Geophysical Research Abstracts
Vol. 18, EGU2016-13011, 2016
EGU General Assembly 2016

Resolving the velocity and strain fields in the Upper Rhine Graben Area from a Combination of Levelling, GNSS and InSAR

Malte Westerhaus, Thomas Fuhrmann, Michael Mayer, Karl Zippelt, and Bernhard Heck
Karlsruhe Institute of Technology / South Campus, Geodetic Institute, Physical and Satellite Geodesy, Karlsruhe, Germany (malte.westerhaus@kit.edu)

The Upper Rhine Graben (URG), located in the tri-national region between Germany, France and Switzerland is the most prominent segment of the European Cenozoic rift system. In recent times, the URG area is characterised by small tectonic movements (less than 1 mm/a) and moderate seismicity up to M=5. Historically, earthquake magnitudes exceeding M=6 have been reported showing that the seismic hazard is quite high. The contemporary tectonic surface deformations are superimposed by displacements caused by anthropogenic activities in various locations in the area, such as coal and potash mining, groundwater usage, oil extraction, geothermal energy and CO_2 storage.

We use data sets from levelling campaigns, InSAR and permanent GNSS sites to raise an inventory of the current 3D surface displacements and strain rates in the URG with high precision and high spatial resolution. Precise levellings carried out by the surveying authorities of Germany, France and Switzerland since the end of the 19th century have been combined to form a network of levelling lines. A kinematic network adjustment is applied on the levelling data, providing an accurate solution for vertical displacement rates at the levelling benchmarks. InSAR is used to fill gaps in the interior of the levelling loops and to significantly increase the number of points. All the available ERS-1/2 and Envisat scenes from two acquisition geometries covering a period from 1992 to 2000 and 2002 to 2010, resp., are processed according to the Persistent-Scatterer approach. In addition, coordinate time series of 76 permanent sites of the GNSS URG Network are used to support the derivation of the horizontal velocity field of the region. Daily GPS-solutions obtained in differential mode are available since 2004.

In a first step, estimates of the surface displacement rates are derived from each technique starting from the raw data. Subsequently, the single-technique deformation estimates are mathematically combined to a 3D velocity field taking into account effects due to different reference frames. As the measurement points of the three techniques do not coincide, appropriate interpolation methods, such as Kriging, are applied in order to calculate the estimates on a common grid.

Mean formal errors of the combined solutions are 0.2 mm/a and 0.4 mm/a for the vertical and horizontal components, respectively, while the spatial resolution is considerably increased compared to earlier studies. The results reflect important aspects of the contemporary kinematic behaviour of the URG: (i) NW-SE shortening of the central URG segment of up to 0.5 mm/a, (ii) subsidence of the graben interior coinciding with known quaternary depocentres, (iii) left-lateral shearing resulting in ongoing shear strain accumulation within the graben. In addition, the solution depicts numerous local deformation phenomena due to man-made activities that have been studied in detail. Our results recover the recent intraplate deformation of the URG area with unprecedented accuracy and spatial resolution and provide an improved insight into the underlying processes.