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Study on the influence of topography and geological features on crustal deformations

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For studies of geodynamic processes the observation of crustal deformations on different spatial and temporal scales is indispensable. For this purpose among others strain- and tiltmeters, permanent GPS and VLBI are deployed. For the first two observation techniques it is well known that the records can be heavily contaminated by cavity and topographic effects in combination with barometric pressure, temperature, and hydrological changes. Additional effects are caused by geological features such as different lithologic units or faults.
For four mid-European observatories (Moxa, Schiltach, Sopron, Wettzell) set in different topographies and geologies the various influences are investigated by high-resolution Finite-Element modelling. Atmospheric pressure is considered for loading. From the studies emerges that even smallish topographic features such as a slight ledge can have a significant effect. By the modelling the understanding of transfer mechanisms is improved and a basis is provided for the development of more sophisticated reduction methods.

While horizontal deformation components are largely affected by local conditions up to distances of some 100 m and negligible effects occur in the vertical, the situation changes when large-scale loadings of several kilometres extension and more are considered. For mid-European sites loading-related vertical displacements with peak-to-peak amplitudes in the order of 20 mm are found and horizontal displacements in the order of about 10 mm. For both, GPS and VLBI clear differences in the solutions were obtained depending on whether or not atmospheric loading was considered (Boy et al., 2008; Gégout et al., 2008; Schuh et al., 2008). Thus the question arises whether for present-day geoscientific issues it is sufficient to compute large-scale loading effects based on a spherically symmetric parameterized earth model. To gain first insights a model for mid-Europe was set up for which the influence of surface topography and topography of crustal layers in combination with lateral heterogeneities can be investigated. In a first step only topographic features are realized together with a parametrisation after PREM and a uniform pressure loading is applied. In the resulting displacement fields of the vertical and the horizontal components the various topographic features can be clearly traced. The impact of the topographic effect on the vertical component (approx. 2.5 mm for uniform 1 hPa loading) is by one order of magnitude larger than for the horizontal components. In a next step the model will be additionally parameterized specifically for mid-Europe to see how effects change by a further approximation to the real crustal conditions.