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Data error quantification for improved time-lapse ERT monitoring of Alpine permafrost

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The development of robust, efficient and remotely controlled measuring equipment has resulted in a renewed interest in the inversion of time-lapse electrical resistivity tomography (ERT) monitoring datasets. In recent years several approaches have been proposed for the inversion of time-lapse ERT datasets including different constraints. However, to date the assessment of ERT data quality and the quantification of data error in monitoring datasets have received only little attention. It is well known that the over-estimation of data error leads to the loss of resolution in the inverted images; whereas its under-estimation results in the creation of artifacts. Hence, the removal of outliers, the quantification of data error and its use in appropriate error models in the inversion (i.e., inverting the data to an adequate error level) is critical in quantitative imaging to optimally balance resolution and reliability of the images. This issue becomes more critical when comparing inversion results computed for different datasets (i.e., collected at different time-lapses) as required in monitoring applications.
The analysis of normal-reciprocal misfit is a well-established approach for the quantification of data error for single datasets. However, not all field conditions or applications permit the collection of reciprocal datasets. Moreover, the extension of the normal-reciprocal analysis for time-lapse measurements has not been thoroughly evaluated and to date there is no model that describes the data error for time-lapse datasets.
Here, we present different approaches to quantify the data error for time-lapse measurements as well as the corresponding inversion results. Measurements were collected at Schilthorn (Switzerland) aiming at the investigation of spatiotemporal processes associated with Alpine permafrost. Data were collected over six years monitoring period on regular intervals and the last year on daily basis. Hence, it is possible to evaluate the application of our methodology for different temporal conditions and time intervals. Our results reveal that the analysis of the ratio between a baseline (i.e., a static model) and the time-lapse data provide the most robust approach for the detection of outliers and for the quantification of the temporal data error. We also propose a linear model to characterize the temporal data error with respect to resistance. The proposed methodology provides inversion results consistent for different monitoring periods and for the two different arrays.