EGU21-15653
https://doi.org/10.5194/egusphere-egu21-15653
EGU General Assembly 2021

Determining frequency dependence of carbon turnover in peat using spectral induced polarization

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Our study discusses imaging results from a spectral induced polarization (SIP) survey to identify concurring processes (such as aerobic respiration, denitrification, or sulfate- and iron reduction) in a biogeochemically active peat in a wetland located in the Lehstenbach catchment in Southeastern Germany. Terrestrial wetland ecosystems such as peatlands are a critical element in the global carbon cycle. Due to their role as natural carbon sinks and ecological importance for an array of flora and fauna, there is a growing demand to conserve and restore degraded peatlands. Biogeochemical processes occur with non-uniform reaction rates within the peat, making the environment sensitive to physical disturbances. To investigate biogeochemical processes in-situ, it is important to avoid disturbing the redox-sensitive conditions in the subsurface by bringing oxygen into anoxic areas. Our previous study demonstrated that the induced polarization (IP) was able to identify biogeochemically active and inactive areas of the peat. The IP response was sensitive to the presence of carbon turnover and P release in the absence of iron sulfide. These highly polarizable areas have high iron concentrations, but most likely in an oxidized form. As most iron oxides are poor conductors, the strong polarization response is unlikely related to an electrode polarization process.

Here we also analyzed the frequency dependence of the SIP data to investigate whether iron oxides and carbon-iron complexes, two possible mechanisms for the high polarization response, can be distinguished. SIP imaging data sets covered the frequency range between 0.06 and 225 Hz and were collected with varying electrode spacing (20 and 50 cm) at different locations within the Waldstein catchment characterized by different properties, e.g., saturated and non-saturated soils. Our imaging results reveal variations of the IP effect within the peat layer, indicating substantial heterogeneities in the peat composition and biogeochemical activity. The frequency dependence allowed us to resolve a sharper contrast between the different features of the peat. Geochemical analyses on a freeze core and pore water samples are used to validate our results and find correlations between the Cole-Cole parameters of the SIP response and the geochemical parameters.