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Introduction

Microgravity surveying is a widely used geophysical method to detect underground voids and cavities. Detecting underground cavities is instrumental to a wide array of applications: for example for collapse hazard mitigation in urban planning and in construction, or in archeological studies to find crypts. In urban settings, the influence of buildings and known underground structures result in strong negative gravity anomalies that may mask the target signal, and needs to be corrected for (Jacob et al. 2020). With the appropriate corrections, microgravity surveying is therefore applicable in dense urban city centers, with a significance and reliability that are closely linked to that of the applied corrections. In order to achieve the most reliable and accurate corrections, the precise 3D geometry of the corrected structures must be determined, which may be obtained by photogrammetry (Panisova et al. 2012), or by laser scanning devices. Hand-held portable laser scanning devices allow quick and easy point cloud generation, with cm-level accuracy (Dewez et al. 2017).

In this study, we test and benchmark different gravity correction schemes for both underground structures and complex historical buildings, using point clouds generated with hand-held portable laser scanning devices, on two case studies.

Method and Results

For the underground structure correction schemes, our case study consists of a two-level cellar in the city center of Reims, France (Figure 1a). This underground structure was discovered following a microgravity survey and subsequent drilling campaign (Figure 1b, (Jacob et al. 2020)). After an access shaft to the cavity was drilled, it was scanned using a portable hand-held laser-scanning device, which resulted in the generation of a 3D point cloud. Using the open-source software CloudCompare, we devised correction schemes based on the 'Rasterize' tool, which generates rastAGESmCityers of maximum and minimum values of point clouds, and based on the Poisson surface reconstruction plugin (Kazhdan et al. 2006), which generates a watertight meshed envelope of the point cloud . While the 'Rasterize' method is efficient in computing time, it overestimates the volume of the cavity and therefore its gravity attraction, as compared to the Poisson reconstruction method. Correcting the Bouguer anomaly for the gravity effect of the scanned cavity (Figure 1c) yields a residual anomaly (Figure 1d) which shows persistent negative anomalies linked to mass deficit in the subsurface.

The second case study is about building corrections for microgravity surveys. Over 200 gravity measurements were performed inside Saint-Remi basilica in Reims, France, which is one of the major religious buildings of the city. Subsequent 3D portable laser-scanning inside and outside the basilica was acquired, generating point clouds. From the latter, Poisson surfaces were reconstructed, defining inner and outer meshes of the building. A right rectangular prism-based model was then constructed, filling in the space between inner and outer meshes with prisms. The model was corrected for inaccessible air-filled spaces and various artefacts in the meshes, and it was used to compute the gravity attraction of the building. The building-corrected gravity map shows a stark negative anomaly over a known crypt.

Conclusions

We have implemented gravity correction schemes for both underground and aboveground structures, using the results of portable hand held laser scanning of said structures. This allows mitigating the gravity effects of known structures, in order to make the target signal from 'forgotten' cavities more readily detectable, even in dense urban settings.

Acknowledgements

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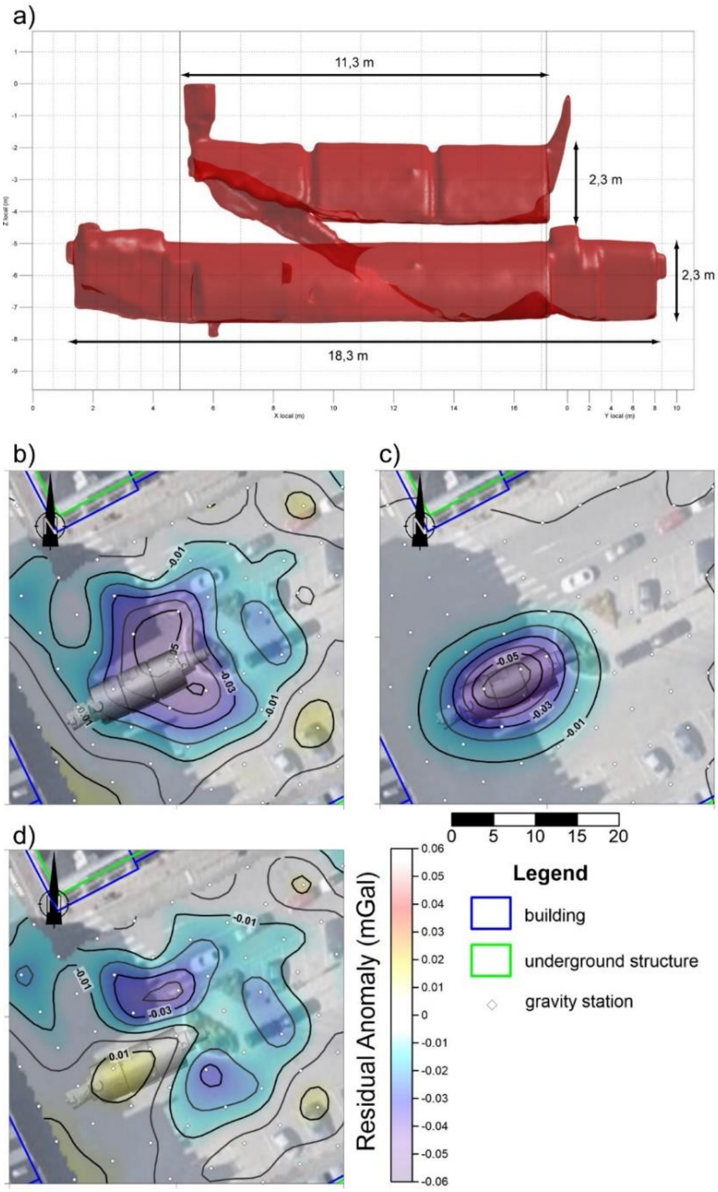

Figure 1 *a) External mesh and dimensions of the two level cellar detected by the microgravity survey, obtained from a point-cloud b) gravity residual anomaly map (mGals), showing the location of the scanned cellar, c) gravity effect of the scanned cellar (mGals), interpolated from the values computed at each gravity station, d) residual anomaly map (mGals) corrected for the effect of the scanned cellar.*

References

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