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Geological control of hydrological transient deformation in the Venetian Southern Alps (Italy)

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Hydrological-induced horizontal deformation have been already detected and precisely measured in the Eastern Southern Alps and Northern Dinarides from the analysis of GPS displacement time-series (Serpelloni et al., 2018). Since they appear to be temporally correlated with cumulated precipitation time-series, in this work we investigate how the hydrological cycle affect GPS time series in a portion of the Venetian Southern Alps, a region of particular tectonic interest since it is where large part of the Adria-Eurasia convergence is accommodated. Here the GPS network is denser than the surrounding regions; furthermore, we included new GPS stations and updated the time series in order to take into account the flood event that occurred in this area during October 2018.
Ground-displacements time series from GPS stations have been analysed by applying a blind source separation algorithm based on variational Bayesian Independent Component Analysis. This analysis highlighted two annual common mode signals and a transient deformation signal. The latter is characterized by a spatially variable response in the horizontal components, causing a succession of horizontal extensions and contractions occurring about normal to natural fractures. We demonstrated that this transient signal is caused by the variation of the water storage in the hydrological basin of this area. Water storage has been modeled by using rainfall-runoff hydrological models, which describe how the precipitation over a basin turns into river flow once given as input rainfall, temperature and potential evapotranspiration. In order to understand how water storage variations generate the observed ground displacements, we built a 2D numerical model, accounting for the geological and topographical features of the study area. Then, we tested different sources of deformation in order to find the one that best reproduces the displacements obtained from the geodetic analysis. We found that the backthrust of the Bassano-Valdobbiadene fault, a major thrust of the south-verging seismogenic Venetian fold-and-thrust belt, is the preferred source of deformation. This backthrust fault is located north of a karstified mountain chain, corresponding to the anticline associated with the Bassano-Valdobbiadenet thrust fault. We made the hypothesis that the meteoric water penetrates through karst fractures at the top of the anticline and flows along the rock layers, converging to a sub-vertical fracture down to 1 km in correspondence of the backthrust of the main thrust fault. Here, the water accumulates because of the larger permeability of the fractured fault rocks, varying its level up to tens of meter and then generating pressure changes that cause the observed ground displacements. The largest pressure changes, associated with periods of larger displacements, cause significant increase/decrease of the Coulomb stress values down to 3 km, at seismogenic depths of the Bassano-Valdobbiadene thrust fault.

Reference:
Serpelloni, E., Pintori, F., Gualandi, A.,Scoccimarro, E., Cavaliere, A., Anderlini, L., et al. (2018). Hydrologically induced karst deformation: Insights from GPS measurements in the Adria-Eurasia plate boundary zone. Journal of Geophysical Research: Solid Earth, 123. https://doi.org/10.1002/2017JB015252