Title: **Contributions of hydropower reservoirs to global carbon emissions: breaking down sources of uncertainties**

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Abstract:
Hydropower reservoirs provide renewable electricity generation and many other services, such as drinking water, irrigation, flood control, and recreation. As with most aquatic ecosystems, reservoirs play an important role in the global carbon cycle and emit biogenic greenhouse gases in the forms of carbon dioxide and methane that influence their net carbon footprints. However, these carbon emissions are poorly quantified in reservoirs, especially in temperate systems. As a result, there is high uncertainty as to the spatiotemporal variability in emissions from individual reservoirs as well as uncertainty in national to global reservoir contributions to carbon emissions. To assess the sources of uncertainty in reservoir carbon emissions, we compared two empirical field-based methods and one modelling method of estimating upscaled, whole-reservoir emissions. We sampled six hydropower reservoirs in the southeastern USA using two different spatial survey designs to quantify the emission rates of carbon dioxide and methane via different emissions pathways. We paired this with modelled emissions estimates from the same six reservoirs and emissions pathways using the GHG Reservoir (G-res) tool. Comparing carbon emissions from the different pathways and different methods showed high uncertainty across the six reservoirs. While both field-based methods indicated strong carbon dioxide influxes (sequestration) at all six reservoirs, the G-res model showed carbon dioxide emissions at all six reservoirs. Methane degassing emissions, a pathway unique to reservoirs, was estimated to be orders of magnitude higher in four of the six reservoirs based on the G-res model compared to field data, but similar in the other two reservoirs. Methane ebullitive emissions showed the greatest variability across reservoirs and methods across all six reservoirs, with no clear consistency. Some reservoirs had similar field-based ebullition estimates while modelling estimated two to five times greater emissions, and others had ebullition estimates from modelling similar to one field-based method but not the other. Given these inconsistent discrepancies, upscaling whole-reservoir carbon emissions is still highly uncertain and can influence our understanding of hydropower reservoirs' carbon footprints. Methane emissions are particularly important to understand, as they are ~34 time more potent than carbon dioxide emissions and have very high within-reservoir spatial variability in ebullition emissions in particular. Hence, additional research breaking down sources of uncertainty in methodology, pathways, and

spatiotemporal variability in reservoir carbon emissions will be vital to understanding the carbon footprint of these renewable energy sources and contextualize their current and projected future contributions to global carbon emissions.