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Bias in chamber-based methane flux estimates in the presence of ebullition and methods for mitigation

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Natural ecosystems, particularly wetlands, are among the largest sources of methane emissions. Accurately quantifying these emissions is crucial for developing effective climate change mitigation strategies. In this context, flux chambers have emerged as a vital tool, allowing researchers to accurately quantify methane emissions over space and time. The increasing availability of high-precision, real time, field deployable methane analyzers has helped improve the accuracy and reliability of these measurements; however this high-resolution data has also introduced new methodological considerations around how to best fit time series data to determine flux rates.

With these new analyzers, ebullition events are easily detected but traditional methods of fitting data to determine fluxes assume diffusion-dominated fluxes and do not appropriately account for ebullitive events. Researchers often adapt existing flux calculation methods to suit the behaviour of the time series data where ebullition is present, however no study of the impacts of these adjustments has been conducted.

Here we use a one-dimensional soil model to simulate diffusive and ebullitive methane fluxes into a chamber and explore the impact of back-diffusion and chamber leakage on the fluxes calculated using traditional and modified approaches. We find that generally diffusive fluxes calculated using these approaches are underestimated when ebullition is present, and the size of the underestimation can be significant in the context of upscaling these chamber based measurements particularly in low flux environments. Approaches to improve accuracy including chamber design, data filtering and new fitting methods are considered as a means to provide more accurate chamber-based methane emissions estimates.