Comparative study of elemental mercury flux measurement techniques over a Fennoscandian boreal peatland

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Quantitative estimates of the land-atmosphere exchange of gaseous elemental mercury (GEM) are biased by the measurement technique employed, because no standard method or scale in space and time are agreed upon. Here we present concurrent GEM exchange measurements over a boreal peatland using a novel relaxed eddy accumulation (REA) system, a rectangular Teflon (R) dynamic flux chamber (DFC) and a DFC designed according to aerodynamic considerations (Aero-DFC). During four consecutive days the DFCs were placed alternately on two measurement plots in every cardinal direction around the REA sampling mast. Spatial heterogeneity in peat surface characteristics (0-34 cm) was identified by measuring total mercury in eight peat cores (57 +/- 8 ng g(-1), average SE), vascular plant coverage (32-52%), water table level (4.5-14.1 cm) and dissolved gaseous elemental mercury concentrations (28-51 pg L-1) in the peat water. The GEM fluxes measured by the DFCs showed a distinct diel pattern, but no spatial difference in the average fluxes was detected (ANOVA, alpha = 0.05). Even though the correlation between the Teflon DFC and Aero-DFC was significant ($r = 0.76$, $p < 0.05$) the cumulative flux of the Aero-DFC was a factor of three larger. The average flux of the Aero-DFC (1.9 ng m(-2) h(-1)) and REA (2 ng m(-2) h(-1)) were in good agreement. The results indicate that the novel REA design is in agreement for cumulative flux estimates with the Aero-DFC, which incorporates the effect of atmospheric turbulence. The comparison was performed over a fetch with spatially rather homogenous GEM flux dynamics under fairly consistent weather conditions, minimizing the effect of weather influence on the data from the three measurement systems. However, in complex biomes with heterogeneous surface characteristics where there can be large spatial variability in GEM gas exchange, the small footprint of chambers (<0.2 m(2)) makes for large coefficients of variation. Thus many chamber measurement replications are needed to establish a credible biome GEM flux estimate, even for a single point in time. Dynamic flux chambers will, however, be able to resolve systematic differences between small scale features, such as experimentally manipulated plots or small scale spatial heterogeneity.
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