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Explosive Infrasonic Events: Sensor Comparison Experiment (SCE)

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Explosive Infrasonic Events
Sensor Comparison Experiment (SCE)

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Release Date: 6 February 2017

Source Information

Launch Site:	not released
Launch Location:	not released

Est. Origin Times: not released

Description: SCE (sensor comparison experiment) 1 through 4 consists of a series of four controlled above-ground explosions designed to provide new data for overpressure propagation. Infrasound data were collected by LLNL iPhones and other sensors.

Permissions: External Audience (Unlimited)
IM release number: LLNL-TR-721758

Infrasound Data

Detections: LLNL iPhones/ Other
  Other: Pending
  Mobile: 1411160001, 1411160002, 1411160003, 1411160004, 1411160005, 1411160006, 1411160007, 1411160008, 1411160009, 1411160010, 1411160011, 1411160012, 1411160013, 1411160014, 1411160015, 1411160016, 1411160017, 1411160018, 1411160019, 1411165020, 1411165021

Data Quality: Good in LLNL iPhones. Awaiting other data for comparison.

References: iPhones were deployed by Arturo Bockman and Arthur Rodgers (LLNL). Details on the experiment can be obtained by contacting Arthur Rodgers (rodgers7@llnl.gov).

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1. Background

SCE (sensor comparison experiment) 1 through 4 consists of a series of four controlled above-ground explosions designed to provide new data for overpressure propagation. Infrasound data were collected by LLNL iPhones and other sensors.

Origin times, locations HOB, and yields are not being released at this time and are therefore not included in this report. This preliminary report will be updated as access to additional data changes, or instrument responses are determined.

Table 1. Emplacement information for Shot 1 – Shot 4

Shot	Yield (kg)	HOB (m)
Shot-1	not released	not released
Shot-2	not released	not released
Shot-3	not released	not released
Shot-4	not released	not released

2. iPhone settings

iPhones running the RedVox app were deployed for the explosion series to record the atmospheric overpressure and were co-located with high-fidelity Hyperion overpressure sensors. This provides the opportunity to directly compare the resolution and frequency content of the devices and validate the iPhone app. The iPhone gain settings and sampling frequencies were varied between explosions with iPhones collocated for comparison. Device settings and distance from the explosive source are summarized in the tables below.

Table 2. Device information

RedVox ID	Model Number	iOS version
1411160001	A1549	10.0.2 (14A456)
1411160002	A1549	10.0.2 (14A456)
1411160003	A1549	10.0.2 (14A456)
1411160004	A1549	10.0.2 (14A456)
1411160005	A1549	10.0.2 (14A456)
1411160006	A1549	10.0.2 (14A456)
1411160007	A1549	10.0.2 (14A456)
1411160008	A1549	10.0.2 (14A456)
1411160009	A1549	10.1 (14B72)
1411160010	A1549	10.0.2 (14A456)
1411160011	A1549	10.0.2 (14A456)
1411160012	A1549	10.1.1(14B100)
1411160013	A1549	10.0.2 (14A456)
1411160014	A1549	10.0.2 (14A456)
1411160015	A1549	10.1.1(14B100)

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1411160016	A1549	10.0.2 (14A456)
1411160017	A1549	10.0.2 (14A456)
1411160018	A1549	10.0.2 (14A456)
1411160019	A1549	10.0.2 (14A456)
1411165020	A1633	10.0.2 (14A456)
1411169021	A1687	10.1.1 (14B100)

Table 3. Gain settings for Shot-1 through Shot-4

RedVox ID	Shot 1 Gain	Shot 2 Gain	Shot 3 Gain	Shot 4 Gain
1411160001	High	High	High	Low
1411160002	Low	Low	Low	Low
1411160003	High	High	High	Low
1411160004	Low	Low	Low	Low
1411160005	High	High	High	Low
1411160006	Low	Low	Low	Low
1411160007	High	High	High	High
1411160008	Low	Low	Low	Low
1411160009	High	High	High	High
1411160010	Low	Low	Low	Low
1411160011	High	High	High	High
1411160012	Low	Low	Low	Low
1411160013	High	High	High	High
1411160014	Low	Low	Low	Low
1411160015	High	High	High	High
1411160016	Low	Low	Low	Low
1411160017	High	High	High	High
1411160018	Low	Low	Low	High
1411160019	High	High	High	High
1411165020	Low	Low	Low	High
1411169021	High	High	High	High

Table 4. Reported distance from source for Shot-1 through Shot-4

RedVox ID	Shot 1 Distance	Shot 2 Distance	Shot 3 Distance	Shot 4 Distance
1411160001	3km	3km	3km	3km
1411160002	3km	3km	3km	3km
1411160003	4km	4km	3km	4km
1411160004	4km	4km	3km	4km
1411160005	5km	5km	4km	5km
1411160006	5km	5km	4km	5km
1411160007	6km	6km	5km	6km
1411160008	6km	6km	5km	6km

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1411160009	7km	7km	6km	7km
1411160010	7km	7km	6km	7km
1411160011	8km	8km	7km	8km
1411160012	8km	8km	7km	8km
1411160013	9km	9km	8km	9km
1411160014	9km	9km	8km	9km
1411160015	9km	9km	9km	10km
1411160016	9km	9km	9km	10km
1411160017	10km	10km	10km	~11km
1411160018	10km	10km	10km	~11.5km
1411160019	10km	10km	10km	~12km
1411165020	10km	10km	10km	~12.5km
1411169021	2.8km	2.8km	2.8km	2.8km

Table 5. Sample rate for Shot-1 through Shot-4

RedVox ID	Shot 1 Hz	Shot 2 Hz	Shot 3 Hz	Shot 4 Hz
1411160001	80Hz	800Hz	800Hz	800Hz
1411160002	80Hz	800Hz	800Hz	800Hz
1411160003	80Hz	800Hz	800Hz	800Hz
1411160004	80Hz	800Hz	800Hz	800Hz
1411160005	80Hz	800Hz	800Hz	800Hz
1411160006	80Hz	800Hz	800Hz	800Hz
1411160007	80Hz	800Hz	800Hz	800Hz
1411160008	80Hz	800Hz	800Hz	800Hz
1411160009	80Hz	800Hz	800Hz	800Hz
1411160010	80Hz	800Hz	800Hz	800Hz
1411160011	80Hz	800Hz	800Hz	800Hz
1411160012	80Hz	800Hz	800Hz	800Hz
1411160013	80Hz	800Hz	800Hz	800Hz
1411160014	80Hz	800Hz	800Hz	800Hz
1411160015	80Hz	800Hz	800Hz	800Hz
1411160016	800Hz	800Hz	800Hz	800Hz
1411160017	800Hz	800Hz	800Hz	800Hz
1411160018	80Hz	800Hz	800Hz	800Hz
1411160019	80Hz	800Hz	800Hz	800Hz
1411165020	800Hz	800Hz	800Hz	800Hz
1411169021	800Hz	800Hz	800Hz	800Hz

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3. Results

Signal to noise is very good for the majority of channels for all four shots. iPhone instrument response has yet to be determined. This is currently in progress and this report will be updated once the instrument response has been estimated. For the time being, a calibration value is applied based on the amplitude of the 1 Hz band in the channel with the highest signal to noise across all four events. For this data set the channel with highest 1 Hz signal to noise is device 1411160002. A S2N scaling factor of 1322870.88311 is applied to all units, where each channel is divided by this value. For each shot, two waterfall plots with devices sorted by distance from the source are provided. The first shows the calibrated waveforms for direct amplitude comparison and in the second the waveforms are normalized to unity to show detail.

Sensor latitudes and longitudes are estimated from the RedVox data packets in the approximately one hour window surrounding each shot. Data from all available packets in the half hour before and half-hour after each shot (~70-~95 packets depending on the sampling rate) are averaged together. Random errors in these average values, computed as the standard deviation of all values divided by the square root of the number of packets, are small enough as to be considered negligible. The largest uncertainty is on the order of 10^{-6} and the only station to have such a large uncertainty is 1411169021. The rest of the latitudes and longitudes have random errors that are either zero or on the order of 10^{-15}. This does not necessarily mean that the latitudes and longitudes reported in the RedVox packets are accurate. There could be systematic errors that are not accounted for. In one case (station 10 for shot 1) there was a large discrepancy between the reported location of the device and the RedVox packet latitudes and longitudes. The plots below display the station range and azimuths as determined by packet averages for each shot. At this time the station latitudes and longitudes are official use only. In some cases the station locations were changed slightly in between shots and most of the iPhones were moved farther away for the final shot in an attempt to prevent the sensors from clipping.

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3a. Shot-1
Yield (kg): not being released
HOB: not being released

Table 6 – Ranges and azimuths from blast location averaged from RedVox packets available from 30 minutes before to 30 minutes after the Shot-1

RedVox ID	Range (km)	Azimuth (deg.)
1411169021	2.800	153.98
1411160001	3.007	154.15
1411160002	3.011	154.09
1411160003	4.014	159.53
1411160004	4.008	159.56
1411160005	4.518	173.72
1411160006	4.511	173.75
1411160007	5.515	180.54
1411160008	5.522	180.53
1411160009	6.518	181.25
1411160010	135.5	147.14
1411160011	7.549	181.71
1411160012	8.008	181.00
1411160013	9.932	180.15
1411160014	8.517	180.19
1411160015	9.016	179.46
1411160016	9.022	179.49
1411160017	9.936	178.96
1411160018	9.932	178.94
1411160019	9.932	178.86
1411165020	9.942	178.92

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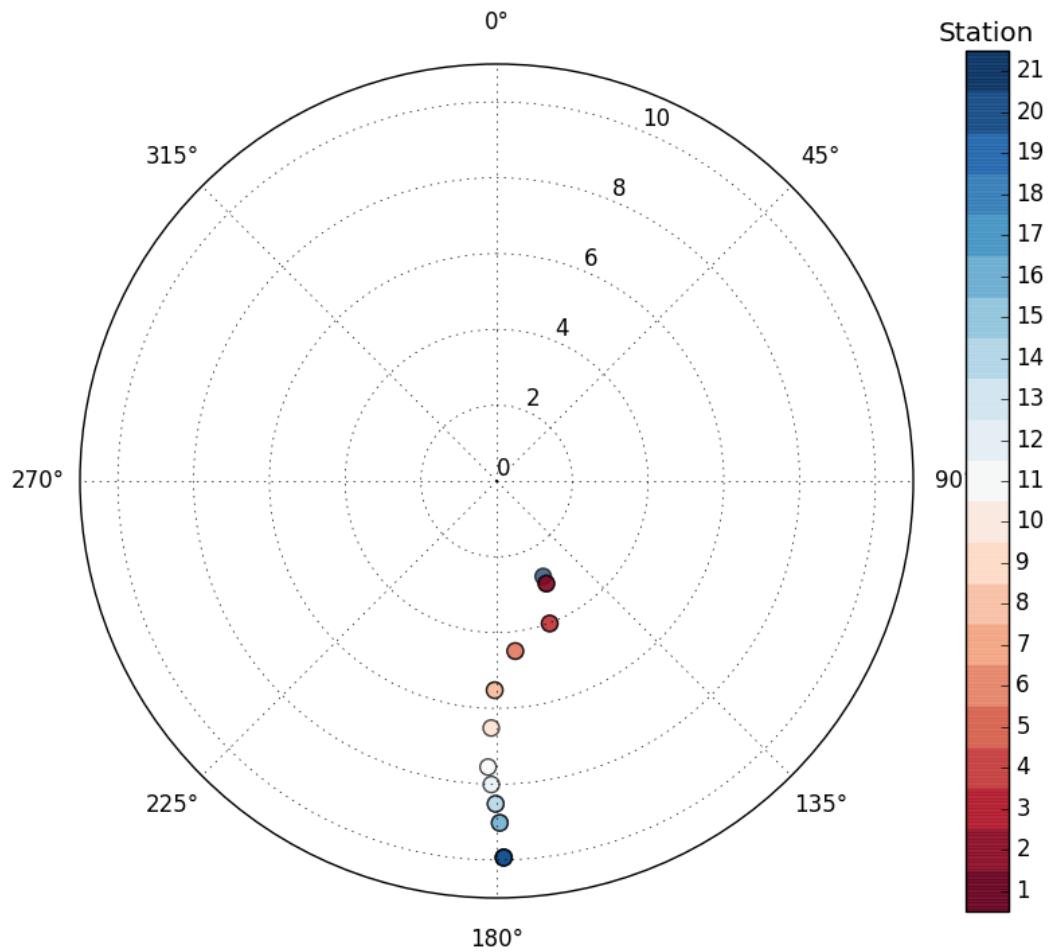
Figure 1- Range and Azimuth showing RedVox configuration for Shot-1

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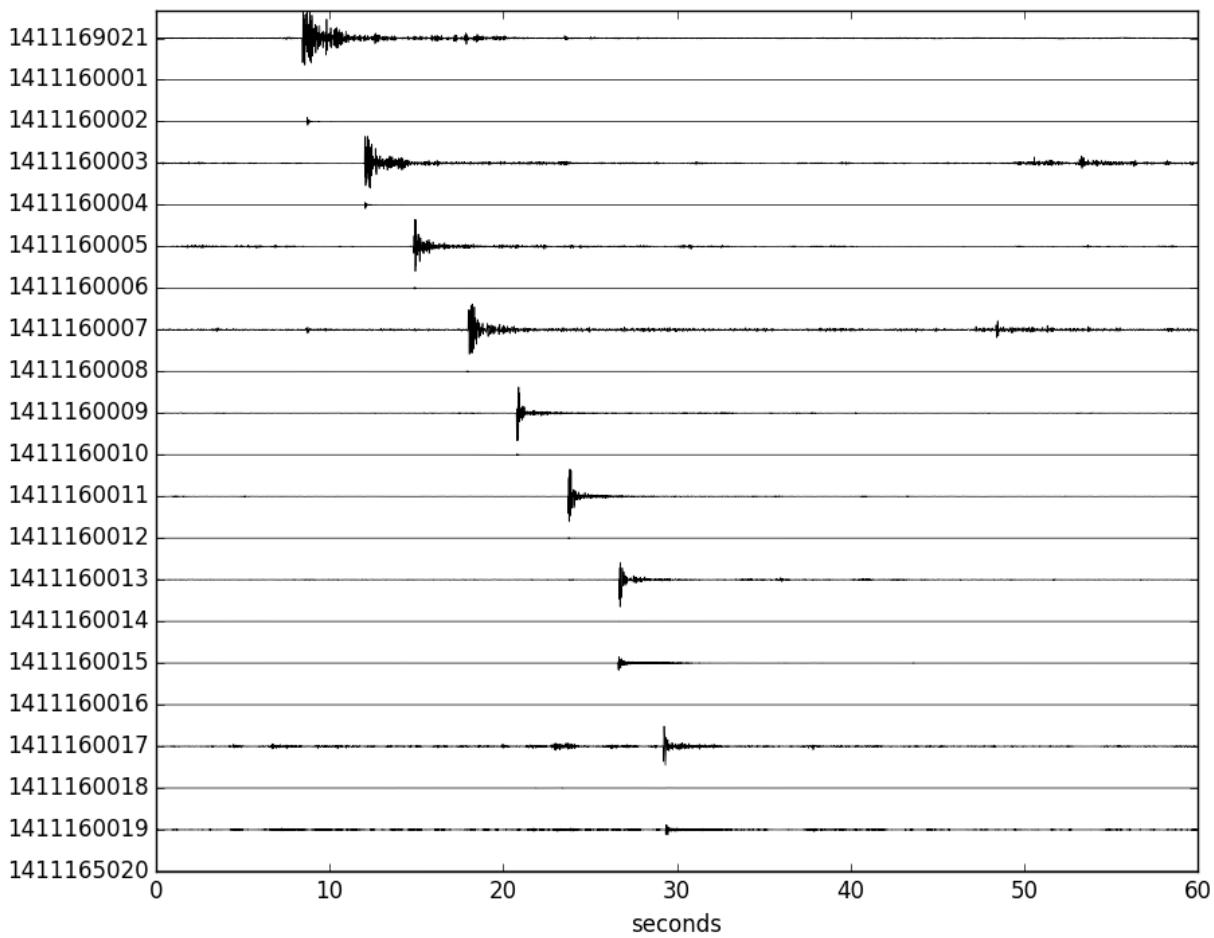
Figure 2- Shot-1 waveforms scaled relative to device 1411160002 for Shot-1 at 1Hz.

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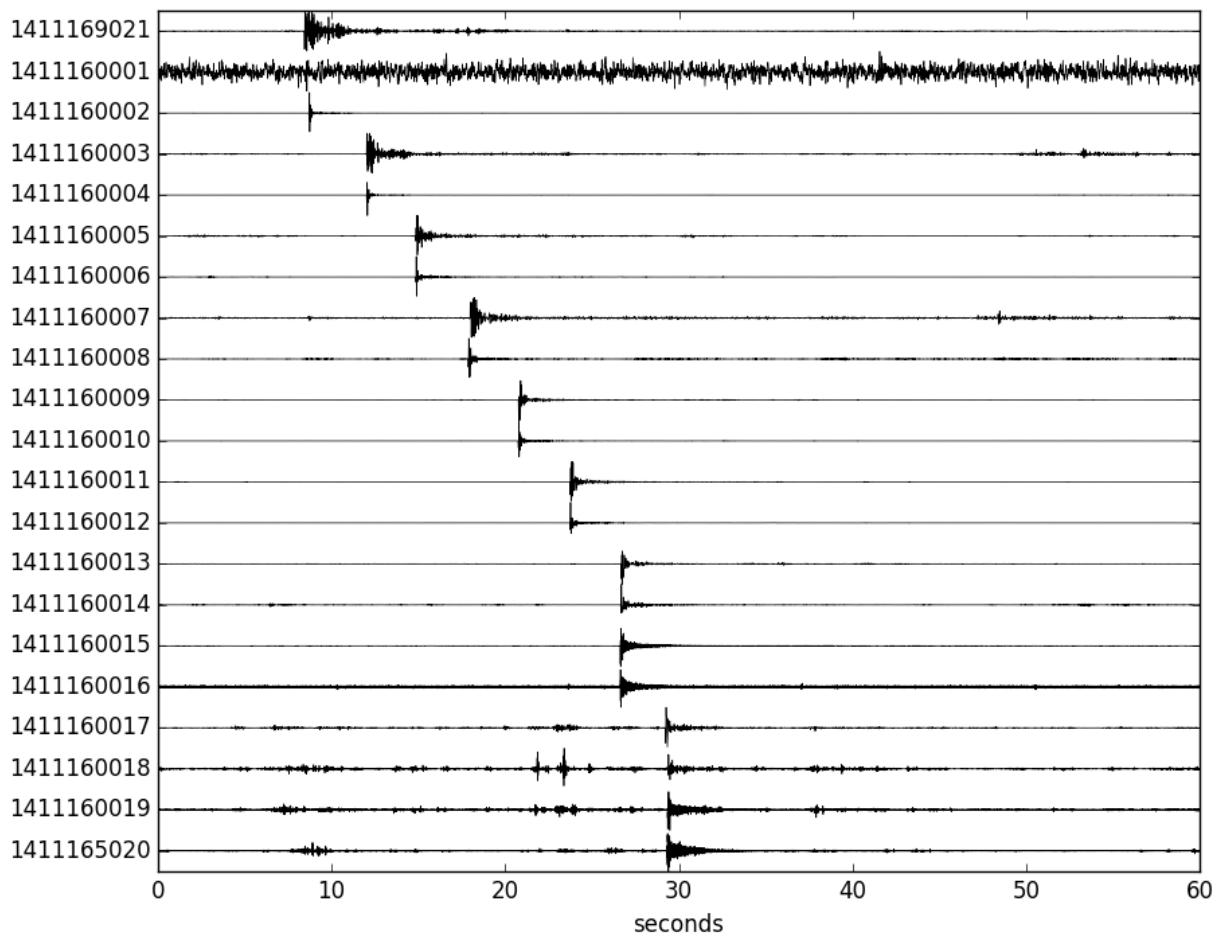
Figure 3- Shot-1 waveforms normalized to unity to show detail.

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3b. Shot-2
Yield (kg): not being released
HOB: not being released

Table 7 – Range and azimuths from blast location averaged from RedVox packets available from 30 minutes before to 30 minutes after Shot-2

RedVox ID	Range (km)	Azimuth (deg.)
1411169021	2.804	154.16
1411160005	4.012	159.61
1411160006	4.009	159.60
1411160007	4.987	178.82
1411160008	4.990	178.79
1411160009	6.012	181.11
1411160010	6.011	181.08
1411160011	6.997	181.46
1411160012	6.999	181.45
1411160013	8.020	181.00
1411160014	8.022	181.00
1411160015	9.017	179.48
1411160016	9.016	179.47
1411160018	9.016	179.49
1411160019	135.5	147.14
1411165020	9.936	178.91

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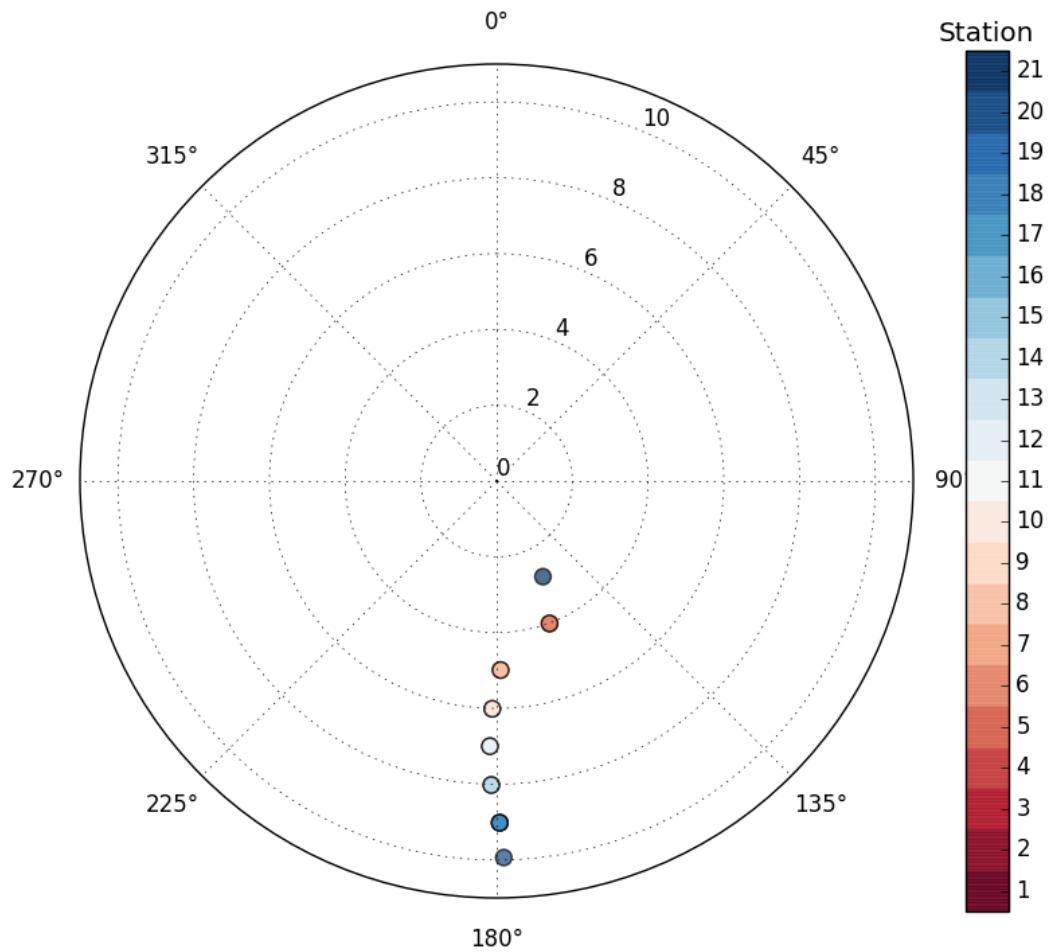
Figure 4- Range and Azimuth plot showing RedVox configuration for Shot-2

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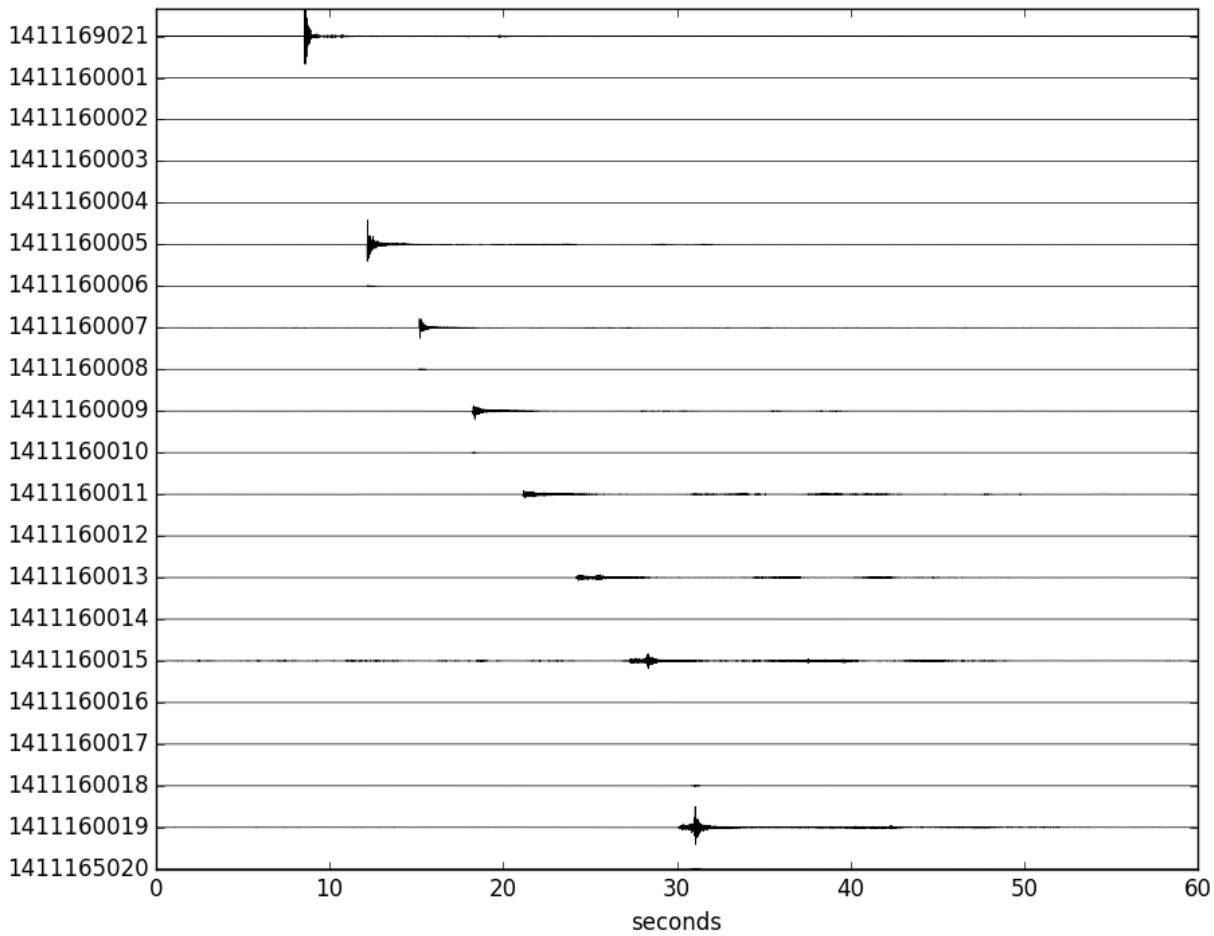
Figure 5- Shot-2 waveforms scaled relative to device 1411160002 for Shot-1 at 1Hz. Channels with missing data (1,2,3,4,17) are shown as a flat line.

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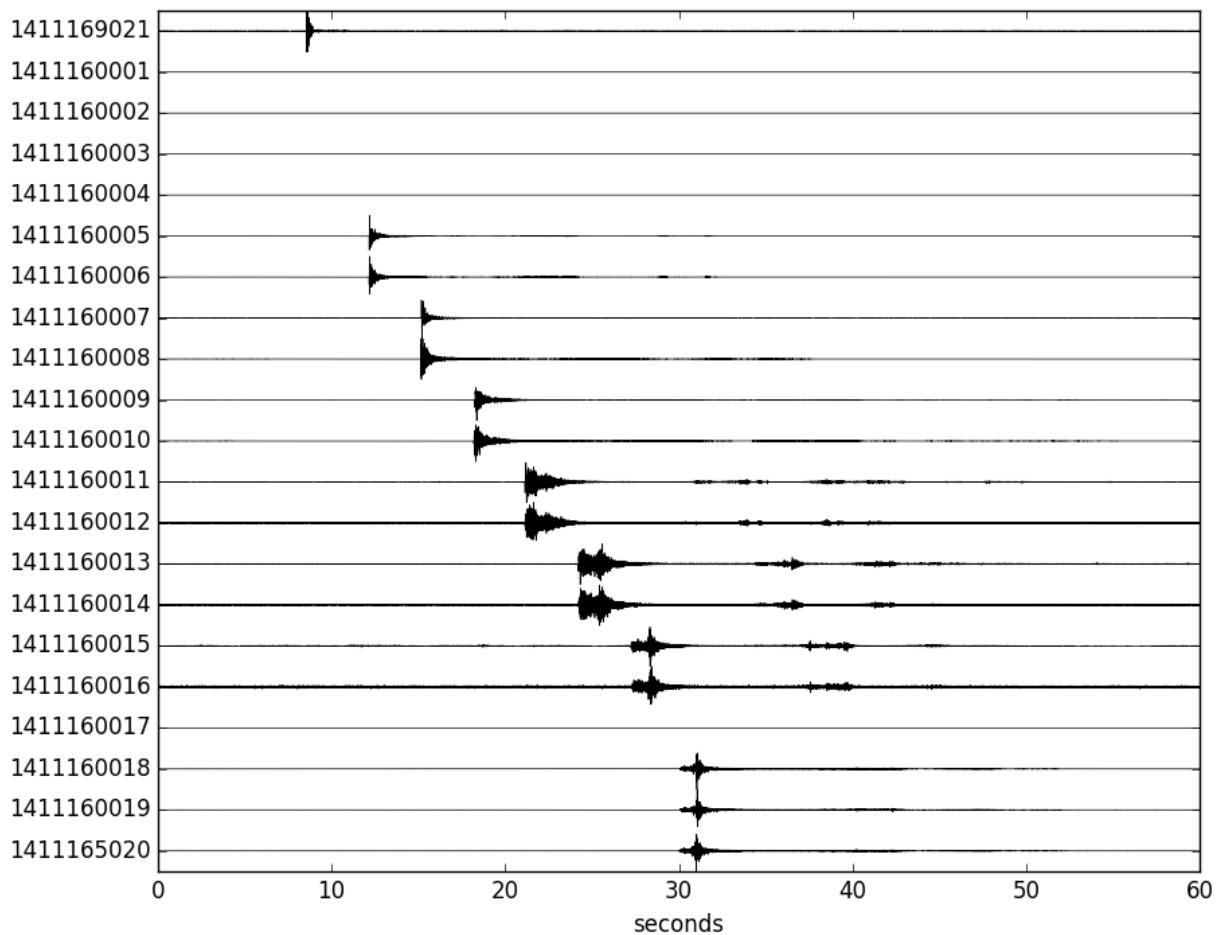
Figure 6- Shot-2 waveforms normalized to unity to show detail.

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3c. Shot-3
Yield (kg): not being released
HOB: not being released

Table 8 – Ranges and azimuths from blast location averaged from RedVox packets available from 30 minutes before to 30 minutes after Shot-3

| RedVox ID	Range (km)	Azimuth (deg.)
1411169021	2.816	154.79
1411160002	3.007	154.09
1411160003	3.012	154.09
1411160005	4.008	159.52
1411160006	4.009	159.56
1411160007	4.996	178.83
1411160008	4.989	178.81
1411160009	6.013	181.09
1411160010	6.017	181.08
1411160011	7.000	181.47
1411160012	6.998	181.50
1411160013	8.029	181.00
1411160014	8.028	181.00
1411160015	9.015	179.49
1411160016	9.016	179.47
1411165020	9.938	178.94

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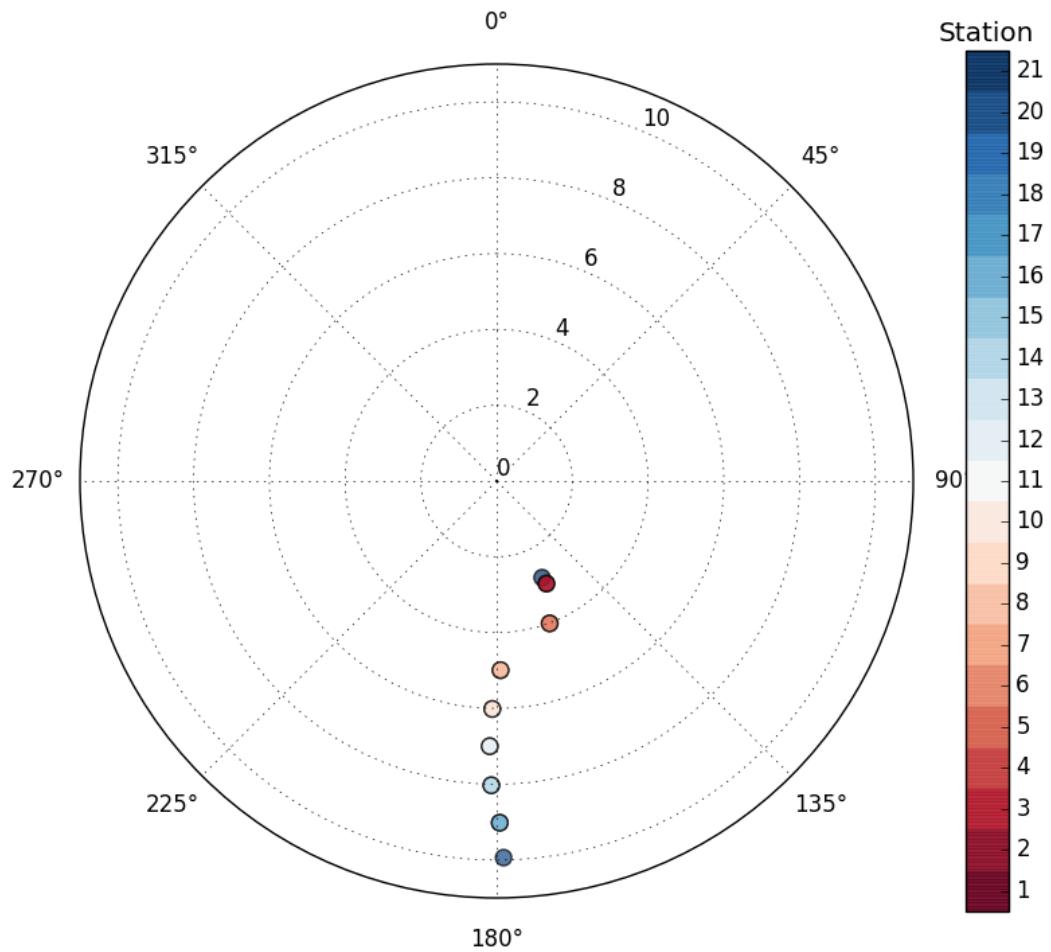
Figure 7- Range and Azimuth plot showing RedVox configuration for Shot-3

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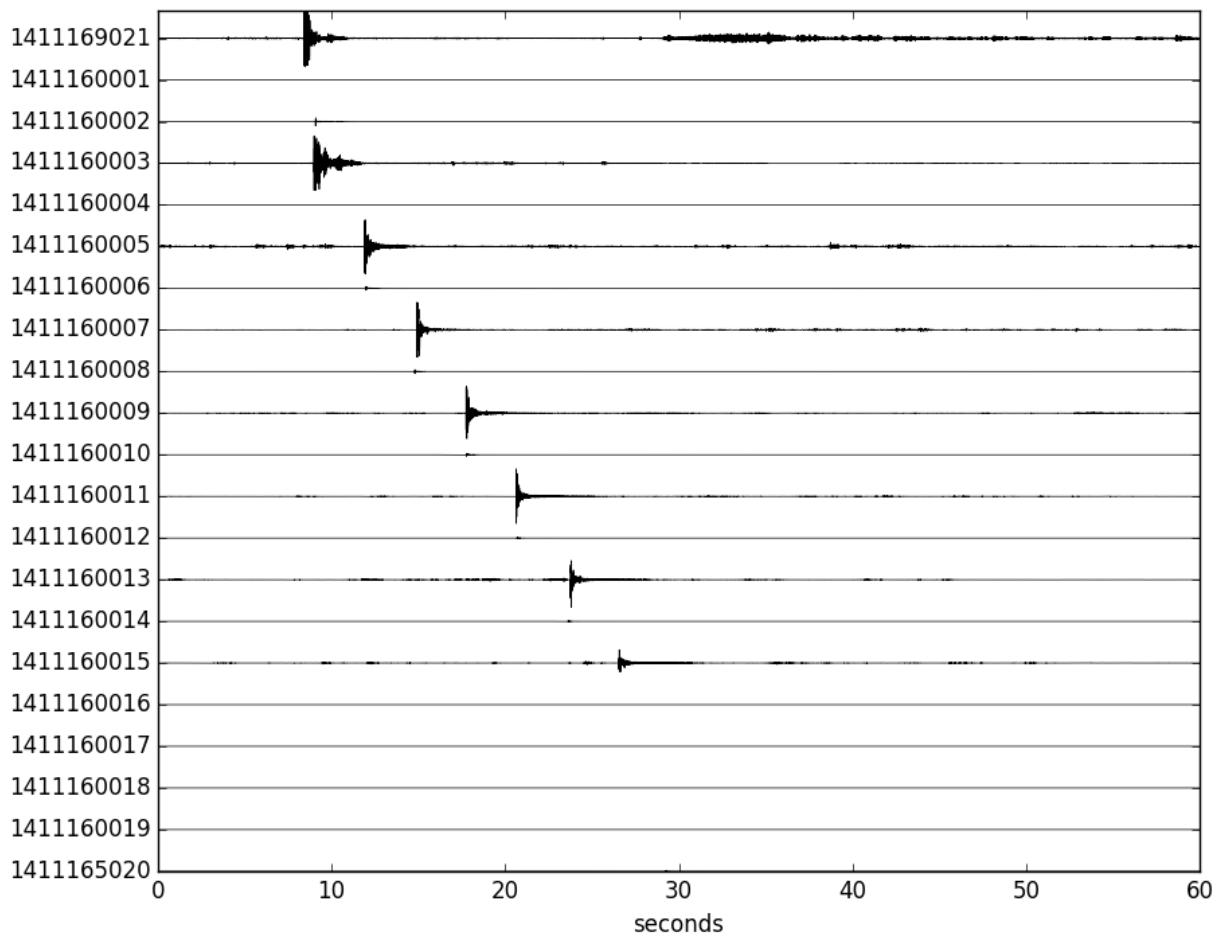
Figure 8- Shot-3 waveforms scaled relative to device 1411160002 for Shot-1 at 1Hz. Channels with missing data (1,4,17,18,19) are shown as a flat line.

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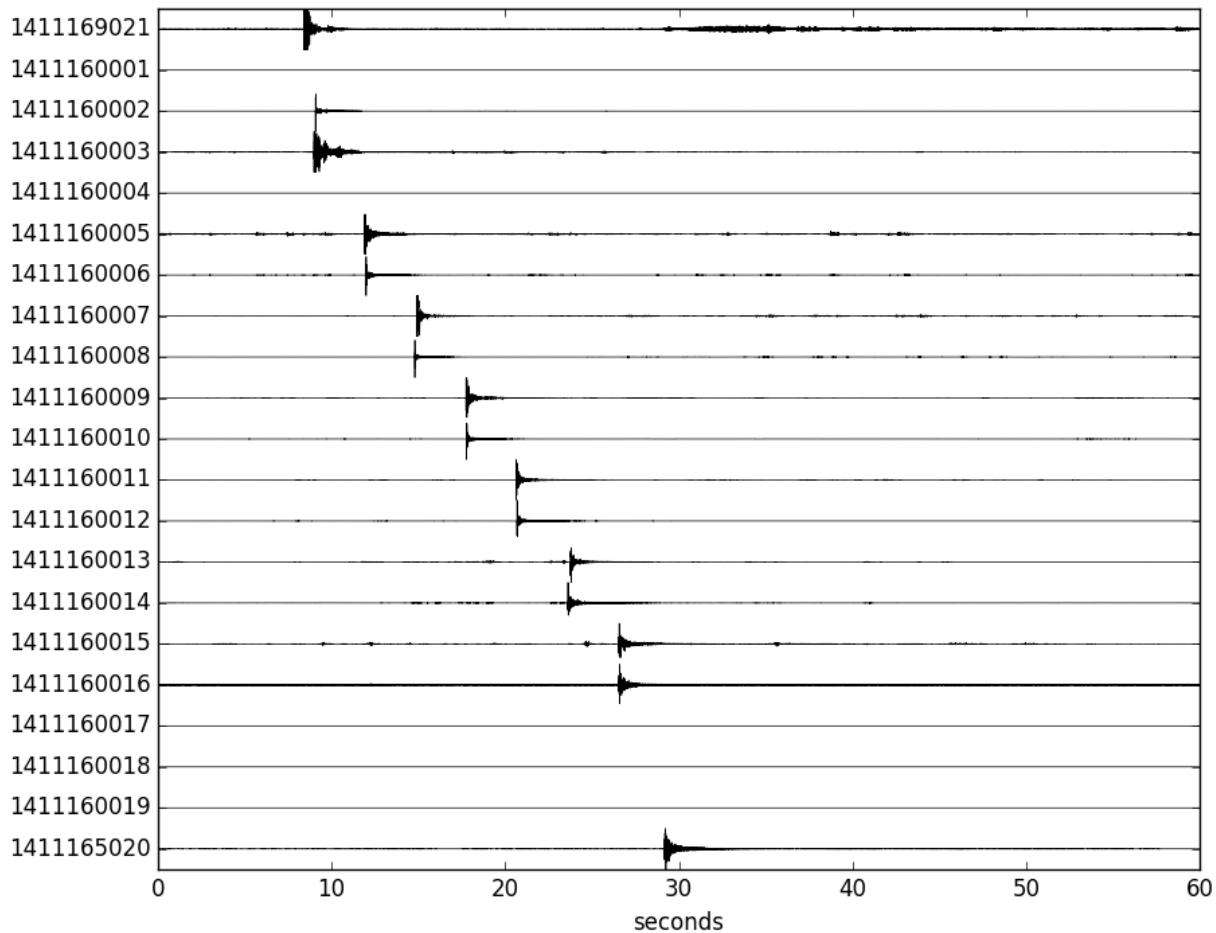
Figure 9- Shot-3 waveforms normalized to unity to show detail.

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3d. Shot-4

Yield (kg): not being released

HOB: not being released

Table 9 –Ranges and azimuths from blast location averaged from RedVox packets available from 30 minutes before to 30 minutes after the Shot-4

| RedVox ID	Range (km)	Azimuth (deg)
1411169021	2.819	154.96
1411160001	3.006	154.30
1411160002	3.013	154.26
1411160003	4.015	159.70
1411160004	4.015	159.71
1411160005	4.996	178.82
1411160006	4.996	178.83
1411160007	6.022	181.14
1411160008	6.017	181.15
1411160009	7.004	181.51
1411160010	7.004	181.55
1411160011	8.024	181.01
1411160012	8.024	180.98
1411160013	9.021	179.50
1411160014	9.022	179.49
1411160015	9.944	178.92
1411160016	9.946	178.91
1411160017	11.41	182.36
1411160018	11.81	181.19
1411160019	12.26	185.02
1411165020	12.34	182.86

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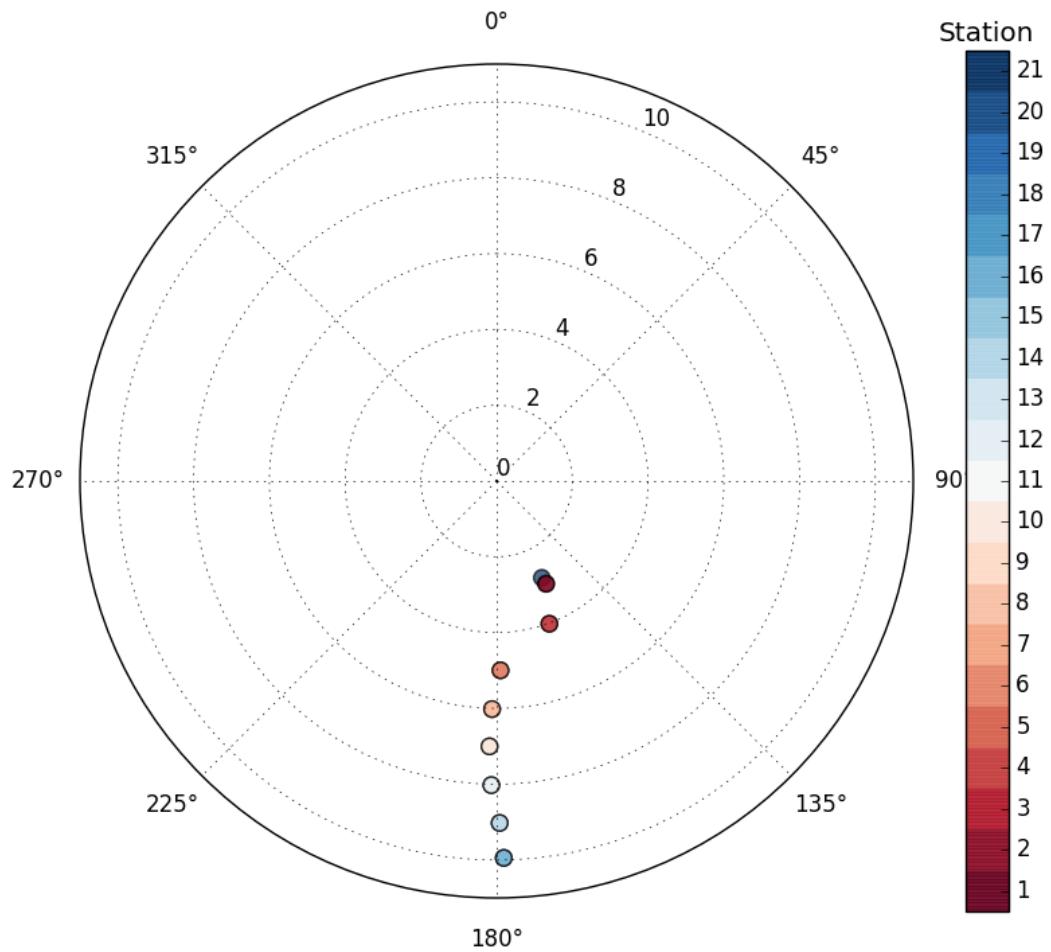
Figure 10- Range and Azimuth plot showing RedVox configuration for Shot-4

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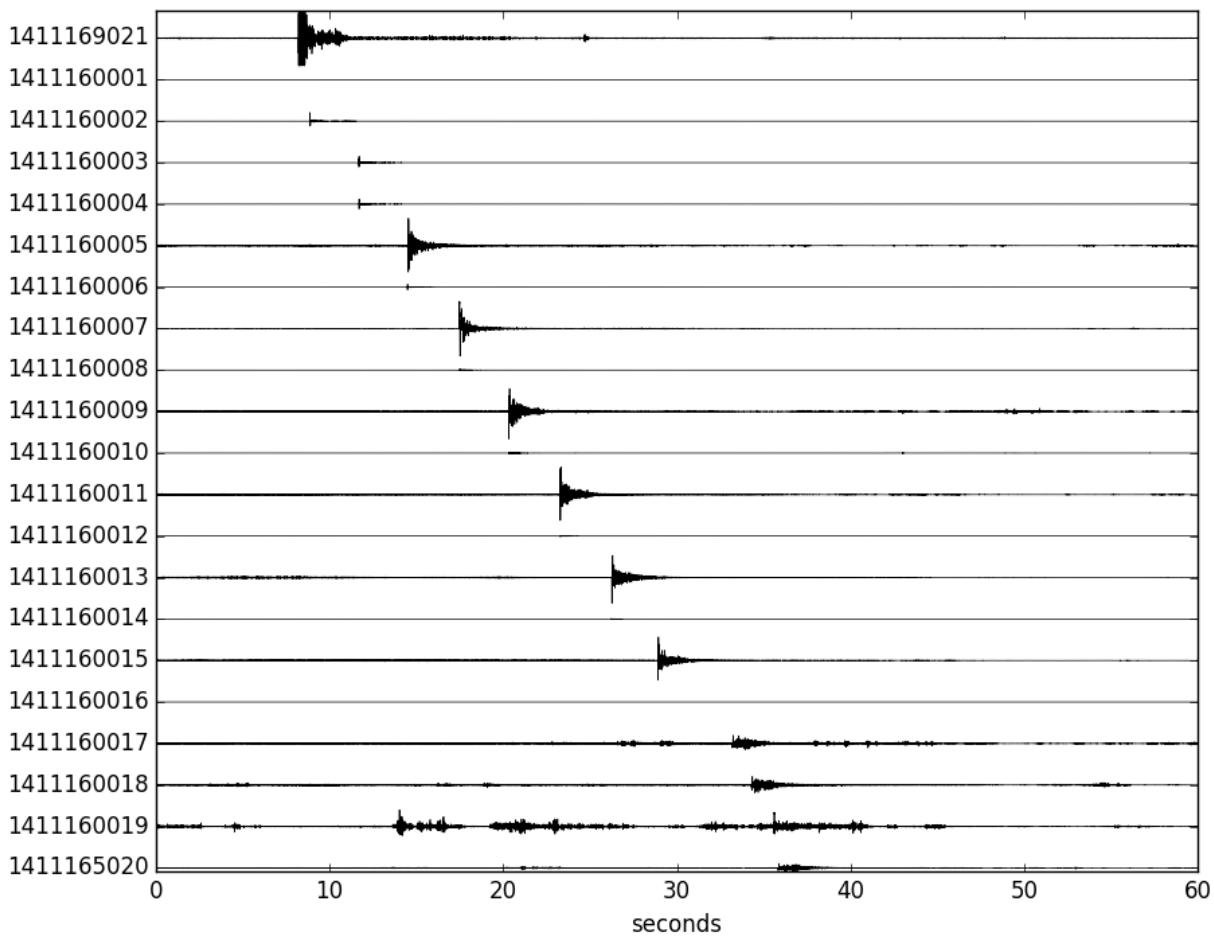
Figure 11- Shot-4 waveforms scaled relative to device 1411160002 for Shot-1 at 1Hz. Channels with missing data are shown as a flat line.

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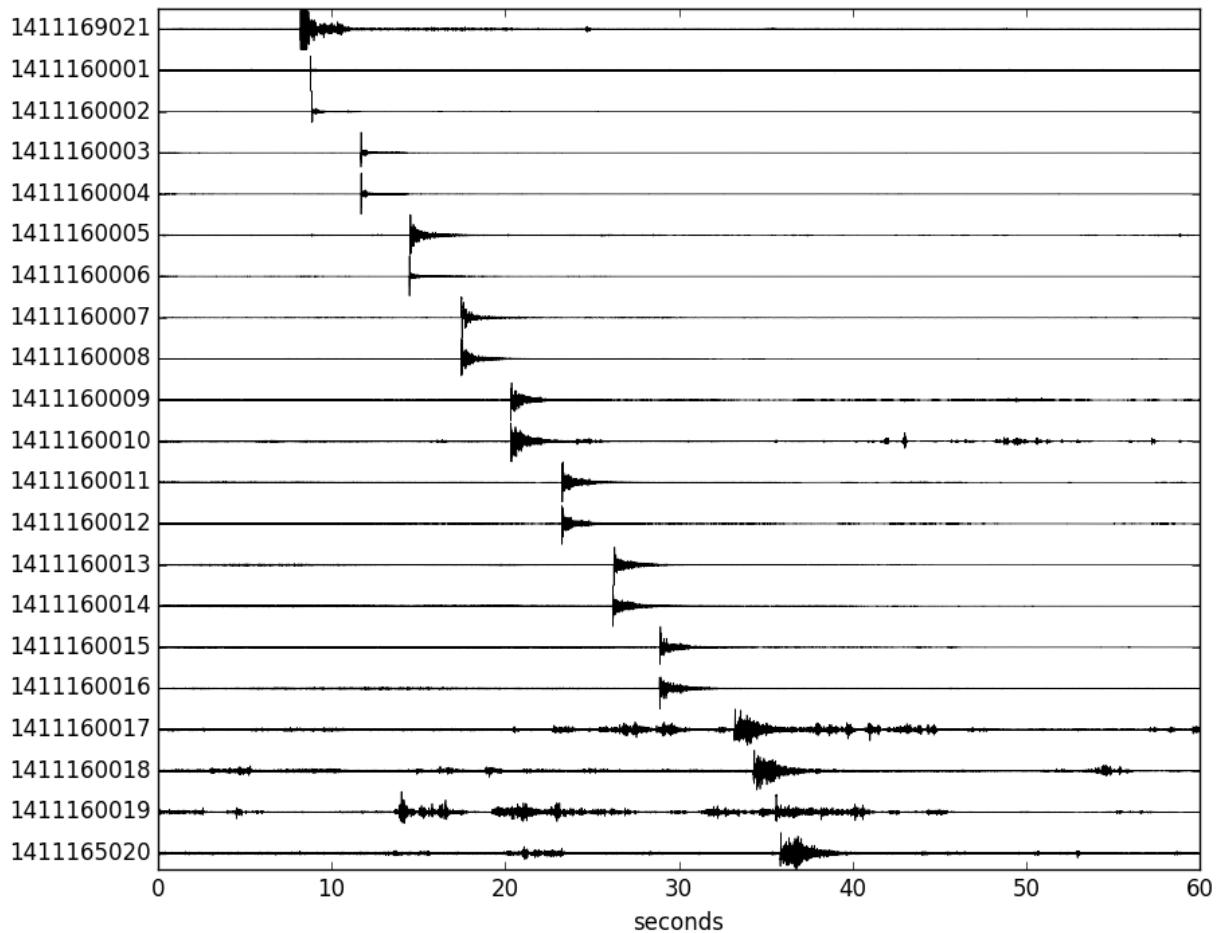
Figure 12- Shot-4 waveforms normalized to unity to show detail.

4. Conclusion and Future Work

This dataset will be valuable for comparing the infrasound response of the internal iPhone pressure sensors to traditional systems and for determining how to best record air blast data with smartphones. Data from the collocated traditional sensors could be used to estimate relative iPhone microphone amplitude and phase responses and to help characterize blast signatures. This report will be updated as access to additional data or instrument responses becomes available.

5. Acknowledgements