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Transient deformation of karst aquifers observed by GPS: improved knowledge from Central Apennines (Italy)

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The redistribution of water masses due to temporal variations of hydrological conditions can produce observable deformation of the shallow crust. Space geodesy, e.g., GPS and InSAR, has provided a considerable improvement in terms of data accuracy and spatial and temporal resolution for the detection and investigation of this kind of deformation. In particular, in the areas where snow and water accumulate for long periods, such as aquifers, relatively high deformation (up to several millimeters) has been observed. Karst aquifers are able to store huge amounts of water and a clear deformation related to the groundwater storage variations has been observed in some regions. In particular, in a recent study we highlighted that the karst aquifers of Southern Apennines deform in response of seasonal and interannual variations of groundwater content, producing a visible transient signal in the time series of the surrounding GPS sites. In this work, we analyze the GPS time series and hydrological data of Central Italy, an interesting and complex area which hosts huge karst aquifers and is characterized by high seismic activity. We show that a noticeable transient signal with features similar to those of Southern Apennines affects also the time series of Central Apennines. This suggests that the large karst aquifers of this region experience a process analogue to the ones in Southern Italy, alternately expanding and contacting in periods of increasing/decreasing precipitations and, consequently, higher/lower water content in the aquifers.
Thanks to the availability of a dense GPS network and different kinds of hydrological data (rainfall, spring discharge, groundwater level) we focus on the process causing the observed deformation. In particular, we model the observed deformation by inverting the GPS data using the Green's functions for finite strain cuboid sources (Barbot et al. 2017). Starting from GPS data, we also discuss eventual interactions between the Mw 6.3 L'Aquila earthquake which struck the Central Apennines in 2009 and the surrounding aquifers.
An enhanced understanding of the causes and implications of the highlighted deformation of karst aquifers is of primary interest for an improved management of this important water resource and for a better understanding of the possible interactions between groundwater variations, variations of pore pressure in the crust and seismicity.