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Current challenges for high-resolution monitoring of deep geological repository boreholes using terrestrial laser scanner and photogrammetry

Dario Carrea (1), Johanna Savunen (2), Antonio Abellan (1), Marc-Henri Derron (1), Jussi Mattila (2), and Michel Jaboyedoff (1)

(1) University of Lausanne, ISTE - Institut des Sciences de la Terre, Lausanne, Switzerland (dario.carrea@unil.ch), (2) Posiva Oy, Eurajoki, Finland

The Onkalo site has been selected as final deep geological repository for the disposal of nuclear waste in Finland. Several exploratory boreholes, similar to those that will host the nuclear waste, are currently under construction in order to analyse various technical aspects of the disposal. Among them, an accurate monitoring of the deformation of each borehole is required. The present study aims at finding the most suitable technique for measuring and monitoring small scale (below mm) deformations of these boreholes with high confidence and accuracy. Two different close-range monitoring techniques are compared here: a phase-shift terrestrial laser scanning (Z+F 5006i) and photogrammetry (Canon EOS 6D&EF20mm + Adamtech 3DM Mine Mapping Suite 2.5). Both techniques are applied using multi temporal acquisitions.

As for the data acquired by the terrestrial laser scanner, our study has revealed that parts of the 3D datasets are affected by an artificial distortion, with a maximum shift up to 6 mm, which is clearly below the required accuracy. The origin of this artifact is related with the data acquisition strategy: since the accuracy of the laser measurement is affected by the incidence angle, we observed that when the incidence angle is higher than 45°, the range is unsatisfactorily underestimated. Furthermore, we found another issue in the influence of the surface condition on range measurement, such as wet versus dry, or dark versus light colored rock surface.

As for the photogrammetric data, we observed that, when compared to a theoretical cylinder, the 3D point cloud was affected by a sub-millimetric distortion. This distortion is due to the construction and georeferencing of the final 3D model. The error can reach up to +/- 0.8 mm in the border areas of the picture, which is significant value as a millimetric deformation should be detected.

Up to now, the photogrammetric acquisitions have provided more accurate results than the laser scanning, but there is a range of improvement in acquisition procedures for both techniques and new acquisitions are in progress. As a concluding remarks, we observed that in order to measure millimetric deformation without ambiguity and accomplish the requested accuracy, several recommendations in terms of scanning and photogrammetry strategies must be carried out in order reduce distortions and artefacts and to improve data quality.