Relative Importance of Mercury Dry Deposition to MD08 in Western Maryland

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Introduction

Regional and global atmospheric transport models are often used to determine the mercury deposition to areas. These models have also been used to predict future deposition scenarios due to mercury emission reductions from coal-fired power plants in the United States. Large scale models produce mean mercury depositions for grids cells of a region that can range in size from 100m^2 (Miller et al 2005) to 100km^2 (Seigneur et al 2004). The coarse scale of these models can make it difficult to determine the deposition to a single site within the grid. Therefore, model predictions of mercury deposition to individual sites is highly variable. This variability stems from discrepancies in modeling approaches, including the deposition velocities for the different mercury species, model grid size, and power plant emissions data. More research is clearly needed to better understand processes controlling atmospheric mercury deposition, to decrease model grid sizes, and to improve model predictions. The purpose of the research summarized in this poster is to compare and contrast modeled atmospheric mercury deposition rates to single site in western Maryland.

Study Site

The study site was our Piney River Reservoir Ambient Air Monitoring Station (PRAAMS) in Garrett County, Maryland. Since the summer of 2003, this site has been measuring several air pollutants, such as O_3, SO_2, OC/EC, Sulfate, NOy and speciated mercury (using a Tekran 2537A, 1130, and 1135 speciation units). This site (MD08) is also a member of the National Atmospheric Deposition Program National Trends Network and Mercury Deposition Network.

Approach

We used three different model approaches to estimate annual total mercury deposition (wet + dry) at MD08 (AL 1, AL 2, and AL3). In all AL models, wet deposition was determined from weekly MDN data collected from January to December 2006. We estimated the dry deposition rates of Hg^0, RGM, and Hg-part, by multiplying the average weekly ambient air concentrations by different deposition velocities and summing over the year for January to December 2006. To examine the variation caused by different dry deposition calculation methods, ambient air concentrations were multiplied by constant dry deposition velocities for three scenarios. In the first scenario dry deposition velocities were 0.01cm s^{-1} for Hg^0, 0.5 cm s^{-1} for RGM, and 0.1 cm s^{-1} for Hg-part (AL-1). These dry deposition velocities are used by the TEAM for dry deposition calculations. The second and third scenarios used a dry deposition velocity for RGM of 2.0 cm s^{-1} (AL 2) and 7.6 cm s^{-1} (AL 3) and the other deposition velocities were unchanged. The deposition velocities for RGM in AL 2 and AL 3 encompass the range of dry deposition velocities that have been observed at other sites (Poissant et al. 2004). The deposition predictions for the other models were obtained from the literature.

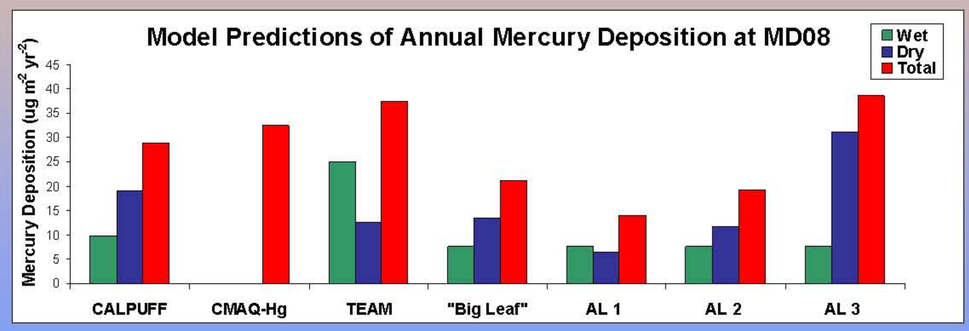
Model	Type	Year Modeled	Hg(0) Deposition Modeled	Deposition Velocities (cm s^{-1})	Reference
Calpuff	Lagrangian Puff	1999	No	Variable	Mark Garrison
CMAQ-Hg	Eulerian Transport	1999	Yes	Variable	Gbor et al 2007
TEAM	Chemical Transport Model	Emissions estimated from 1998 - 1999 inventories	Yes	RGM - 0.5 Hg(0) - 0.01 Hg-part - 0.1	Seigneur et al 2004
"Big Leaf"	Big Leaf Vegetation	Aggregated variables for several years	Yes	Variable	Miller et al 2005
AL-1	Constant	2006	Yes	RGM - 0.5 Hg(0) - 0.01 Hg-part - 0.1	This project
AL-2	Constant	2006	Yes	RGM - 2.0 Hg(0) - 0.01 Hg-part - 0.1	This project
AL-3	Constant	2006	Yes	RGM - 7.6 Hg(0) - 0.01 Hg-part - 0.1	This project

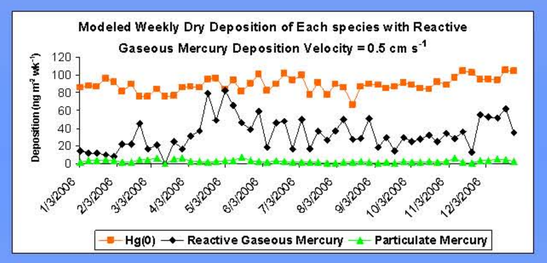
Literature

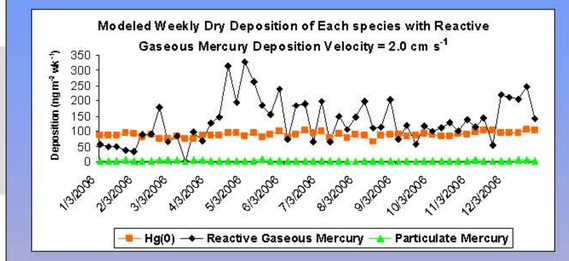
Gbor, P. K., D. Wen, F. Meng, F. Yang, and J. J. Sloan. 2007. Modeling of mercury emission, transport and deposition in North America. Atmospheric Environment **41**:1135-1149.
Seigneur, C., K. Vijayaraghavan, K. Lohman, P. Karamchandani, and C. Scott. 2004. Global source attribution for mercury deposition in the United States. Environmental Science & Technology **38**:555-569.
Miller, E. K., A. Vanarsdale, G. J. Keeler, A. Chalmers, L. Poissant, N. C. Kamman, and R. Brulotte. 2005. Estimation and mapping of wet and dry mercury deposition across northeastern North America. Ecotoxicology **14**:53-70.
Poissant, L., M. Pilote, X. H. Xu, H. Zhang, and C. Beauvais. 2004. Atmospheric mercury speciation and deposition in the Bay St. Francois wetlands. Journal of Geophysical Research-Atmospheres **109**:-.

Results

Model predictions of the annual total mercury deposition at MD08 varied by a factor of ~3. Although the wet deposition is known from our measurements (shown in the AL models), some of the models do not accurately reproduce that value. There is also disagreement as to which component of mercury deposition is the most important. For example, the AL 1 and TEAM models predict that wet deposition dominates, but all other models (unknown for CMAQ-Hg) predict that dry deposition dominates at MD08. AL 3 is the only AL model that reproduces the total deposition estimates of the CALPUFF, CMAQ-Hg, and TEAM models. While the AL 2 model estimates are almost identical to the "Big Leaf" model predictions. Although many advancements in modeling the deposition of mercury have been made, the variability in model estimates illustrate that additional improvement are necessary to determine the most accurate total mercury deposition rate at MD08.







Much of the variation in total deposition estimates comes from uncertainties in the dry deposition velocities of the mercury species in ambient air. As the dry deposition velocities change, so does the predicted dry deposition rate. For instance if a dry deposition velocity of 0.5cm s^{-1} is used for RGM (AL 1), Hg^0 dominates dry deposition (upper panel). If a dry deposition velocity of 2.0cm s^{-1} is used for RGM (AL 2) then RGM dominates dry deposition (lower panel). However, the actual dry deposition velocity of all mercury species is variable, and the only way to truly know the total mercury deposition at this site is to measure the dry deposition velocities.

Conclusions

- **The uncertainty with the dry component of mercury deposition can be one reason for the wide variation in predicted total mercury deposition to MD08.**
- **Depending on the dry deposition velocities used, mercury dry deposition at MD08 could be dominated by RGM or Hg^0.**
- **Depending on the model chosen, total mercury deposition at MD08 could be dominated by wet or dry deposition.**
- **The only way to remove the uncertainty with the dry component of mercury deposition, to improve current deposition estimates, and see the effects of mercury emission regulations at MD08 is to actually make measurements of mercury dry deposition at MD08.**