Mercury Research Intensives at the NOAA Grand Bay Monitoring Site

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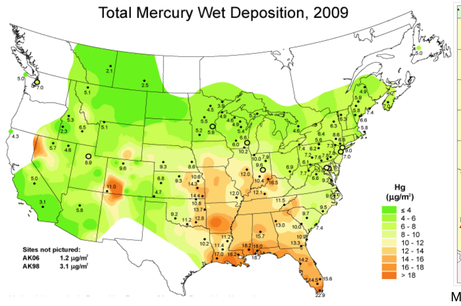
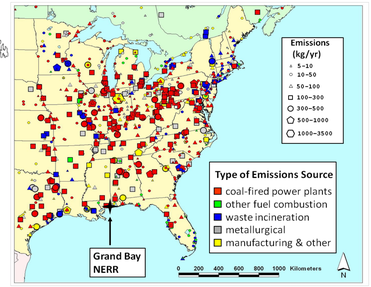
Background and Key Science Questions Addressed

Mercury exists in the atmosphere in several distinct chemical and physical forms, which dictate to a large degree their ultimate impact on the environment. Once deposited to watersheds, mercury compounds can undergo methylation and thus enter the food chain through bioaccumulation. Human exposure to mercury results from the consumption of contaminated fish and other aquatic organisms. Mercury deposition in the Southeastern United States is especially high, for reasons which are not entirely clear.



Map courtesy of the National Atmospheric Deposition Program (NADP) Mercury Deposition Network (MDN)



Map of the eastern United States showing the location of the Grand Bay NERR monitoring site and anthropogenic sources from the 1999 EPA National Emissions Inventory

Direct injection of elemental (Hg^0), reactive gaseous (RGM), and fine particulate (FPM) mercury from anthropogenic sources accounts for the bulk of mercury emissions to the atmosphere. Hg^0 is also evaded from soils and oceans, and chemical reactions in the atmosphere transform natural and anthropogenic mercury into RGM and FPM species and vice versa.

Key questions addressed by ARL's work include:

- **What are the relative contributions of natural and anthropogenic processes to mercury concentrations at a coastal location in the Southeastern U.S.?**
- **What role is played by halogen chemistry, either in the marine boundary layer or upper troposphere/lower stratosphere (UT/LS)?**
- **How important is transport from the upper troposphere in influencing mercury concentrations at the surface?**
- **Can we identify individual RGM species to infer details of halogen chemistry?**

Approach

ARL established a mercury monitoring station at the NOAA Grand Bay National Estuarine Research Reserve (NERR) in 2006, and its dual Tekran detectors provide continuous data to NADP's Atmospheric Mercury Network (AMNet). ARL monitors continuously mercury and ancillary species (NO, NO_y, CO, O_3, SO_2, black carbon, meteorology) at Grand Bay, making the site an ideal host location for research intensives. During the August 2010 intensive, the following capabilities were added:

Measure mercury at the surface in air and precipitation (ARL, MSDEQ, FSU)

Measure halogen species (BrO, HOBr, etc.) at the surface (GATECH)

Measure Hg^0 and RGM aloft, using the University of Tennessee Space Institute (UTSI) Piper Navajo aircraft, to infer the importance of *in-situ* photochemistry in mercury transformations

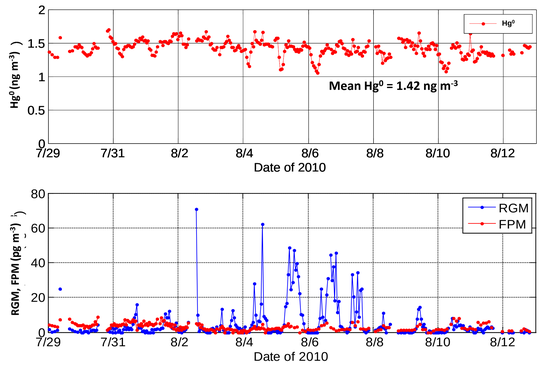
Employ a novel technique to identify collected RGM species (UMiami)

Measure SO_2, O_3, and particles to interpret mercury data aloft (ARL)

Use ozonesondes to identify high ozone aloft as a surrogate for transport from the UT/LS (ARL)

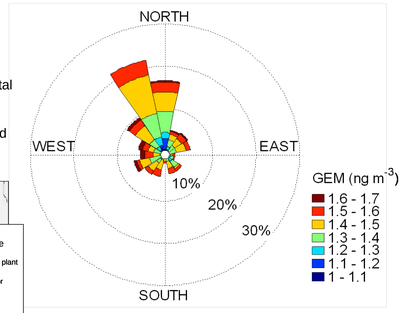
Measure deposition fluxes of mercury compounds at the NERR (CVI)

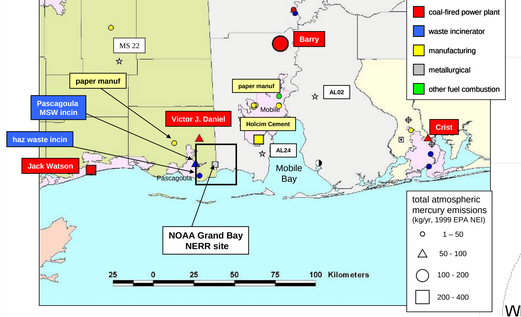
Accomplishments

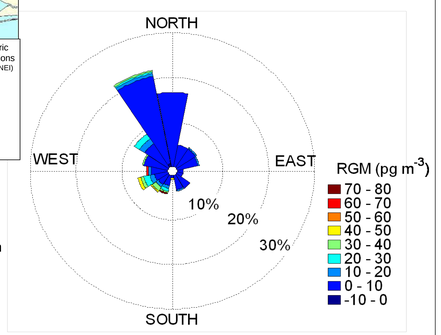


Above: Time series of elemental, reactive gaseous, and fine particulate mercury data during the intensive. RGM events were noted on August 2, 4, 5, 6, and 7, 2010. RGM concentrations typically correlated with SO_2 (not shown), suggesting that direct emissions from local and regional sources were an important driver of surface concentrations during the intensive.

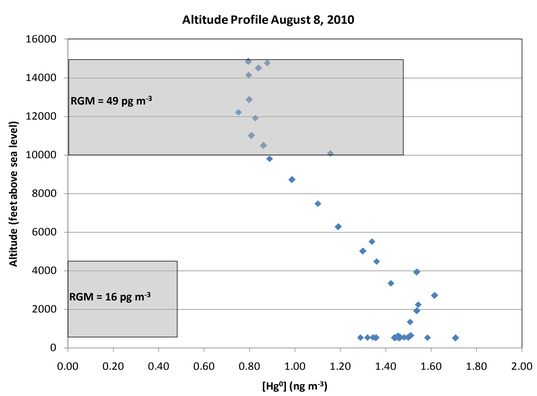
Right: Frequency plot of surface Hg^0 (also referred to as Gaseous Elemental Mercury, or GEM) concentrations, binned by wind direction. Although Hg^0 concentrations were somewhat elevated in winds from westerly and northeasterly directions, elemental mercury is relatively uniformly distributed in the troposphere, a result of its long atmospheric lifetime (months)







Right: Unlike elemental mercury, RGM is easily removed from the atmosphere within a few days. Surface concentrations thus reflect more recent emissions or transport events. RGM concentrations were substantially elevated in winds from the west and southwest, the direction of major sources in the region.



Left: Profile of elemental mercury concentrations measured from the UTSI aircraft. Hg^0 concentrations are highest in the planetary boundary layer. Measured RGM concentrations at altitudes of 10,000-15,000 feet (top) and 550-4,500 feet (bottom) are noted as gray-shaded bars. The presence of significant RGM in the middle free troposphere suggests that local sources alone cannot explain all the behavior of RGM in the troposphere, and that long-range transport or photochemical formation may also be important. Under the right conditions, downward mixing of RGM pools aloft may play an important role in driving RGM concentrations at the surface. Data courtesy of Dr. Anthony Hynes, U. Miami.

Partners

Future Direction

The second phase of the intensive began on April 18, 2011. RGM concentrations at Grand Bay are typically elevated in the Spring months (perhaps a result of more frequent downward mixing of UT/LS air following cold frontal passage), so it was desirable to make additional measurements at that time. The following changes were made to the second phase of the research intensive:

- More frequent ozonesonde launches (daily or twice-daily) to better document the downward transport of UT/LS stratospheric air as a mechanism of delivering RGM to the middle, and possibly lower, troposphere (ARL)
- Addition of an aerosol sampler for the collection and measurement of ^7Be (an unequivocal tracer of stratospheric air) at the surface (ARL)
- Improvements to sampling protocols for elemental and reactive gaseous mercury to reduce uncertainties arising from variations in blank levels, and to better quantify total loadings on denuders (UMiami)
- Routine flights at higher altitudes (20,000 feet) to better sample mid- and (descending) upper-tropospheric air (ARL, UTSI, UMiami)
- Expansion of the RGM gradient measurements to better quantify RGM flux (CVI)

Ozonesonde launch from Grand Bay

The UTSI Piper Navajo

Trace gas measurement rack in the Navajo cabin.