Physiological and climate controls on foliar mercury uptake by European tree species

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Despite the importance of vegetation uptake of atmospheric gaseous elemental mercury (Hg(0)) within the global Hg cycle, little knowledge exists on the physiological, climatic, and geographic factors controlling stomata! uptake of atmospheric Hg(0) by tree foliage. We investigate controls on foliar stomatal Hg(0) uptake by combining Hg measurements of 3569 foliage samples across Europe with data on tree species' traits and environmental conditions. To account for foliar Hg accumulation over time, we normalized foliar Hg concentration over the foliar life period from the simulated start of the growing season to sample harvest. The most relevant parameter impacting daily foliar stomatal Hg uptake was tree functional group (deciduous versus coniferous trees). On average, we measured 3.2 times higher daily foliar stomatal Hg uptake rates in deciduous leaves than in coniferous needles of the same age. Across tree species, for foliage of beech and fir, and at two out of three forest plots with more than 20 samples, we found a significant ($p < 0.001$) increase in foliar Hg values with respective leaf nitrogen concentrations. We therefore suggest that foliar stomatal Hg uptake is controlled by tree functional traits with uptake rates increasing from low to high nutrient content representing low to high physiological activity. For pine and spruce needles, we detected a significant linear decrease in daily foliar stomatal Hg uptake with the proportion of time during which water vapor pressure deficit (VPD) exceeded the species-specific threshold values of 1.2 and 3 kPa, respectively. The proportion of time within the growing season during which surface soil water content (ERAS-Land) in the region of forest plots was low correlated negatively with foliar Hg uptake rates of beech and pine. These findings suggest that stomatal uptake of atmospheric Hg(0) is inhibited under high VPD conditions and/or low soil water content due to the regulation of stomatal conductance to reduce water loss under dry conditions. Other parameters associated with forest sampling sites (latitude and altitude), sampled trees (average age and diameter at breast height), or regional satellite-observation-based transpiration product (Global Land Evaporation Amsterdam Model: GLEAM) did not significantly correlate with daily foliar Hg uptake rates. We conclude that tree physiological activity and stomatal response to VPD and soil water content should be implemented in a stomatal Hg model to assess future Hg cycling under different anthropogenic emission scenarios and global warming.
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