EGU21-13388
EGU General Assembly 2021

Geophysical monitoring of temperature variation and water movement in a frost weathering cave

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One third of the caves in the north-eastern part of the Eastern Alps are assumed to be created by frost weathering. The geomorphological process of frost weathering is linked to temperature variations around the freezing point and a sufficient amount of water in the inner of a rock. Fractured areas are highly sensitive to frost weathering and are characterised by high variations of temperature and water content. Geophysical electrical methods are widely used to monitor variations of temperature and water content with time, considering the sensitivity of the electrical resistivity to both properties. In this study, we present imaging results for electrical monitoring conducted in February 2020 in the ceiling of the Untere Traisenbacherhöhle, a frost weathering cave, which is located in the foothills of the Eastern Calcareous Alps. In total, 77 imaging measurements were conducted during the monitoring period of approximately 60 hours with an electrode separation of about 10 cm to gain data with high temporal and high spatial resolution during and after a raining event. Simultaneously, temperature was measured at one point in different rock depths. Geophysical data was pre-processed by a four-step filtering procedure to identify and remove spatial and temporal outliers. Then the data was inverted with the open-source library Pybert. Inversion results reveal that during the entire monitoring the resistivity varies up to ±30% compared with the values at the start of the monitoring. To investigate in more detail the temporal changes, we extracted pixel values in 16 areas. These pixels show a strong negative linear correlation with the temperature (correlation coefficients up to 99%), which ranges between 2 °C and 8 °C. However, in some areas a simple linear model seems to not represent the relationship of both parameters in the low temperature range adequately. Based on such correlation, the resistivity data was temperature-corrected to investigate water content changes affecting the resistivity of the ceiling of the cave. Such analysis permitted to delineate clear anomalies related to water seeping into the rock as well as drying processes at the inner parts of the rock wall. Further, geophysical measurements were conducted by means of the low-induction number electromagnetic method in June 2020 to evaluate the applicability of this to map the entire rock wall of the cave. Electrical resistivity (ERT) data differs strongly from the low-induction number electromagnetic (EMI) mapping, likely because of a contamination of the EMI data due to the presence of the metallic electrodes used for the ERT monitoring and due to different weather conditions. Our study reveals the possibility to quantify water content changes in caves in an imaging framework. Further, this information can be used to delineate fractured zones in carbonate rocks, which are supposed to be more sensitive to frost weathering.