ROLE OF FORESTS IN THE GLOBAL BIOGEOCHEMICAL CYCLING OF MERCURY

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Introduction

Terrestrial forest has been regarded as a largely underestimated sink for atmospheric mercury (Hg) on global scale (Lindberg et al., 2007). Forest vegetation removes atmospheric Hg through uptake by stomata/cuticle in surface foliage, transport to forest floor through litterfall/throughfall, or storage in live biomass (e.g., stem), and sequestration in soil (Gustin et al., 2008). Hg deposition through litterfall has been considered the lower bound of Hg dry deposition to forest ecosystems (Risch et al., 2012). Studies on Hg deposition through litterfall at global forest sites suggested that such deposition is significantly greater than wet deposition, poses a significant impact on the size of Hg storage in forest soil (Zhou et al., 2013), and can be used for gauging Hg dry deposition flux obtained by modeling (e.g., CMAQ-Hg, GEOS-Chem). However, few studies systematically evaluated the role of Hg deposition through litterfall in global biogeochemical cycling of Hg. In this study, the quantity and geospatial distribution of global Hg deposition through litterfall is assessed through statistical modeling using published datasets of litterfall biomass production, tree density and Hg concentration in litterfall. The statistical estimate in this work and global Hg modeling results are compared. The implications in terms of the role of Hg input through litterfall in Hg cycling are discussed.

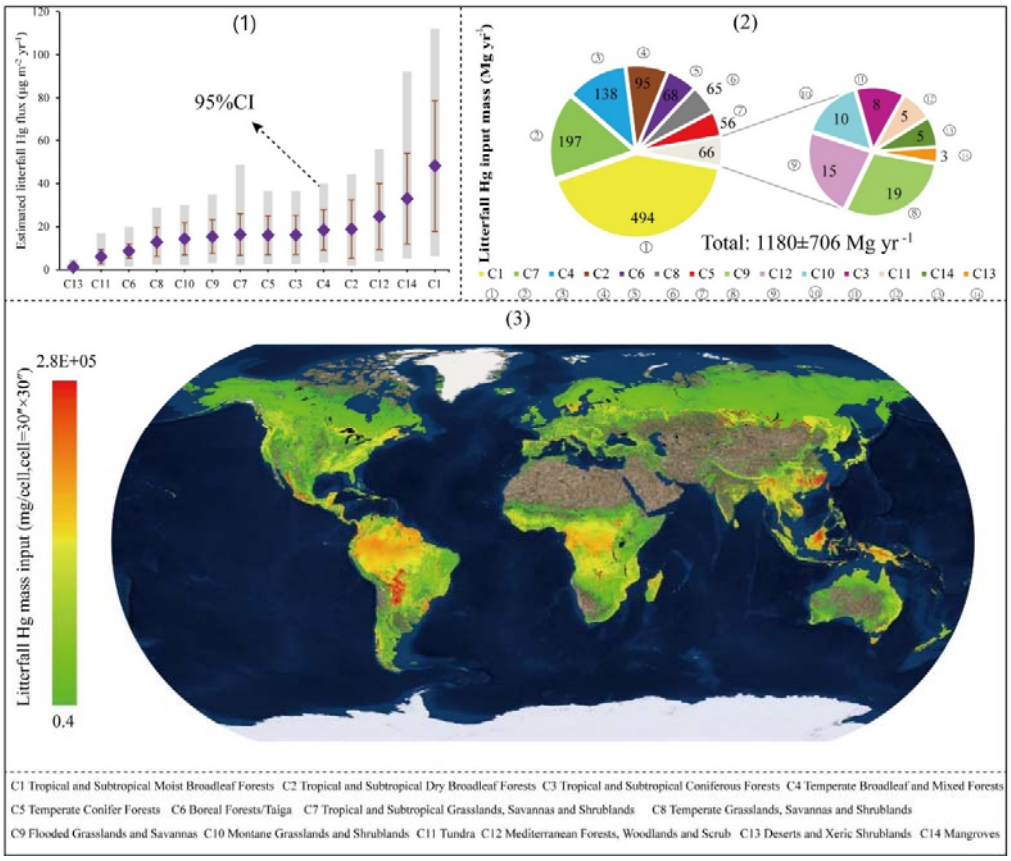
Methods

Data from peer-reviewed literature published during 1995-2015 for 138 relatively remote/rural sites where atmospheric Hg concentrations were $\leq$ 5.0 ng m^{-3}. A global database of litterfall biomass production (sites=575) is available on-line from Oak Ridge National Laboratory Distributed Active Archive Center (http://dx.doi.org/10.3334/ORNLDAAC/1244). Using these data, Monte Carlo simulation was applied to integrate the datasets of Hg concentration in litterfall and litterfall biomass to produce the probability distribution of Hg deposition through litterfall, which was then utilized to estimate the input of Hg to global forest ecosystems.

Results

Hg deposition flux through litterfall for different biomes as well as the contributions to Hg deposition through litterfall are shown in Figure 1. Existing data show that dry deposition of Hg (defined as the sum of Hg deposition through litterfall and Hg deposition difference caused by throughfall and rainfall) is the predominant pathway of Hg loading to forest floor, accounting for an average of 77% of total (dry+wet) deposition at 27 sites globally. Using the model results, the global annual Hg deposition through litterfall is estimated to be 1180±706 Mg yr^{-1}. Estimate for Hg fixed by leaf biomass in this study is >2 times higher than the estimate by GEOS-Chem. Spatial distribution of Hg deposition through litterfall suggests that deposition flux decreases spatially from tropical to temperate/boreal regions. Approximately 70% of global Hg dry deposition occurred in tropical/subtropical regions. More measurement data in tropical and sybtropical regions will greatly improve the accuracy of the current estimate.

Figure 1: (1) Hg deposition flux through litterfall for different biomes. (2) Global Hg deposition budget through litterfall of different biomes. (3) Gridded Hg deposition through litterfall in mg/cell



Conclusion

Using a mass balance approach, the net Hg sink caused by global forest ecosystems is estimated to be 1805 Mg yr^{-1}, highlighting importance of forest ecosystem in global Hg cycling.

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