An Alternate Method for Creating a Statewide Isopleth Map of Total Mercury Wet Deposition with an Example for Indiana

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TRADITIONAL METHOD

Data about mercury in precipitation are collected by the National Atmospheric Deposition Program (NADP) at more than 100 Mercury Deposition Network (MDN) sites in North America. Each year, the data from MDN sites with a record that is more than 75 percent complete are used by NADP to create color isopleth maps of annual precipitation-weighted mercury concentrations and annual total mercury wet deposition (fig. 1). The NADP prepares the isopleth maps using geographic information system (GIS) software that applies an inverse-distance-weighted interpolation algorithm to estimate mercury concentrations or deposition for each cell in a map grid of North America. Isopleth bands are generated by the GIS software for selected ranges of mercury concentrations or deposition. These maps illustrate an interpretation of the spatial distribution of mercury concentrations in precipitation and mercury wet deposition.

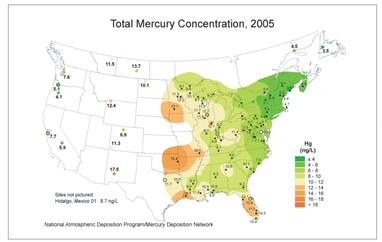
NEED FOR AN ALTERNATE METHOD

Isopleth maps of mercury wet deposition for an individual state derived from the NADP North America maps may lack the desired level of detail because the spatial distribution of monitoring sites is too sparse, and because the isopleth ranges are too broad for detailed interpretations at a state or local scale. An alternate method for preparing a statewide map of total mercury wet deposition was utilized in an example for Indiana. Because mercury wet deposition is computed as the product of mercury concentration and precipitation (fig. 1), a more detailed wet deposition isopleth map can be made by using precipitation data from an array of 127 National Weather Service Cooperative Observer Program sites in Indiana. The traditional NADP method used data from approximately 75 MDN sites in North America (fig. 1), of which five sites are in Indiana.

THE ALTERNATE METHOD

The alternate method for creating isopleth maps of mercury wet deposition in this example for Indiana is different from the traditional NADP method in four ways. First, average data for the period 2001--2006 were used. Second, a concentration isopleth map of annual precipitation-weighted average total mercury concentrations in Indiana, 2001--2006, (fig. 2) was prepared with data from nine MDN sites (five in Indiana and four from surrounding states, fig. 3). This isopleth map was prepared with GIS software using a inverse-distance-weighted interpolation algorithm. The resulting map was made into a grid of precipitation-weighted average mercury concentrations for each 2,000 square meter grid cell for Indiana. Third, the wet deposition isopleth map was prepared using annual precipitation data, 2001--2006, from 127 National Weather Service (NWS) Cooperative Observer Program sites in Indiana (fig. 4). The 127 NWS sites were overlain on the grid so that a mercury concentration value could be assigned to each NWS site. The concentration value associated with each NWS site was multiplied by the precipitation value for that site to obtain a mercury wet deposition value for that site. The GIS-software interpolation algorithm was then applied to the 127 wet deposition values to prepare a grid and a resulting isopleth map (fig. 5). Fourth, the ranges of deposition for the isopleth bands are 1 microgram per square meter, compared with 2 micrograms per square meter in the traditional method.

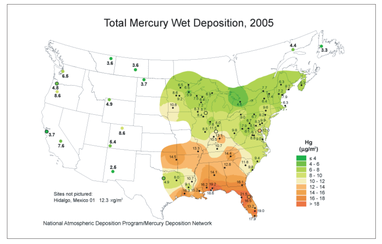
TRADITIONAL METHOD FOR NORTH AMERICA, 2005



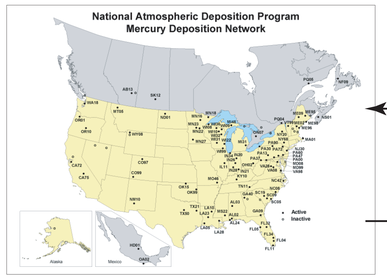
Annual precipitation-weighted average total mercury concentration at MDN sites

$$C \times P = D$$

C = annual precipitation-weighted average total mercury concentration, in nanograms per liter
P = annual precipitation, in centimeters
D = annual total mercury wet deposition, in micrograms per square meter



Annual total mercury wet deposition at MDN sites



Annual precipitation at MDN sites

Figure 1. Illustration of method for computing annual total mercury wet deposition and creating North America isopleth map for National Atmospheric Deposition Program Mercury Deposition Network, 2005.

ALTERNATE METHOD EXAMPLE FOR INDIANA, 2001--2006

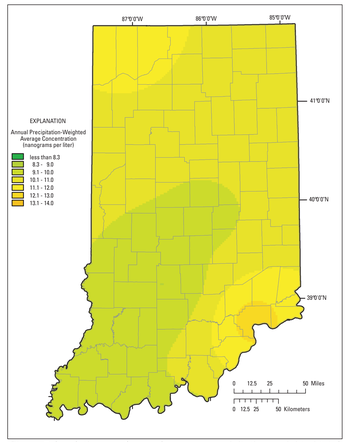


Figure 2. Isopleth map of annual average precipitation-weighted total mercury concentration in Indiana, 2001--2006.

Figure 3. National Atmospheric Deposition Program Mercury Deposition Network sites in Indiana and surrounding states with annual precipitation-weighted average mercury concentrations, 2001--2006, used for isopleth map of mercury concentrations in Indiana.

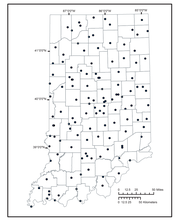


Figure 4. National Weather Service Cooperative Observer Program sites in Indiana with more than 75 percent complete annual precipitation records, 2001--2006.

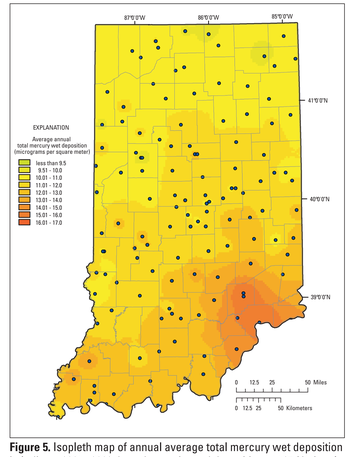
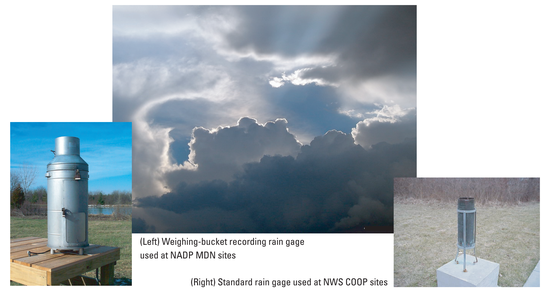


Figure 5. Isopleth map of annual average total mercury wet deposition in Indiana, 2001--2006, based on estimated deposition at 127 National Weather Service Cooperative Observer Program sites.



(Left) Weighing-bucket recording rain gage used at NADP MDN sites

(Right) Standard rain gage used at NWS COOP sites

PRECIPITATION DATA IN INDIANA

The National Weather Service (NWS) Cooperative Observer Program (COOP) was created in 1890 under the Organic Act which established the Weather Bureau. A cooperative station is a site where observations are taken by volunteers or contractors. As of 2007, there are over 11,000 volunteers spread across the U.S. in all types of environments. Data are collected at each site to provide observational meteorological information including daily maximum and minimum temperatures, snowfall, and 24-hour precipitation totals. These data are necessary for understanding the climate, measuring long-term changes, and forecasting weather.

Indiana has approximately 390 COOP sites. Some sites have records from as far back as 1893. For the years 2001--2006 there were 127 sites in Indiana that had more than 75 percent complete data in each year. These 127 sites were used in this analysis.

"Because of its many decades of relatively stable operation, high station density, and high proportion of rural locations, the Cooperative Network has been recognized as the most definitive source of information on U.S. climate trends for temperature and precipitation." http://www.nws.noaa.gov/om/coop/what-is-coop.html

COMPARISON OF ISOPLETH MAPS MADE WITH TRADITIONAL AND ALTERNATE METHODS

The traditional method for determining annual total mercury wet deposition utilizes data from approximately 75 MDN sites in North America. This array of sites gives a good general interpretation of the spatial distribution of mercury deposition. Figures 6, 8, and 10 show the Indiana portion of the MDN North America isopleth maps for total mercury wet deposition for 2003, 2004, and 2005. Figures 7, 9, and 11 show the same time periods, but total wet deposition was computed and mapped with the alternate method using precipitation amounts from 127 NWS COOP sites.

The same general differences between years are apparent in both sets of figures; 2003 has areas of higher total deposition while values tend to decrease through 2004 and 2005. The important contrast in the maps prepared with the traditional method and the alternate method is the level of detail accomplished with the alternate method. For 2003, 2004, and 2005, there are more areas that show higher or lower levels of deposition with the alternate method than are shown with the traditional method.

The alternate method provides a level of detail that can be useful to state- and local-scale assessments of mercury deposition. State- and local-scale assessments may need to include mercury deposition to watersheds whose areas are smaller than the isopleth areas that are mapped with the traditional method. (The Indiana map to the right shows watersheds associated with monitoring sites for mercury in streams as an example of a scale that can benefit from the alternate method.) The finer level of detail in the isopleth areas helps to distinguish local differences that are masked when the isopleth areas are larger than the watershed.

CONCLUSION

Based on this example from Indiana, the alternate method can be used for preparing mercury wet deposition isopleth maps for state- and local-scale assessments of mercury deposition. The main requirements for the alternate method are MDN sites to compute precipitation-weighted mercury concentrations and reliable long-term precipitation data from a dispersed and comprehensive network of locations such as NWS COOP sites.

TOTAL MERCURY WET DEPOSITION ISOPLETH MAPS FOR INDIANA BY TRADITIONAL AND ALTERNATE METHODS -- 2003, 2004, AND 2005

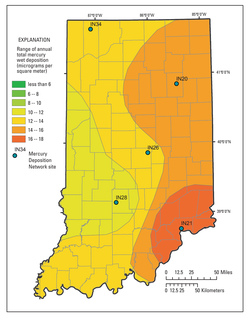


Figure 6. Isopleth map of annual total mercury wet deposition in Indiana, 2003, from National Atmospheric Deposition Program Mercury Deposition Network North America map made with the traditional method.

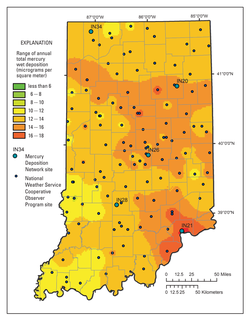


Figure 7. Isopleth map of annual total mercury wet deposition in Indiana, 2003, based on estimated deposition at 127 National Weather Service Cooperative Observer Program sites and 5 MDN sites.

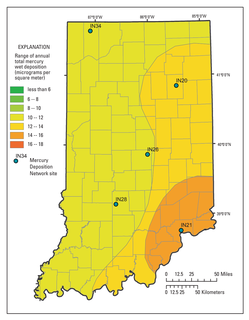


Figure 8. Isopleth map of annual total mercury wet deposition in Indiana, 2004, from National Atmospheric Deposition Program Mercury Deposition Network North America map made with the traditional method.

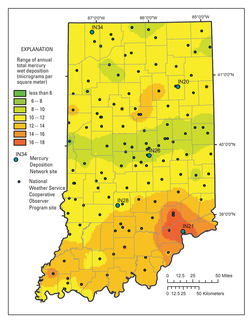


Figure 9. Isopleth map of annual total mercury wet deposition in Indiana, 2004, based on estimated deposition at 127 National Weather Service Cooperative Observer Program sites and 5 MDN sites.

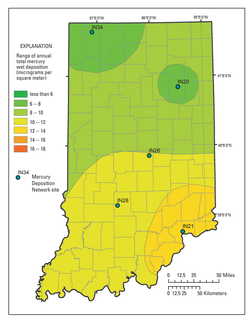


Figure 10. Isopleth map of annual total mercury wet deposition in Indiana, 2005, from National Atmospheric Deposition Program Mercury Deposition Network North America map made with the traditional method.

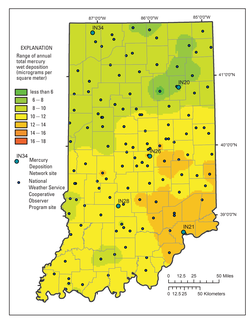


Figure 11. Isopleth map of annual total mercury wet deposition in Indiana, 2005, based on estimated deposition at 127 National Weather Service Cooperative Observer Program sites and 5 MDN sites.