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First observation of multi-groundwater level responses to the strongest worldwide seismicity in Central Apennines (Central Italy).

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Earthquakes are the main natural processes which are able to cause the strongest crustal perturbations in the world. Seismic events change crustal stress, both static and dynamic, in the co-seismic and post-seismic phases. In particular, hydrogeological and hydrogeochemical responses include: changes in water level, temperature, chemical composition, stream flow, and gas geochemistry. Among these parameters water level changes is the most recorded signal because of its fast acquisition and easy instrumentation. Depending on the involved mechanism, groundwater level variation is different. In particular, previous studies have highlighted permanent and transient signals which are characterized by step and spike changes both upward and/or downward. Only few studies have reported groundwater level variations induced by earthquakes that are very far away from the observation point and they are known as "teleseism". In order to investigate relationship between groundwater properties and seismic cycle, since July 2014 we installed a multiparameter probe in a 100 m deep groundwater well (PF60.3) in Central Apennines (Central Italy). This monitoring well is part of a more complex monitored test site developed for this aim and it has recorded already hydrogeochemical anomalies related to Amatrice-Norcia 2016-2017 seismic sequence. The occurrence of the strongest earthquakes in the world (≈M_w>7.5), from the well probe installation (July 2014) until January 2020, has caused significant changes in groundwater level data. We analysed groundwater level behaviour in relationship to the occurrence of all 218 seismic events with M_w>6.5. We identified 16 interactions, where groundwater level is characterized by an anomalous spike change both upward and/or downward. In particular, we observed a significant interaction between signals for all the strongest seismic events with a M_w≥7.6, except for those happened in Papua Nuova Guinea and for those with ipocenter depth greater than 150 kilometers. We also found some interactions for less strong seismic events (6.5<M_w<7.5) but closer to the monitoring site. Among the observed correlations, 5 are characterized by a M_w between 8 and 8.2 meanwhile the others have a M_w between 6.5 and 7.9. The ipocenter depths of the considered 16 events are within 100 km, except two events that are deeper. We calculated the maximum amplitude of the perturbation and its duration. In this study we present our results with the main aim of expanding our understanding about perturbations due to distant earthquakes in the upper crust and in particular the relative fluid migration.