The structure of signal space: a case study of direct mapping between seismic waveforms and event distribution

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Under special circumstances, waveform observations of seismic events related by a common, spatially-distributed source process exhibit a geometric architecture that is a distorted image of event distribution in the source region. We describe a prescription for visualizing this signal space image and use a machine-learning algorithm, Isomap, and an algorithm due to Menke to invert collections of waveforms directly for relative event location. We illustrate concepts and methods with well-characterized induced seismicity at a coal mine in the U.S. state of Utah observed by two local seismic instruments, and with synthetics. We anticipate application of these methods to repetitive volcanic seismicity, icequakes and induced seismicity.

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