EGU21-7206
https://doi.org/10.5194/egusphere-egu21-7206
EGU General Assembly 2021

Characterisation of seismic events using time-reverse imaging

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In addition to stable and accurate hypocenters of seismic events, the characterisation of events is crucial for the investigation of seismicity in the context of geothermal reservoirs, CO2-sequestration and other geotechnical applications. Since the origin and nature of the seismicity in such cases is still under investigation, tools should rely on as few a priori assumptions about the sources as possible. Here, an approach is presented to determine the time-dependent moment tensor and origin time in addition to commonly derived hypocenter locations of seismic events using time-reverse imaging (TRI). The full six component moment tensor is derived and may be used to display for example focal mechanisms. The workflow consists of determining the location of potential sources, discriminating artificial and true source locations and obtaining the time-dependent moment tensors by recording the stress components at the derived source locations. Since TRI does not rely on the identification of seismic phases but on the simulation of the time-reversed wavefield through an adequate velocity model, no assumptions about the source location or the type of source mechanism is made. TRI is less affected by low signal-to-noise ratios and is thus promising for noisier sites and quasi-simultaneous events. However, a sufficient number of seismic stations are needed to accurately sample the wavefield spatially. The proposed workflow is demonstrated by locating and characterising microseismic events in the geothermal field of Los Humeros, Mexico. Although higher levels of noise are present and only a one-dimensional velocity model is available at this time, selected events could be located and characterised.