Applications of distributed acoustic sensing in urban seismic hazard assessment and reservoir monitoring

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Recent advances in distributed acoustic sensing (DAS) have turned optical fibers into dense seismic arrays, providing many new opportunities in seismic hazard assessment, structural analysis, and earthquake monitoring. These fiber-optic cables have the advantages of existing within many infrastructures and being easier to maintain in harsh environments (such as in boreholes) compared to mechanical sensors. In this talk, I present several DAS applications from my PhD research, including (1) using telecom cables for near-surface structure characterization, and (2) using borehole DAS for structure and microearthquake monitoring. In the first application, I use five days of ambient noise captured by the telecom cables at the Massachusetts Institute of Technology campus to resolve the shallow structure. I simulate ground motion transfer functions using the resolved velocity profile to assess the resonance frequency and amplification during earthquakes. The telecom cable provides us with a non-intrusive tool for site characterization in densely populated urban areas. In the second application, I use cables deployed within boreholes at the Brady and Cape Modern geothermal fields for temporal monitoring, characterizing a detailed attenuation profile, and resolving the source properties during reservoir stimulation. The downhole DAS can capture high-frequency energy, which is crucial for characterizing microearthquakes but is often not captured by surface sensors because of near-surface attenuation. Source parameter modeling using downhole cables is also less affected by site effects. I discuss the instrument response of DAS that should be considered when including DAS in conventional seismic analysis. With careful processing, DAS can be a promising tool for urban seismic hazard assessment, structure monitoring, and microearthquake analysis.