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Never mind the methane? – A comprehensive perspective on peatland flooding gained from long-term measurements and radiative forcing modeling

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Rewetting through flooding can be a cost-effective measure to restore the C sink and habitat functions of drained and subsided peatlands. However, flooding as a management strategy is under debate, because it is uncertain whether the targets concerning ecosystem state and functions can be achieved in due time. In particular, high methane (CH4) emissions are expected to offset the climate cooling effect of carbon dioxide (CO_2) sequestration immediately after flooding. It is not well established how long this initial high emission phase lasts.
In this case study, we present a nine-year time series of CO_2 and CH4 measurements from a degraded rich fen that was flooded after two decades of abandonment. We investigated how flooding, in addition to other controls, affected the CO_2 and CH4 budgets. Further, we assessed how the initiated shift in CO_2 and CH4 budgets affected the radiative forcing of the peatland and, thus, evaluated the suitability of peatland flooding as climate protection measure.
Dilapidated drainage infrastructure and slowly rising water levels had turned the fen to a net CO_2 sink and negligible CH4 emitter at the end of the abandonment phase. Subsequent flooding lowered both CO_2 component fluxes, ecosystem respiration (RECO) and gross ecosystem productivity (GEP), by approximately 50%. Hence, in sum, the net CO_2 budget remained stable. Further, flooding elevated CH4 emissions by a factor of 100 in the short-term though emissions leveled off at a moderate level already in the second year of flooding. Altogether, flooding caused a distinct shift in the magnitude of RECO, GEP and CH4 budgets, but eventually, all budgets stabilized quickly at a new, fairly steady state. Already in the second year of flooding, the interannual variation of RECO, GEP and CH4 budgets could be attributed to the year-to-year fluctuations in hydrology and phenology.
At present state, significant CH4 emissions turn the flooded peatland to a distinct greenhouse gas source. Under the (conservative) assumption, that current C exchange characteristics will remain constant in the future, sustained CO_2 sequestration will offset the warming effect of the short-lived CH4 within 500 years. Indeed, such a time span goes far beyond the scope of contemporary societies. However, when compared with conventional utilization scenarios where drained peatlands act as permanent CO_2 emitters, flooding can achieve substantial reductions in radiative forcing already after 25 years. Therefore, we suggest that any management decision stopping peat decomposition can constitute a climate mitigation measure. However, from a climate perspective, there is considerable potential to optimize peatland restoration by avoiding flooding and thereby shortening the time required to compensate for initial methane emissions.