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Exploration of Distributed Acoustic Sensing (DAS) data-space using a trans-dimensional algorithm, for locating geothermal induced microseismicity

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Distributed Acoustic sensing (DAS) data have been widely recognised as the next generation of seismic data for applied geophysics, given the ultra-high spatial resolution achieved. DAS data are recorded along a fiber optic cable at pre-defined distances (called “channels”, generally with 1-10 meters spacing). DAS data have been benchmarked to standard seismic data (e.g. geophones) for tasks related to both exploration and monitoring of georesources.

The analysis of DAS data has to face two key-issues: the amount of data available and their “directionality”. First, the huge amount of data recorded, e.g. in monitoring activities related to georesources exploitation, can not be easily handled with standard seismic workflow, given the spatial and temporal sampling (for example, manual picking of P-wave arrivals for 10 000 channels is not feasible). Moreover, standard seismic workflow have been generally developed for “sparse" network of sensors, i.e. for punctual measurements, without considering the possibility of recording the quasi-continuous seismic wavefield along a km-long cable. With the term “directionality" we mean the ability of the DAS data to record horizontal strain-rate only in the direction of the fiber optic cable. This can be seen as a measure of a single horizontal component in a standard seismometer. Obviously, standard seismic workflow have not been developed to work correctly for a network of seismometers with a unique horizontal component, oriented with variable azimuth from one seismometer to the other. More important, “directionality” can easily bias the recognition of the seismic phase arriving at the channel, which could be, based on the cable azimuth and the seismic noise level, a P-wave or an S-wave.

We developed a novel application for exploring DAS data-space in a way that: (1) data are automatically down weighted with the distance from the event source; (2) recorded phases are associated to P- or S- waves with a probabilistic approach, without pre-defined phase identification; and (3) the presence of outliers is also statistically considered, each phase being potentially a converted/refracted wave to be discarded. Our methodology makes use of a trans-dimensional algorithm, for selecting relevant weights with distance. Thus, all inferences in the data-space are fully data-driven, without imposing additional constrains from the seismologist.