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Towards multi-observational full-waveform inversion

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With the benefit of high spatial and temporal sampling even in remote and urban areas using existing fiber-optic infrastructure, Distributed Acoustic Sensing (DAS) has the potential to revolutionise seismological data acquisition on multiple scales across the Earth.
By combining (1) theoretical, (2) numerical and (3) experimental investigations, we want to underline the strengths and weaknesses of DAS and present a “roadmap for DAS in seismology”, with the ultimate goal being a full waveform inversion workflow that can combine all observed quantities (e.g. strain, displacement and rotation) at once.

(1) In the theoretical part, we demonstrate that existing seismological applications need to be adapted to a variety of newly emerging observational quantities, using the example of ambient noise interferometry. Specifically, we investigate how seismic interferometry may be used with newly emerging DAS data. We extend the theory of seismic interferometry to a variety of observational quantities with the focus on strain and strain rate - such as obtained from DAS systems.

(2) Using 3D spectral-element simulations based on the high-performance wave propagation software Salvus, we implement the new theoretical framework. At this early stage, it serves to investigate the impact of heterogeneous ambient noise sources and different measurements on the simulated interferograms and their sensitivity to Earth structure.

(3) The third part consists of a series of DAS experiments from a tunnel system in the Grimsel Rock Laboratory in southern Switzerland. This is intended to assess the quality of DAS data in a broad range of frequencies, including earthquake recordings from regional to global scale, ambient noise recordings and a wide range of active seismic experiments.

While the goal of multi-observable full-waveform inversion is not within reach yet, first results are promising and underline the great potential and possible impact that the recent advances in instrumentation could have on seismology across all scales.