EGU22-6984
https://doi.org/10.5194/egusphere-egu22-6984
EGU General Assembly 2022

Array signal processing on distributed acoustic sensing data: directivity effects in slowness space

Sven Peter Näsholm[1,2], Kamran Iranpour[1], Andreas Wuestefeld[1], Ben Dando[1], Alan Baird[1], and Volker Oye[1,3]

[1]NORSAR, Kjeller, Norway (peter@norsar.no)
[2]Department of Informatics, University of Oslo, Norway
[3]Department of Geosciences, University of Oslo, Norway

Distributed Acoustic Sensing (DAS) involves the transmission of laser pulses along a fiber-optic cable. These pulses are backscattered at fiber inhomogeneities and again detected by the same interrogator unit that emits the pulses. Elastic deformation along the fiber causes phase shifts in the backscattered laser pulses which are converted to spatially averaged strain measurements, typically at regular fiber intervals.

DAS systems provide the potential to employ array processing algorithms. However, there are certain differences between DAS and conventional sensors. The current paper is focused on taking these differences into account. While seismic sensors typically record the directional particle displacement, velocity, or acceleration, the DAS axial strain is inherently proportional to the spatial gradient of the axial cable displacement. DAS is therefore insensitive to broadside displacement, e.g., broadside P-waves. In classical delay-and-sum beamforming, the array response function is the far-field response on a horizontal slowness (or wavenumber) grid. However, for geometrically non-linear DAS layouts, the angle between wavefront and cable varies, requiring the analysis of a steered response that varies with the direction of arrival. This contrasts with the traditional array response function which is given in terms of slowness difference between arrival and steering.

This paper provides a framework for DAS steered response estimation accounting also for cable directivity and gauge-length averaging – hereby demonstrating the applicability of DAS in array seismology and to assess DAS design aspects. It bridges a gap between DAS and array theory frameworks and communities, facilitating increased employment of DAS as a seismic array.