Geophysical Research Abstracts
Vol. 17, EGU2015-11012, 2015
EGU General Assembly 2015

Peatland restoration measures may have dramatic consequences – Greenhouse gas exchange and peat properties in a coastal fen in the first year after rewetting

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Rewetting is a common restoration measure for drained peatlands, i.e. to re-establish the natural habitat and biodiversity and to decrease the amount of greenhouse gas (GHG) emissions, especially of carbon dioxide (CO_2). Every restoration measure, however, is itself disturbance to the ecosystem that may, for instance, lead to partial die-back of vegetation or to increases in CH_4 emissions, especially when rewetting is actually achieved by flooding.
Here, we examine an ecosystem shift in a coastal brackish fen at the southern Baltic Sea, which was rewetted by flooding. The analyses are based on one year of bi-weekly dynamic closed chamber data gathered in the year after rewetting at measurement spots that were located in different vegetation stands (*Carex acutiformis* Ehrh., *Phragmites australis* L., *Schoenoplectus tabernaemontani* (C.C. Gmel.) Palla and *Bolboschoenus maritimus* (L.) Palla) and replicated at different inundation heights. During GHG measurement campaigns we recorded data on water levels, peat temperatures, and peat water chemical properties. Peat chemical properties were analysed before and after flooding.
Rewetting turned the site from a summer dry fen with mean annual water levels of around -0.08m into a shallow lake with water levels up to 0.60m. In the first year after flooding, we observed a substantial die-back of vegetation, especially in stands of Carex acutiformis. Peat water properties became more heterogeneous. Both TOC and TNb in the peat water significantly increased in the first year after flooding, whilst concentrations of (potentially) seaborne anions Cl^- and ${SO_4}^{2-}$ dropped. The changes in peat properties after flooding were inconsistent across vegetation stands, inundation heights and peat depths. Only dry bulk density and concentrations of C, N and S increased at (almost) all measurement spots. The average exchange of GHG amounted to 0.26 ± 0.06 kg m^{-2} CH_4 and 2.13 ± 0.34 kg m^{-2} CO_2 from dark soil respiration. This is equivalent to a 190-times increase in CH_4 compared to pre-flooding conditions. Highest GHG fluxes occurred in sedge stands that suffered from the heaviest die-back due to water level rise. None of the recorded environmental variables showed consistent correlation with the amounts of CH_4 and CO_2 exchanged.
In the short term perspective covered in this study, rewetting by flooding did not – especially due to the dramatic increase in CH_4 emissions – decrease GHG emissions. Furthermore, we observed an overall destabilization of the ecosystem functioning: The environmental parameters that are commonly used to explain variation in GHG exchange did not show any consistent correlation and some showed dramatic changes when comparing pre- and post-flooding. Our results suggest that rewetting projects should be monitored not only with regard to vegetation development but also with respect to biogeochemical conditions. Further, high CH_4 emissions that likely occur directly after rewetting by flooding should be considered when forecasting the overall effect of rewetting on GHG exchange of a particular site.