Docket #: S26-026

Depth-dependent seismic sensing for hydrological monitoring

Stanford researchers have developed a non-invasive seismic sensing method to monitor groundwater and subsurface pressure changes at multiple depths using passive ground vibration data. Groundwater managers need reliable information about how aquifers change over time, but traditional monitoring often relies on wells or boreholes that are expensive, sparse, and have limited coverage. This approach uses sensors at or near the land surface and analyzes different seismic frequency bands to estimate groundwater-related pressure changes at different depths. The method can generate depth-dependent hydrographs, maps, and drought indices to support groundwater modeling, drought monitoring, and water resource management. In a real-world demonstration using seismic stations across Greater Los Angeles, the method tracked aquifer changes continuously from 2003 to 2023 without invasive drilling.

Stage of Development: *Demonstrated with real-world seismic data from the Greater Los Angeles region. Research is continuing at Stanford, including the application of the method to California's Central Valley for aquifer storage monitoring.*

Applications

- Groundwater monitoring
- Aquifer storage management
- Drought assessment and mapping
- Environmental consulting services
- Hydrological model calibration
- Repurposed telecom fiber sensing networks

Advantages

- Monitors groundwater without drilling
- More cost-effective than traditional borehole pressure monitoring
- Provides information at multiple depths from the same sensor data
- Can generate hydrographs, maps, and drought indices
- Scalable to larger regions using seismic networks or telecom fiber sensing infrastructure

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