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Vertical Displacements in the Upper Rhine Graben Area Derived from Precise Levelling Data

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The analysis of precise levelling data enables an accurate determination of vertical displacement rates at levelling benchmarks, if repeated measurements at identical benchmarks are available. In order to gain detailed insight into vertical crustal deformations in the Upper Rhine Graben (URG) area, a consistent analysis of levelling measurements carried out in Germany, France and Switzerland is in progress at the Geodetic Institute, Karlsruhe Institute of Technology. The data used for this study was primarily measured by the ordnance survey of the participating countries to contribute to a terrestrial height system. As the levelling lines were remeasured up to five times within the last 100 years, a calculation of reliable vertical displacement rates with accuracies of about 0.2 mm/a is possible.

In a first step, the geodetic dataset was analysed using a kinematic network adjustment. Within this approach the exact dates of the measurements are used in a time-dependent model for the estimation of displacement rates. The adjustment model delivers a detailed picture of the recent vertical displacement field in the URG and the surrounding regions. On average, the magnitudes of estimated displacement rates are of the order of 0.15 mm/a, which is in an overall agreement with tectonic concepts. Since the formal error of the adjustment is of the same order of magnitude, only rates above this value can be treated as significant.

Two features of the displacement field are studied in more detail:
(i) An apparent regional tilt from +0.2 mm/a in the URG to about -0.3 mm/a in the eastern part of the investigation area is detected, which is not supported by tectonic models. We are currently investigating whether regional geochemical processes in the subsurface could be responsible for this large scale deformation observation.
(ii) Subsidence rates of -0.5 mm/a are observed along the main border fault in the south-eastern part of the URG. A comparison of benchmark heights of consecutive measurement epochs is used to provide a detailed assessment of this area. It turned out that the surface displacements are influenced by mining activities. However, it seems unlikely that mining is responsible for the observed 40 km wide subsidence bowl. Therefore, other possible reasons like groundwater usage and slip on existing faults are discussed.

The separation between anthropogenic deformation (e.g., induced by mining or groundwater usage), environmental deformation (e.g., geochemical processes, hydrological changes) and tectonic deformation is challenging, as the subsurface processes are not known in detail. Thus, additional information and expertise from various geosciences is needed in order to achieve a deeper understanding of the internal processes detected at the surface.