Spectral Induced Polarization for permafrost environments in the Swiss and Austrian Alps – Improvement of data quality and first applications/results

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Warming of permafrost regions with associated increase in the active layer thickness and decrease in ice content has been detected worldwide. The electrical resistivity tomography (ERT) method is already used to assess the spatial distribution of permafrost and its temporal changes. Especially ice-rich permafrost, commonly associated with a significant increase in the electrical resistivity, is detectable with ERT. However, in many cases the interpretation of the subsurface electrical resistivity is ambiguous, since air and ice exhibit similar electrical resistivity values. Therefore, additional information is needed to improve the quantification of the ice content within the subsurface. We therefore extend the investigation of electrical conduction mechanisms by taking into account the capacitive properties of the subsurface by means of induced polarization (IP) measurements. Moreover, IP measurements were conducted over a broad range of frequencies (in the so-called spectral IP (SIP)), to assess the frequency dependence of the IP. Eight representative permafrost sites distributed over the entire Swiss Alps and one site located in the Austrian Central Alps have been chosen to test the applicability of the method. The selected study areas are long-term permafrost monitoring sites and provide comprehensive geophysical data and temperatures for validation. The sites range from rock glaciers and talus slopes with high ice content to bedrock permafrost with lower ice contents. Here we focus on IP imaging results for data collected at 1 Hz for all field sites. Additionally, we present SIP imaging results collected over the frequency range from 0.1-225 Hz for a specific site in the Valais Alps, the Lapires site, a large north-facing talus slope at ~2600 m altitude. For the quantification of data error, measurements were conducted as normal and reciprocal pairs. We also present field techniques used to enhance data quality at high frequencies through the deployment of shielded and separated cables. Our results show that SIP anomalies agree with ice-rich permafrost as delineated from borehole data. Thus, spatial variations in the SIP response might permit to distinguish between ice- and air-filled pores, improving the interpretation of ERT.