Geophysical Research Abstracts
Vol. 13, EGU2011-8549, 2011
EGU General Assembly 2011

Monitoring the thermal state of permafrost by automated time-lapse capacitive resistivity imaging

Oliver Kuras (1), Paul Wilkinson (1), Phil Meldrum (1), Michael Krautblatter (2), Julian Murton (3), and Richard Ogilvy (1)

(1) Geophysical Tomography Team, British Geological Survey, Nottingham, United Kingdom (oku@bgs.ac.uk), (2) Department of Geography, University of Bonn, Bonn, Germany (michael.krautblatter@giub.uni-bonn.de), (3) Department of Geography, University of Sussex, Brighton, United Kingdom (j.b.murton@sussex.ac.uk)

The British Geological Survey, in partnership with the Universities of Sussex and Bonn, is investigating and seeking to prove a new technology concept for the non-invasive volumetric imaging and routine temporal monitoring of the thermal state of permafrost, a key indicator of global climate change. Capacitive Resistivity Imaging (CRI), a technique based upon a low-frequency, capacitively-coupled measurement approach is applied in order to emulate Electrical Resistivity Tomography (ERT) methodology, but without the need for galvanic contact on frozen soils or rocks. Recent work has shown that temperature-calibrated ERT using galvanic sensors is capable of imaging recession and re-advance of rock permafrost in response to the ambient temperature regime. However, the use of galvanic sensors can lead to significant practical limitations on field measurements due to high levels of and large variations in contact resistances between sensors and the host material as it freezes and thaws. The capacitive technology developed here overcomes this problem and provides a more robust means of making high-quality resistance measurements with permanently installed sensors over time. Reducing uncertainty due to uncontrolled noise from galvanic sensors increases the value of time-lapse ERT datasets in the context of monitoring permafrost.

We present early results of ongoing work on the numerical simulation of dense capacitive multi-sensor geometries, which are invariably affected by mutual inter-sensor coupling and stray capacitances. These modelling studies are undertaken in support of laboratory-scale freeze-thaw experiments on rock samples scheduled to be carried out in the permafrost laboratory at the University of Sussex in summer 2011. First results indicate that the basic assumptions of CRI remain valid under such circumstances; a point-pole approximation can be applied to the capacitive sensor network despite the finite extent of individual sensors and the close proximity of neighbouring sensors. As a consequence, apparent resistivities determined by CRI comply with well-known DC interpretation schemes, so that conventional ERT methodology (including time-lapse interpretation) becomes applicable to the capacitive measurements.

Finally, we report on our progress with designing and building a functional prototype time-lapse CRI measurement system. The practical system architecture draws upon conceptual ideas incorporated in existing, field-scale CRI instrumentation designed by BGS; however, the use of dense capacitive sensor networks at the laboratory scale and the need for collecting tomographic imaging data across multiple sensors without manual interference required a novel technical approach. The new prototype system must be able to automatically select current and potential dipoles from the set of available capacitive sensors within the permanently installed array. This task is considerably more challenging for a low-frequency capacitive architecture than for conventional DC resistivity equipment.