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Sensitivity maps for time-reverse imaging

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Microseismic events may occur during geothermal energy production due to fluid migration along fractures and faults which induces small pressure changes in the reservoir. Therefore, the distribution and origin time of these events may indicate flow paths as well as the size and orientation of the fractures and faults. However, these microseismic events often occur close in time and with low signal-to-noise ratios. Hence, the localisation of these events with standard localization tools is challenging. Alternatively, time-reverse imaging (TRI) does not rely on identifiable onsets of recorded events and is therefore exceptionally well-suited to locate and characterise these microseismic events. For TRI, seismic traces are reversed in time and reinserted into the medium at their recording positions. The time reversed wavefield is then back-propagated through a velocity model adequately representing the reservoir and focuses on the initial event locations. This method enables to spatially and temporally resolve the event localisations while handling a high level of noise and a complex velocity model. To investigate the seismicity in the geothermal system of Los Humeros (Mexico), 44 seismic stations were deployed as part of the GeMex project (a collaborative project of the European Union and Mexico).
This preliminary numerical study aims at estimating the possible localisation success using TRI with the deployed stations. Therefore, different subsets of the stations were compared for their ability to locate sources in different parts of the model. However, the exceptional sensitivity of TRI to the station distribution results in different location accuracies in different parts of the model. To quantify this effect, a synthetic test is proposed. Numerous synthetic sources are distributed evenly throughout the whole model domain and are excited simultaneously. The resulting wavefield is recorded at surface stations and used in the TRI scheme to localise all of the sources. The location accuracy of each event can then be converted into a map indicating areas with high and low location accuracy. Here, a sensitivity map is created for an ideal array with numerous surface stations as well as the real station positions as they were deployed at the geothermal site in Los Humeros. These sensitivity maps enable the evaluation of spatial variation in location accuracy. Additionally, it will provide a basis for evaluating the uncertainty of source locations by comparing the source location with the predicted location accuracy at that point provided by the sensitivity map.