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A Ground Truth Database of Seismo-Acoustic Events in Northern Europe

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The international network of infrasound sensors records a continuous datastream containing signals from events of both known and unknown origin. For events of known origin, i.e. with the location and time well-determined, we are able to validate and improve upon our characterization of the wind and temperature structure of the atmosphere, since we can compare directly infrasonic observations with model predictions. For events of unknown origin, such as unannounced or accidental explosions or extreme natural phenomena, infrasound should ideally be exploited to locate the event(s) in time and space and to characterize the source(s). The ability to do this will clearly improve with an improved atmospheric specification and modeling capability.
"Ground Truth", or GT, denotes events for which the origin time and source location are known. Calibration experiments (explosions of specified yield, time and location) have been performed in order to validate atmospheric specifications and propagation models and to investigate the detectability of infrasound over networks. However, such explosions are extremely expensive to execute and so can only sample the evolving atmosphere on a very limited number of occasions. Fortunately, many other types of explosions occur regularly. These include detonations of expired ordnance by militaries and routine quarry blasting. There are many such sources in northern Europe which generate infrasound signals detected at distances from many hundreds to several thousands of kilometers, but which also generate seismic signals which have been recorded by stations in Fennoscandia for over 25 years. The seismic signals generated by events at a given location, recorded on any given seismometer, are like a fingerprint for that source region and pattern recognition methods (e.g. waveform correlation and Empirical Matched Field Processing or EMFP) can attribute a signal to a particular source given sufficient calibration information. The seismic signals can constrain the event origin time to within under a second and the source location to within a few hundred meters, depending upon the a priori information available.
Events at repeating sources have been characterized as far back as 1987 when data from the ARCES seismic array first became available. For some known sources, such as the ammunition destruction blasts at Hukkakero in Northern Finland, many hundreds of explosions have been identified using simple correlation detectors on the seismic waveforms. For ripple-fired quarry blasts, such as the large explosions at Khibiny and Olenegorsk on the Kola Peninsula, correlation detectors struggle due to the dissimilarity between waveforms from subsequent explosion sequences. However, EMFP identifies the source of these events very effectively based upon the spatial characteristics of the seismic wavefronts over arrays. Infrasound observations on the network of arrays in Fennoscandia have revealed several new sites (all open-cast mining operations) which have been identified using a combination of careful seismic network event location, commercial satellite imagery and published documentation from the mine operators. This work has been performed under the ARISE (Atmospheric dynamics Research InfraStructure in Europe) Design Study project funded by the FP7 European Commission under the Capacities Programme.