Seismo-Acoustic Coupled Signals - Epicentral and Secondary Sources of Infrasound

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Abstract:

A sequence of moderate and strong earthquakes is recorded by infrasound arrays up to an epicentral distance of 750 km. As expected, two distinct signals originating at the earthquake source or epicentral region are detected; (1) A seismic signal consisting of body and surface phases is detected with a celerity (average propagation velocity) range of ~5 to ~2.5 km/s, and (2) An infrasound signal is detected with a celerity range of ~350 to ~220 m/s. However, using array processing, a third type of signal can sometimes be detected. This signal arrives after the seismic detections and before the epicentral infrasound detections with a celerity of ~1 km/s to 460 m/s. This intermediate signal, as well as the epicentral infrasound signal, traverses the array with a trace velocity of roughly 350 m/s. Relative to the epicentral infrasound detections, which exhibit a stable back-azimuth pointing toward the epicenter, the intermediate signal detections are scattered with ±30°.

The trace velocity of the intermediate signal indicates that it is infrasound but the celerity is too fast for it to originate at the epicenter. Therefore, this intermediate infrasound signal must have a propagation path which is part seismic and part atmospheric. The region where seismic ground motions couple to infrasound waves in the atmosphere is a secondary infrasound source and is the focus of our research.

Using the seismic celerity (~3 km/s) and the epicentral infrasound celerity (~300 m/s), we simultaneously propagate seismic-waves from the source and infrasound from the arrays to outline the region where this intermediate infrasound signal can potentially originate from. To further narrow down the secondary source region we back-project rays using three-dimensional ray tracing through high-resolution atmospheric conditions available from the European Centre for Medium-Range Weather Forecasts (ECMWF).

We show that the manifestation of an intermediate, apparently fast-arriving infrasound signal occurs when ground motions over a secondary source region are efficiently coupled to an existing atmospheric duct connecting the secondary source region and the infrasound array.

Understanding seismo-acoustical coupling is of interest for the verification of the CTBT, where large underground explosions generate infrasound, which can be detected over long ranges. The fusion of seismic and infrasound data from underground sources will lead to better source characterization in terms of for example source depth and yield.