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Development of Low Cost Autonomous Electrical Resistivity Monitoring Systems for continuous active-layer monitoring in harsh environment

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The last overview of the thermal state in the Western Antarctic Peninsula shows that permafrost is close to 0°C in the region. This fact reinforces the importance to study the evolution of permafrost and active layer in the region. However, monitoring of the active layer and permafrost dynamics in Antarctica is generally conducted using only 1-dimensional borehole and meteorological data, which restricts the analysis to point information that often lack representatives at the field scale. In addition, being an invasive technique, the drilling of boreholes disturbs the subsurface and is not feasible to conduct over large areas, especially in environmentally sensitive ecosystems such as the Antarctic.

In this context, we developed automated electrical resistivity tomography (A-ERT) systems using a 4POINTLIGHT_10W (Lippmann) instrument with a solar panel-driven battery and multi-electrode configuration for autonomous and non-invasive monitoring of active layer and permafrost in Antarctica. The A-ERT measurements are sensitive to the electrical conductivity of materials, allowing to distinguish between frozen and unfrozen soil and thus to monitor the active layer dynamics including freezing, thawing, water infiltration and refreezing processes in a spatial context. We deployed the system in two monitoring sites at Deception and Livingstone Islands

(South Shetland Islands, Maritime Antarctica) for quasi-continuous measurements at 6h interval from early 2019 and 2020 respectively.

Detailed investigation of the A-ERT data and obtained models reveals that the A-ERT system can detect the seasonal active-layer freezing and thawing events with very high resolution. In addition, the brief surficial refreezing and thawing of the active layer during summer and winter respectively were well resolved by A-ERT data, highlighting the significance of the continuous A-ERT monitoring setup which enables detecting fast changes in the active layer during short-lived extreme meteorological event. This suggests that the A-ERT measurements can provide valuable subsurface information to improve the spatio-temporal understanding of active layer and permafrost dynamics with very high resolution and minimal environmental disturbance in Antarctica. The set-up is very flexible and can be used with different configurations to investigate different depth ranges for site-specific detailed investigation.

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