Identification of outliers, electrode effects and process dynamics in electrical self-potential monitoring data

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keywords: Self-potential monitoring, permafrost, data processing

Spatial self-potential monitoring data offer opportunities to map spatio-temporal subsurface process dynamics, such as water flow giving rise to streaming potentials. Process dynamics are, however, often masked by data outliers, varying contact potentials, and thermal electrode drift effects. Effective removal schemes are desired to elucidate process dynamics and provide appropriate input data to process-based inversion schemes, for the determination of spatio-temporal flow patterns for example.

Based on both synthetic and field data measured with a permanent monitoring setup at an Alpine permafrost site in Switzerland, where temperature-dependent electrode responses are particularly pronounced, we present a method to ensure the consistency of time-lapse self-potential data without detailed knowledge of the subsurface. Formulated as a linear inverse problem, all acquired voltages over time are inverted for a consistent and spatially smooth, yet temporally varying, potential distribution at the surface. To cope with electrode effects, additional shift and drift parameters are introduced at each electrode position and simultaneously inverted for.

We discuss the resolvability and distinctness of time-lapse self-potential maps and electrode effects during stable periods and during spring, where the most pronounced self-potential signals are visible in our data set due to the onset of snow cover thaw. Although preliminarily developed as an intermediate step to assess the suitability of the self-potential method to monitor permafrost hydraulics, the method is directly applicable to any type of time-lapse potential data.