



The infrasonic wavefield at regional distances from repeating seismo-acoustic events

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Hukkakero is a site in northern Lapland where the Finnish military detonate expired ammunition in a sequence of between 10 and 60 explosions every year. The yield per explosion is around 20000 kg TNT equivalent and strong seismic signals recorded on the ARCES array at a distance of 178 km indicate seismic magnitudes around 1.5. The seismic signals from each event are almost identical and demonstrate that the sources are almost co-located, have a simple source-time function, and are similar in yield. They also facilitate detection and identification of the events using a waveform correlation detector. Coupled infrasonic signals are observed on the seismic sensors of the array for almost every event and non-observation of infrasound is usually accompanied by exceptionally high noise levels or the presence of unrelated seismic signals. ARCES provides exceptionally high slowness resolution for acoustic signals allowing a very accurate description of the acoustic wavefield along this path.

Reprocessing ARCES data throughout the archive has identified approximately 500 such events since 1988. Although they are all conducted in August and September, they have the advantage of being conducted on consecutive days, indicating that the most significant changes in the infrasonic wavefield occur over a several-day time-scale. Numerous events have fairly impulsive arrivals after around 500 seconds which are presumed tropospheric phases. Almost all events are associated with longer duration signals at around 600 seconds, presumed to be stratospheric arrivals, although these "shadow zone" observations are seldom predicted by ray-tracing. A far smaller number of events are associated with presumed thermospheric arrivals at around 900 seconds with shorter duration, smaller amplitude, higher apparent velocity, and a lower frequency content. The sequences in 2008, 2009, and 2010 were also recorded by a temporary microbarograph mini-array within ARCES with a lower detection threshold than offered by the seismic sensors. This has indicated that the stratospheric signals are of far longer duration than is observed on the seismometers, which only register the largest amplitudes. The new data also suggests that far more events are associated with thermospheric arrivals than were first assumed.

The microbarograph mini-array has detected many low amplitude infrasound signals from numerous different seismo-acoustic sources in the European Arctic. Many of these are associated with several hundreds of events, and it is a focus of ongoing research to map out the active sources and characterize the variability of the associated infrasonic wavefield as a function of time, range, and direction.