# Geoelectrical methods for landslide monitoring: case study Laakirchen, Upper Austria

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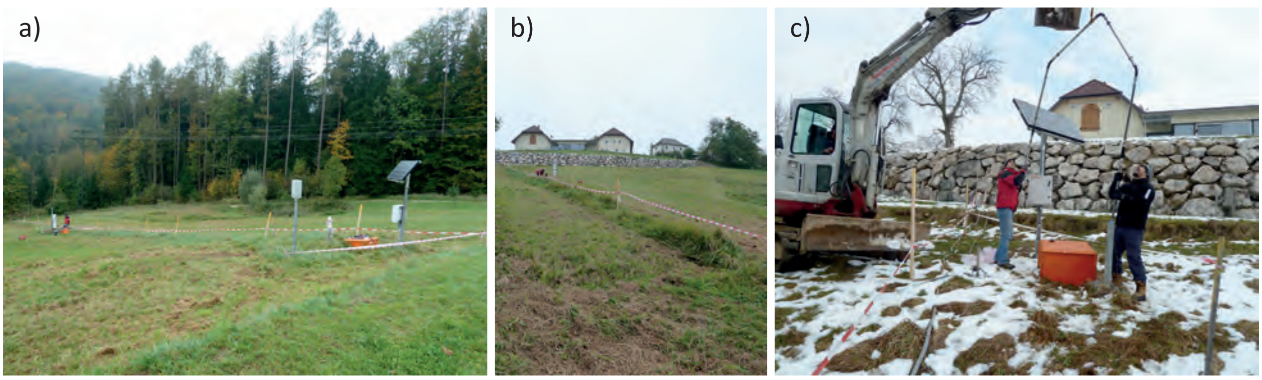
One of the main precursors for landslide activation/reactivation is intense and prolonged precipitation, with consequent pore water pressure rise due to infiltration of rainfall that seeps into the ground. Monitoring hydrological parameters such as precipitation, water content and pore pressure, in combination with displacement analysis for early warning purposes, is necessary to understand the triggering processes. Since the reduction over time of electrical resistivity corresponds to an increase of water content, electrical resistivity monitoring can help to interpret the modifications of slope saturation conditions after heavy rainfalls.

In this Master thesis (Amabile, 2016) we mainly refer to the study from the Laakirchen site, located in the judicial district of Gmunden (Upper Austria). During March 2010, a shallow rotational landslide was triggered by snow melting and intense rainfall, in the vicinity of a newly constructed house. Laakirchen landslide was monitored by geophysical/geotechnical measurements from September 2011 to June 2013. In less than two years, a maximum movement of about 700 mm has been recorded at a depth of 3.5 m b.g.l. by an automatic inclinometer (DMS automatic inclinometer, C.S.G. patents, Text-Fig. 1c). The orientation of the permanent geoelectrical profile is parallel to the gradient of the slope, including 60 electrodes, placed at intervals of 1 m (Text-Fig. 1b). The power supply for the automatic inclinometer is provided by a solar panel and a corresponding battery (Text-Fig. 1a), as well as the connection to the local power grid, brought no limitation to the number of daily measurements (every four hours) carried out for geoelectrical monitoring.

Focusing on the most intense precipitation events, the apparent resistivity data have been processed with an innovative 4D-inversion algorithm (Kim et al., 2009) developed within the cooperation between the Geological Survey of Austria (GBA) and the Korea Institute of Geoscience and Mineral Resources (KIGAM). We select a significant rainfall event in December 2011 to interpret the electrical response of the slope. The geoelectrical inversion results show a significant contrast in electrical resistivity between two areas of the section: the upper layer is characterised by higher resistivity (above 50 Ωm) lying on a less resistive clayey substratum (Text-Fig. 2a). This pattern can be correlated to the presence of a sliding surface, which is confirmed by the displacements measurements recorded at a depth of 3.5 m b.g.l. by the automatic inclinometer.

Text-Fig. 1.
Situation of the autonomous resistivity monitoring system: solar panel for remote monitoring (a), profile tracking (b) and installation of the DMS automatic inclinometer (c).

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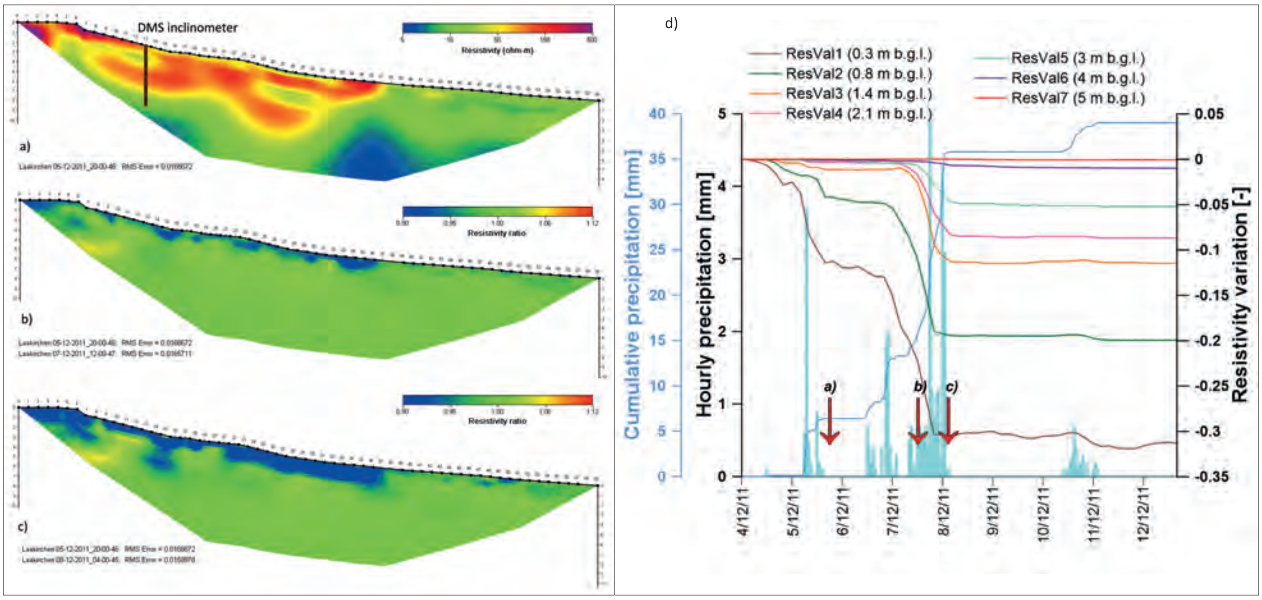


The dependence of electrical resistivity variation with depth is evident: greater resistivity reductions are recorded in the most superficial points, where the water content changes with a larger range (resistivity decrease is around 20–30 % on the shallow surface) (Text-Figs. 2b–d). The areas affected by the most significant decrease in resistivity probably correspond to the mobilised layers, indicated also by displacement monitoring results.

Text-Fig. 2.
Distribution of electrical resistivity in the subsurface [Ωm] (a), distribution of resistivity ratio ρt/ρ0 [-] (b, c), Electrical Resistivity Tomography (ERT) images are compared with the reference time in (a), graphic of hourly precipitation (turquoise), cumulative precipitation (light blue) and 4D inverted resistivity time series at different depths (d). The arrows indicate the dates of the results displayed in a, b and c.

## Acknowledgements

The analysis of the monitoring data of Laakirchen landslide, carried out during my internship at the Geological Survey of Austria in Vienna, is part of a larger study designed to develop and test the GEOMON4D geoelectrical system, in combination with complementary geotechnical monitoring sensors (rain gauge, automatic inclinometer, water pressure and water content sensors) to support the interpretation of the electrical response of the near surface (Supper et al., 2014).

In order to undertake this study, within the TEMPEL project (founded by the Austrian Science Fund, TRP 175-N21) and the LAMOND project (in the frame of the ESS program of the Austrian Academy of Science), the Geological Survey of Austria has organised a network of monitoring stations (Supper et al., 2012) including also the Laakirchen station. The main goal of the TEMPEL and LAMOND projects is to evaluate temporal changes of geoelectrical properties of the subsurface as possible indicator of future failure of high risk landslides; such indicators would be beneficial to any effective early warning system.

## References

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