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Distributed detection and fusion of multi-signature explosion-sourced waveforms: predictive capability, quantitative performance, and experimental demonstration

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Quantitative methods that enable multi-physics waveform fusion support explosion monitoring and general research in geophysical processes that comprises background emissions for explosion monitoring. We offer a constructive method to fuse statistics that we derive from multi-physics waveforms and improve our capability to detect small, above-ground explosions over methods that consume single waveforms. Our method advances Fisher's Method to operate under both hypotheses of a binary test on noisy data and provides density functions required to forecast our ability to screen fused explosion signatures from noise. We apply this method against 12-day, multi-signature chemical explosion and noise records to illustrate three primary results. We show that: (1) a fused multi-physics statistic that combines radio, acoustic, and seismic waveforms can identify explosions roughly 0.8 magnitude units lower than an acoustic emission, STA/LTA detector for the same detection probability; (2) we can quantitively predict how this fused, multi-physics statistic performs with Fisher's Method; and (3) that this data stream method competes well with lower fidelity, decentralized detection approaches. We additionally present our preliminary, but more general work that addresses multi-signature association of data streams to a common source.

Promotional text

This work supports the objective of improving nuclear test monitoring and verification by using chemical explosion test data to develop better methods of signal detection.

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