Geophysical Research Abstracts
Vol. 12, EGU2010-5760, 2010
EGU General Assembly 2010

Normal-reciprocal error models for quantitative ERT in permafrost environments: bin analysis versus histogram analysis

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Electrical resistivity tomography (ERT) has been used for the monitoring of permafrost-affected rock walls for some years now. To further enhance the interpretation of ERT measurements a deeper insight into error sources and the influence of error model parameters on the imaging results is necessary. Here, we present the effect of different statistical schemes for the determination of error parameters from the discrepancies between normal and reciprocal measurements – bin analysis and histogram analysis – using a smoothness-constrained inversion code (CRTomo) with an incorporated appropriate error model. The study site is located in galleries adjacent to the Zugspitze North Face (2800 m a.s.l.) at the border between Austria and Germany. A 20 m * 40 m rock permafrost body and its surroundings have been monitored along permanently installed transects – with electrode spacings of 1.5 m and 4.6 m – from 2007 to 2009. For data acquisition, a conventional Wenner survey was conducted as this array has proven to be the most robust array in frozen rock walls. Normal and reciprocal data were collected directly one after another to ensure identical conditions. The ERT inversion results depend strongly on the chosen parameters of the employed error model, i.e., the absolute resistance error and the relative resistance error. These parameters were derived (1) for large normal/reciprocal data sets by means of bin analyses and (2) for small normal/reciprocal data sets by means of histogram analyses. Error parameters were calculated independently for each data set of a monthly monitoring sequence to avoid the creation of artefacts (over-fitting of the data) or unnecessary loss of contrast (under-fitting of the data) in the images. The inversion results are assessed with respect to (1) raw data quality as described by the error model parameters, (2) validation via available (rock) temperature data and (3) the interpretation of the images from a geophysical as well as a geomorphological perspective. Our study highlights the importance of carefully chosen error parameters for a reliable interpretation of ERT images in permafrost environments.