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Integration of displacement observations from InSAR and leveling to obtain horizontal displacements associated with surface uplift in the City of Staufen (Germany)

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Since the beginning of 2008, the city centre of Staufen is strongly affected by surface uplift. Based on extensive geological and hydrogeological studies, a volumetric expansion caused by groundwater induced mineral conversion of anhydrite layers in depths between 60 and 130 m has been identified as driving mechanism for this localised uplift phenomenon. A dense network of leveling benchmarks has been established by regional authorities to keep track on the extension of the affected area as well as actual vertical displacement rates. Horizontal displacements are not systematically observed so far but are indicated by displacement of three cadastral points.

We use TerraSAR-X interferometry to retrieve information on spatial extent and rates of surface uplift in the urban area of Staufen. A preliminary analysis of a reduced stack of 17 ascending scenes covering the time period from July 2008 to June 2009 revealed constant displacement rates. The maximum line-of-sight displacement rate is about 14 mm per month. Strong spatial gradients occur, since a relatively small area of approximately 300x200 m is affected. The LOS displacement rates are significantly larger than vertical displacement rates obtained from precise leveling, indicating an additional contribution from horizontal movements. This conforms to the observation of north-west directed horizontal displacement of the three available cadastral points with a displacement up to 20 cm.

This presentation will focus on the decomposition of observed line-of-sight displacements into vertical and horizontal components. We use a stack of precise leveling data combined with a TerraSAR-X persistent scatterer stack from 49 ascending acquisitions and a stack of small baseline interferograms of 10 descending acquisitions as input data. In general, the points from any of these data stacks are not coincident with those from the other two, neither in temporal domain nor in spatial domain. While for most surface displacements with comparably small spatial gradients a simple comparison of leveling points with neighboured persistent scatterer points is tolerable, in this case study an interpolation in space and time is necessary for successful decomposition of observed line of sight displacements into vertical and horizontal surface movements. It is also inevitable to account for the actual height of the persistent scatterer points. Leveling benchmarks are generally close to, or even on the ground while the persistent scatterer signal may origin from the roof or frontage of buildings so that tilting of buildings and annual height variations may bias the actual ground displacement. An accurate laser DEM with meter resolution is used in combination with estimates of the baseline dependent and spatially uncorrelated look angle error to determine the actual height above ground for each PS point. Two corner reflectors have been installed to serve for precise geocoding and as common data points for leveling and InSAR.