The acoustic signature of underground chemical explosions during the SPE

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Introduction

Phase I of the Source Physics Experiment (SPE) consisted of **six chemical explosions in granite.** The experiment was designed to produce **a high quality, multiparameter geophysical data set** to facilitate the development of **physics-based models** of signals from buried explosions. Infrasound characterization emerged as one of the primary goals of the experiment, and an eight element acoustic network was deployed for that purpose.
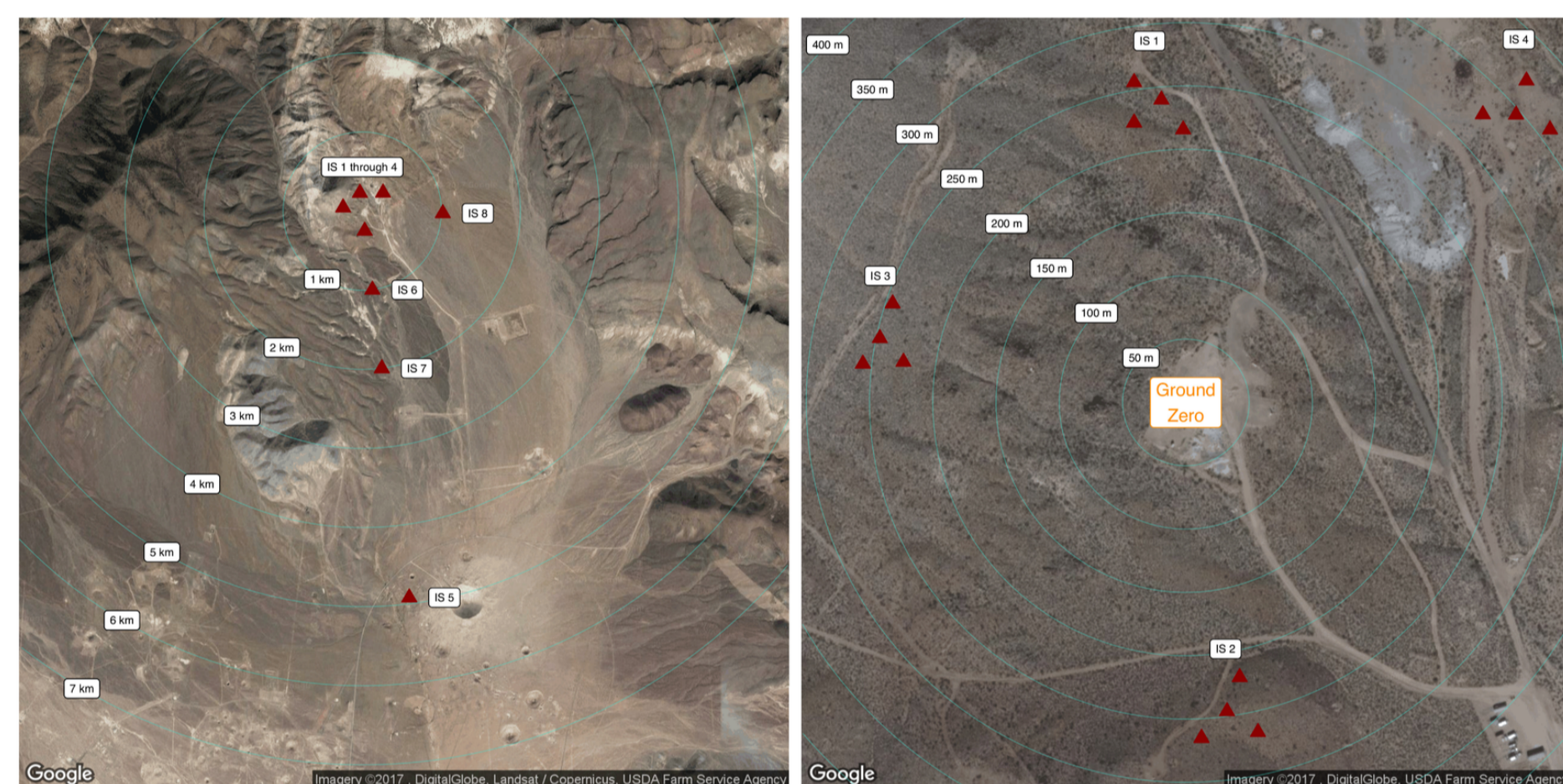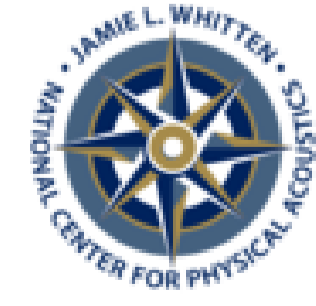
Network

Figure 1: Far view of the eight infrasound stations deployed during the SPE (left) and close up view showing individual array elements (right).

Infrasound sensors were placed 200 m to 5 km from the explosion epicenter. Each station consisted of four sensors approximately 30 m apart. Sensors consisted of Inter-mountain Labs microphones (SPE-1 and SPE-2) replaced with Hyperion microphones (SPE-3 through 6). Wind mitigation consisted of porous hoses and high frequency shrouds. Most microphones at stations IS-1 through IS-4 were replaced with seismically decoupled versions for SPE-5 and SPE-6.

Wave Forms

SPE-1: 90 kg @ 55 m 0.77 Pa Peak to Peak
SPE-2: 1000 kg @ 46 m 13 Pa Peak to Peak
SPE-3: 900 kg @ 47 m 19 Pa Peak to Peak
SPE-4P: 89 kg @ 87 m 0.19 Pa Peak to Peak
SPE-5: 5000 kg @ 77 m 16 Pa Peak to Peak
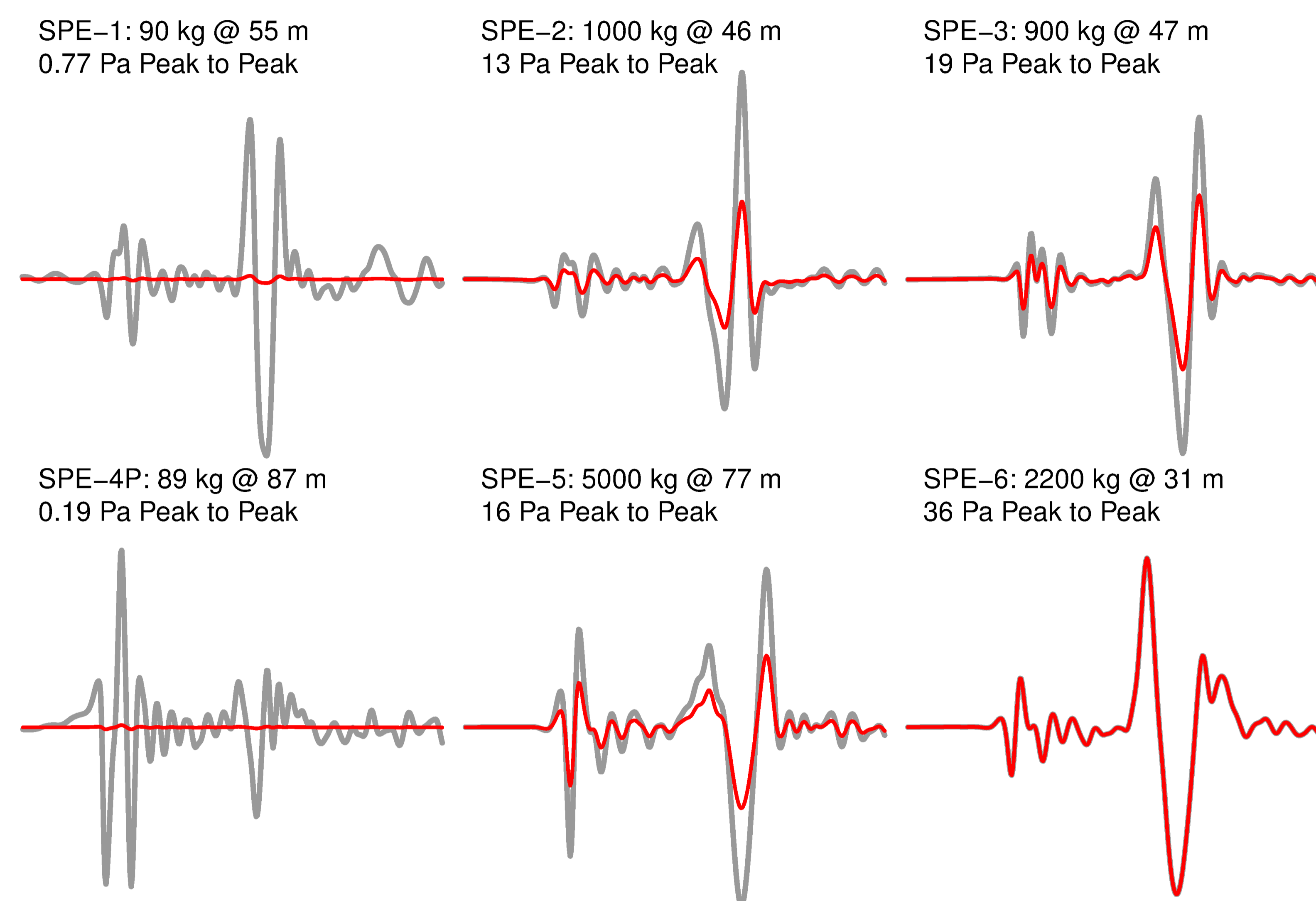SPE-6: 2200 kg @ 31 m 36 Pa Peak to Peak

Figure 2: Infrasound recorded at station IS-3, approximately 250 m from the epicenter. The red line is scaled to the maximum amplitude recorded during the series. Shot weights are in TNT equivalent.
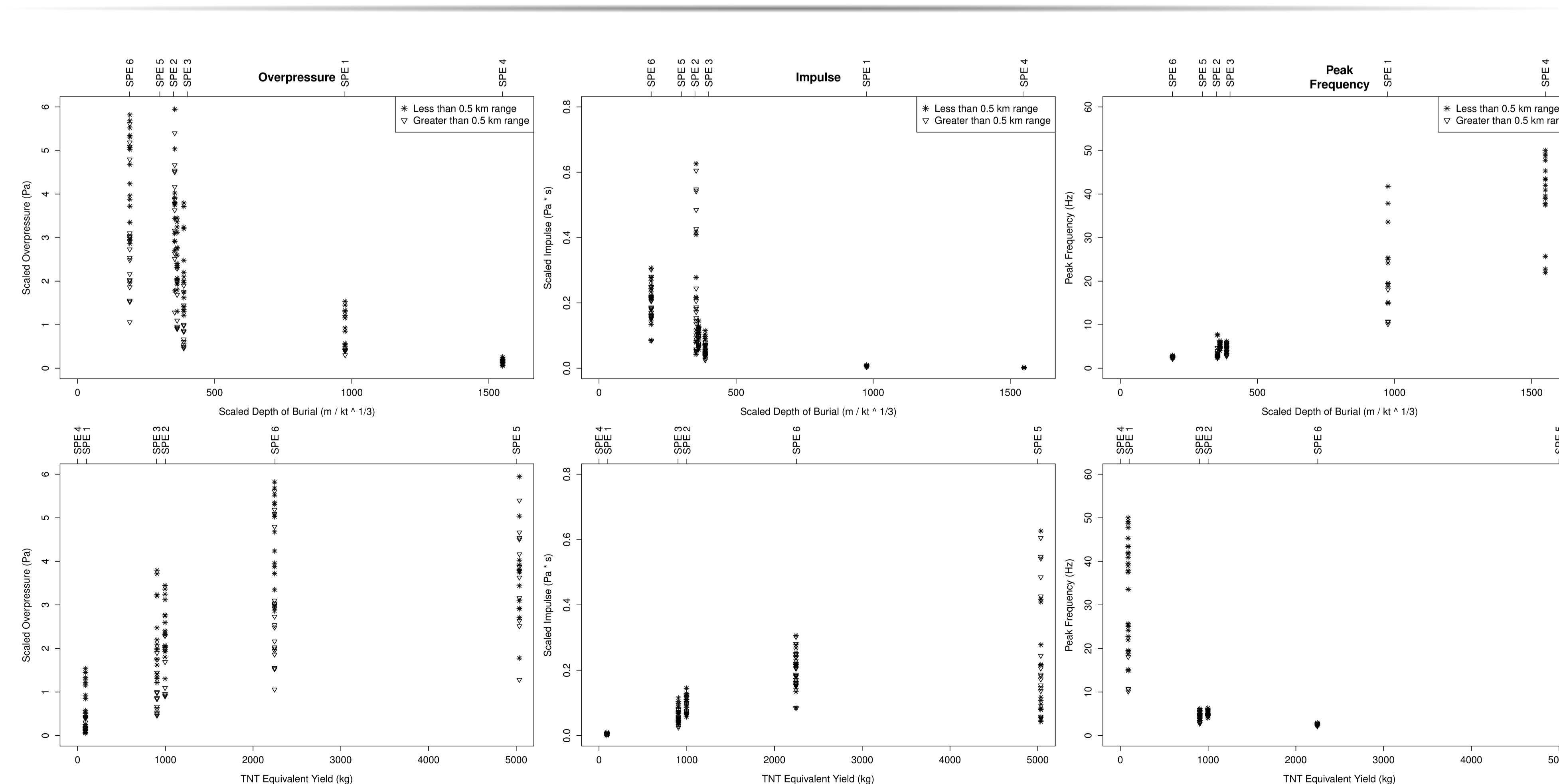
Signal Characteristics

Figure 3: Overpressure, impulse, and peak frequency for each sensor that had an identifiable signal. Overpressure and impulse were scaled to 1 km from the epicenter assuming a geometrical attenuation of $1/r$, where r is distance from source.
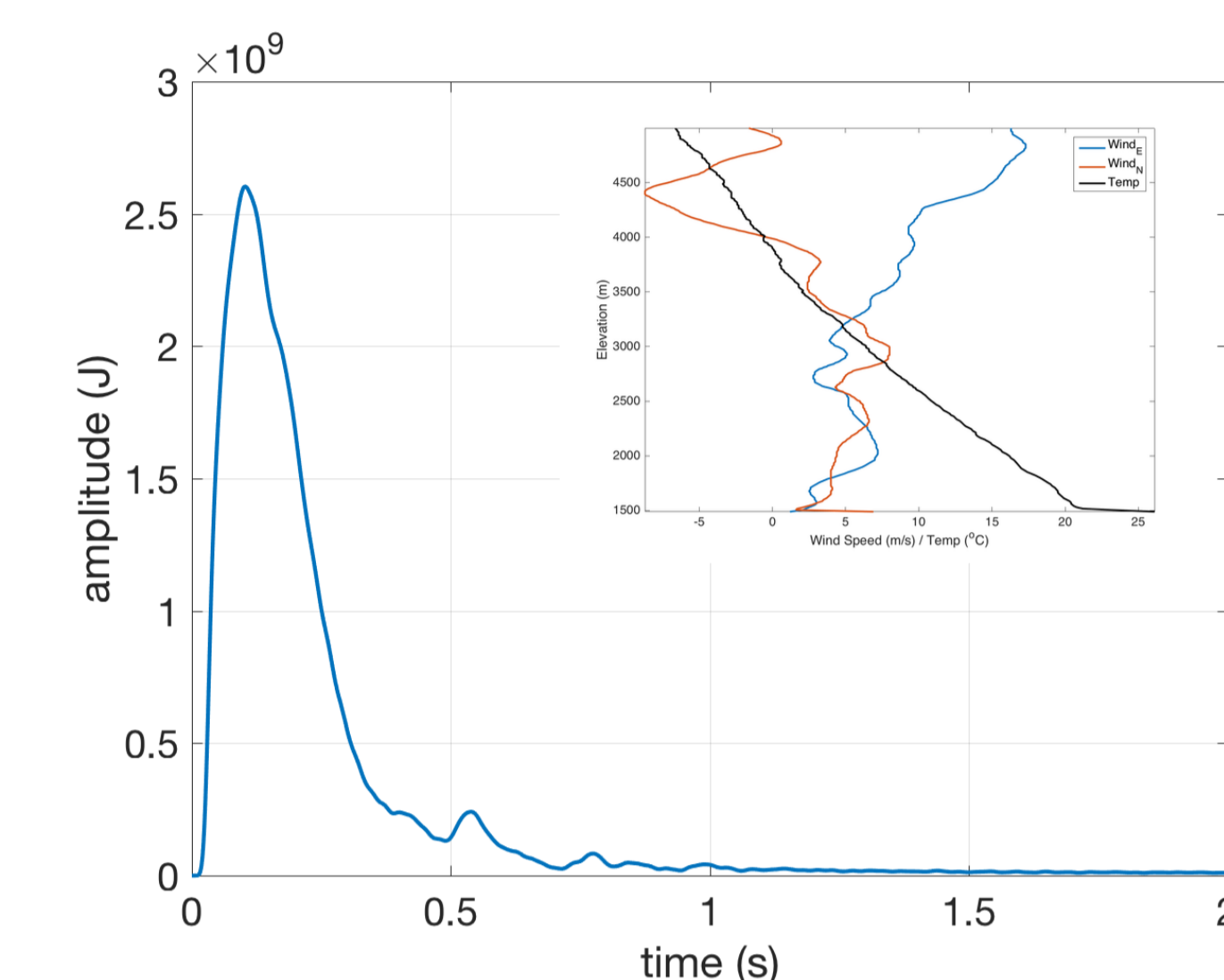
Source Inversion

Figure 4: Acoustic source-time function for SPE-1 calculated using frequency-domain inversion of pressure signals and a 3-D synthetic Green's function.
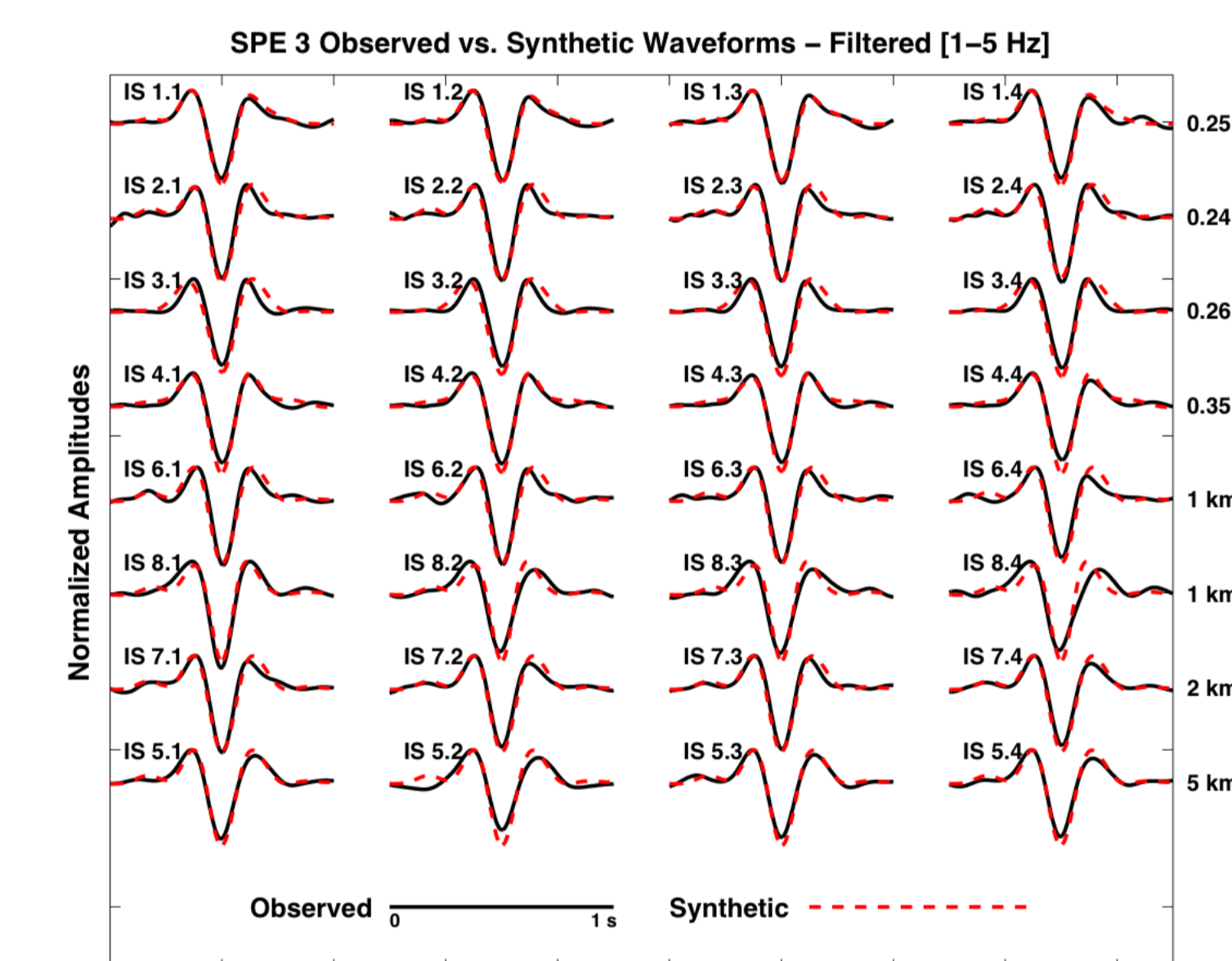
Rayleigh Integral

Figure 5: Forward modeling of SPE-3 signals using near-source surface accelerometers and the Rayleigh integral method.
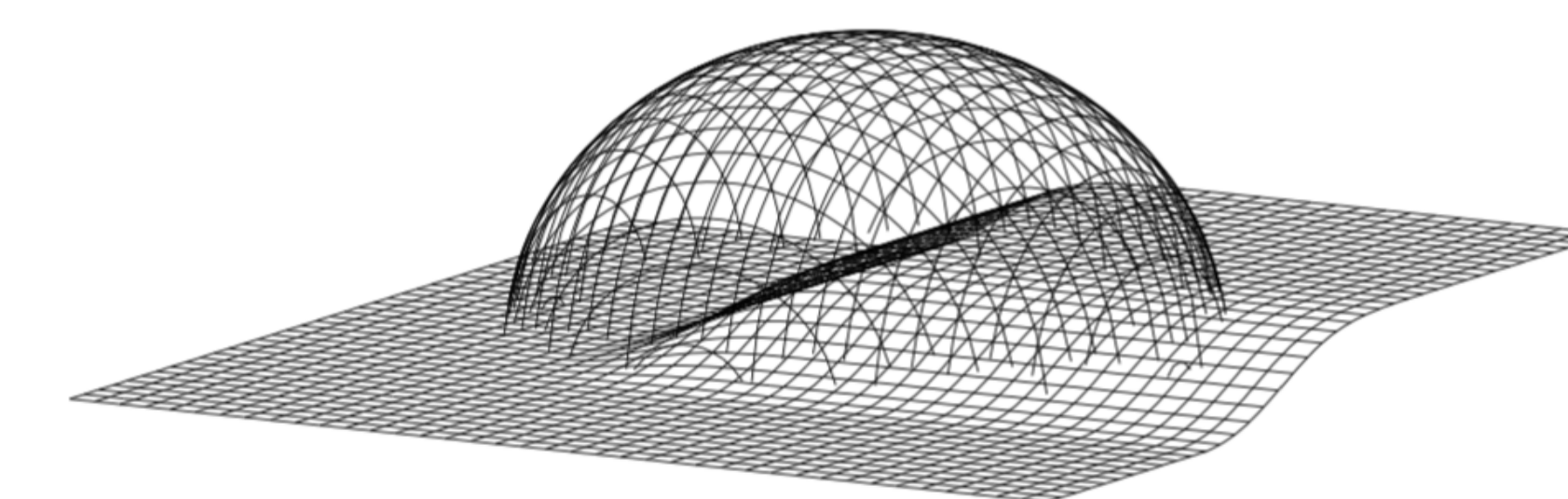
Boundary Element Model

Figure 6: Schematic of the boundary element model for calculating an infrasound source function from a buried explosion.