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Induced polarization for the spatial characterization of biogeochemical hot spots

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Biogeochemical hot spots are spatially confined areas where biogeochemical processes take place with anomalously high reaction rates. On the landscape scale, biogeochemical hot spots are of major interest due to the possible emission of greenhouse gases (carbon dioxide) and high nutrient turnover. Such hot spots are sensitive environments and given their environmental impact, there is a growing demand for noninvasive methods to investigate such hot spots without disturbing the biogeochemical settings. Classical geochemical sampling methods (e.g., piezometers or suction cups) often disturb the redox-sensitive settings by bringing oxygen into anoxic areas. Induced polarization (IP) is a noninvasive geophysical method that was initially developed to explore metal-ore deposits but more recently developed into a versatile tool for environmental studies. Here, we present imaging results from a geophysical survey using the IP method to characterize hot spots in a wetland located in the Lehstenbach catchment in Southeastern Germany. We collected IP imaging data sets along 64 profiles using 64 electrodes deployed with a spacing of 20 cm. Our highly resolved measurements aimed at delineating hot spots within a thin layer (approximately 20 cm) heterogeneous peat material on top of the local granite bedrock. To validate the field-scale IP signatures, geochemical analyses (e.g., dissolved and solid iron concentration) were performed on freeze-core samples obtained in areas characterized by anomalous high and low IP responses. Furthermore, the thickness of the peat was measured with a dipstick along every fifth profile to evaluate the IP imaging results. Our imaging results reveal an increase in the IP response within the upper 20 cm of the subsurface, which correlates with the variations in the iron concentrations and variations in the geochemical composition of groundwater accompanying microbial activity within the biogeochemical hot spots observed in the soil samples. The IP response decreases in the deeper regions, which can be associated with the granite bedrock.