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Integration of point clouds from UAV photogrammetry and laserscan survey for the assessment of the risk of collapse of the vault of an underground cavity

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Photogrammetric surveys from UAV and LiDAR surveys are two techniques that allow for the production of very high resolution point clouds. The use of these techniques result in a detailed reconstruction of difficult-to-access environments such as underground cavities. A rigorous georeferencing of the acquired data allows for a comparison of the hypogean development of the cave to the overlying territory. This study presents a case of integration between these two techniques, applied to the risk assessment of the collapse of the vaults in a natural cavity in the Trieste Karst (north east Italy). This site is particularly delicate given that on the slope above the cave there is an abandoned stone quarry. In order to survey the quarry above the cave, a flight was performed with UAV, while the cave was surveyed with Laser Scan from the ground. The flight was made using a UAV DJI Phantom RTK, which carried a 20 Mpixel 1" sensor camera. 8 ha of terrain was surveyed, capturing about 733 high resolution images and surveying 22 GCPs (Ground Control Point) with a GNSS RTK receiver. It was possible to reduce the number of GCPs, since the drone recorded the shooting positions very accurately with the on-board GPS RTK. Data were analyzed using Agisoft Metashape Professional to produce an orthophoto and a DSM (Digital Surface Model) with a ground resolution of 0.02 m and 0.04 m respectively. The point cloud has a density of 586 points/m². The LiDaR survey was carried out using an ILRIS 3D ER laser scanner from Optec. The point cloud has a density of approximately 2500 points/m² and 5 stations were needed to cover the underground development of the cavity. The georeferencing of the data was carried out by roto-translation on geo-referenced benchmarks, surveyed with GPS RTK and total station. The point cloud was processed using Terrascan software (Terrasolid). The two point clouds were aligned, geo-referenced and combined using Polyworks software (Innovmetric), in order to check the thicknesses of the material present above the vault of the cave. The integration of epigeal and hypogean data made it possible to identify some critical points related to a vault thickness of approximately 1.5 meters, located at the quarry square. This work made it possible to highlight critical issues difficult to detect without the integrated approach of these different survey methodologies.