EGU22-11599
https://doi.org/10.5194/egusphere-egu22-11599
EGU General Assembly 2022

Comparing two fiber-optic sensing systems: Distributed Acoustic Sensing and Direct Transmission

Daniel Bowden[1], Andreas Fichtner[1], Thomas Nikas[2], Adonis Bogris[3], Konstantinos Lentas[4], Christos Simos[5], Krystyna Smolinski[1], Iraklis Simos[3], and Nikolaos Melis[4]
[1]Institut für Geophysik, ETH Zürich (Eidgenössische Technische Hochschule Zürich), Zürich, Switzerland (daniel.bowden@erdw.ethz.ch)
[2]Dept. of Informatics and Telecommunications, National and Kapodistrian University of Athens, Athens, Greece
[3]Informatics and Computer Engineering, University of West Attica, Athens, Greece
[4]Institute of Geodynamics, National Observatory of Athens, Athens, Greece
[5]Dept. of Physics, University of Thessaly, Lamia, Greece

Distributed Acoustic Sensing (DAS) systems have gained popularity in recent years due to the dense spatial coverage of strain observations; with one fiber and one interrogator researchers can have access to thousands of strain or strain-rate observations over a region. DAS systems have a limited range, however, with usual experiments being on the order of 10's of kilometers, owing to their reliance on weakly backscattered light. In contrast, systems that transmit light through a fiber and measure signals on the other end (or looped back) can traverse significantly longer distances (e.g., Marra et. al 2018, Zhan et. al 2021, Bogris et. al 2021), and have the added advantages of being potentially cheaper and potentially operating in parallel with active telecommunications purposes. The disadvantage of such transmission systems is that only a single measurement of strain along the entire distance is given.

During September - October 2021, we operated examples of both systems side-by-side using telecommunications fibers underneath North Athens, Greece, in collaboration with the OTE telecommunications provider. Several earthquakes were detected by both systems, and we compare observations from both. The DAS system is a Silixa iDAS Interrogator measuring strain-rate. The newly designed transmission system relies on interferometric use of microwave frequency dissemination; signals sent along the fiber and back in a closed loop are compared to what was sent to measure phase differences (Bogris et. al 2021). We find that both systems are successful in sensing earthquakes and agree remarkably well when DAS signals are integrated over the length of the cable to properly mimic the transmission observations.

The direct transmission system, however, may not be as intuitive to interpret as an integral of displacement ground motions along the fiber. We discuss both theoretical and data-driven examples of how the observed phases depend on the curvature of a given length of fiber, and describe how asymmetries in the fiber's index of refraction play a role in producing observed signals. Such an understanding is crucial if one is to properly interpret the signals from such a system (e.g., especially very long trans-oceanic cables). Given a full theoretical framework, we also

discuss a strategy for seismic tomography given such a system: with a very long fiber, the spatial sensitivity should evolve over time as seismic signals reach different sections.