Seismically induced ground motions and source mechanism passively retrieved from remote infrasound detections

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The amplitude of ground motions caused by earthquakes and subsurface explosions generally decreases with distance from the epicenter. However, in the near-source region, other factors, e.g., near surface geology, topography, and the source radiation pattern, may significantly vary the amplitude of ground motions. Although source location and magnitude (or yield), can be rapidly determined using distant seismic stations, without a dense seismological network in the epicentral region, the ability to resolve such variations is limited.

Besides seismic waves, earthquakes and subsurface explosions generate infrasound, i.e., inaudible acoustic waves in the atmosphere. The mechanical ground motions from such sources, including the effects from the above mentioned factors, are encapsulated by the acoustic pressure perturbations over the source region. Due to the low frequency nature of infrasound and facilitated by waveguides in the atmosphere, such perturbations propagate over long ranges with limited attenuation and are detected at ground-based stations. In this work we demonstrate a method for resolving ground motions and the source mechanism from remotely detected infrasound. This is illustrated for the 2010 Mw 7.0 Port-au-Prince, Haiti earthquake, and the 6th and largest nuclear test conducted by the Democratic People's Republic of Korea in 2017.

Such observations are made possible by: (1) An advanced array processing technique that enables the detection of coherent wavefronts, even when amplitudes are below the noise level, and (2) A backprojection technique that maps infrasound detections in time to their origin on the Earth's surface.

Infrasound measurements are conducted globally for the verification of the Comprehensive Nuclear-Test-Ban Treaty and together with regional infrasound networks allow for an unprecedented global coverage. This makes infrasound as an earthquake disaster mitigation technique feasible for the first time and contributes to the Treaty's verification capacity.