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The Great Lakes Atmospheric Mercury Monitoring Network:
Design and Implementation

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National Atmospheric Deposition Program

LADCO
Lake Michigan Air Directors Consortium

Overview

- Mercury (Hg) is an ecosystem problem
- Atmospheric mercury monitoring in the Great Lakes Region
- Evaluation and design for the Great Lakes Atmospheric Mercury Monitoring Network in the NADP
- First year of data for this new network

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Mercury is an ecosystem problem

- Human activities add Hg to the environment
- Hg in the air returns in the precipitation
- Dry deposition – cities and forests are ‘sinks’, places of Hg accumulation
- Some Hg becomes methylmercury– a persistent and bioaccumulative toxin

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Methylmercury in Ecosystems

- Freshwater and marine and terrestrial ecosystems have methylmercury
- Health risks for young and adult humans from subsistence and sport fishing
- Adverse affects on fish, along with the mammals and birds that eat them

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The Need for Atmospheric Hg Monitoring

Mercury Deposition Network

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The Atmospheric Mercury Signal

- Concentrations of mercury in the atmosphere originating from major anthropogenic sources can be expected to decrease in USA and Canada
- State rules require Hg emissions reduction in Illinois, Minnesota, Michigan, Wisconsin, and New York passed from 2006-2012; Ontario's rule was in 2010
- USEPA Mercury and Air Toxics Standards planned for 2015—preemptive Hg emissions reductions
- 11 percent of coal-based energy in the Great Lakes Region will be gone by 2019, most by 2014 – 89 energy units in 39 cities retired or converted to gas

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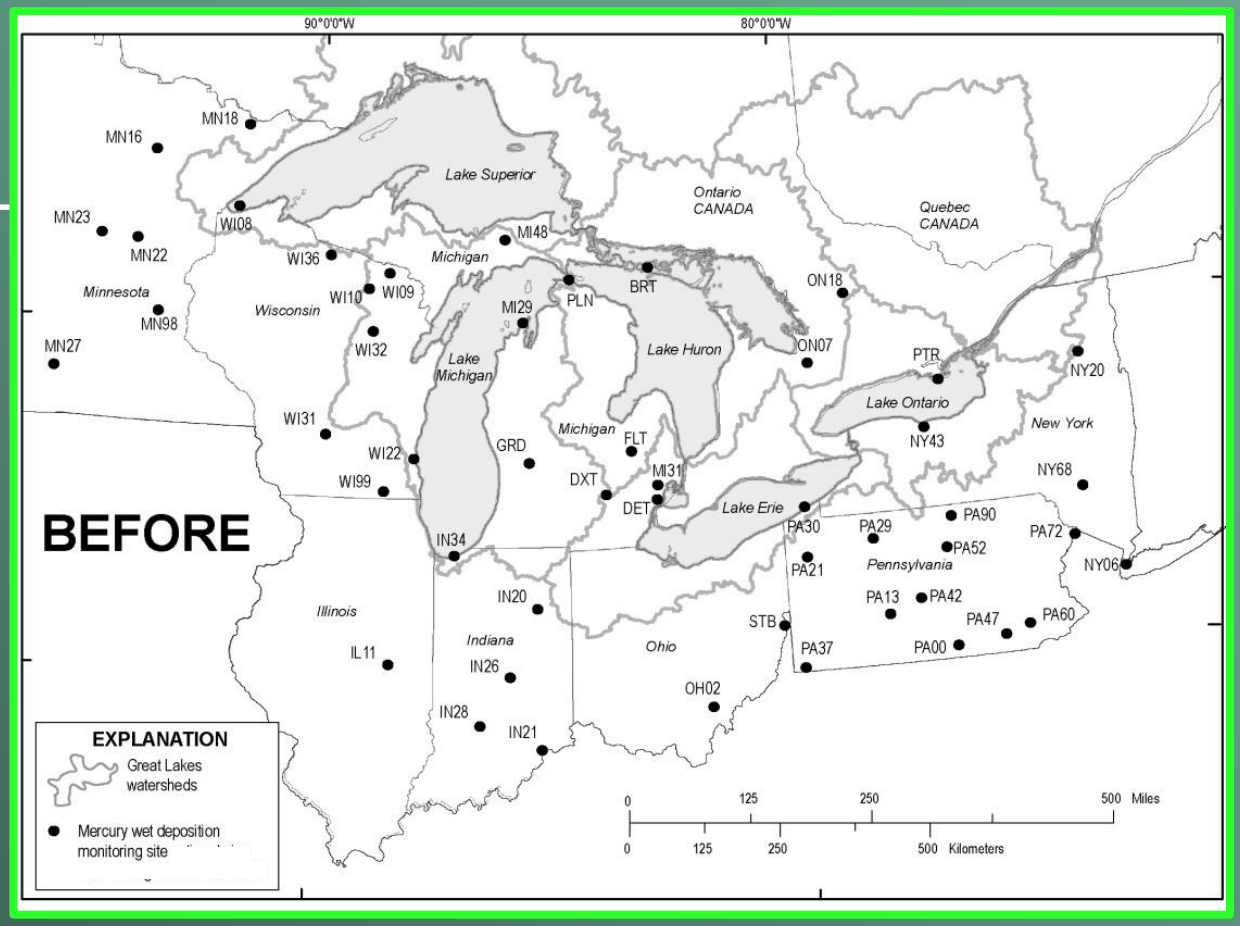
Hg wet-deposition monitoring in the Great Lakes Region, 1996-2012 (51 sites)

NADP Mercury Deposition Network (42 sites, 1996-2012)

Michigan Mercury Monitoring Network (7 sites, 2002-2008)

Integrated Atmospheric Deposition Network (2 sites, 2001-2007)



Great Lakes Region = 8 USA States and Ontario

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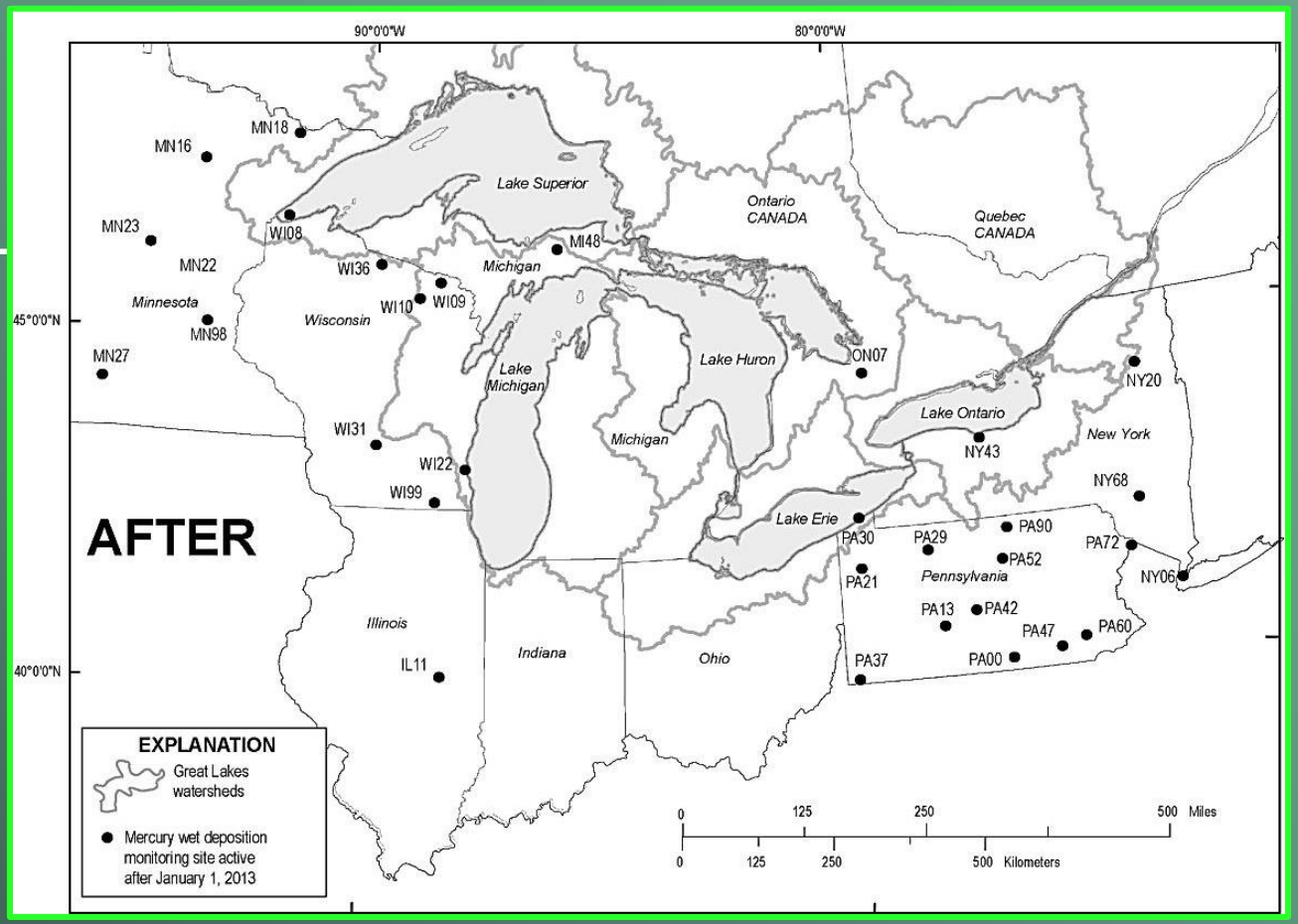
Over time….
the number of Hg-monitoring sites ever operated in the Great Lakes Region was reduced by 39% for the 15-year period 1996-2012, so that only 31 of 51 sites were active.



As of January 2013, approximately half of the Region in IL, IN, OH, and MI Lower Peninsula were represented by a single site in central IL.

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Will we miss the change in the atmospheric Hg signal ?

The Great Lakes Atmospheric Mercury Network

- Evaluation of active and historic Hg wet deposition monitoring sites with >75 % complete annual records for at least 6 of 9 years 2002-2012 = 36 sites
- Rating system of 21 factors for location and Hg data
- Scoring of factors for each site by quartile or points
- Compilation of spatial data and GIS analysis
- Quantitative, statistical, and spatial analysis
- Optimized design for Hg monitoring to fill data gaps, reduce data overlaps, maintain long-term records, and increase efficiency of network operation

From Risch, Kenski, & Gay (2014)
Atmos. Env. v. 85

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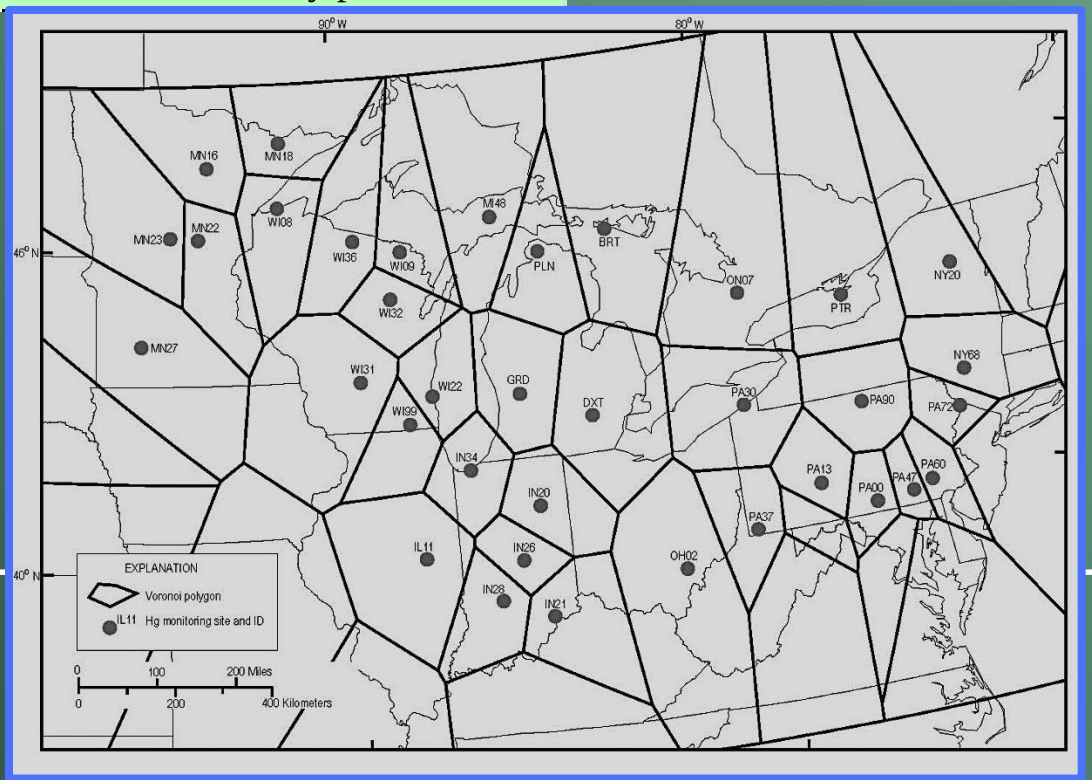
Quantitative Analysis

Factor Group	Factor for rating
1. Location	Geographic area represented
	Population represented
	Population density
	Protected natural area location
	Urban area location
	Co-located acid rain monitoring site
	Great Lakes watershed location
2. Hg sources	Number of nearby Hg emissions point sources
	Annual Hg emissions from nearby point sources

Evaluation:

● special location

★ quantification within the area represented by site



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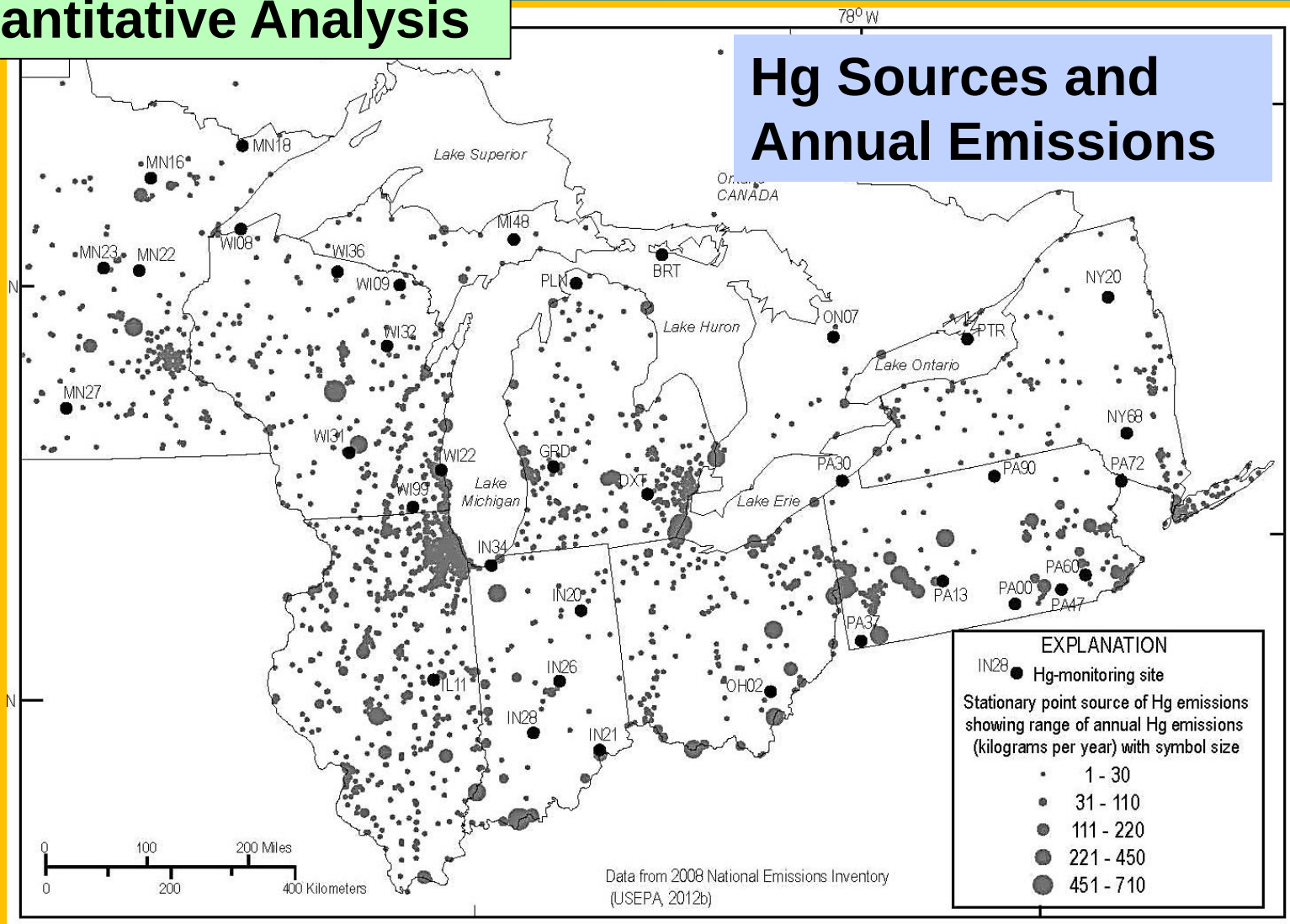
Quantitative Analysis

Hg Sources and Annual Emissions



Where are the Hg sources ?

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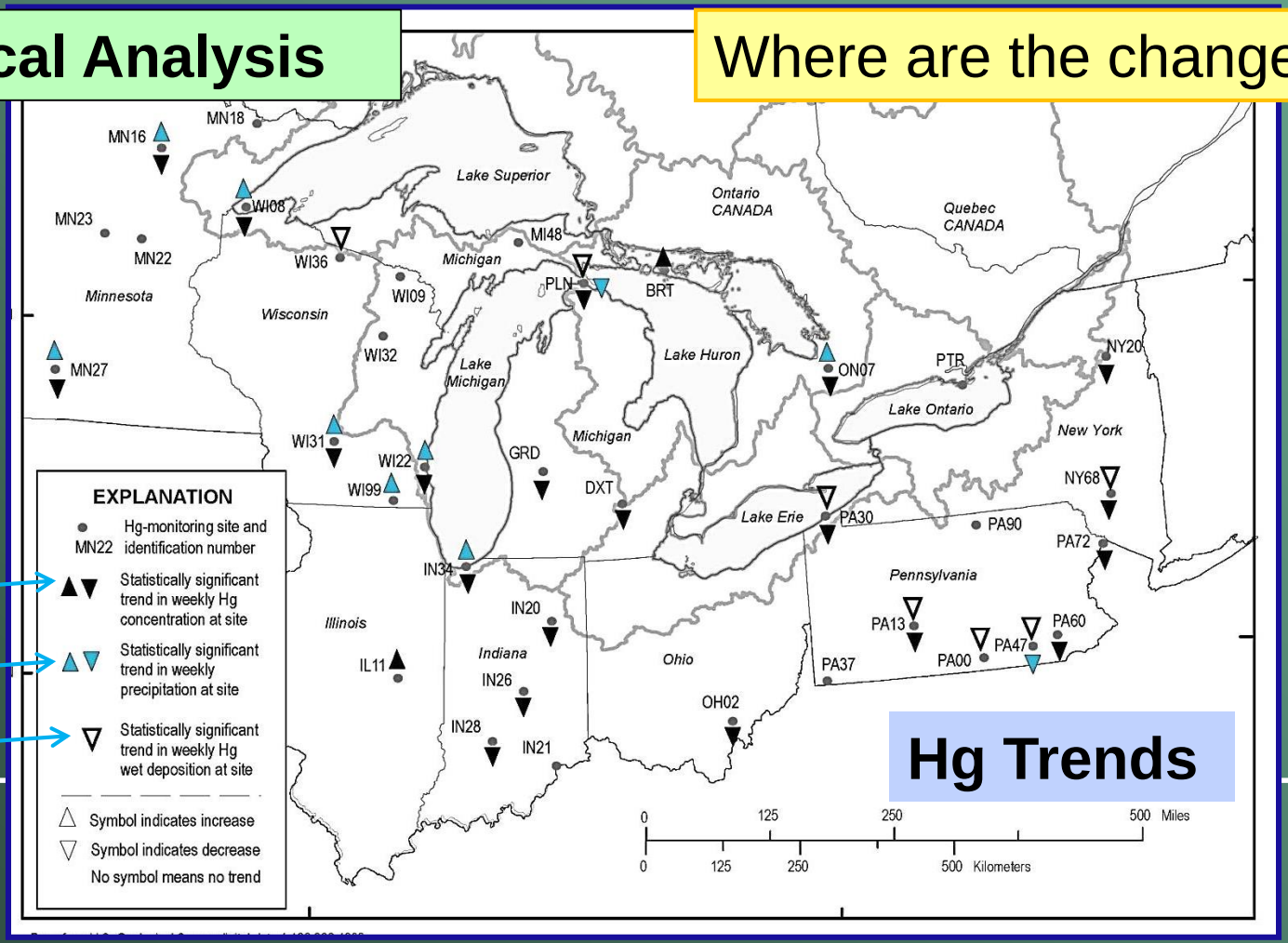
Factor Group	Factor for rating
4. Hg trends and changes	Significant trend in weekly Hg concentration or weekly Hg deposition, 2002–2010, 90- 95 % confidence
	9-year percent change in Hg concentrations or Hg deposition, increasing or decreasing

Statistical Analysis

Where are the changes?



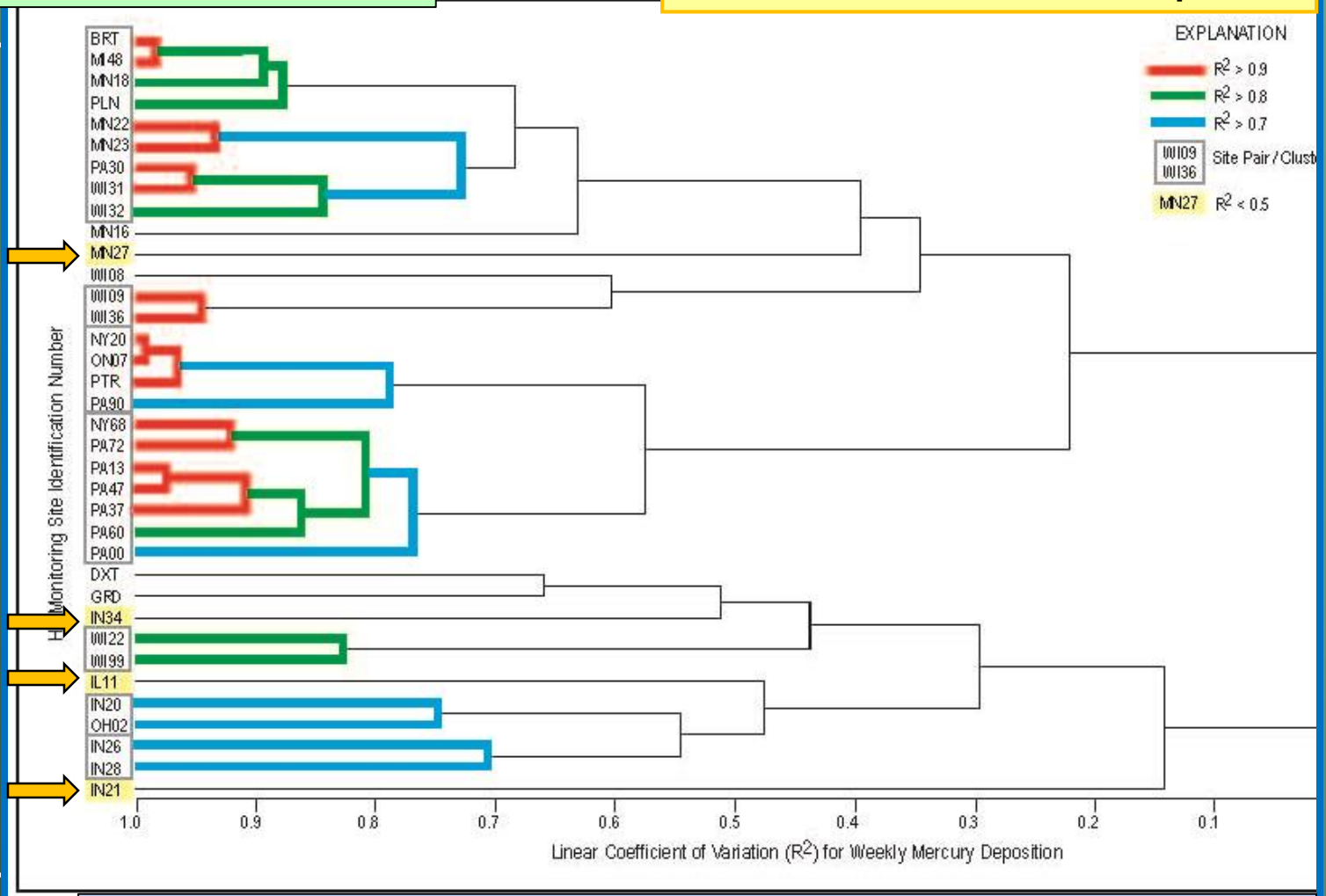
22 sites

10 sites

8 sites

Statistical Analysis

Which sites are unique ?



Cluster diagram of weekly Hg deposition per site

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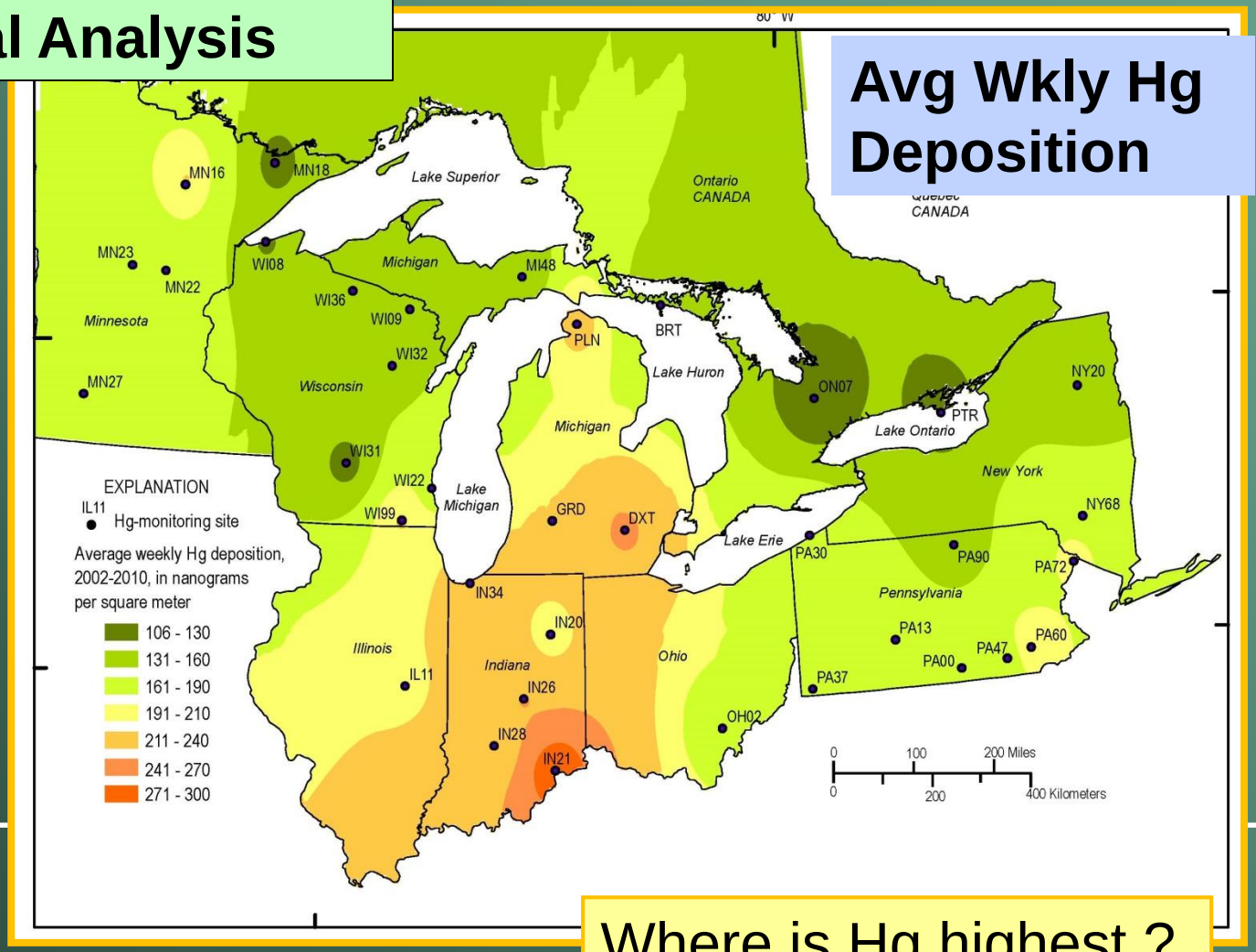
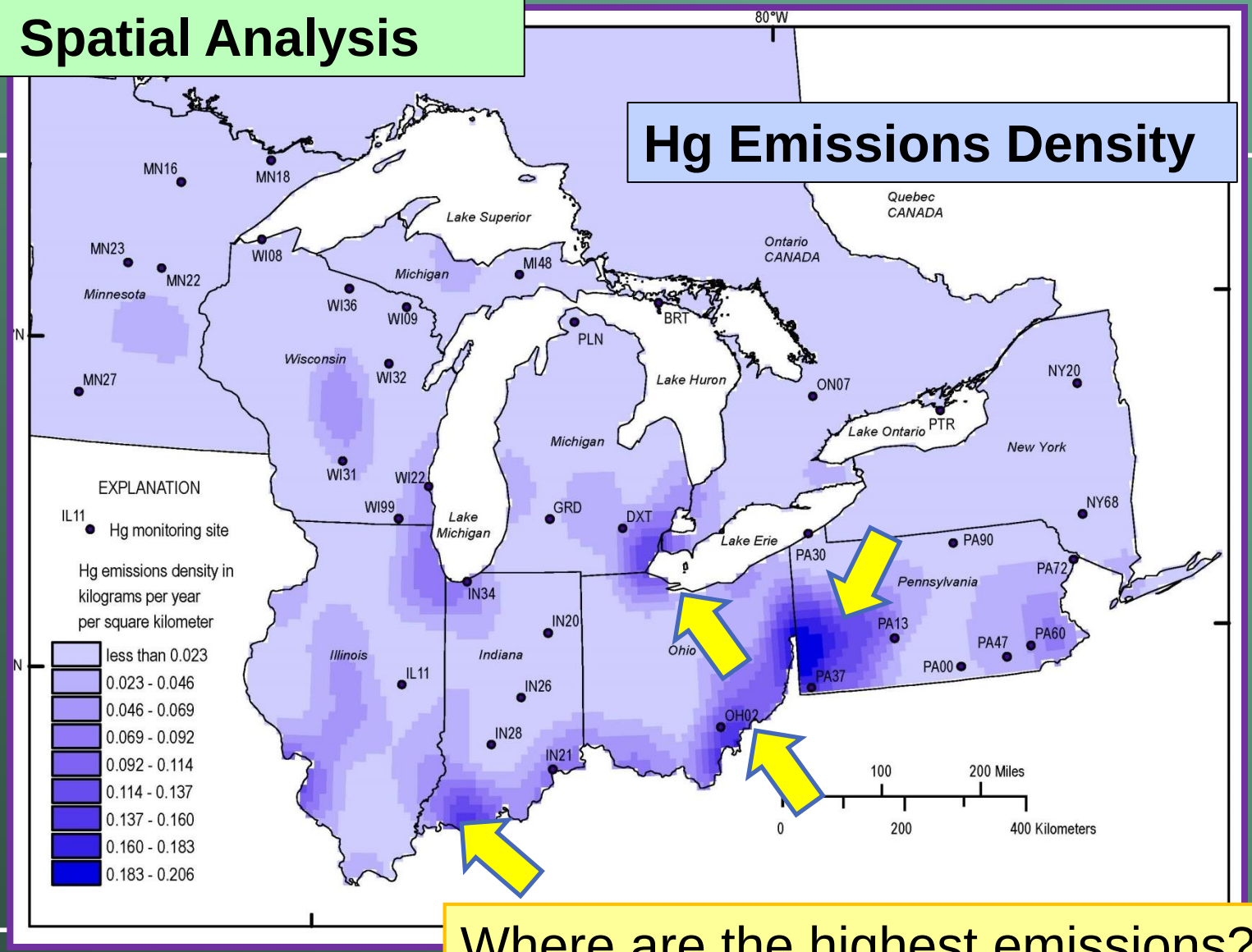
Factor Group	Factor for rating
3. Hg data average	Average weekly Hg deposition, 2002–2010
	Average weekly Hg concentrations, 2002–2010

Spatial Analysis



Where is Hg highest ?

Spatial Analysis



Where are the highest emissions?

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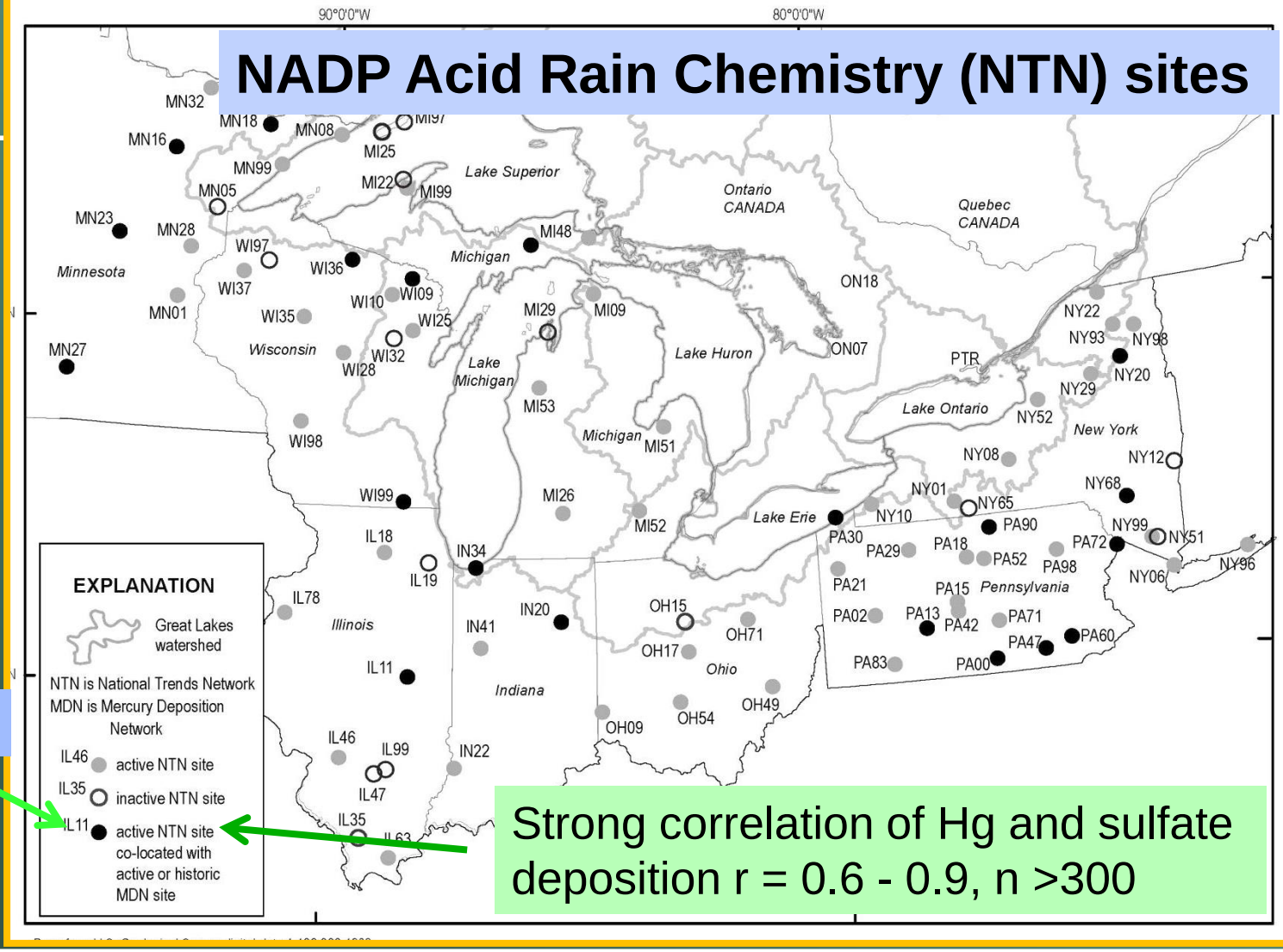
NADP Acid Rain Chemistry (NTN) sites



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Strong correlation of Hg and sulfate deposition r = 0.6 - 0.9, n >300

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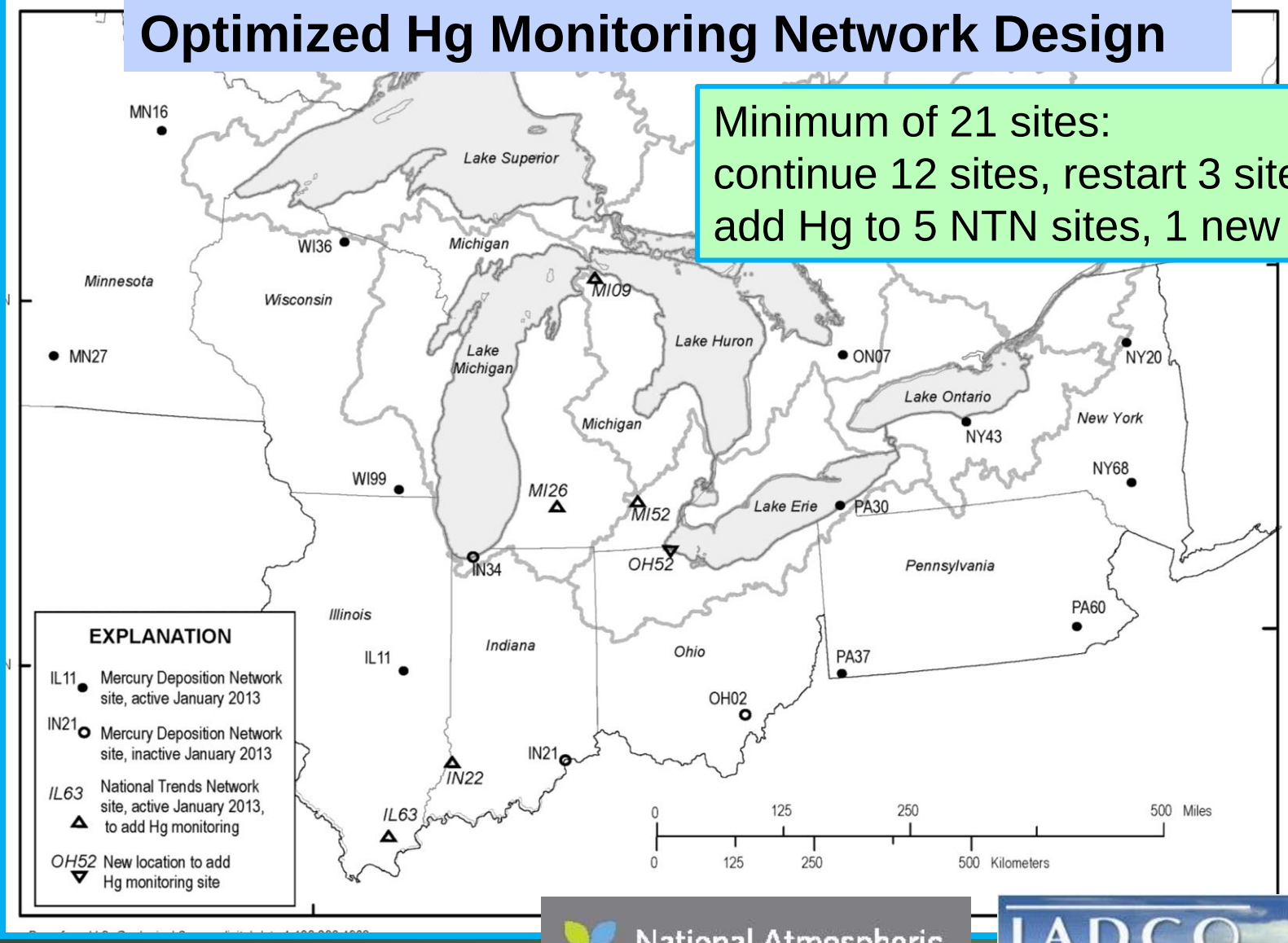
Efficiency--Where are the NADP monitoring sites?

Optimized Hg Monitoring Network Design

Minimum of 21 sites:
continue 12 sites, restart 3 sites,
add Hg to 5 NTN sites, 1 new site



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Implementation of the Great Lakes Mercury Monitoring Network in NADP

- USEPA Region 5 Air Program funds for GLAMM
- New and restarted NADP MDN sites – administered by LADCO
- Existing state supported MDN sites continued
- New and restarted sites active January 2014
- Framework for additional Hg monitoring—AMNet and litterfall Hg
- Structure for maintaining long-term sites

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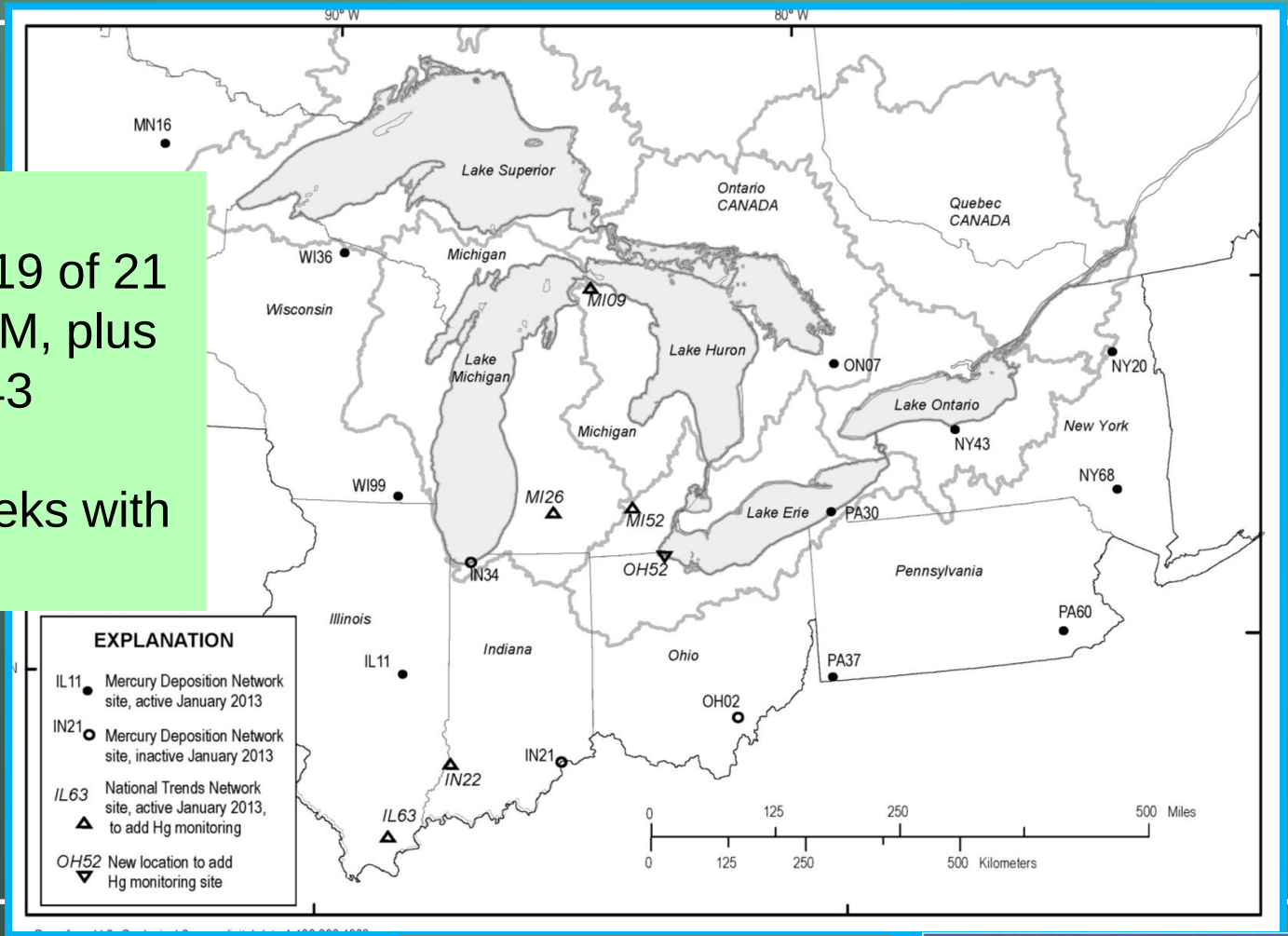
Hg Data from the GLAMM in 2014

-- 52 weeks of monitoring at 19 of 21 sites in GLAMM, plus one site with 43 weeks;
-- 42 to 52 weeks with Hg deposition



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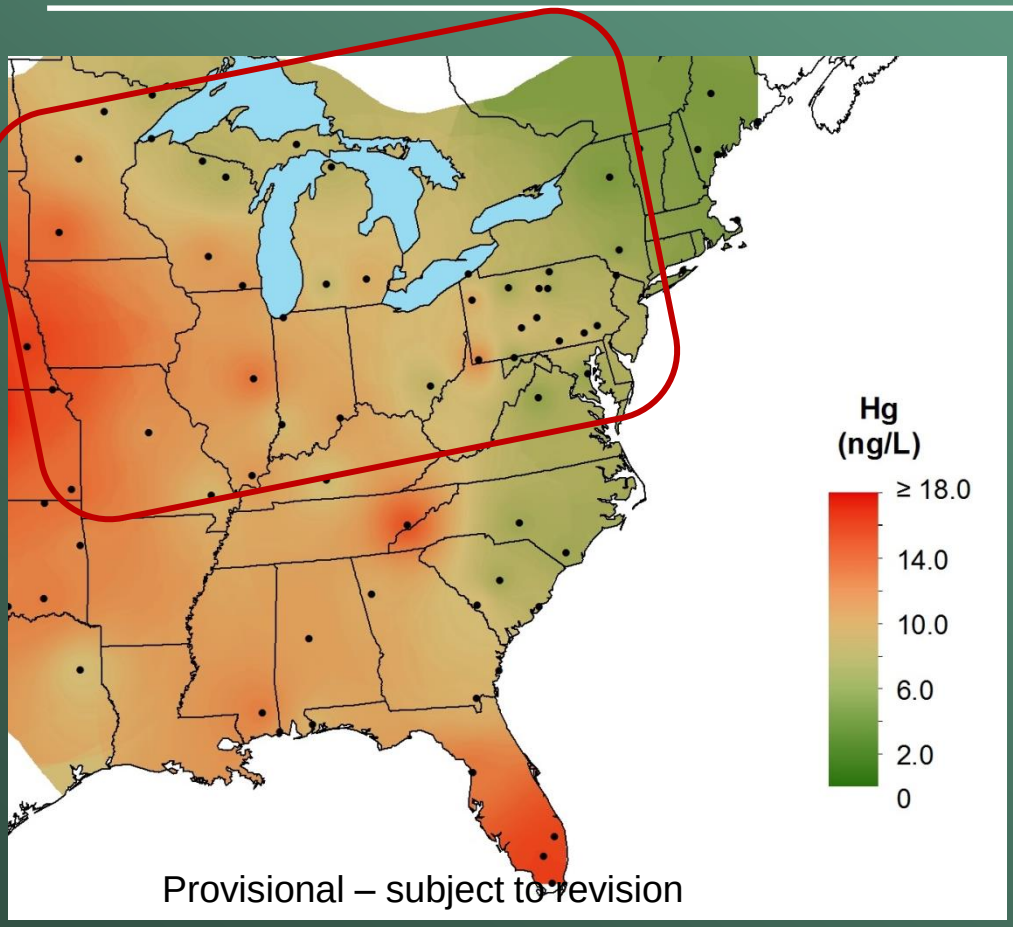
NADP annual Hg concentration gradients in 2014



For 20 GLAMM sites:
Precipitation-weighted annual Hg concentrations
-- median 8.3 ng/L
-- 6 sites > 10 ng/L

IN21	10.4
IL11	11.7
IL63	10.8
WI99	11.2
PA37	12.9
MN27	11.5

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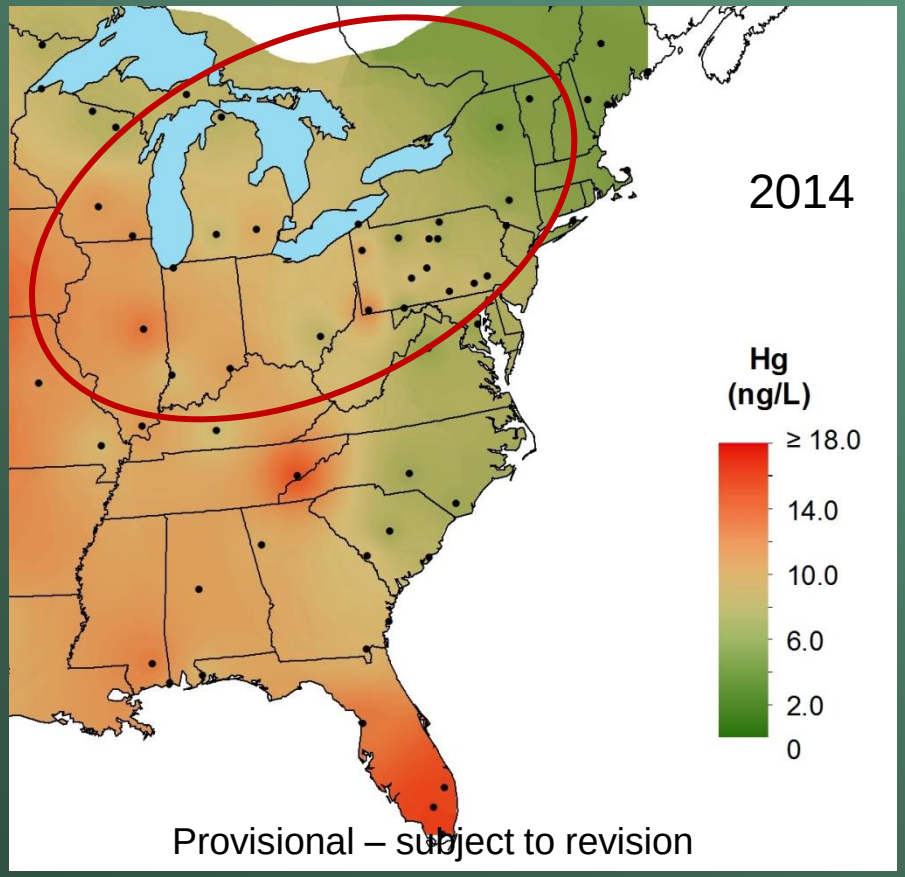
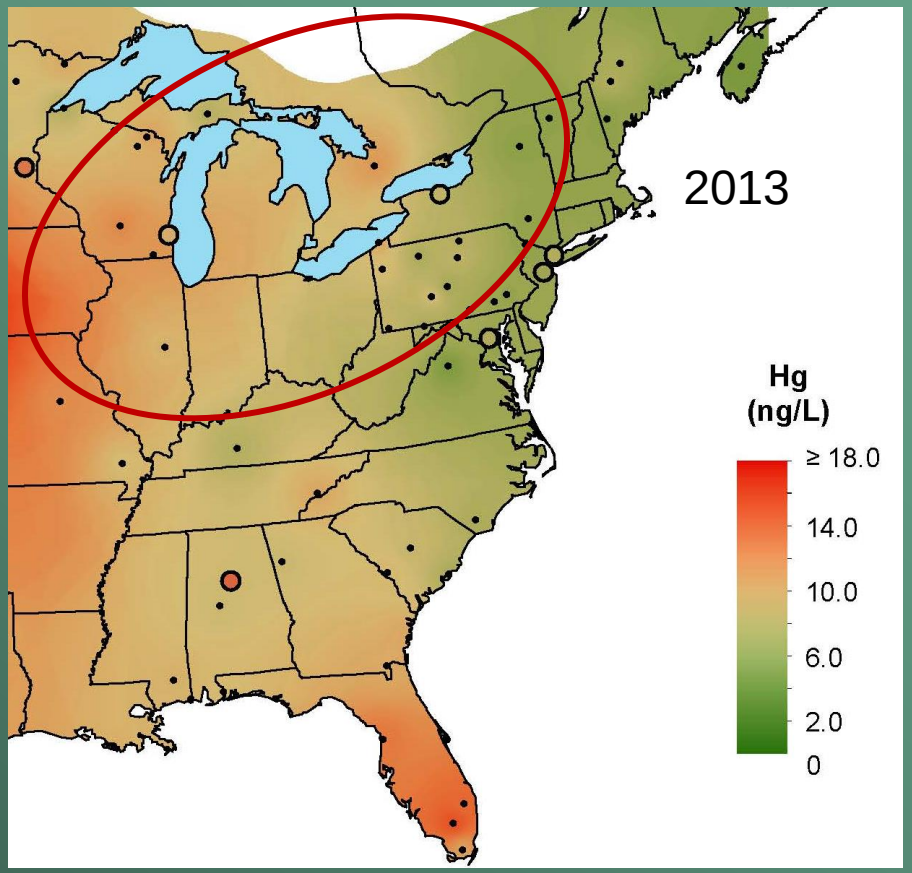
NADP Hg annual concentration gradients, 2013-2014



Provisional – subject to revision



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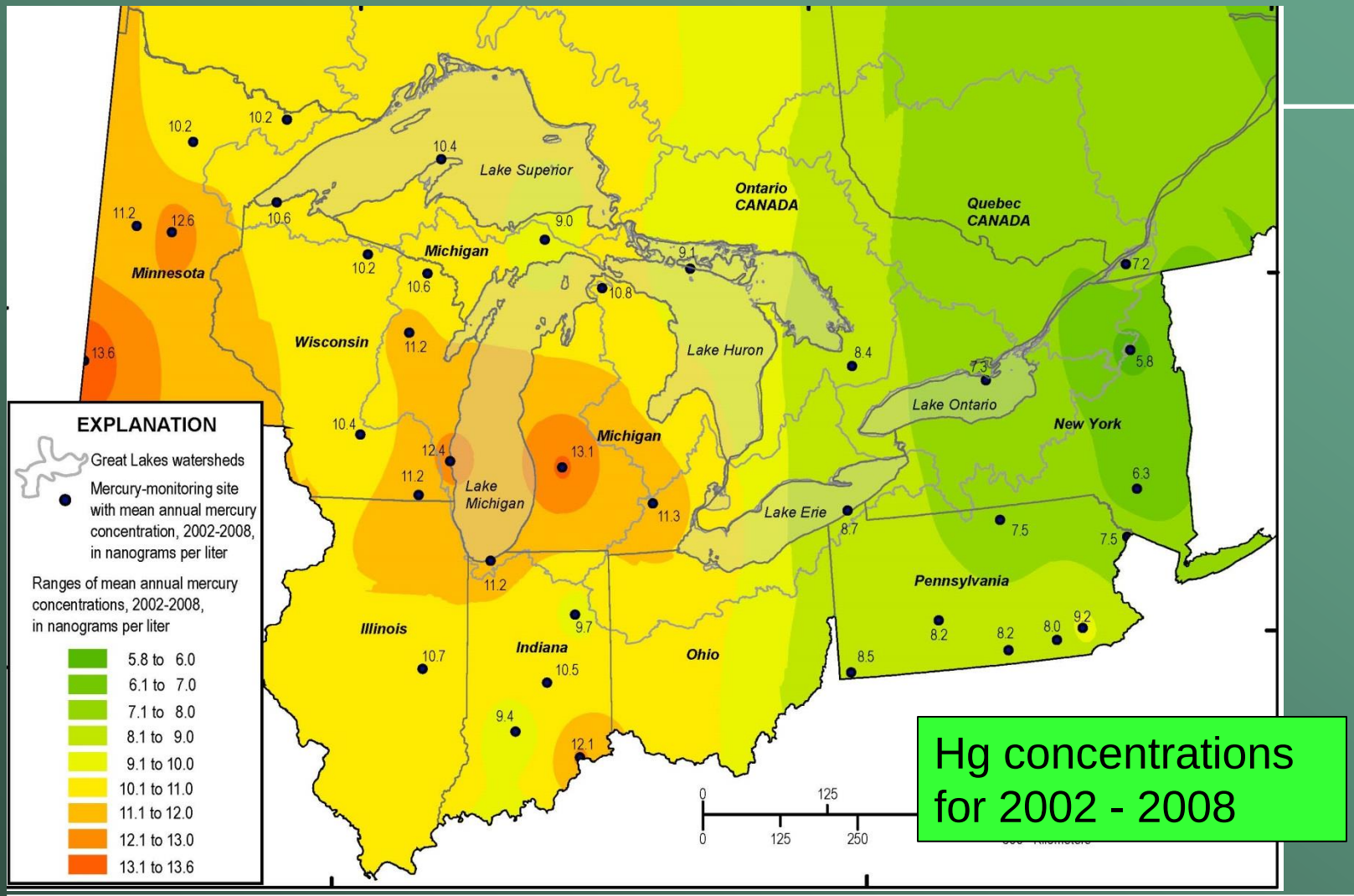
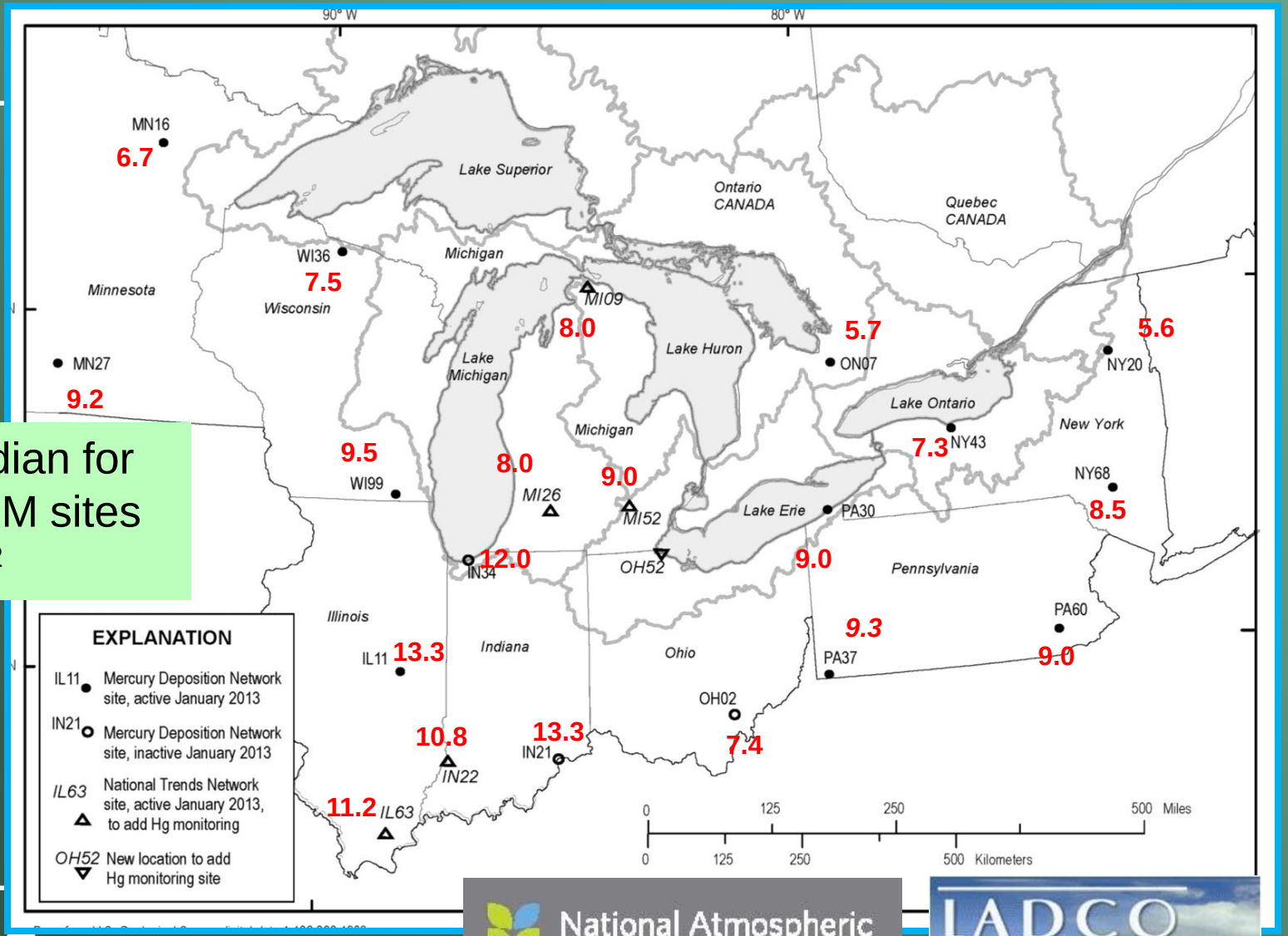


Hg concentrations for 2002 - 2008

From Risch and others (2012) *Env. Poll*. v. 161

NADP Hg annual wet deposition in 2014 at GLAMM sites



2014 median for 20 GLAMM sites
9.0 μg/m^2

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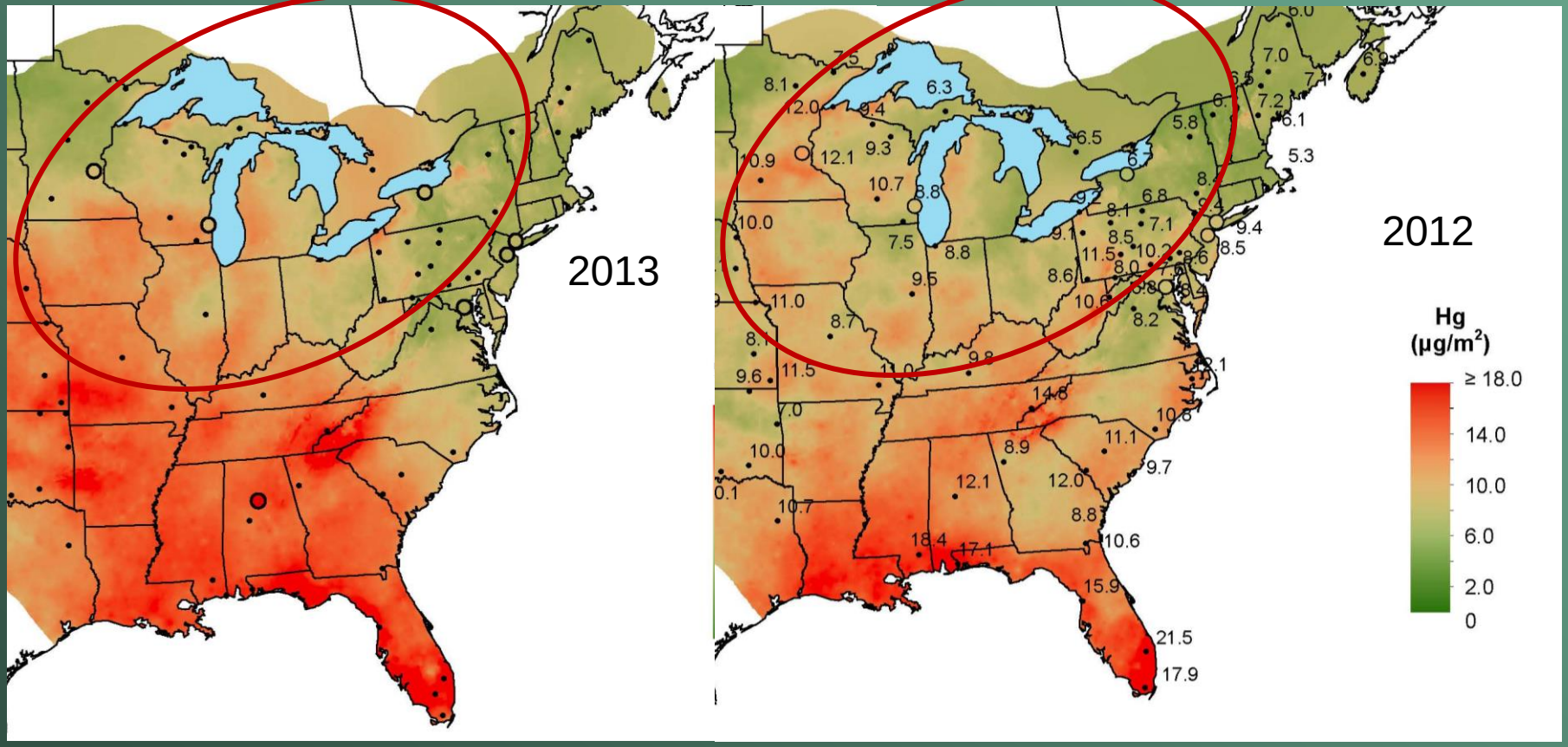
NADP Hg annual deposition gradient, 2012-2013



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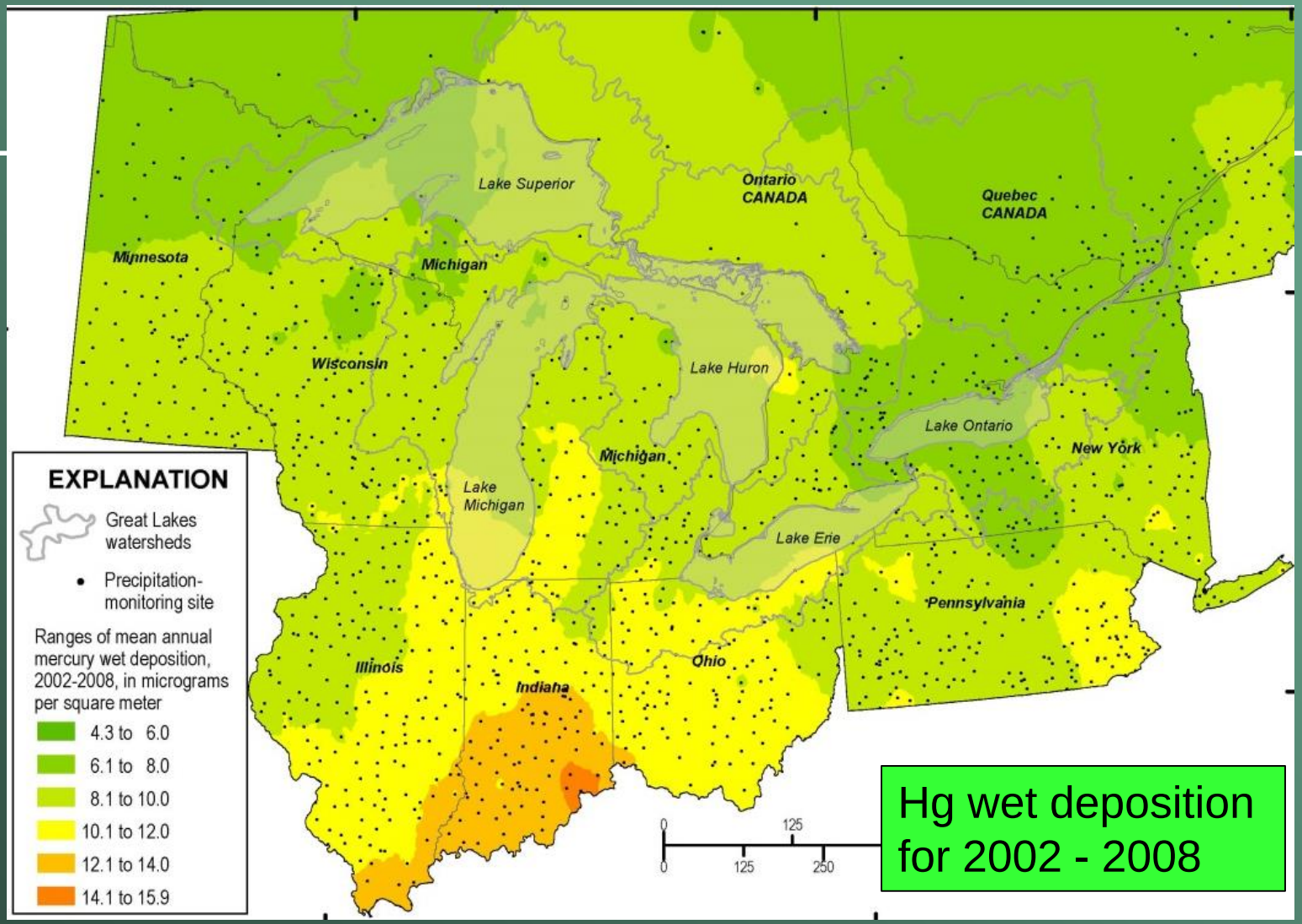

Hg wet deposition for 2002 - 2008

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From Risch and others (2012) *Env. Poll*. v. 161

Summary and Conclusions

- Mercury is an ecosystem problem.
- Long-term monitoring in an optimized network is needed to detect changes in the atmospheric Hg signal.
- The Great Lakes Atmospheric Mercury Monitoring network of the NADP fills data gaps and corrects data overlaps from previous years, while maintaining many long-term data sites.
- Potential evidence for changes in annual Hg concentrations and Hg wet deposition in some parts of the Great Lakes region in 2014.
- Stability in network operation is needed to verify trends.

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