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Effects on crustal deformations on regional scale

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Various kinds of geodetic and geophysical methods e.g. strainmeter, tilmeter, seismometer, permanent GPS-station, and gravimeter observations are deployed to monitor crustal deformations. These observations contain components of different magnitude and greatly diverse origins:
- periodic signals (tides, . . .)
- aperiodic signals (tectonics, . . .)
- local influences (cavity effect, topographic and geologic effects, . . .)
- regional effects by surface loads (barometric pressure, . . .)
In the past a number of studies have been carried out in order to separate, analyze, and interpret the various signals and effects. In this the superimposing effects originating from the local and regional environment of the observation site present an on-going challenge. Deformation effects by the interaction between barometric pressure and the local surrounding mostly have the largest amplitudes.
During the last years a number of studies were carried out focusing on local scale, which have been recently continued. The effects caused by cavity and topographic features are in the order of magnitude, e.g. of about 2 nstrain/hPa for strainmeters. Regarding these studies, in which often the Finite-Element-Method (FEM) was deployed, no significant deformations were found for displacements.
In this study the Finite-Element (FE)- Method has been used to investigate the effect of topography and geology in the context of a barometric pressure load on horizontal and vertical crustal deformations on regional scale for the example of Central Europe. The topography is taken from the digital terrain model (DTM) ETOPO2 and the geology from PREM and EuCRUST-07. The latter model consists of the mantle, the lower and upper crust and a top layer. Deformations at four selected broadband observatories are investigated: the Black Forrest Observatory, the Geodynamic Observatory Moxa, the Sopron Observatory, and the Geodetic Observatory Wettzell.
For comparison of observed and simulated deformations the FE-model is loaded with the barometric pressure distribution which occurred during the ‘Kyrill’ event in January 2007. Significant deformations are found for the horizontal and vertical displacements. The relation for the vertical component is estimated to about 0.3mm/hPa, as it is found from gravimetric and VLBI studies.
From the study it emerges that topographic and geologic features play a negligible role in crustal deformations on regional scale. The loading field in its temporal and spatial structure dominantly influences the deformations. Thus to improve the reduction of loading effects loads need to be known in a better spatio-temporal resolution as it is presently the case. Also a good agreement is found between reductions based on Green’s functions and derived from the FE model.