Monitoring Global groundwater change using seismic methods

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Project Description

Over 2 billion people worldwide suffer from water stress and groundwater is one of the least well-known components of the hydrologic cycle. Geodetic and gravity measurements often provide useful insights on spatiotemporal groundwater changes but they suffer from limited spatial and temporal resolution and only constrain a depth-integrated quantity (i.e., mass, surface displacement), the interpretation of which is inherently non-unique.

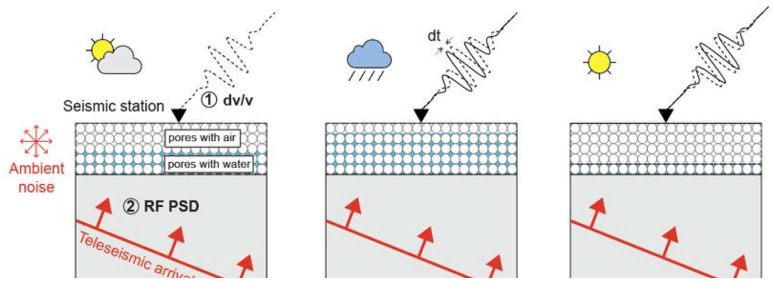

Figure 1: Conceptual diagrams depicting changes in groundwater (blue) within an aquifer and two seismic methods(autocorrelation of ambient noise and teleseismic receiver functions) for detecting them. After Kim et al., (2019).

Previous studies demonstrated that the two well-known independent seismic data types– ambient noise and teleseismic earthquake recordings – extracted from a single seismic station can reliably estimate temporal changes in groundwater on annual-to-decadal timescales (**Figure 1;** https://eos.org/editor-highlights/remotely-monitoring-groundwater-using-standard-techniques). The groundwater level changes effect P-wave more strongly than S-wave speeds, which indicates that this technique is a much higher-sensitivity tool for characterizing aquifer systems lacking monitoring wells, compared to methods based on inter-station cross-correlations.

The aim of this project is to characterize groundwater variations using available joint geodetic-seismic data (e.g., https://www.science.org/doi/10.1126/sciadv.aau2477; https://doi.org/10.1029/2019GL084719) and to quantitatively tie seismic constraints on the depth-distribution of groundwater to key hydraulic parameters. This will ultimately allow data collected by seismic stations to be used to map changes of those key parameters (e.g., hydraulic conductivity, permeability, porosity, and tortuosity) over time. We plan to improve the existing single station technique by incorporating analysis of correlation tensors derived from all three-components, which emphasizes mode conversions (P- to S-wave or vice versa) and provides independent and complementary constraints on subsurface structure. One of the expected outcomes will involve the development of a hydrological model relating the variations observed from seismic data to groundwater level and precipitation. This model will allow us to predict the groundwater changes before and after a rainfall event to be quantitatively related to and compared against relative velocity perturbations constrained by seismic data. This research can be extremely beneficial to developing nations under sever water stress (i.e., Sahel, South Africa, India, and Pakistan) and in other regions that lack extensive well monitoring networks.

The successful candidate will join, and be supported by, a vibrant and dynamic research group with world-class expertise modelling geophysical flows. The candidate will have the opportunity to develop their career and profile by presenting at international conferences and publishing in high impact journals. Candidates for PhD positions should have a good mathematical background and a good degree in an appropriate field such as earth science, physics, mathematics, computer science or engineering.