Air Resources Laboratory

Mercury Modeling and Observations

Conducting World-Class Research on the Atmospheric Mercury Cycle

Mercury is a potent neurotoxin, particularly damaging to the development of fetuses, infants and young children. Human exposure to methylated mercury, the most toxic form, is largely through eating contaminated fish. Today, nearly every U.S. state warns residents to restrict their consumption of certain fish due to mercury contamination. The U.S. Food and Drug Administration and U.S. Environmental Protection Agency (US EPA) also have fish consumption advisories for mercury. New research indicates that mercury is even accumulating at potentially dangerous levels in terrestrial wildlife that do not eat fish.

The primary pathway by which mercury enters most aquatic and terrestrial ecosystems is atmospheric deposition (in rain and snow and "dry" deposits) originating from mercury emissions. The largest sources of mercury emissions in the U.S. and worldwide are coal-fired power plants, waste incinerators, metallurgy/mining operations (especially gold mining), and chlor-alkali plants that employ mercury-cell technology. Another source of mercury is disposable products, such as compact fluorescent bulbs and personal electronics (cell phones, LCD TVs, digital cameras), which contain mercury. Mercury can be released to the environment when these items are broken or crushed.

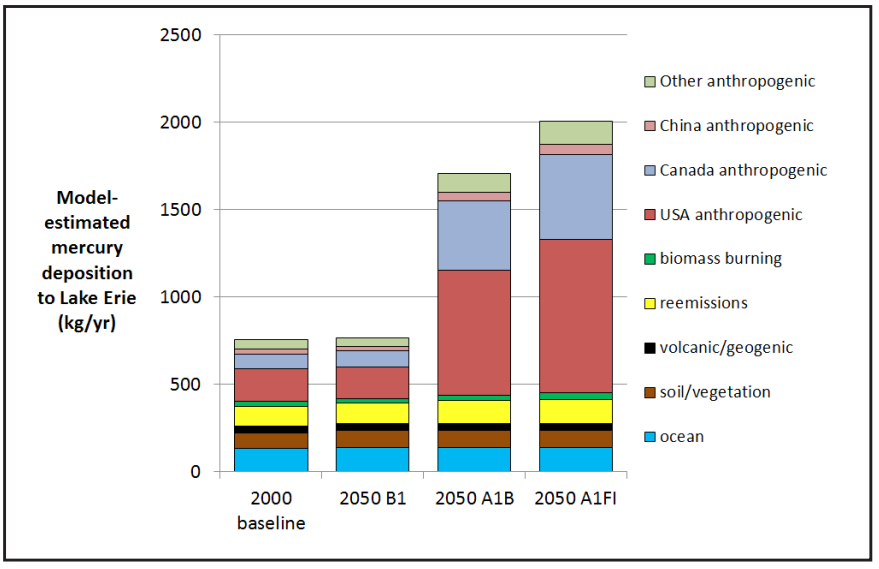
Our Research

NOAA's Air Resources Laboratory (ARL) conducts world-class research in the atmospheric mercury cycle. A cornerstone of this research is the enhancement and application of a state-of-the-art modeling system that tracks mercury emission sources and links these emissions to atmospheric transport, transformation, and deposition. ARL also conducts long-term intensive monitoring of mercury in ambient air, as well as short-term field studies for basic understanding of chemical processes. Data collected are analyzed to gain insights into the origin, transport, and deposition of atmospheric mercury and for evaluating and improving the mercury modeling system.

Mercury Modeling System

The HYbrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model is a very powerful and useful analytical tool developed by ARL and used at NOAA and throughout the world to investigate atmospheric dispersion of harmful material. ARL has created a special version of the HYSPLIT model (HYSPLIT-Hg) to simulate the atmospheric fate and transport of mercury.

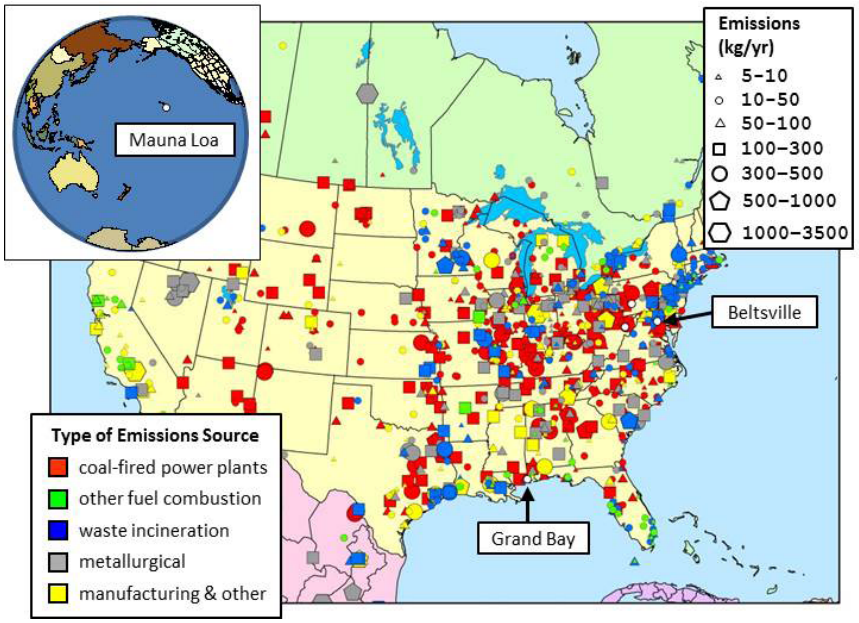
HYSPLIT-Hg starts with a mercury emissions inventory; then utilizes meteorological data assembled by NOAA and others to estimate the atmospheric dispersion of mercury from each source. Chemical reactions in the air; the partitioning of mercury into gaseous, aerosol, and droplet phases; and wet and dry deposition are then simulated by the model. A key feature of HYSPLIT-Hg is that it can estimate the overall atmospheric concentrations and deposition arising from emissions of mercury to the air and at the same time keep track of the individual contributions of each source to the overall



Atmospheric mercury deposition to Lake Erie from anthropogenic and natural sources estimated with the HYSPLIT-Hg model for baseline conditions (year 2000) and for three different 2050 future emissions scenarios: B1 includes the introduction of clean and resource-efficient technologies; A1B includes a balance across a mix of energy sources; and A1F1 is relying on intensive fossil fuel technologies. Source: Modeling Atmospheric Mercury Deposition to the Great Lakes: Projected Consequences of Alternative Future Emissions Scenarios, 2014 Final Report to the USEPA, through the Great Lakes Restoration Initiative.

totals. ARL evaluates the model's performance by comparing its predictions against ambient air measurements collected by ARL and other scientists.

To date, model results are encouragingly consistent with observations. However, important research continues to be needed to evaluate, refine, update and extend the modeling system. This will allow a better estimation of the relative contribution of different source types and source regions to deposition to sensitive key ecosystems.



ARL's three AMNet sites in the United States (Mauna Loa, Beltsville, and Grand Bay) and 2002 mercury emissions sources based on data from USEPA, Environment Canada, and the Commission for Environmental Cooperation.

Monitoring Mercury in the Air and Deposition

Mercury is a complicated pollutant to measure and track because it can be emitted in different forms (gaseous-oxidized, particle, and elemental) and be converted from one form to another. Each form's atmospheric lifetime varies as well.

As part of a national effort to monitor ambient air mercury concentrations and estimate deposition, ARL operates three long-term, research-grade monitoring stations as part of the National Atmospheric Deposition Program's Atmospheric Mercury Monitoring Network (AMNet). Analysis of the data collected and other information, such as concentrations of pollutants often emitted with mercury (sulfur, nitrogen) and local and regional meteorology, provide valuable insight into the mechanisms controlling the transport, distribution, and fate of mercury. Coupled with modeling, the observed mercury concentrations are used to understand how particles and gases released into the air are exchanged with the Earth's surface—a process known as "air-surface exchange." Concentrations in precipitation are quantified through chemical analysis of collected rain and snow samples, allowing estimates of wet deposition.

Short-term Field Studies

To complement long-term concentration and deposition monitoring, ARL also conducts research for basic understanding of chemical processes. This research typically takes the form of short-term, intensive field studies that test emerging chemical measurement technologies and improve our understanding of the atmospheric and terrestrial processes and factors (i.e., wind, temperature, surface roughness) controlling air-surface exchange of mercury compounds.

Our Partners

- U.S. Environmental Protection Agency
- National Park Service
- NOAA/Earth System Research Laboratory
- NOAA/National Ocean Service
- MS Department of Environmental Quality
- University of Tennessee

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