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Managing hydrology can reduce methane emissions of high-emitting freshwater marshes by half making them present-day net greenhouse gas sinks

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Restoring wetlands for climate mitigation purposes could provide an effective method to protect existing soil carbon stocks, as well as act as a negative emission technology by sequestering atmospheric carbon for 100-1000s of years. However, many peatlands have low productivity limiting carbon sequestration, while high productivity marshes often emit large amounts of methane. Studies on water level management to control methane emissions have shown differing results depending on wetland type, climate, as well as measurement method and duration. Here we show with multi-year flux measurements that water level changes were likely responsible for significantly reducing annual methane emissions. To assess management impacts on annual greenhouse gas budgets, continuous high frequency measurements of fluxes are needed, such as by eddy covariance. However, this method is less suited to monitor concurrent manipulation experiments to compare treatments. We compared the impact of water level fluctuations by creating a second timeseries where water drawdown events were removed, which was then gap-filled by a random forest model trained only on measurements from periods when the water table was above the surface. These estimates were used to compare the annual budgets with the complete data and showed that annual methane emissions were up to 50% lower in years where water levels went sufficiently below the peat surface. This threshold was key, as only reductions in water depth above the surface were related to temporary increases in emissions. We further show that in some cases the drawdowns tipped the greenhouse gas budgets so that marshes were net greenhouse gas sinks, as long as the drawdown did not also reduce plant productivity through drought stress. In comparison, wetlands with average annual fluxes would require between approx. 50 and 200 years given current levels of net carbon uptake to offset high methane emissions and become cumulative greenhouse gas sinks.