Application of a novel data analysis for time lapse multi frequency data in Induced Polarization imaging

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In spectral induced polarization monitoring, an adequate error quantification is essential to achieve reliable inversion results for both different frequencies and times. Thus, we developed a data processing method to evaluate signal strength and quantify data error. The collection of normal and reciprocal data has been widely accepted for the identification of outliers and parameterization of error models; yet, the acquisition is time-consuming and not suited for the monitoring of fast processes. Moreover, acquisition of reciprocals may be limited in particular electrode configurations with different dipole lengths for current and potential dipoles, and hinder the use of multichannel instruments, i.e., increasing the acquisition time (i.e., multiple gradient). To overcome this limitation, we present a different strategy for analysing multidimensional data sets as collected in time-lapse spectral induced polarization imaging measurements. Our method assesses the variations in the signal strength, related to both the magnitude of the voltage and phase-lag recorded. Moreover, we also investigate the consistency between these phase and voltage readings. In this regard, we can evaluate high and low polarizable areas as well as highly conductive or highly resistive anomalies within the same framework. The assumption is that the phase values should be clouded when plotted against the voltages (as illustrated in Figure 1). The spatial inconsistency within the point cloud indicates then the outliers. Moreover, we investigate through a moving average algorithm the consistency between measurements as a function of the signal-to-noise ratio, along different times and frequencies. To validate the performance of our new approach compared to the NR method, we run benchmark tests based on spectral induced polarization data collected at permafrost and frost weathering sites. Our results show that the new process successfully quantifies random errors at different frequencies.

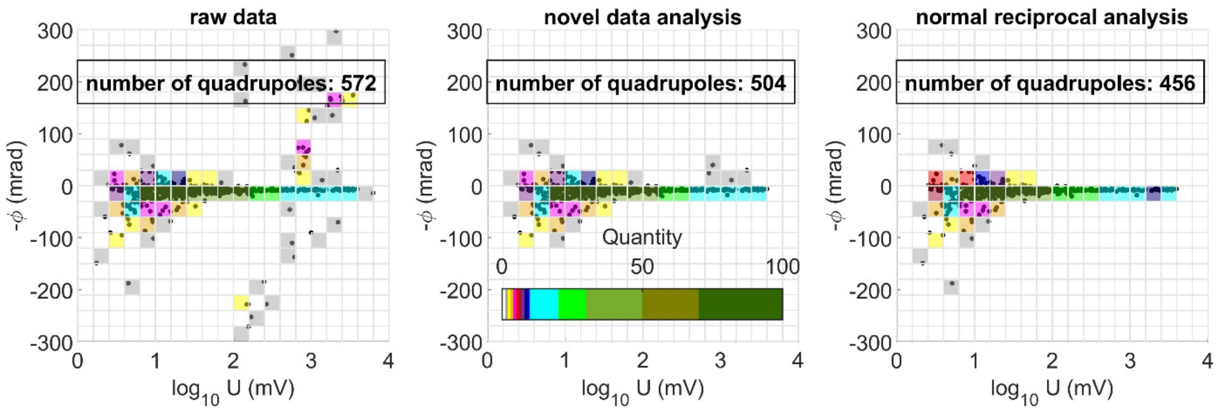

Figure 1: Bivariate histogram of the voltage and phase shift at 0.250 Hz of the raw data (left panel), and after the application of the novel data analysis (middle panel) and after the normal reciprocal analysis (right panel). The colors indicate the number of the data inside of each pixel. Data were collected at a permafrost monitoring site at Schilthorn, Swiss Alps.