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Real-Time Data Simulator for the Qualification of DAS Passive Seismic Geothermal Monitoring Systems

Echtzeit-Datensimulator für die Qualifizierung von DAS Passive Seismic Geothermal Monitoring Systems

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The use of distributed acoustic sensing (DAS) technology is gaining traction as the scientific community values its versatility while benefiting from its ease of deployment. This technology has been applied in a wide range of geophysical applications. The distributed nature of the sensing coupled to the large aperture array enabled by long cable(s) provides robust passive seismic monitoring systems. We developed a simulator of DAS-acquired passive seismic data for geothermal injection monitoring, which outputs data at real-time speed. The simulator serves for the verification of the acquisition geometry and the processing system when monitoring hydraulically-induced fracture network.

The simulator consists of two parts (1) seismicity modeling, and (2) waveform simulation. We rely on a statistical seismicity model to simulate seismicity distributions. We assume events are occurring in a cluster shape in space, and its time-spatial series are following statistical models as documented in the literature. We use the Gutenberg–Richter distribution to populate different type of magnitudes. The strain waveforms are generated for each passive seismic event using the parameters computed by the previous step. The output waveforms are continuous data. To achieve high-performance computation, (1) traditional ray-tracing adapted to strain (as opposed to velocity) is used to compute the strain waveform, and (2) parallel computation is employed.

The simulator generates the continuous synthetic data as expected. In one of the test cases used to validate the simulator, the scenario considering 2,000 channels of a DAS system with an average of 12 events per minute, the simulator completed the simulation in 13 hours with the 1-day continuous seismic data spanning 3TB.
A couple of technical challenges remain to commonly implement such array for day-to-day seismic monitoring operations. Firstly, a DAS-based system outputs a huge volume of data compared to any existing seismometer-based system. Thus, one needs to ensure that the processing infrastructure in place can handle such large volume of data in real time. Secondly, a DAS system measures the single component strain along the axis of the fiber while a seismometer measures the particle velocity or displacement leveraging three components. Therefore, one needs to assess the processing system in terms of event location capabilities and source parameters extraction including magnitude. The real-time simulator serves to validate the system in those aspects.