Geophysical Research Abstracts
Vol. 19, EGU2017-17812, 2017
EGU General Assembly 2017

Time-lapse gravity and levelling in the sinkhole-endangered urban area of Bad Frankenhausen, Germany

Martin Kobe (1), Gerald Gabriel (1), Adelheid Weise (1), Charlotte Krawczyk (2), and Detlef Vogel (1)

(1) Leibniz Institute for Applied Geophysics, Hannover, Germany (martin.kobe@liag-hannover.de), (2) German Research Centre for Geosciences, Potsdam, Germany (lotte@gfz-potsdam.de)

Sinkholes, resulting from subrosion in the subsurface, can reach diameters of several hundred meters and thus pose a severe hazard for infrastructure and inhabitants in urban areas. Subrosion is the leaching of readily-soluble rocks, such as rock salt, gypsum, anhydrite and limestone by ground or meteoric water and leads to mass transport and relocation. Two scenarios of sinkhole evolution are conceivable: First, the surface subsides continuously in order to compensate for the mass loss. Second, the mass relocation leads to development of subsurface cavities. If they reach a critical size and the cover layers are not supported anymore, the surface collapses abruptly.

To improve the understanding of subrosion processes and the related surface deformation a case study is conducted in Bad Frankenhausen, Germany, where subrosion leaches the Zechstein evaporates of the Permian. One part of the study is to analyse the spatiotemporal development of sinkholes by applying time-lapse observations. Therefore, we established a monitoring network consisting of 15 gravity and additional levelling points covering the main sinkhole areas in the city centre. In March 2014, the baseline survey was carried out. Since then, quarterly measurement campaigns are performed. In each campaign four different gravity meters are used to collect a statistical significant amount of data and to control the plausibility of our data. The gravity measurements are complemented by levelling surveys.

The rectification of the time-lapse gravity data comprises the correction for jumps and systematic errors, as well as for well calculable influences, such as earth tides and air pressure changes. Furthermore, special interest was applied to seasonal changes of hydrological parameters such as soil moisture or groundwater level. We found the hydrological influence to be in the single digit up to the lower two-digit μGal range, depending on the season and the station. The standard deviations of the adjusted gravity differences are in the range of 2-7 μGal, depending on the gravity meter, and this leads to a significance of the correction for hydrological influences. Another challenge comes from anthropogenic activities. For example, the influence of urban development near one of our gravity stations provides ca. 10 μGal.

The gravity acceleration changes in the range of 0 to 15 μGal over a timespan of three years. A subsidence of 0 to 15 mm is found from levelling at the gravity stations in the sinkhole-related areas of Bad Frankenhausen, mainly around the leaning spire.

We show the feasibility of the time-lapse gravity method by observing the mass loss in subrosion-dominated areas. Gravity measurements in addition to levelling may be useful to improve the knowledge about local surface deformation. Both methods could be part of an early recognition system for sinkholes.