EGU25-13436, updated on 02 Jul 2025
https://doi.org/10.5194/egusphere-egu25-13436
EGU General Assembly 2025

Illuminating discontinuities in alpine bedrock permafrost by saline tracer tests coupled with 3D time-lapse electrical resistivity tomography

Clemens Moser[1], Nathalie Roser[1], Tomasz Gluzinski[2], Umberto Morra di Cella[3], Christian Hauck[2], and Adrián Flores Orozco[1]
[1]Research Unit of Geophysics, Department of Geodesy and Geoinformation, TU Wien, Vienna, Austria (clemens.moser@geo.tuwien.ac.at)
[2]Department of Geosciences, University of Fribourg, Fribourg, Switzerland
[3]Climate Change Unit, ARPA VdA (Environmental Protection Agency of Valle d'Aosta), Saint-Christophe (AO), Italy

Tracking the movement of saline tracers by time-lapse electrical resistivity tomography (ERT) has been established as a suitable method in hydrogeological investigations. In our study, we test the potential of the method to illuminate discontinuities (i.e., joints, fractures and clefts) in bedrock permafrost. Identification of such features is key as they represent preferential flow paths for water and advective heat exchange between the atmosphere and the subsurface (i.e., the permafrost body). Recent studies have suggested that clefts and fractures might lead to the large heterogeneity in subsurface temperature and ice content observed at the Cime Bianche plateau (Aosta valley, Italy), a mountain permafrost monitoring area at 3100 m a.s.l. undergoing permafrost degradation. In this study, we injected saltwater into eight locations at the Cime Bianche site and monitored changes in the subsurface electrical conductivity by time-lapse ERT to investigate the presence and geometry of water flow paths of the saline solution. ERT data were collected with the Syscal Terra (from Iris Instruments) within a 3D electrode grid array with a temporal resolution of 3–7 minutes. To resolve temporal changes in the electrical conductivity in the subsurface we inverted the data with a time-lapse difference approach using the R3t code in the ResIPy wrapper. In three of the eight injection points the water infiltrated quickly into the subsurface (within a few seconds) and, based on the time-lapse ERT results, moved into depths of up to 10 m, suggesting the presence of fractures. In the other five positions, the water infiltrated slowly into the subsurface (within a couple of hours) leading to only small changes in the electrical conductivity close to the injection point. While our study demonstrates the potential of time-lapse ERT to localize clefts and fractures in bedrock permafrost, the results demonstrate the need for stochastic inversion strategies to resolve thin and sharp objects more accurately. Knowing the geometry and location of such features is essential in thermal modeling and further understanding of the permafrost degradation processes at the site.