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Forest-Atmosphere Mercury Exchanges: Implications for Mercury Cycling

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Summary

Recent modeling studies suggest that only one-half to one-third of the total atmospheric deposition of mercury is being measured by existing wet deposition monitoring stations (Miller et al. 2005). Dry deposition of reactive gaseous mercury (RGM = $HgCl_2$ + Hg Br_2) and gaseous elemental mercury (GEM) is likely to be very significant in forested landscapes. Some fraction of the deposited mercury is re-volatilized and re-emitted to atmosphere. The mechanisms controlling ecosystem mercury emissions are not well understood and the magnitude of these emissions has not been well quantified. There have been only a few short-term measurements of RGM concentrations in rural environments (Poissant et al. 2004). A small number of total gaseous mercury (TGM) and GEM flux measurements have been made during short-term (weeks – months) studies mostly over wetlands (e.g. Lee et al. 2000, Lindberg et al. 2002, Poissant et al. 2004) with just a few days of measurements made over forests (Lindberg et al. 1998).

Ecosystems Research Group Ltd., in cooperation with the Vermont Monitoring Cooperative, University of Vermont, University of Michigan, and the Vermont Agency of Natural Resources, is conducting the first multi-year measurements of RGM concentrations and mercury vapor fluxes to and from the atmosphere over a forested landscape. Measurements are being conducted at VMC's forest canopy tower at the UVM Proctor Sugar Maple Research Center in Underhill, VT. The measurements are co-located with existing monitoring programs for wet deposition of mercury, acid deposition and atmospheric chemistry. A Tekran® 1130 module and 2537A analyzer are used to measure the ambient air concentrations of RGM and GEM in addition to the concentration gradient of TGM above the forest canopy. A suite of micrometeorological instruments is deployed on the tower to measure atmospheric turbulence and surface energy balance. The flux of mercury is calculated using the measured mercury gradient, water vapor and sensible heat fluxes. The flux of CO_2 is being quantified simultaneously to facilitate understanding the relationship between canopy physiological activity and mercury fluxes.

Ambient TGM concentrations ranged from 1.0 to 3.5 ng m^{-3} and averaged 1.72 ng m^{-3} over the first 4 months of operation. RGM concentrations ranged from 2 to10 pg m^{-3} through most of the summer with frequent excursions to 20-35 pg m^{-3} during the warm, dry early part of the summer. The mid and late summer of 2004 were unusually wet and cool with low oxidant levels and low RGM concentrations. Diurnal patterns in RGM

concentrations suggested frequent periods of local RGM production via photochemistry (c.f. Poissant et al. 2004). Other periods of elevated RGM from late day through the overnight hours suggested the possibility of regional RGM transport events. Periods of both mercury vapor deposition and emission were observed. Preliminary flux calculations suggest the forest was a net source of mercury vapor with a median net emission of 60 ng m^{-2} h^{-1} during the wet summer of 2004.

These preliminary results confirm that dry deposition of mercury is an important deposition pathway. This study, in conjunction with the ongoing wet deposition monitoring at Underhill, will provide the first direct measurements of net forest-atmosphere exchange of mercury. Understanding the major mercury fluxes and the mechanisms controlling those fluxes is critical to assessing the persistence of mercury pollution in the environment.

References

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