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Ponds as disproportionate sources of CO_2 and CH_4: A global data perspective

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Inland waters, including small lakes and ponds, play a major role in the global carbon cycle. While they typically act as organic carbon sinks, they also emit the greenhouse gases (GHGs) carbon-dioxide (CO_2) and methane (CH_4) to the atmosphere. Nonetheless, small inland waters, defined as those with a surface area (SA) of less than 5 hectares (further referred as "ponds"), are often excluded from large-scale CO_2 and CH_4 budgets. To help overcome this gap, we reviewed available global datasets on inland waters and selected G1WBM, GLCF, and OSM to assess the global distribution of ponds. We compiled a dataset of CO_2 and CH_4 emissions plus water chemistry data from 950 ponds worldwide from the literature. Next, we applied a Monte Carlo analysis to the estimated surface areas and CO_2 and CH_4 emission ranges of ponds. The results suggest that ponds with SA<1 ha emit 0.25-0.42 Pg C yr^{-1}, and those of 1-5 ha emit 0.18-0.45 Pg C yr^{-1}, accounting for up to 14 and 17%, respectively, of the total carbon gas emissions from all-sized lakes and ponds worldwide. Our estimates thus highlight the potentially disproportionate, yet poorly constrained, importance of ponds in global GHG budgets. We also extracted gridded hydrometeorological and socio-economic data matched to each basin of the 950 ponds. Using Random Forest regression (RFR) models, we found that pond water pH and watershed urbanization were the most important predictors of the CO_2 emissions, while electrical conductivity (EC), SA, and pond depth were the most important variables for the CH_4 emissions. The RFR modeling revealed that ponds in urban areas typically exhibit elevated pH levels, probably due to the ubiquitous use of cement-based construction materials. High pH levels, in turn, suppress CO_2 emissions by retaining dissolved inorganic carbon under the form of aqueous bicarbonate. The role of non-sulfate-derived EC in modulating the CH_4 emissions is attributed to the effect of salinity on the mixing intensity and the associated impact on water column oxygenation. Overall, our findings highlight the role of ponds in global carbon cycling and the variability in their GHG emissions driven by land use and water chemistry.