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Finding appropriate models to better extract information from time lapse seismic data on hydrosystems

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Porosity, permeability and saturation are properties of the Critical Zone (CZ) that naturally influence the seismic signal. Pressure (P-) and shear (S-) waves present, by definition, partially decoupled behaviors in the presence of fluids. The ratio of their propagation velocities (VP and VS respectively), or the Poisson's ratio therefore classically permit imaging the presence of fluids in rocks. This strategy however remains underused in near-surface applications, hence in hydrogeophysics. In the framework of the French program CRITEX, we showed how combined P-wave refraction tomography and surface-wave dispersion inversion can help describing both lithological heterogeneities of the CZ and spatial variations of its water content. We present here a collection of time-lapse application of this approach on hydrosystems of distinct hydrogeological characteristics. Seismic signals where recorded at different spatial resolutions (using 20 to 500 m long profiles) and at different time scales (with hourly to yearly acquisition frequency). At each site, both spatial and temporal variations observed in P- and surface-wave data indicated marked changes of the mechanical properties in the CZ, helping to better describe not only the geometry, but also the dynamic of the hydrosystems. The tools currently available to interpret seismic data however fail to properly describe or quantify continuous variations of the subsurface hydrological properties. This brings the need to explore petrophysical links to build alternative forward models and to improve inversion processes in order to exploit the full wealth of seismic signals in hydrogeophysics.