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SANDIA INFRASOUND GROUND-TRUTH SIGNALS DATABASE (SINGS)

Developing a catalogue of infrasound events and arrivals for model calibration and validation

Nora R. Wynn, Fransiska Dannemann Dugick

Sandia National Laboratories – Geophysical Detection Programs

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BACKGROUND AND MOTIVATION



Accurate ground truth event information is necessary for validating event detection, location and characterization methodologies

Instead, researchers rely on explosive sources such as volcanic eruptions, mining events, bolides or anthropogenic explosions which generate acoustic signals detectable at regional distances

Infrasound sensors do not reliably record naturally occurring tectonic events

We build a database of anthropogenic explosions for use as a calibration tool for model validation

Catalogs of signal arrival characteristics will be hosted on open-source sites (GitHub) for longevity and continued use by the international infrasound and monitoring communities.

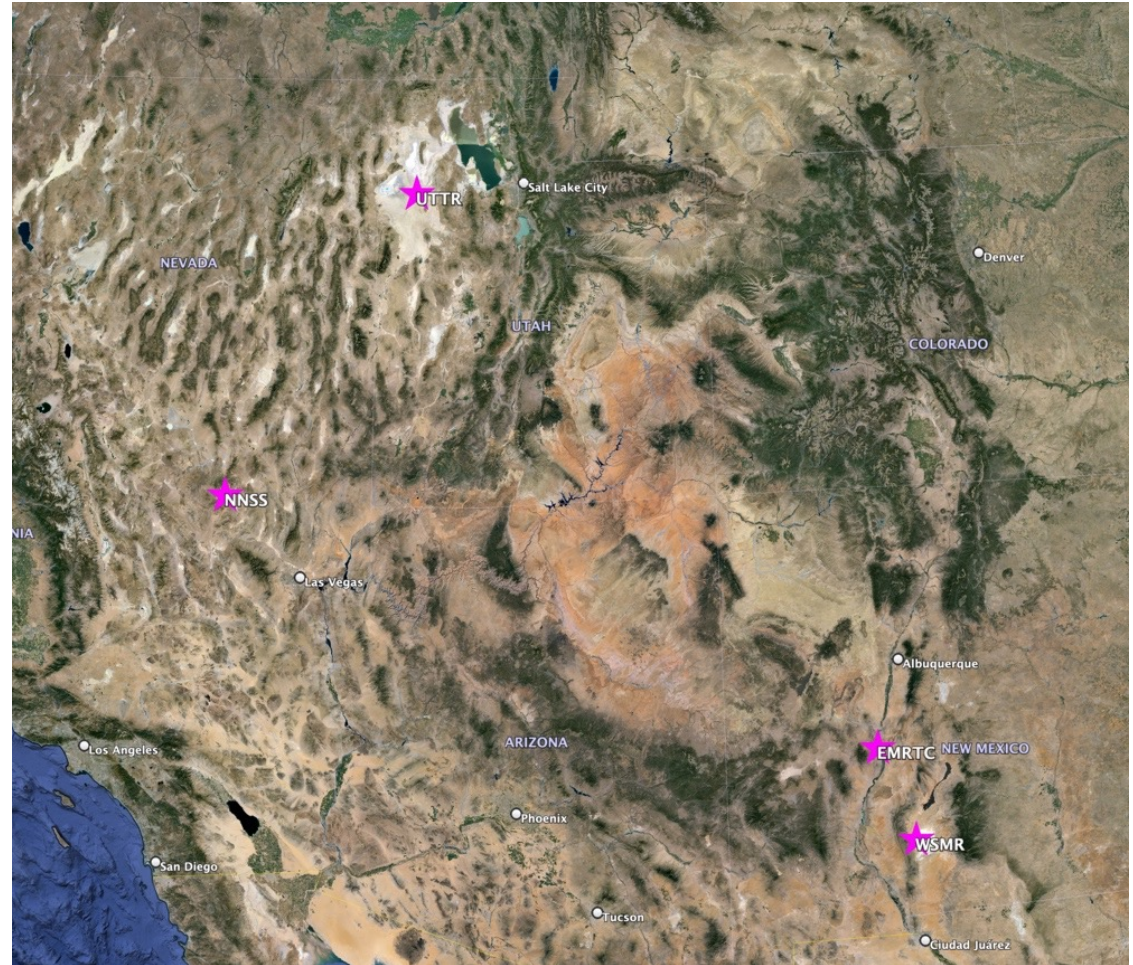
BACKGROUND AND MOTIVATION



- Seismoacoustic waveform model development improves precision and accuracy in event characterization estimates by refining travel time models for infrasound signal propagation
- The SINGS database offers empirical infrasound arrival data from ground truth explosive tests in the Southwestern U.S.
 - This data can be used to refine transmission loss models, improving travel time estimates
- The SINGS database will aggregate arrival information in a standardized format so it can be used as inputs for network-level analysis including location and characterization, including yield estimation
- Consistent input information, i.e. arrival times, amplitudes, peak frequencies, signal duration, across events reduces uncertainties in network-level estimation
- **Key improvement = ability to hone in on improvements related to algorithms rather than inputs**

THE DATASET

- Curated source information for 119 explosive events which generated regional infrasound signals in the American Southwest
- Data sources include:
 - Publicly available literature
 - Reports available from the U.S. Department of Energy Office of Scientific and Technical Information
 - Conversations with network operators and campaign managers
- Some events in the GT dataset have signal arrival data documented in scientific literature, but arrivals are not identified in a consistent and reproducible manner

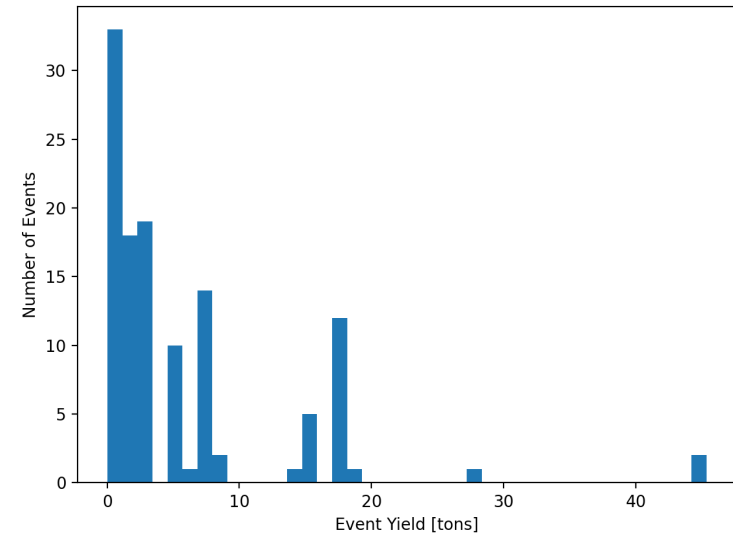
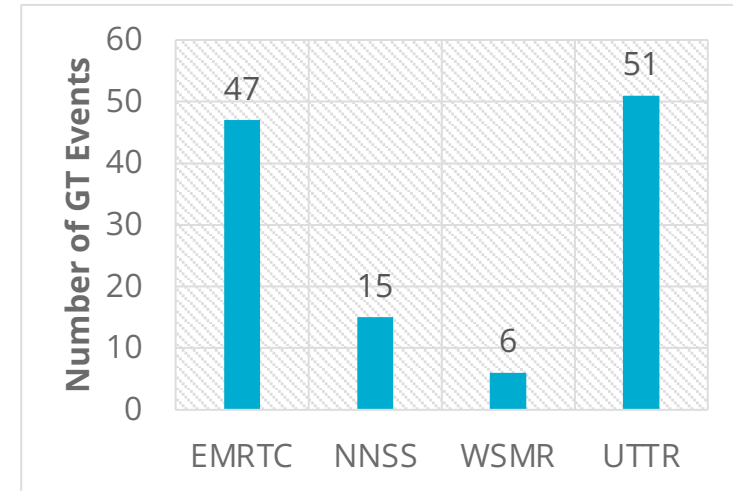


Data from Utah Testing and Training Range, Energetic Materials Testing Center, Nevada National Security Site, and White Sands Missile Range



GROUND TRUTH EVENT TABLE

- Included explosions took place from 2002–2023
- Yield ranges from 0.1–45 tons
- All included explosions were conducted at the surface
- Some events at UTTR are rocket motor tests. In these entries, the number of motors is listed in the GT table
- This GT table is separate from the SINGS arrival tables, and was completed prior to building the main database



EVENT ID	Date	Time (UTC)	Latitude	Longitude	Elevation	Weight	Weight	Weight	No. Motors	Depth	Product /Notes
	mm/dd/yyyy	hh:mm:ss	degrees	degrees	meters	lbs	kg	tons		meters	





DATABASE TABLES

- SINGS is structured after CSS3.0 (Anderson et al., 1990), with new tables specifically designed to record infrasound arrival information
- The new tables are tied in each other and back to the existing CSS3.0 tables via common variables

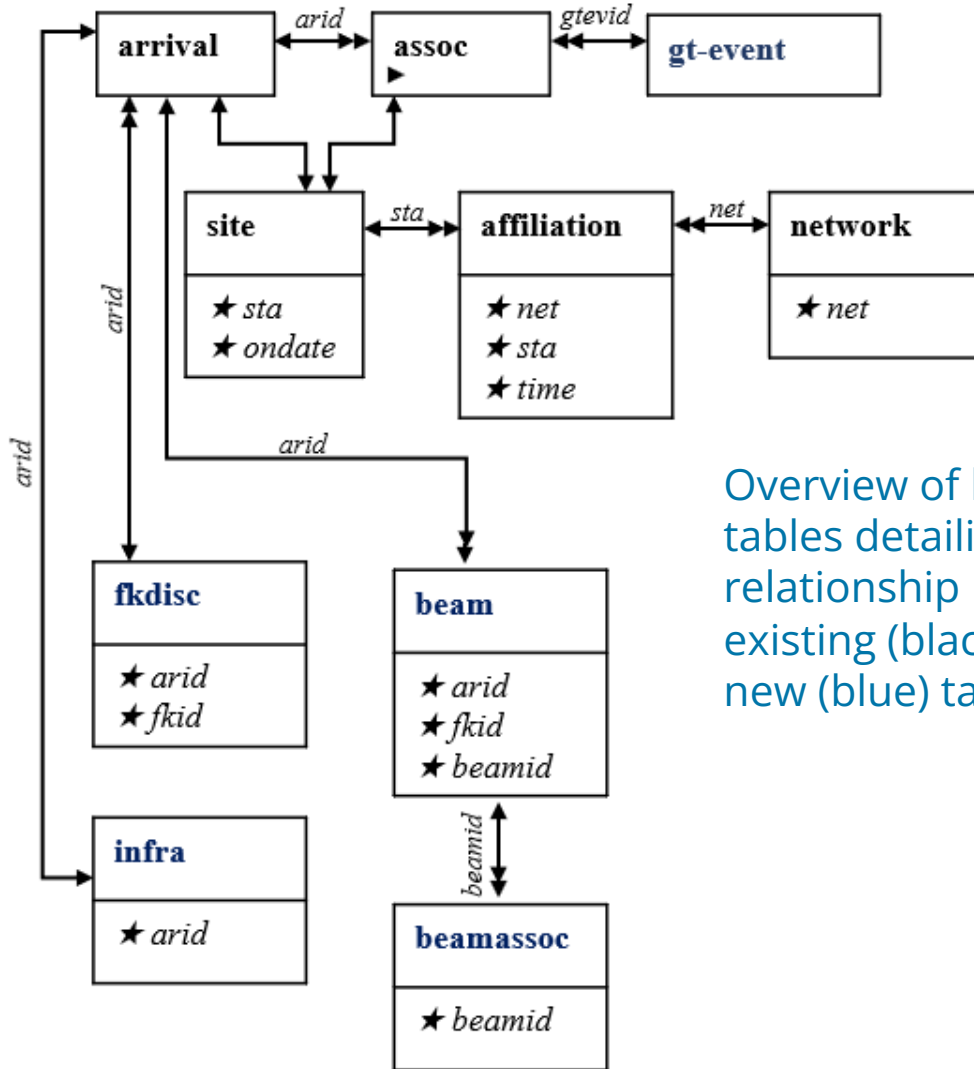
SINGS TABLES

- fkdisk – table focused on frequency-wavenumber (fk) information
- infra – table focusing on infrasound information
- beam – describes beams from accompanying data
- beamassoc – connects beams to the station, channel, and instrument that were used to generate it

CSS3.0 TABLES

- **Note:** seismic-specific variables in CSS3.0 tables are excluded from the SINGS data tables
- arrival – summary information on arrivals
- assoc – table that connects arrivals to GT events
- affiliation – network station affiliations
- network – description and ID
- site – station location and on/off dates

TABLE CONNECTION AND INTEGRATION



Overview of lookup tables detailing relationship between existing (black) and new (blue) tables

arrival	← arid →	assoc	← gtevid →	gt-event
★ arid ☆ sta ☆ time ☆ chan ☆ iphase ☆ auth ☆ chanid		★ arid ★ orid		★ gtevid ★ orid
sta time arid jdate stassid chanid chan iphase stype deltim azimuth delaz slow delslo ema rect amp per logat clip fn snr qual auth commid		arid orid sta phase belief delta seaz esaz timeres timedef azres azdef slores slodef emares wgt vmodel commid lddate		gtevid evname type typecertainty lat lon depth time yield yalgorithm auth commid lddate

Primary tables including new table (gt-event) detailing linkages with lookup tables

SIGNAL ARRIVALS – SINGLE STATION PICKING AND PROCESSING

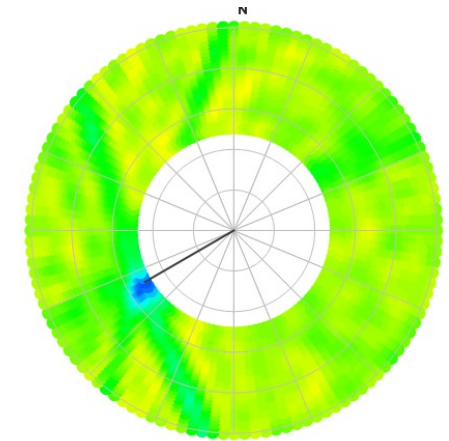
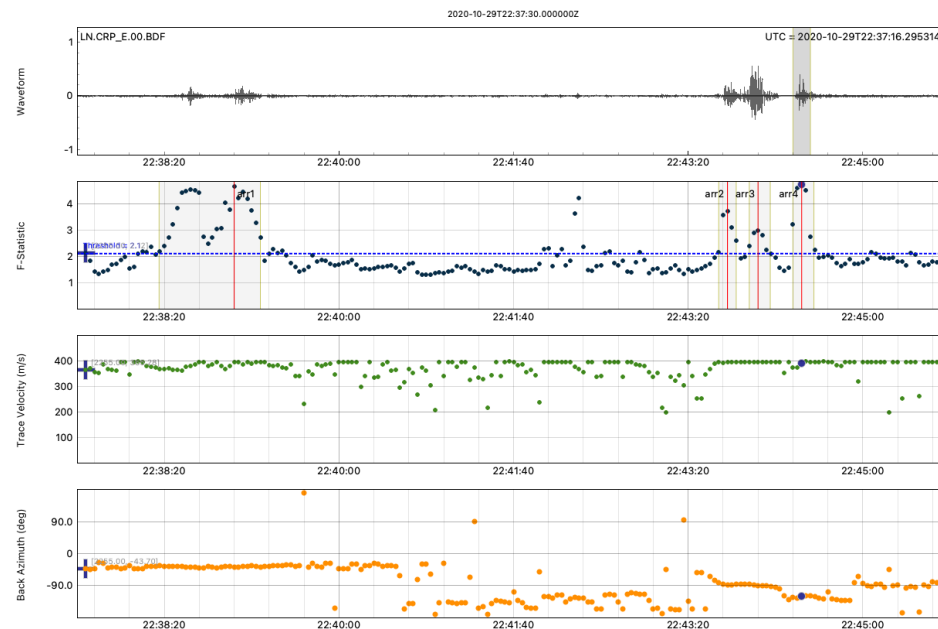


- Infrasound time series and frequency data at regional distances from events in the GT table was pulled from publications, Sandia datasets available on OSTI.gov, and openly available EarthScope data.
- Data was trimmed to fast (0.4 km/s) and slow (0.2 km/s) acoustic travel times based on source to receiver distance
 - Waveform data in these windows for each infrasound station was inspected for possible arrivals
- Waveforms were demeaned, detrended, and bandpass filtered from 1-20 Hz
- Arrival onset times, peak amplitude times, and coda length were manually picked and recorded using Pyrocko's Snuffler tool

SIGNAL ARRIVALS – ARRAY PICKING AND PROCESSING



- The same initial process for identifying waveforms was used as in single station cases
- Los Alamos National Laboratory's InfraPy array processing tool suite was used
 - 10 second windows with 50% overlap, bandpass filtered at 1-20 Hz



**Calculated Back
Azimuth: -121.05
Calculated Trace
Vel: 391.36 m/s**

CONCLUSIONS AND CONTINUING WORK

- An evolving version of this dataset will be available in coming weeks via a Sandia hosted, open-source data sharing platform
- This database is an ongoing effort, and we aim to add new events as data becomes available
- Feedback is welcome– the dataset is meant as a useful and useable resource

THANK YOU!

nwynn@sandia.gov

