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Geophysical investigation of the Soda Lakes at the Seewinkel National Park (Austria) through electromagnetic and electrical methods

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The Seewinkel National Park in Burgenland (Austria) encompasses the largest inland soda lakes in central Europe. The shallow aquifer in the soda lakes is confined by an impermeable clay-rich layer, which is nourished with salts through capillary upward transport during the summer periods. Sinking groundwater levels are responsible for a decline in the upward transport and a decrease in salt content within the impermeable unit, threatening the ecological state of the lakes and their rich and unique biosphere. Yet, the extension of the hydraulic barrier, its salt content, and changes within the system accompanying seasonal temperature variations are still open to debate due to the lack of subsurface information with high spatial and temporal coverage. Here, we propose the application of geophysical methods to complement existing drill core data. Our research aims at reconstructing the architecture of the lakes, particularly the geometry and composition of the impermeable layer with a higher spatial and temporal resolution. We applied electromagnetic induction (EMI) for contactless rapid mapping of the lateral extent of the impermeable layer, assumed to have higher electrical conductivity due to its clay and salt content, and solving for the mean features in the shallow aquifer. To resolve vertical variations of the electrical conductivity with high resolution, we applied electrical resistivity tomography (ERT) at selected locations. The initial independent inversion results from EMI and ERT, inherently ambiguous, showed discrepancies in the thickness of the impermeable layer. To permit an adequate interpretation of the geophysical data and harness the strengths of both methods, we employed numerical simulations, including ERT data to constrain EMI inversion and vice versa, as well as borehole electrode data, which allowed us to resolve for a subsurface electrical conductivity model able to explain both EMI and ERT data. Our results permit us to understand the characteristics of the impermeable layer and to develop a suitable technique to apply EMI and ERT to investigate other lakes in the national park.