Groundwater changes affect crustal deformation, elastic properties and seismicity rates in the Southern Alps (Italy)

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We show the results of a multidisciplinary study on hydrologically-induced deformation in the Southern Alps (Italy) developed integrating geodetic, seismological and hydrological observations. The study region, located across the Belluno Valley and the Montello Hill, is part of the Adria-Eurasia boundary, where \textasciitilde{}1 mm/yr of N-S shortening is accommodated across a S-verging fold-and-thrust belt. GNSS time-series show the occurrence of non-seasonal horizontal transient displacements, characterized by a sequence of extensional and contractional deformation episodes oriented along the direction of the tectonic shortening. This signal is temporally correlated with water storage changes that are estimated using a lumped hydrological model based on precipitation, temperature, potential evapotranspiration and Piave river flow measurements. Geodetic and hydrological information are integrated in a 2D mechanical model with the goal of defining possible geological structures responsible for the measured subcentimetric geodetic displacements. Our interpretation implies that precipitation water rapidly penetrates the epikarst developed at the hinge of the anticline associated with the Bassano-Valdobbiadene thrust, converging toward a sub-vertical, deeply rooted hydrologically-active fracture (associated with its back-thrust), which tend to focus groundwater fluxes and pressure changes, generating ground displacements. Accordingly, seismic velocity changes computed from the analysis of ambient seismic noise cross-correlation show a temporal (anti) correlation with the evolution of water storage changes, suggesting that fluid increase in the aquifer perturb the Earth crust at depth by decreasing the seismic velocity (and vice-versa, during water storage decrease phases). Finally, by analyzing the seismicity recorded between 2012 and 2017 by a local network using a covariate model, we found that seismicity rates from a cluster of background seismicity correlate with changes in water storage. Although a spatial correlation between these seismic events and Coulomb stress changes associated with transient deformation episodes is not clear, it is worth noting that our model suggests stress perturbations of the order of 5-10 KPa down to 5-10 km of depth.