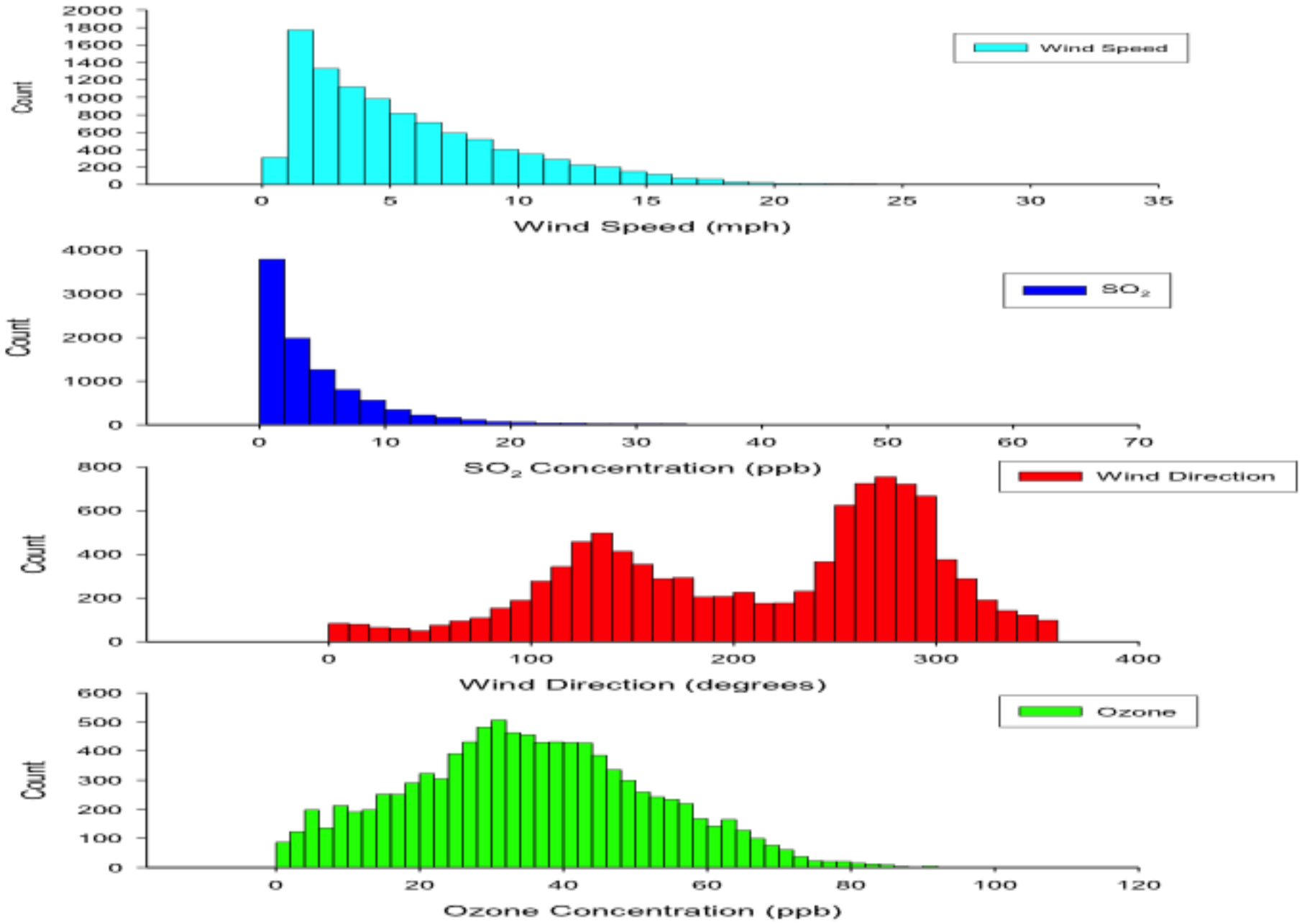


Geographic Distribution of Largest Anthropogenic Mercury Emissions Sources in the U.S. (1999) and Canada (2000)

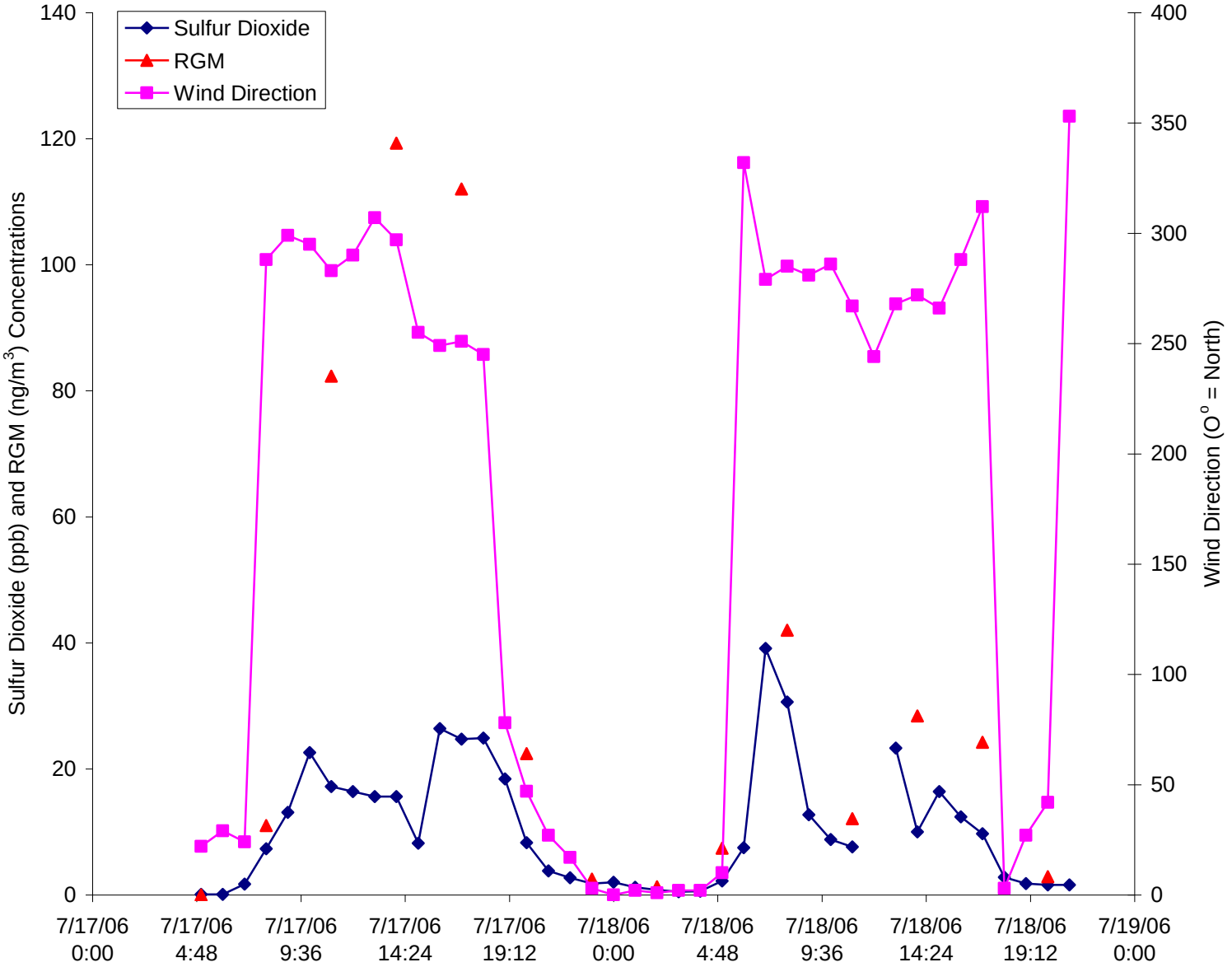
Source: Dr. Mark Cohen

State	National Rank 2010	2010 Hg Emissions (lbs)
Ohio	2	4,218
Pennsylvania	3	3,964
West Virginia	7	2,495
Virginia	27	659
Maryland	39	155

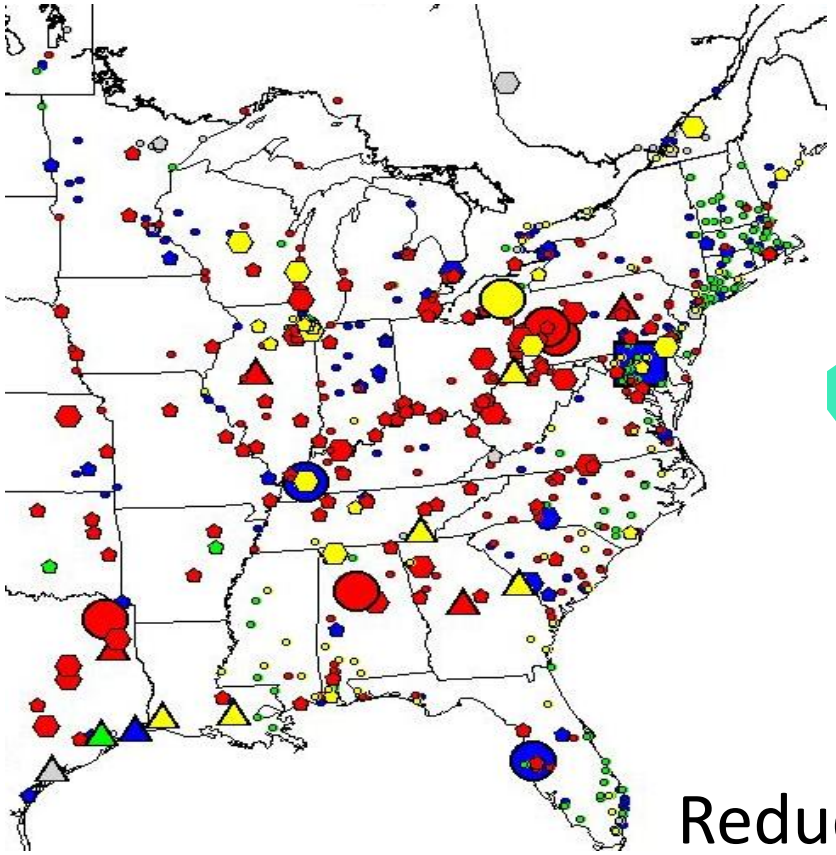
Source: America's Biggest Mercury Polluters, Environment America Research and Policy Center, November 2011

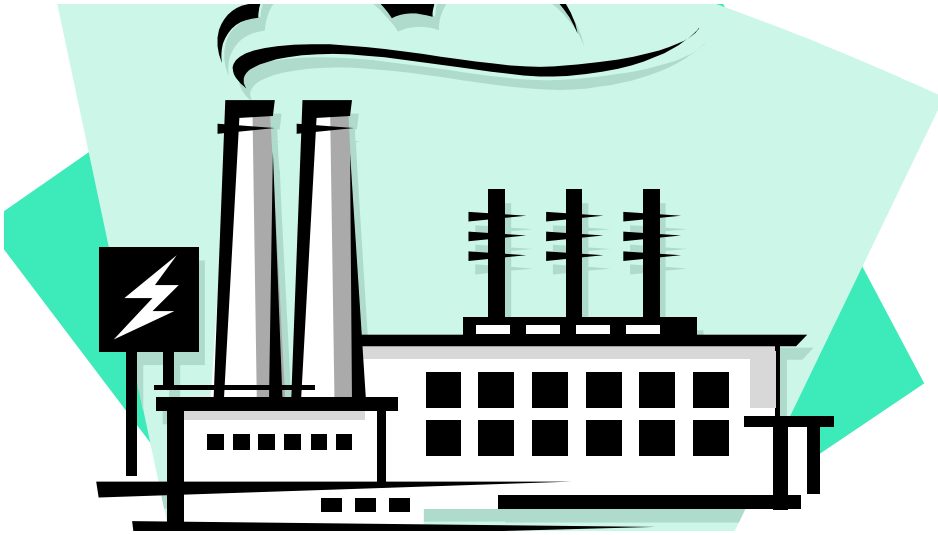

Count
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
5
10
15
20
25
30
35
Wind Speed (mph)
Wind Speed
Count
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
SO2 Concentration (ppb)
SO2
Count
800
600
400
200
0
0
100
200
300
400
Wind Direction (degrees)
Wind Direction
Count
600
500
400
300
200
100
0
0
20
40
60
80
100
120
Ozone Concentration (ppb)
Ozone

July 2006: GOM and Sulfur Dioxide Event



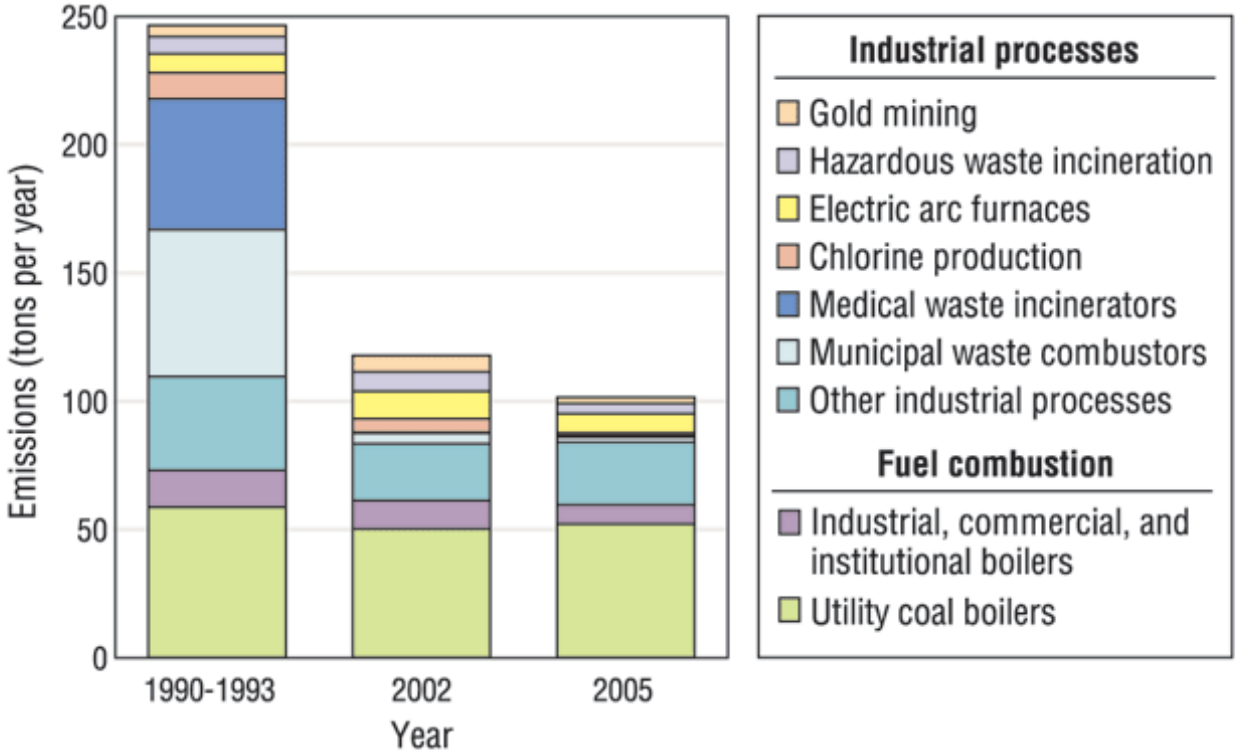
Mercury Emissions From Power Plants





Reductions in mercury emissions, 1990s to 2011

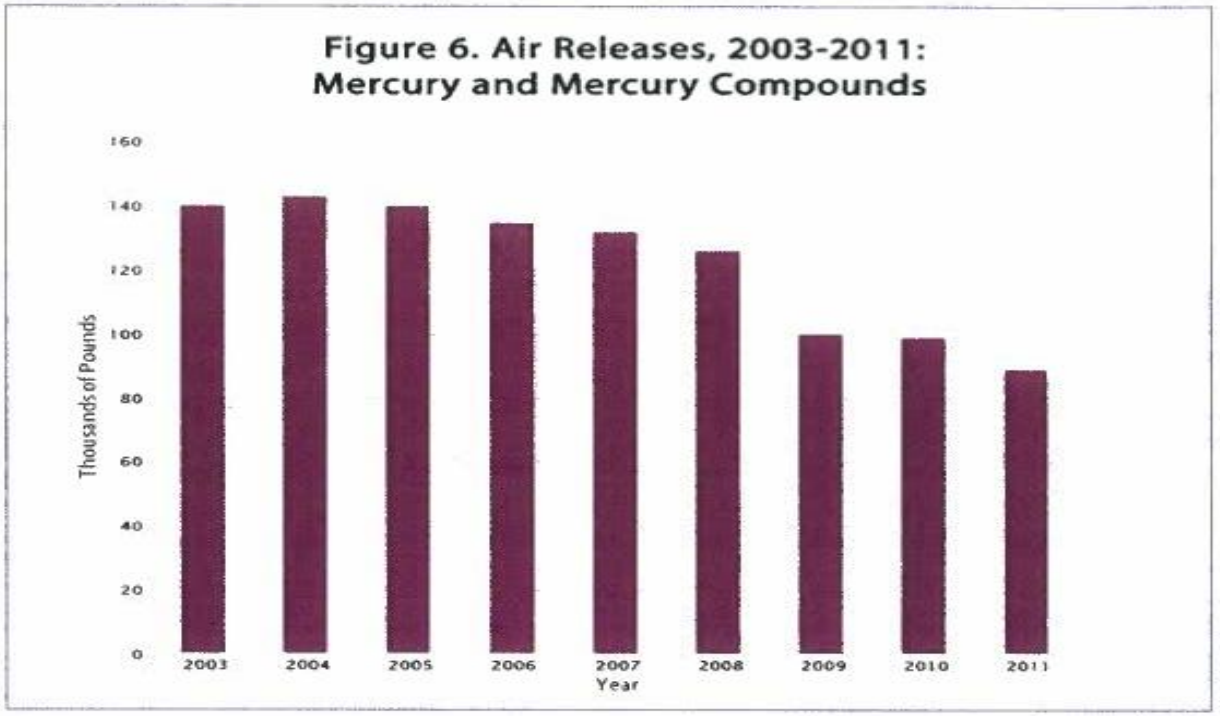
Exhibit 2-39. Mercury emissions in the U.S. by source category, 1990-1993, 2002, and 2005[a,b]



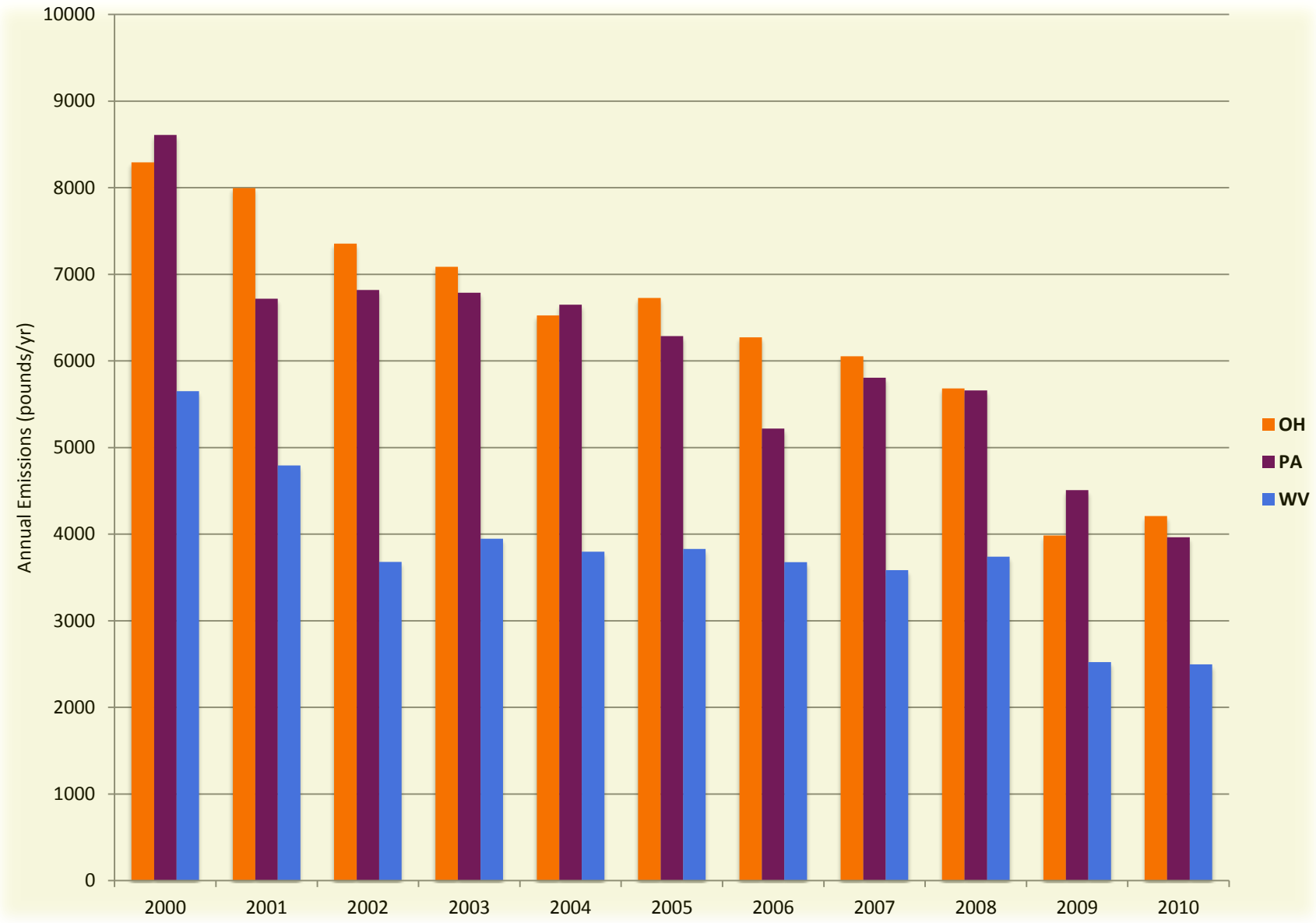
[a]1990-1993 is considered the baseline period for mercury emissions. The baseline period spans multiple years due to the availability of emissions data for various source categories. The data presented for the baseline period are annual emissions (tons per year) and are therefore comparable to the 2002 and 2005 data.

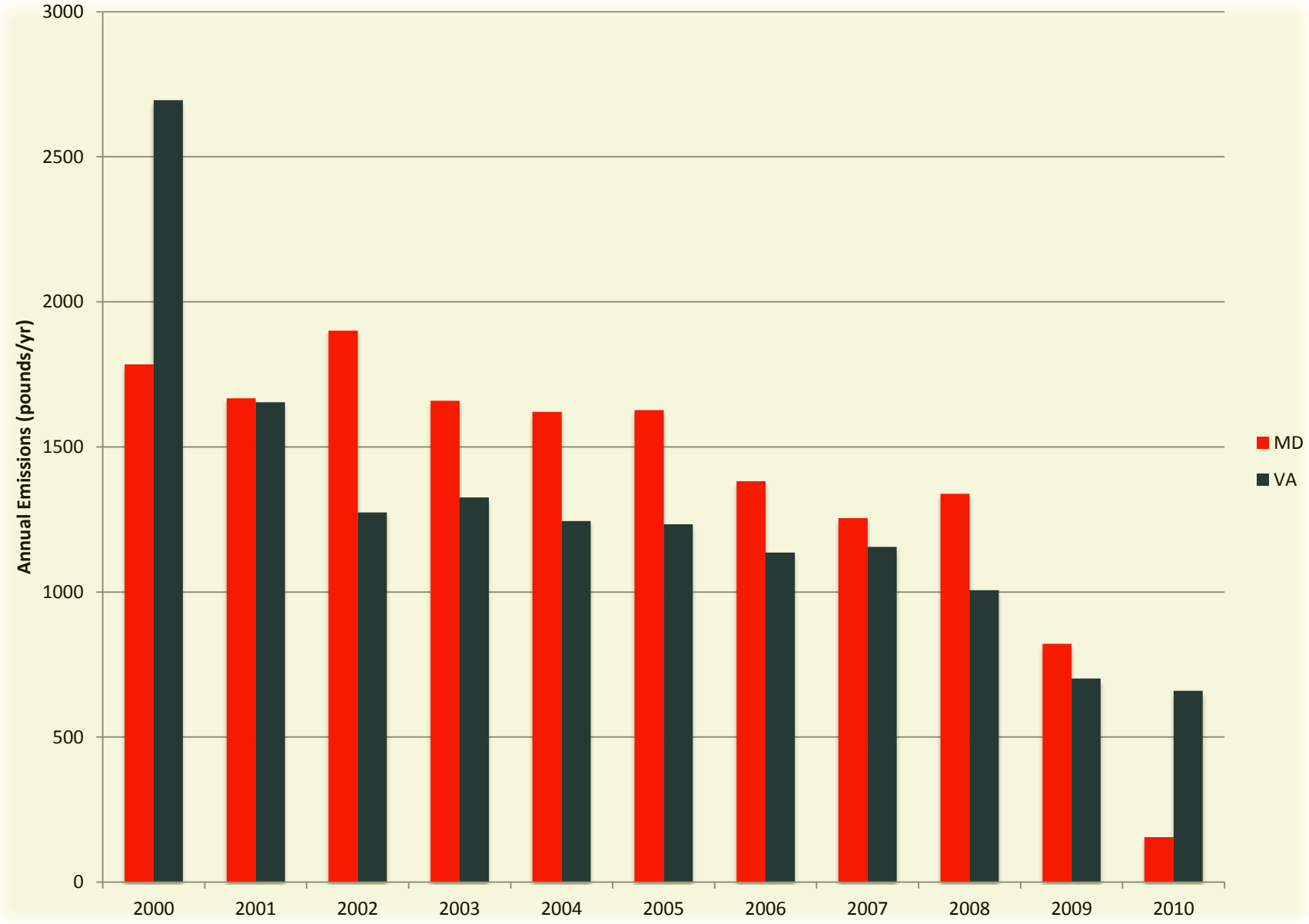
[b]Mercury emissions from mobile sources are not depicted because they have been estimated only for inventory years 2002 (0.8 tons) and 2005 (1.1 tons), not for the baseline period.

Data source: *U.S. EPA, 2009*



Source: 2011 Toxics Release Inventory National Analysis Overview, January 2013


10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Annual Emissions (pounds/yr)
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
OH
PA
WV


3000
2500
2000
1500
1000
500
0
Annual Emissions (pounds/yr)
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
MD
VA

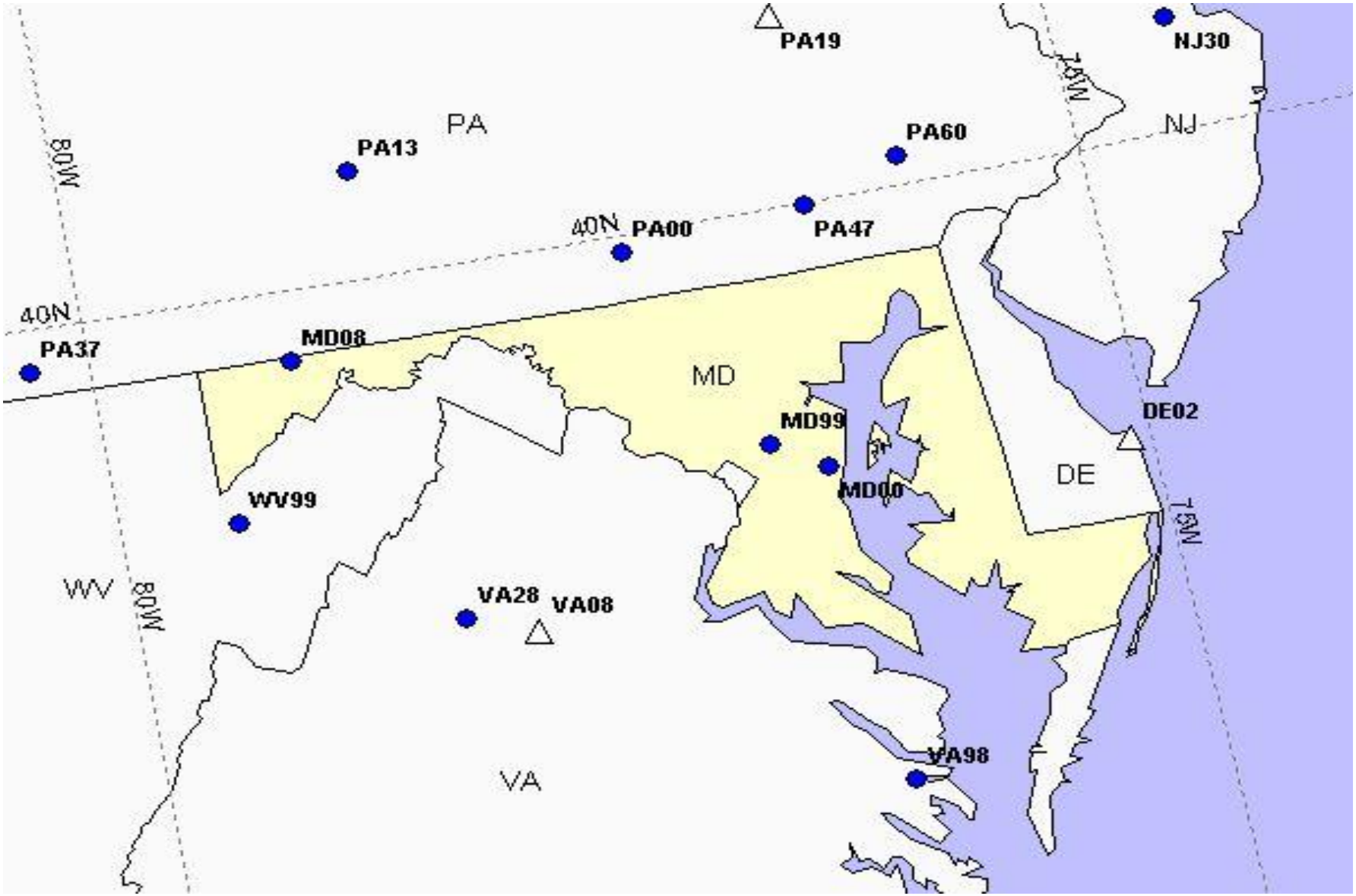
Clearly, there have been reductions in mercury emissions from US power plants from 1990s to 2011.

Question

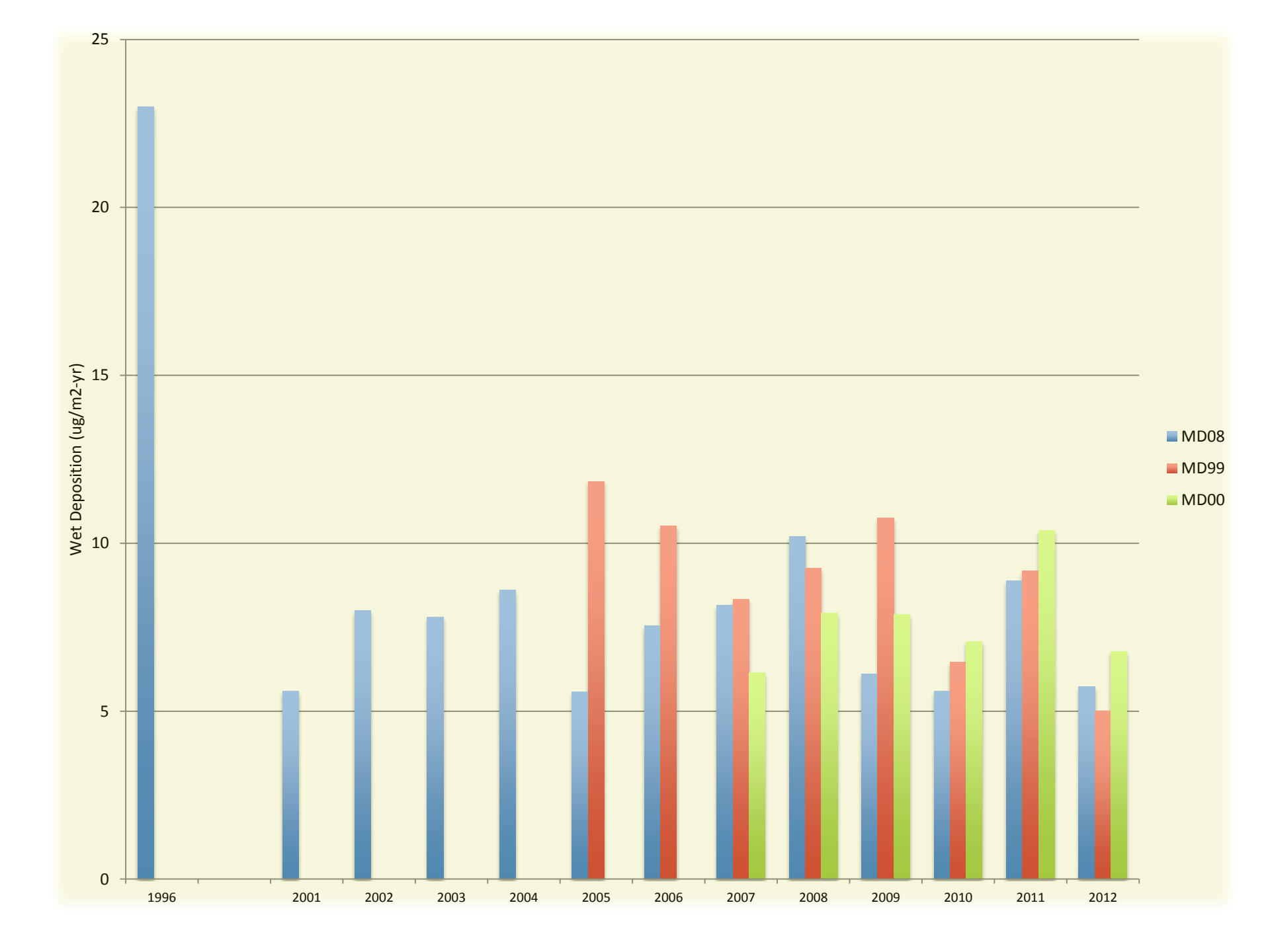
Have reductions in mercury emissions from US power plants lowered wet and dry deposition of mercury compounds?

---Note, I am using ambient air concentrations as a surrogate for dry deposition.---

Study Site: MD 08----Piney Creek Reservoir



Source: NADP-MDN


25
20
15
10
5
0
Wet Deposition (ug/m2-yr)
1996
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
MD08
MD99
MD00

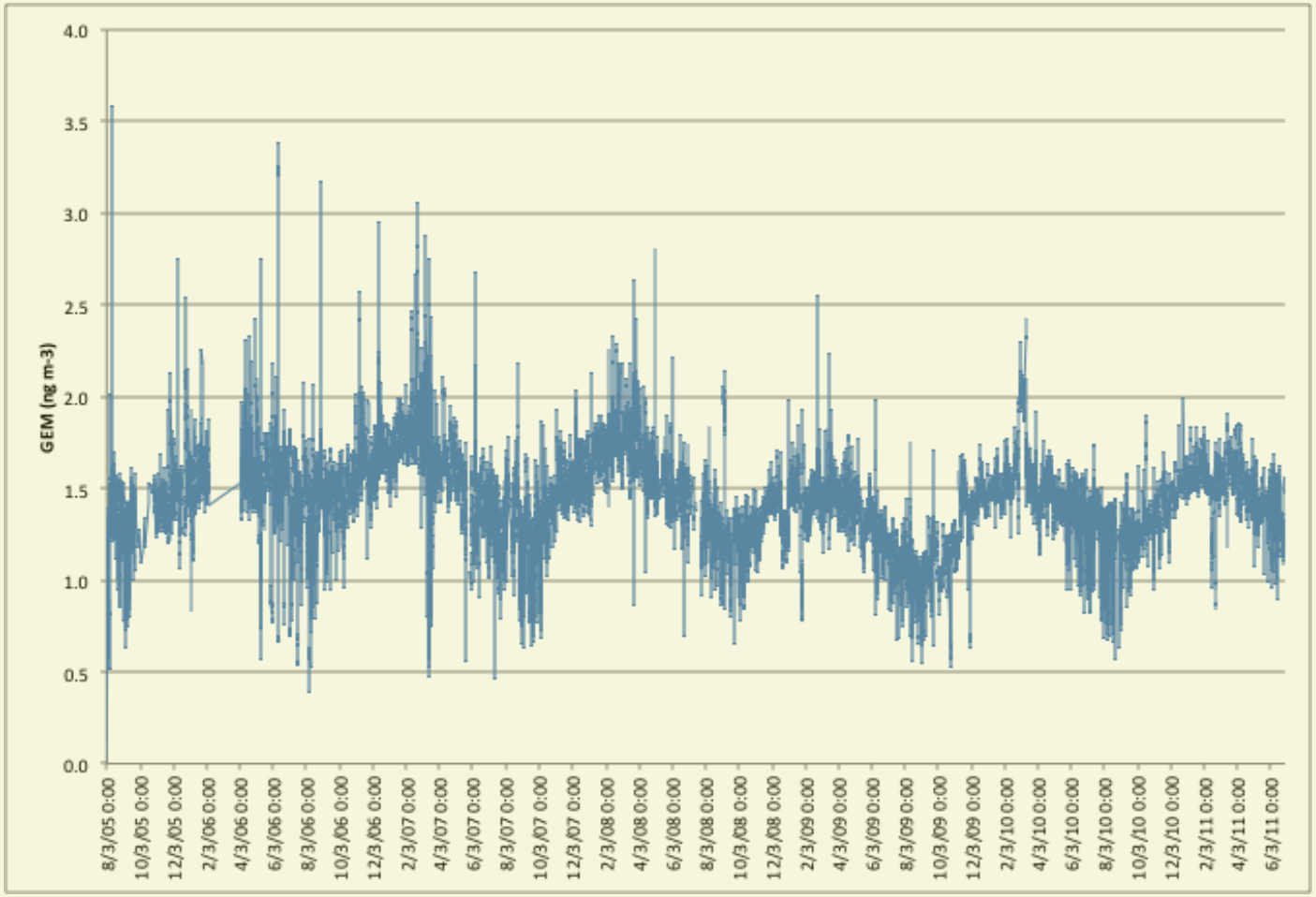
Atmospheric Mercury Compounds

GEM (gaseous elemental mercury)

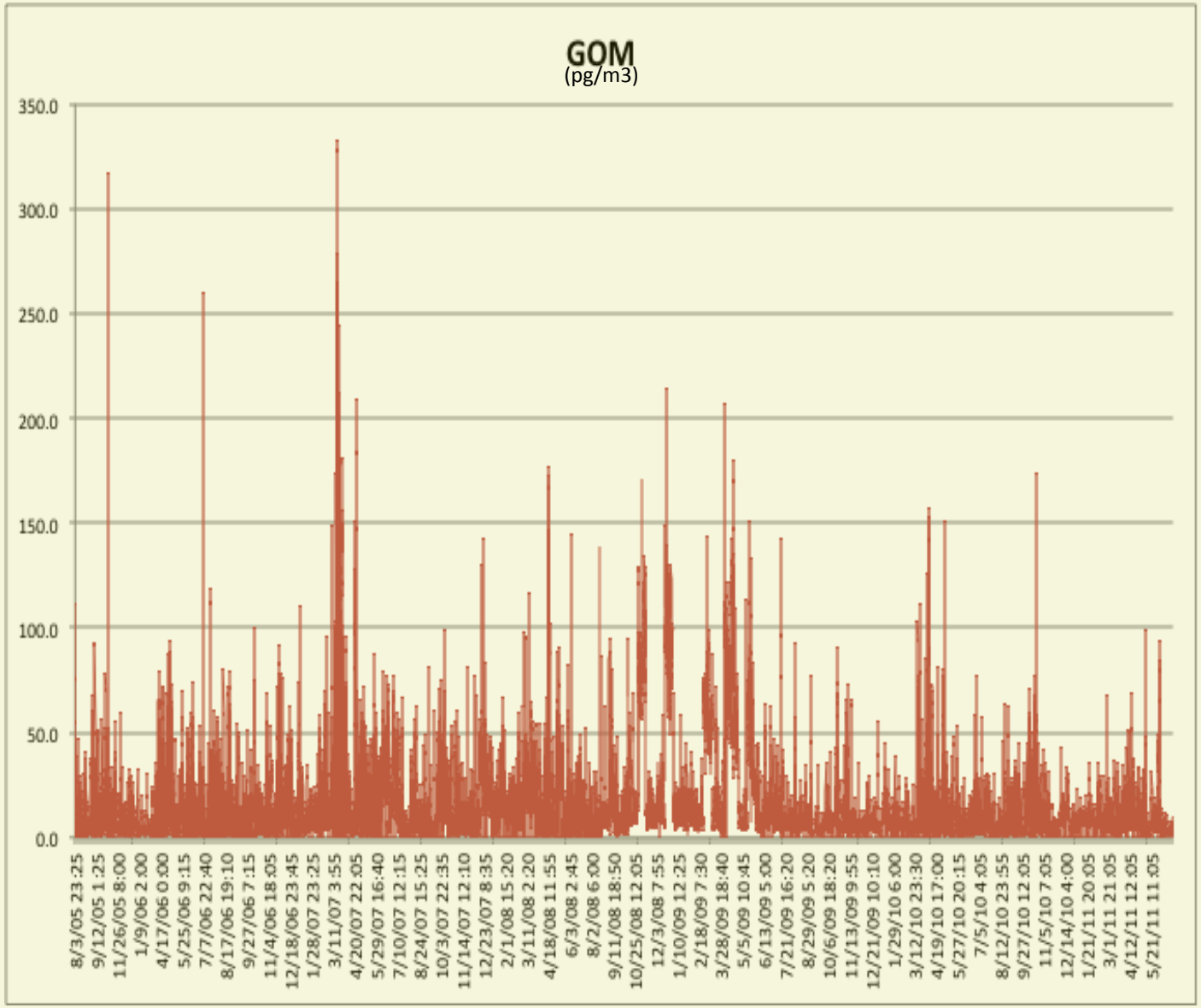
GOM (gaseous oxidized mercury)

PBM2.5 (Fine Particulate Bound Mercury)

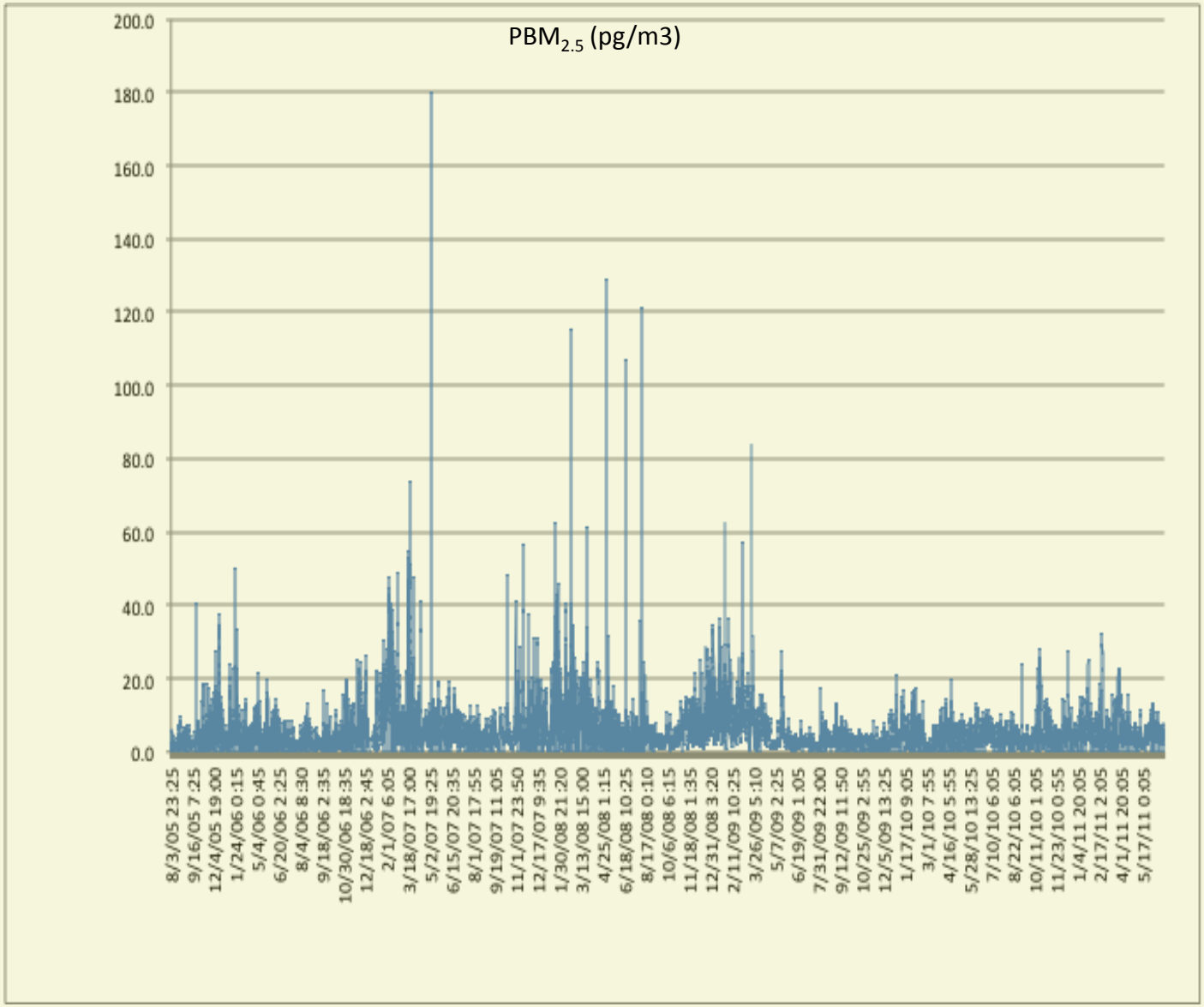
Ambient Air Concentrations

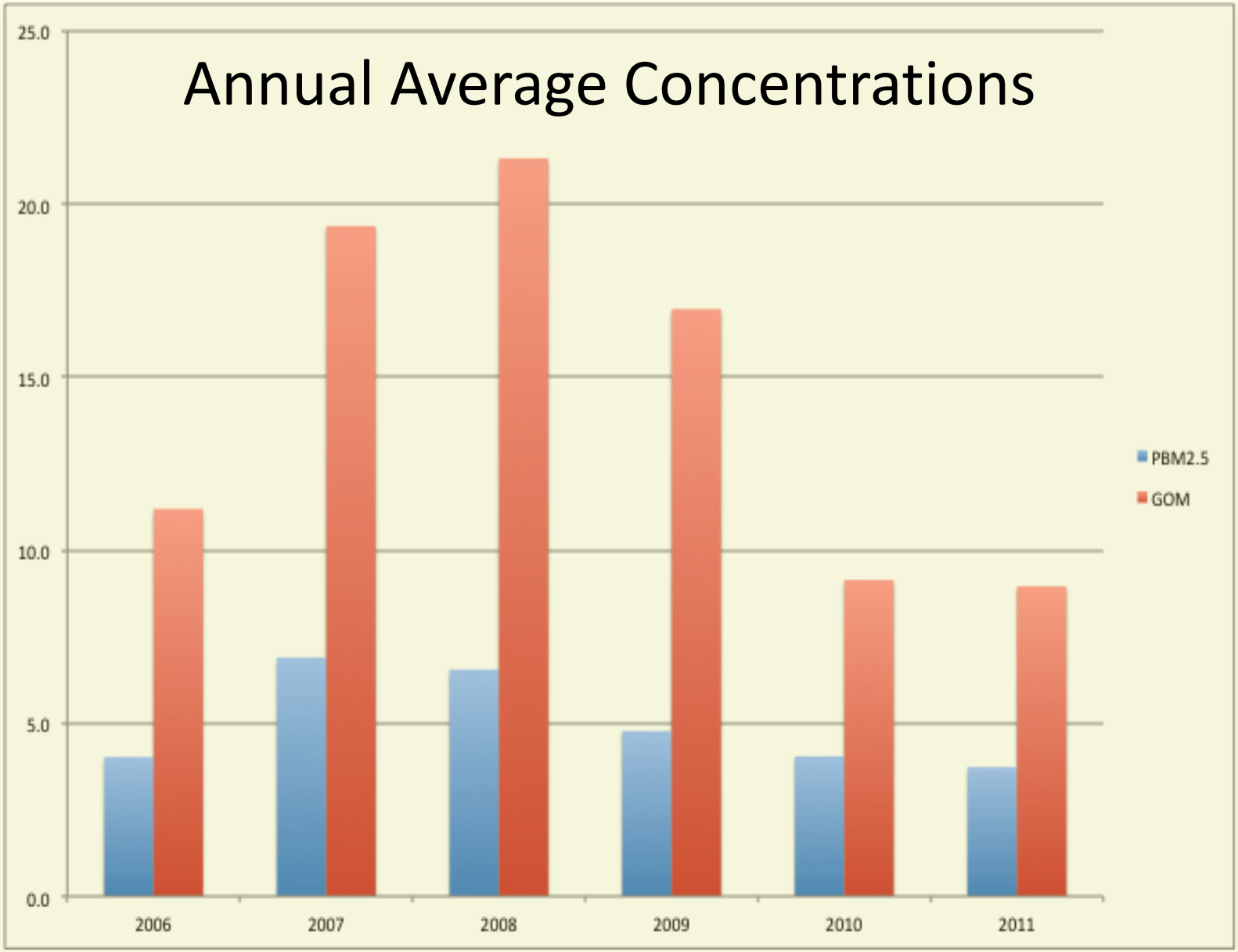


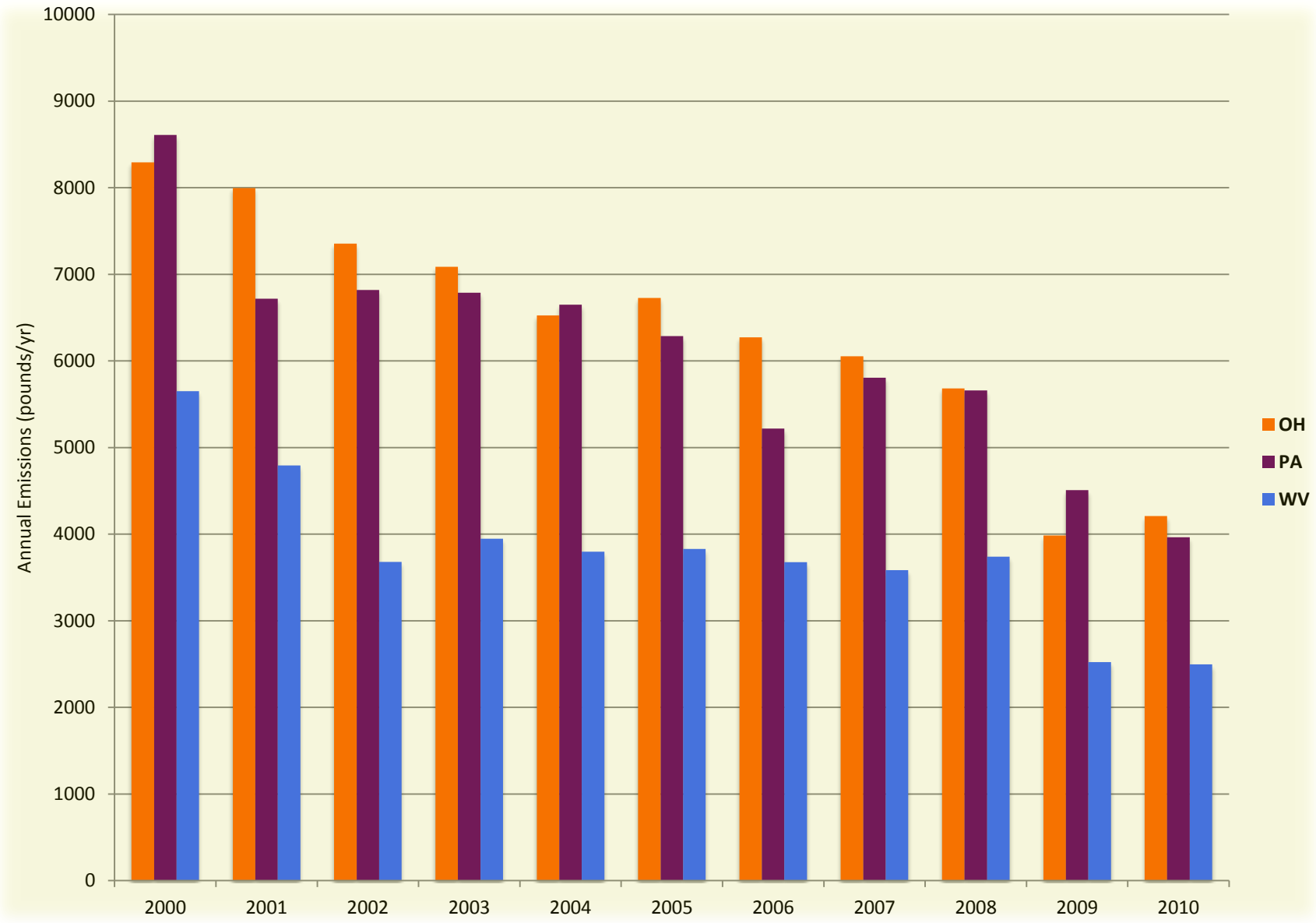
Ambient Air Concentrations

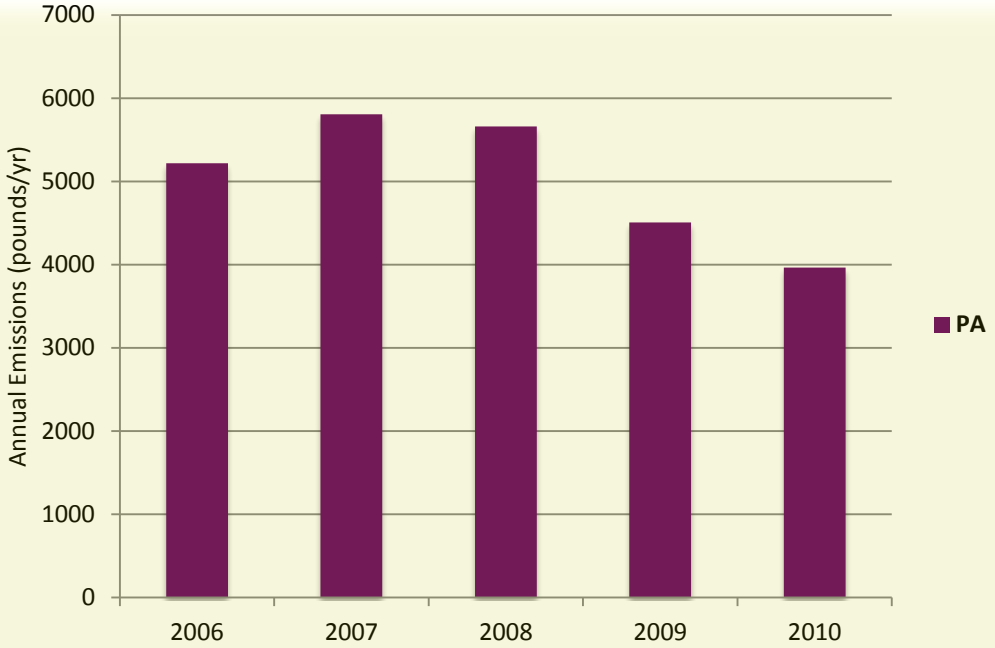


Ambient Air Concentrations




Annual Average Concentrations
25.0
20.0
15.0
10.0
5.0
0.0
2006
2007
2008
2009
2010
2011
PBM2.5
GOM


10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Annual Emissions (pounds/yr)
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
OH
PA
WV


7000
6000
5000
4000
3000
2000
1000
0
Annual Emissions (pounds/yr)
2006
2007
2008
2009
2010
PA


25.0
20.0
15.0
10.0
5.0
0.0
2006
2007
2008
2009
2010
2011
PBM2.5
GOM

Summary

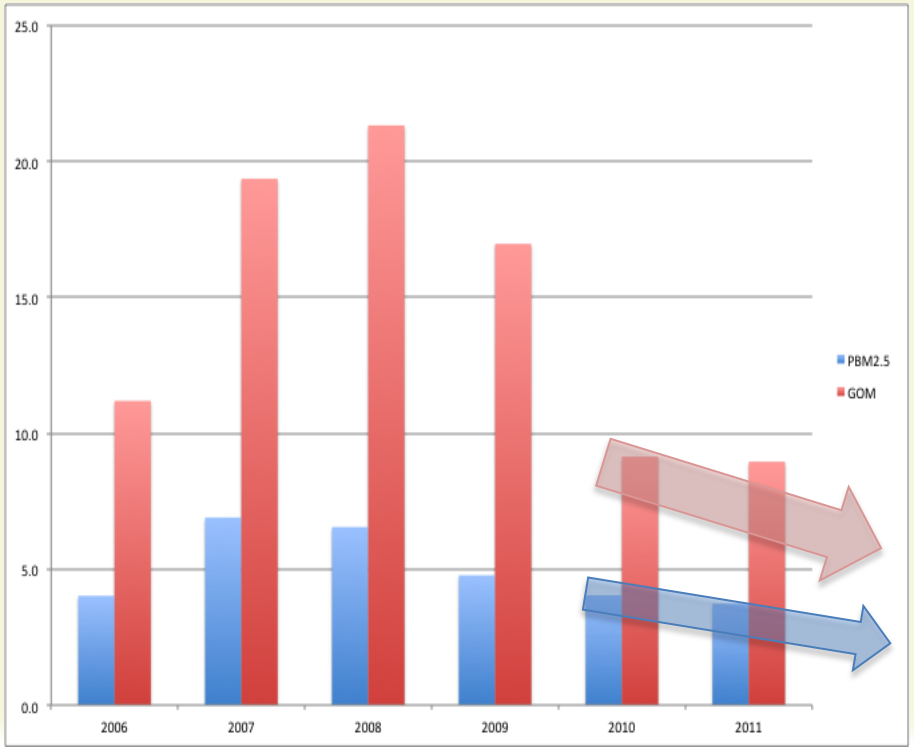
- Lower Power Plant Mercury Emissions 1990s to 2011
- Wet Deposition Trends
  - Lower Deposition (1996 to 2000)
  - Little Overlap with Emission Patterns (2000 to 2011)
- Ambient Air Concentrations
  - No Change in Annual Average GEM concentrations
  - Lower Annual Average GOM and $PBM_{2.5}$ concentrations
  - Mirror reductions in PA power plant mercury emissions

Future Power Plant Emission Reductions

Mercury and Air Toxics Standards for Power Plants

(3 to 4 years)

90% reduction in US Power Plants Mercury Emissions




MD 08
Questions/Comments
Image U.S. Geological Survey
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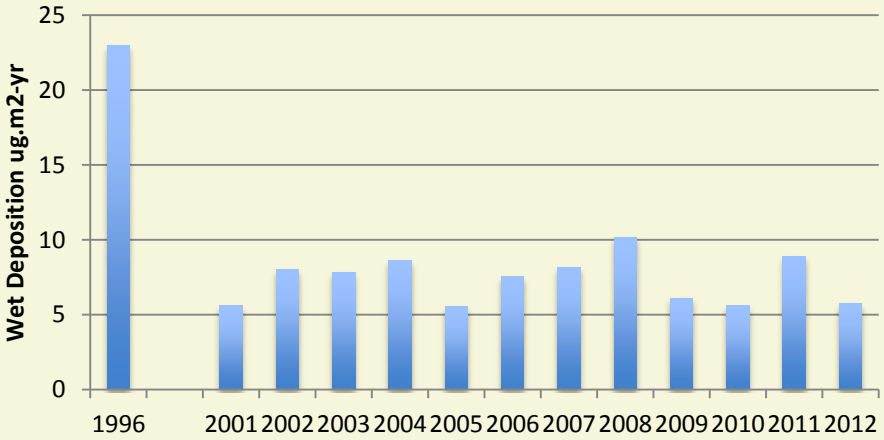
Image PA Department of Conservation and Natural Resources-PAMAP/USGS
Google earth

MD08



2012 data, up to end of September

MD08