Report on Developments in the Acoustics-Based Localization Project

Introduction

We have started working on the evaluation of the SwellEx-96 Dataset. So far, our goal has been to visualize the SwellEx-96 data and compare our findings with the description provided. We have made considerable progress on this, and a description of the results will be provided in this report.

Dataset Description

The SwellEx-96 Dataset consists of two events: S5 and S59. The focus of my work so far has been the evaluation of the dataset from the S5 event, which involves two sources that were simultaneously towed by the R/V Sproul. One of them was a deep source and the other a shallow source.

The deep source was towed at a depth of 54m, and it transmitted numerous tonals at frequencies ranging from 49 Hz to 400 Hz. 5 sets of 13 tones were transmitted. A description on the frequency and magnitudes of the tones is provided below:

Deep Source Signals	Frequencies (Hz)													Magnitude(dB)
High Signal Level	49	64	79	94	112	130	148	166	201	235	283	338	388	158 dB
2nd Set of Tonals	52	67	82	97	115	133	151	169	204	238	286	341	391	132 dB
3rd Set of Tonals	55	70	85	100	118	136	154	172	207	241	289	344	394	128 dB
4th Set of Tonals	58	73	88	103	121	139	157	175	210	244	292	347	397	124 dB
5th Set of Tonals	61	76	91	106	124	142	160	178	213	247	295	350	400	120 dB

At the beginning, midway point, and end of the track, the deep source stopped projecting CW tones and started projecting FM chirps.

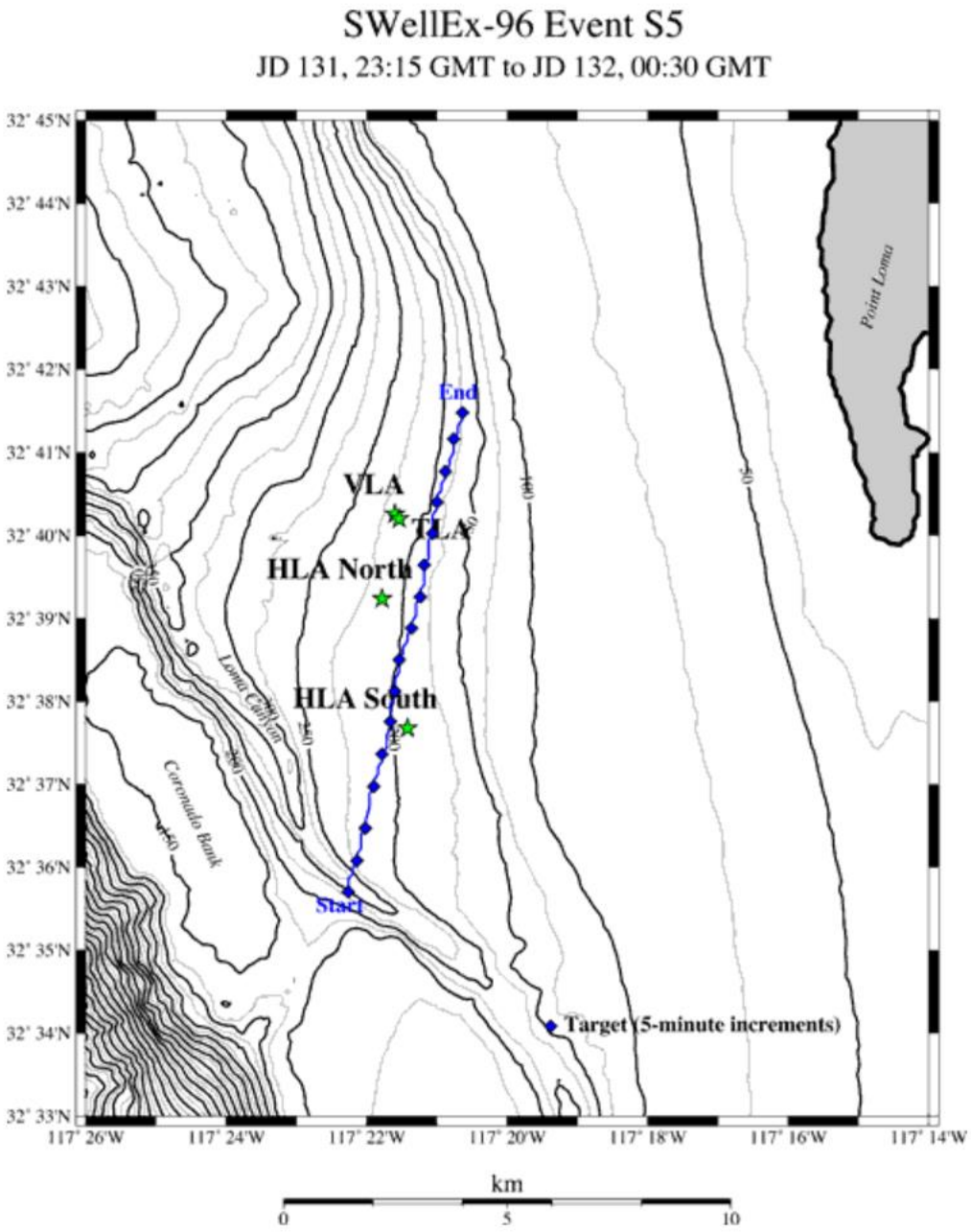
Next, we have the shallow source that was towed at a depth of about 9m, and it transmitted tones at frequencies between 109 Hz and 385 Hz. A description on the frequency and magnitudes of the tones is provided below:

Shallow Source Signals	Frequencies (Hz)													Magnitude(dB)
Single Tonal Set					109	127	145	163	198	232	280	335	385	(Not provided in description)

According to the S5 dataset description, some initial post-processing utilized so-called "noise frequencies." Those frequencies chosen to be representative of the noise field are listed below:

Noise	Frequencies (Hz)													Magnitude(dB)
Expected Noise Tones	62	77	92	107	125	143	161	179	214	248	296	351	401	(Not provided in description)

The event set-up looks as follows:



Here, VLA, TLA, HLA North and HLA South represent the positioning of different sets of sensors that were arranged in different ways.

VLA stands for Vertical Line Arrays, which represents an array of sensors that were arranged in a vertical line. Details on VLA setup is provided below:

VLA	
Position	32d40.254' N, 117d21.620' W
Aperture	120 m
Number of Elements, Total	64
Number of Elements, Processed	21
Array Sampling Rate	1500 Hz
Sensor Calibration	185.3dB
Line of Bearing, *re* clockwise North*	N/A
Water Depth	216.5 m

Description of the depth of each of the sensors that were processed is provided below:

Element Number	Depth (m)
1	212.25
4	206.62
7	200.99
10	195.38
13	189.76
16	184.12
19	178.49
22	172.88
25	167.26
28	161.62
31	155.99
34	150.38
37	144.74
40	139.12
46	127.88
49	122.25
52	116.62
55	111.00
58	105.38
61	99.755
64	94.125

The following table shows the range (per minute) information for the distance between VLA sensors and the source ship during the experiment:

Jday	Time	Duration	Range(km)
131	23:15	0	8.648
131	23:16	1	8.502
131	23:17	2	8.368
131	23:18	3	8.219
131	23:19	4	8.083
131	23:20	5	7.932
131	23:21	6	7.78
131	23:22	7	7.627
131	23:23	8	7.495
131	23:24	9	7.343
131	23:25	10	7.192
131	23:26	11	7.042
131	23:27	12	6.891
131	23:29	14	6.573
131	23:30	15	6.423
131	23:31	16	6.273
131	23:32	17	6.104
131	23:33	18	5.953
131	23:34	19	5.802
131	23:35	20	5.651
131	23:36	21	5.519
131	23:37	22	5.368
131	23:38	23	5.218
131	23:39	24	5.087
131	23:40	25	4.938
131	23:41	26	4.79
131	23:42	27	4.641
131	23:43	28	4.53
131	23:44	29	4.381
131	23:45	30	4.251
131	23:46	31	4.103
131	23:47	32	3.955
131	23:48	33	3.825
131	23:49	34	3.677
131	23:50	35	3.529
131	23:51	36	3.382
131	23:52	37	3.254
131	23:53	38	3.108
131	23:54	39	2.981
131	23:55	40	2.838
131	23:56	41	2.714
131	23:57	42	2.574
131	23:58	43	2.453

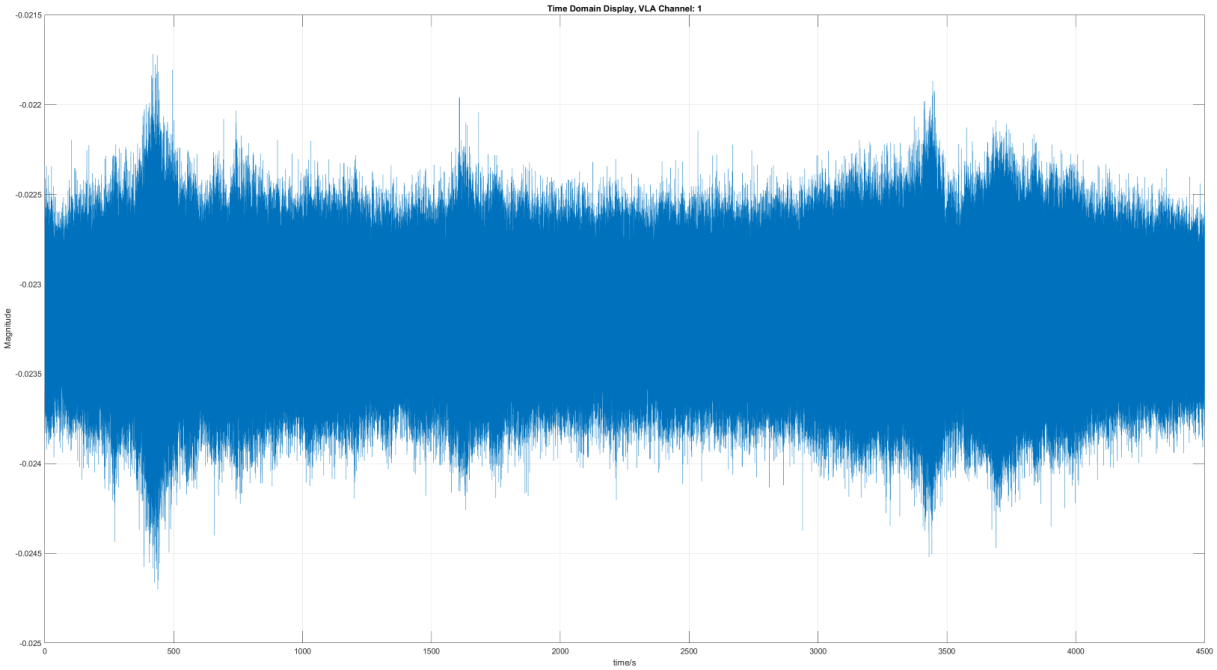
131	23:59	44	2.316
132	0:00	45	2.196
132	0:01	46	2.064
132	0:02	47	1.93
132	0:03	48	1.8
132	0:04	49	1.69
132	0:05	50	1.567
132	0:06	51	1.442
132	0:07	52	1.345
132	0:08	53	1.241
132	0:09	54	1.147
132	0:10	55	1.067
132	0:11	56	1.001
132	0:12	57	0.948
132	0:13	58	0.919
132	0:14	59	0.903
132	0:15	60	0.905
132	0:16	61	0.959
132	0:17	62	1.019
132	0:18	63	1.097
132	0:19	64	1.172
132	0:20	65	1.286
132	0:21	66	1.396
132	0:22	67	1.523
132	0:23	68	1.655
132	0:24	69	1.778
132	0:25	70	1.905
132	0:26	71	2.046
132	0:27	72	2.179
132	0:28	73	2.323
132	0:29	74	2.46
132	0:30	75	2.608
132	0:31	76	2.756
132	0:32	77	2.896

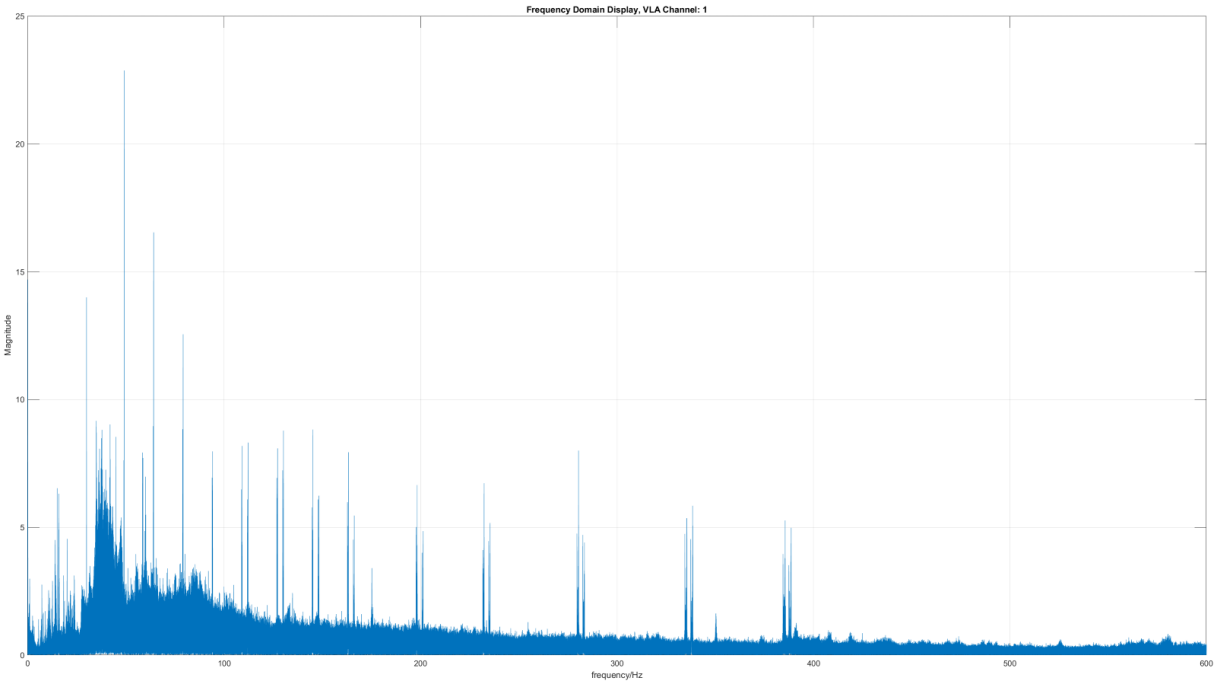
Results and Visualizations:

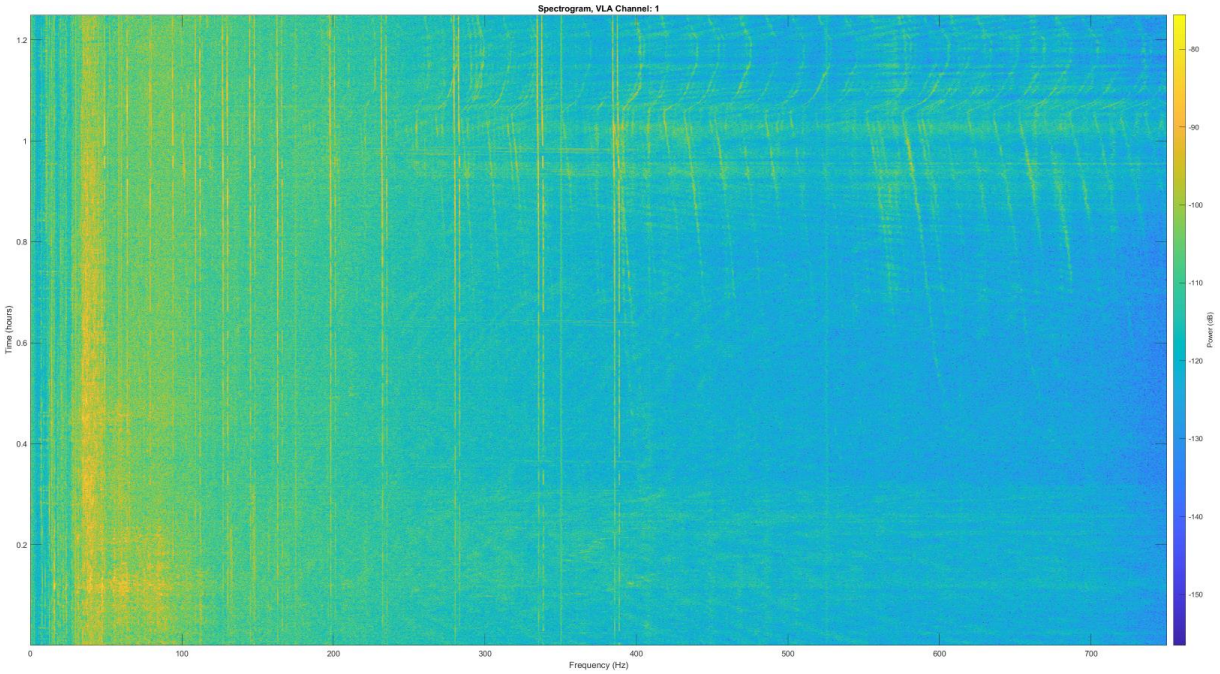
The other sets of sensors include TLA (Tilted Line Array) and HLA (Horizontal Line Array) North and South. Details on these datasets will be provided in future reports. On this report, we will mainly focus on findings from some of the VLA channels.

I focused on generating some time-series graphs, FFT spectra and Spectrograms for selective channels and comparing it with the dataset description. Based on the dataset description, we expect to find that all the frequencies generated by the deep and shallow sources will be picked up by the VLA sensors, and we also expect to find the noise frequencies as provided in the dataset description. We do not expect to find tones from other frequencies in the processed data.

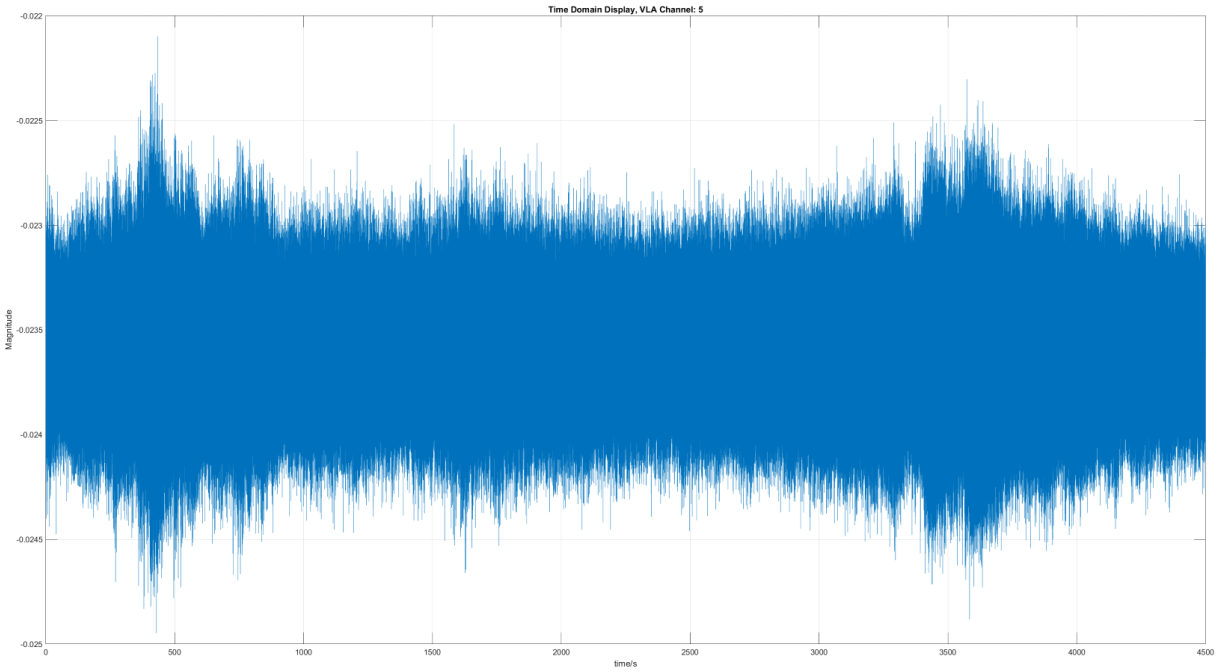
Channel 1:

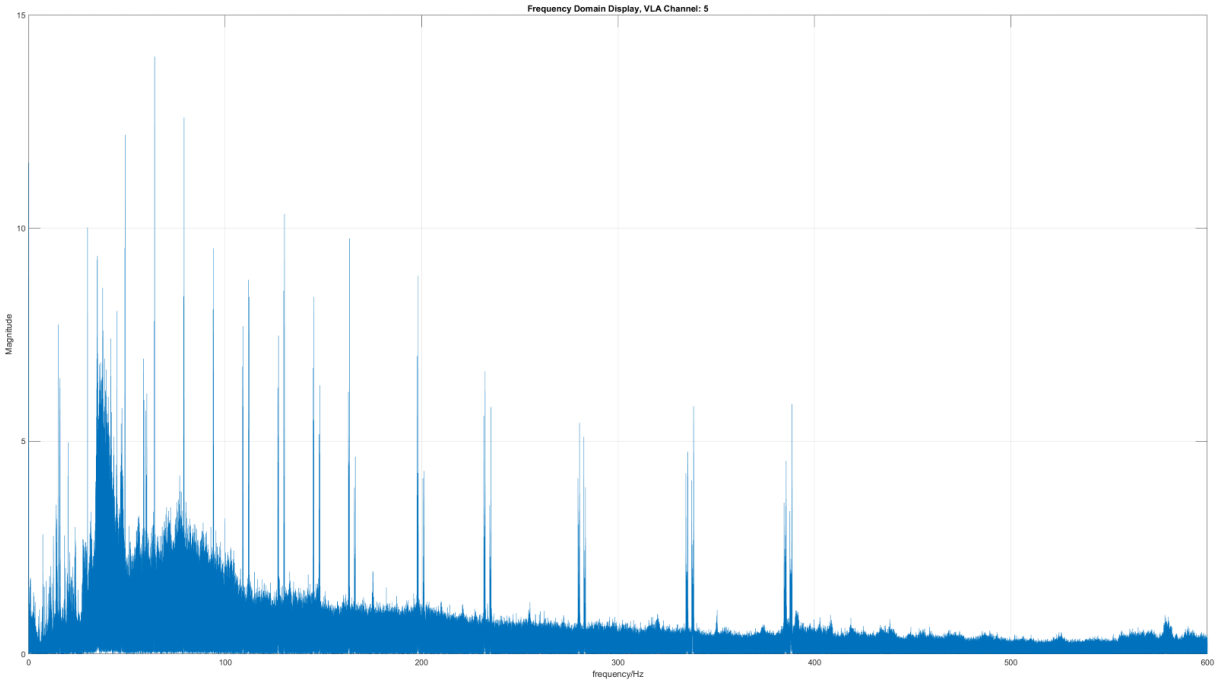

Time Domain Display, VLA Channel: 1
-0.0215
-0.022
-0.0225
-0.023
-0.0235
-0.024
-0.0245
-0.025
Magnitude
0
500
1000
1500
2000
2500
3000
3500
4000
4500
time/s

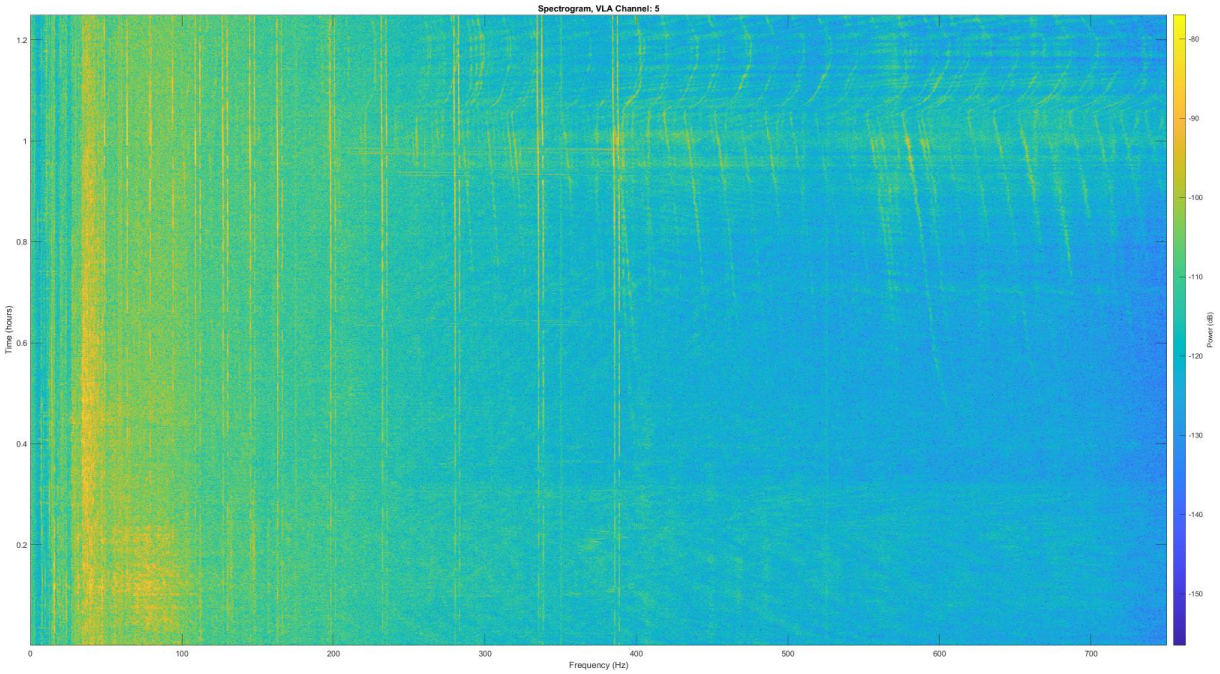

Frequency Domain Display, VLA Channel: 1
25
20
15
10
5
0
Magnitude
0
100
200
300
400
500
600
frequency/Hz


Spectrogram, VLA Channel: 1
Time (hours)
1.2
1
0.8
0.6
0.4
0.2
0
100
200
300
400
500
600
700
Frequency (Hz)
-80
-90
-100
-110
-120
-130
-140
-150
Power (dB)

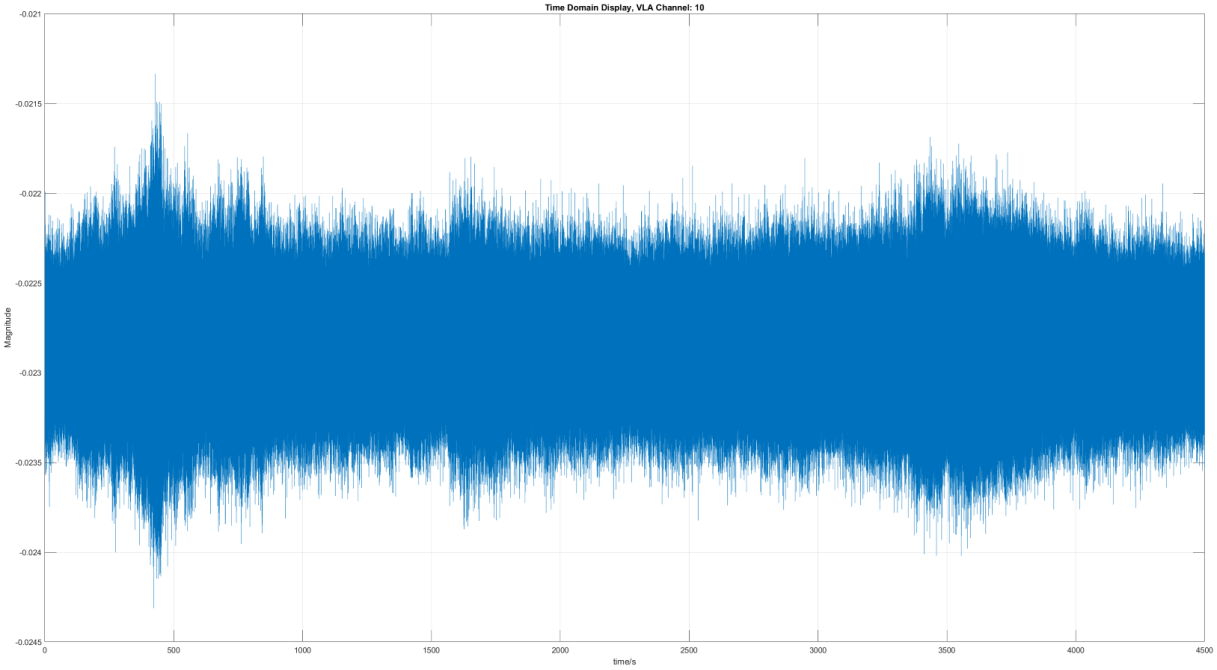
Channel 5:

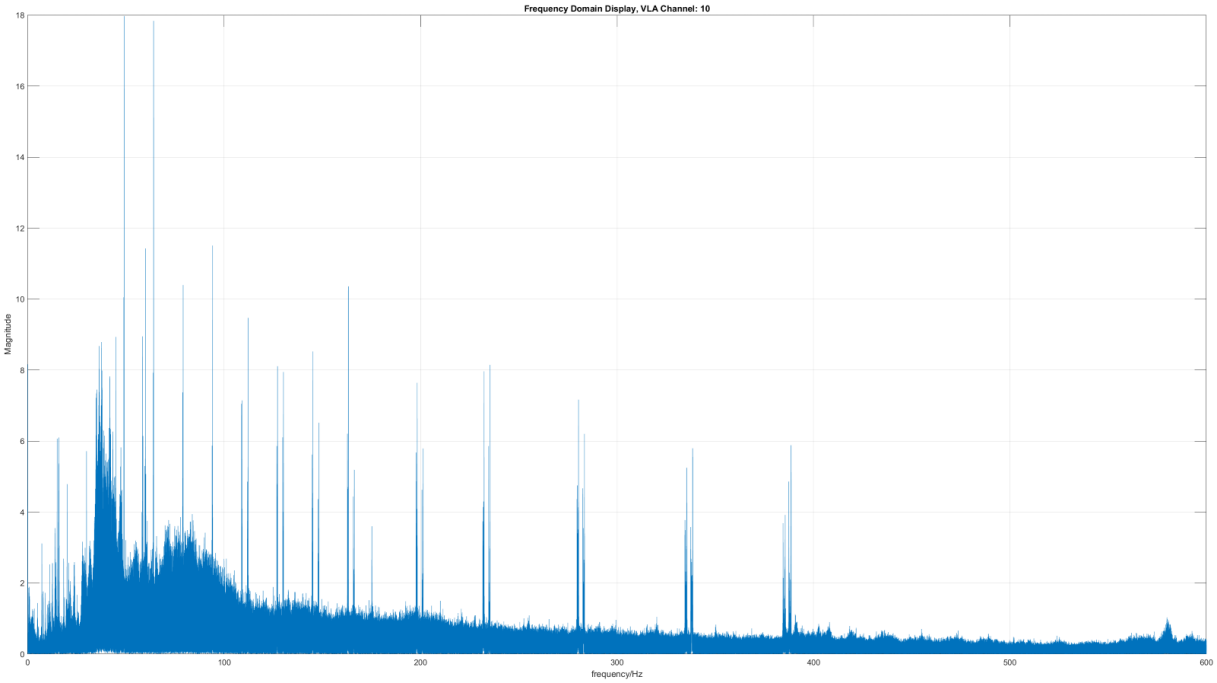

Time Domain Display, VLA Channel: 5
-0.022
-0.0225
-0.023
-0.0235
-0.024
-0.0245
-0.025
Magnitude
0
500
1000
1500
2000
2500
3000
3500
4000
4500
time/s

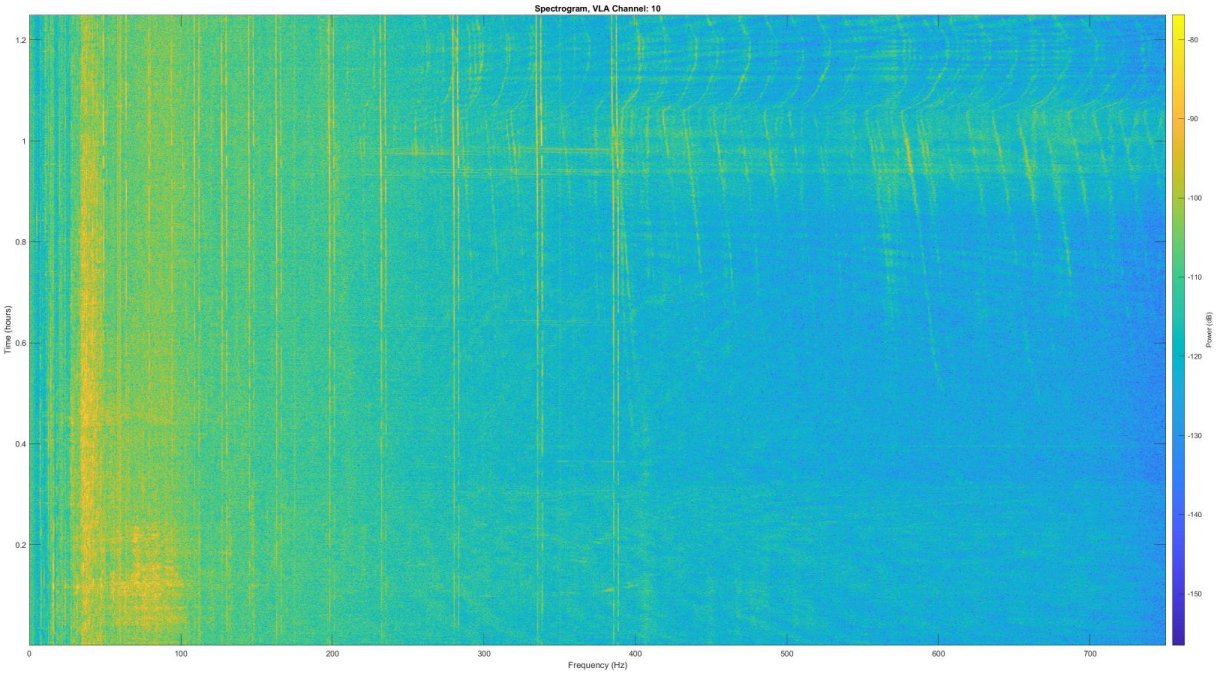

Frequency Domain Display, VLA Channel: 5
15
10
5
0
Magnitude
0
100
200
300
400
500
600
frequency/Hz


Spectrogram, VLA Channel: 5
Time (hours)
1.2
1
0.8
0.6
0.4
0.2
0
100
200
300
400
500
600
700
Frequency (Hz)
-80
-90
-100
-110
-120
-130
-140
-150
Power (dB)

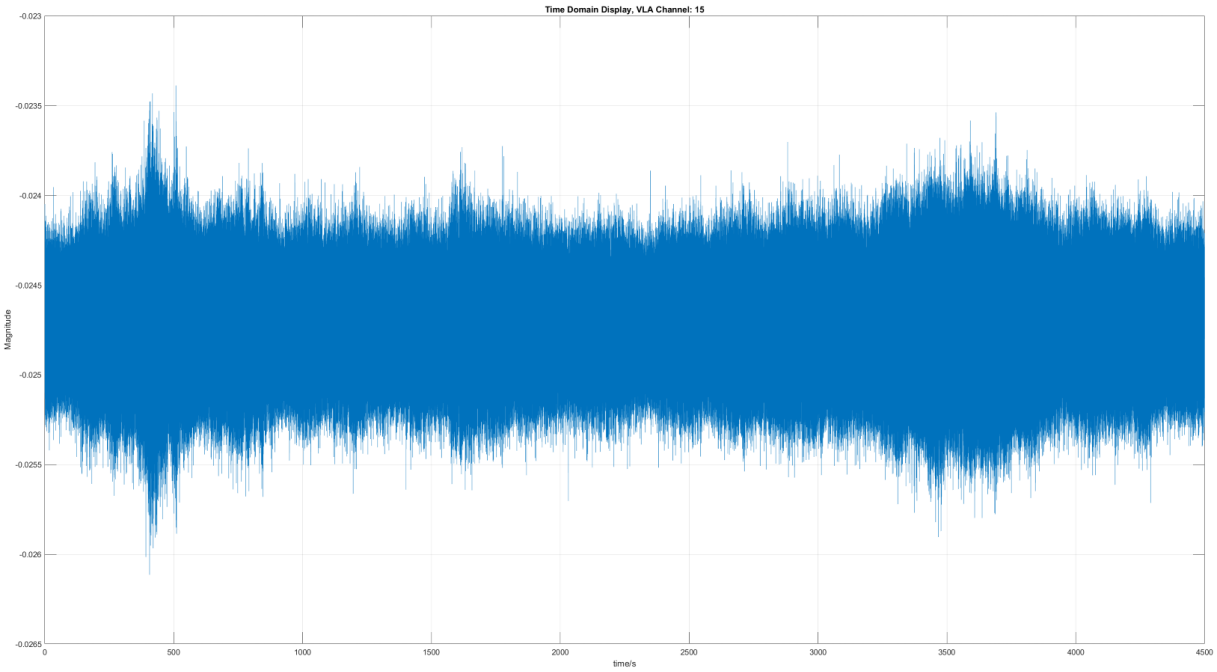
Channel 10:

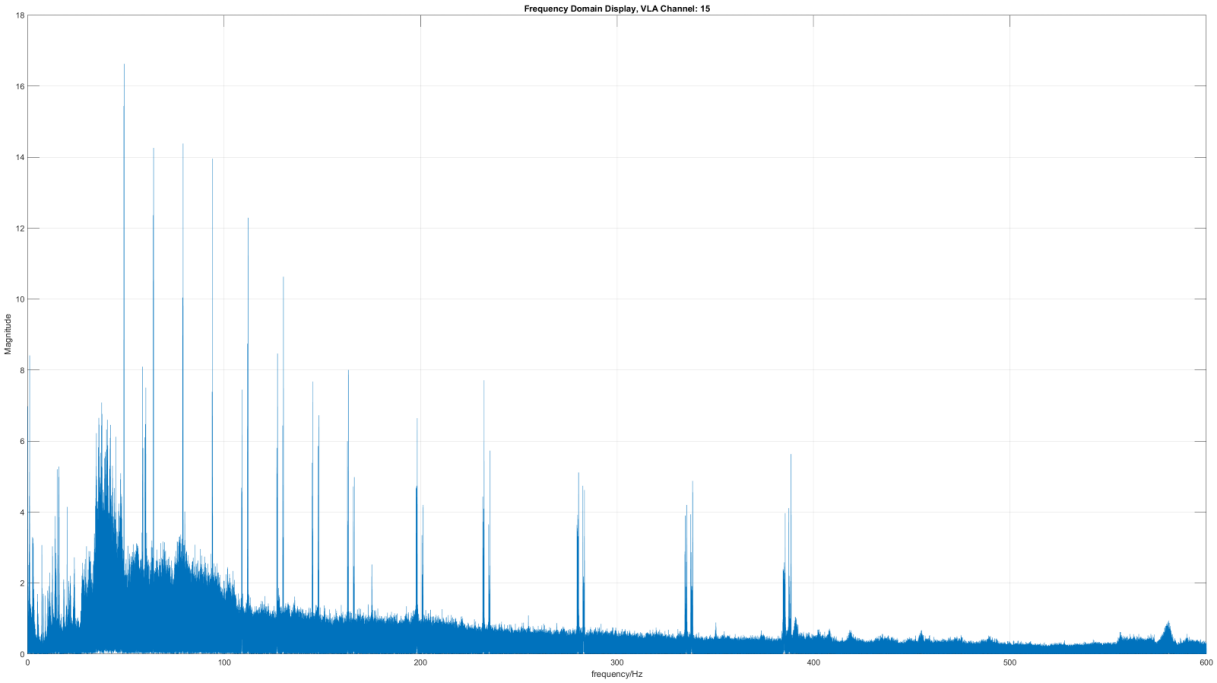

Time Domain Display, VLA Channel: 10
Magnitude
time/s
-0.021
-0.0215
-0.022
-0.0225
-0.023
-0.0235
-0.024
-0.0245
0
500
1000
1500
2000
2500
3000
3500
4000
4500

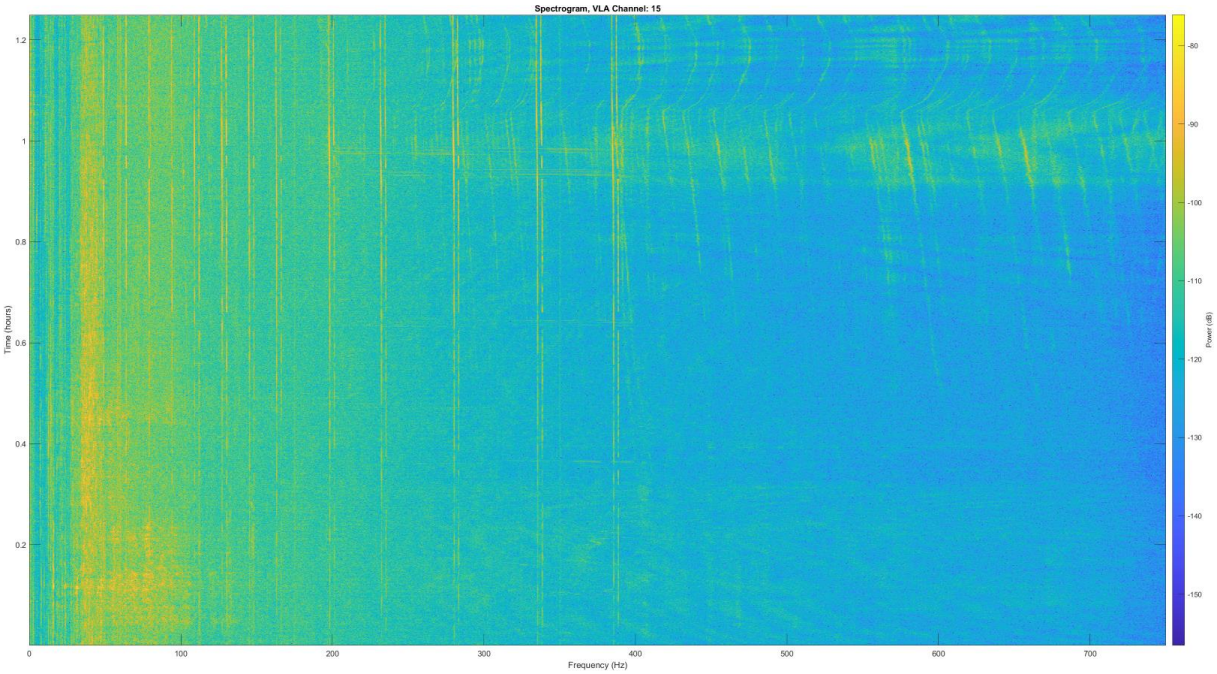

Frequency Domain Display, VLA Channel: 10
Magnitude
frequency/Hz
18
16
14
12
10
8
6
4
2
0
0
100
200
300
400
500
600


Spectrogram, VLA Channel: 10
Time (hours)
1.2
1
0.8
0.6
0.4
0.2
0
100
200
300
400
500
600
700
Frequency (Hz)
-80
-90
-100
-110
-120
-130
-140
-150
Power (dB)

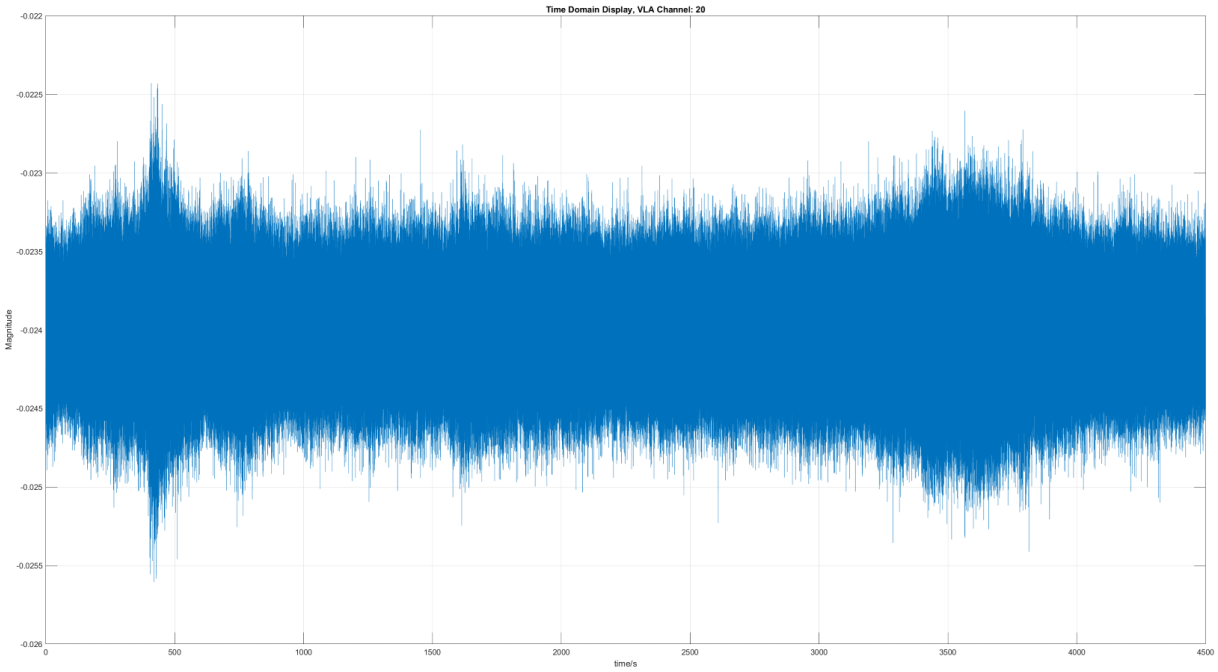
Channel 15:

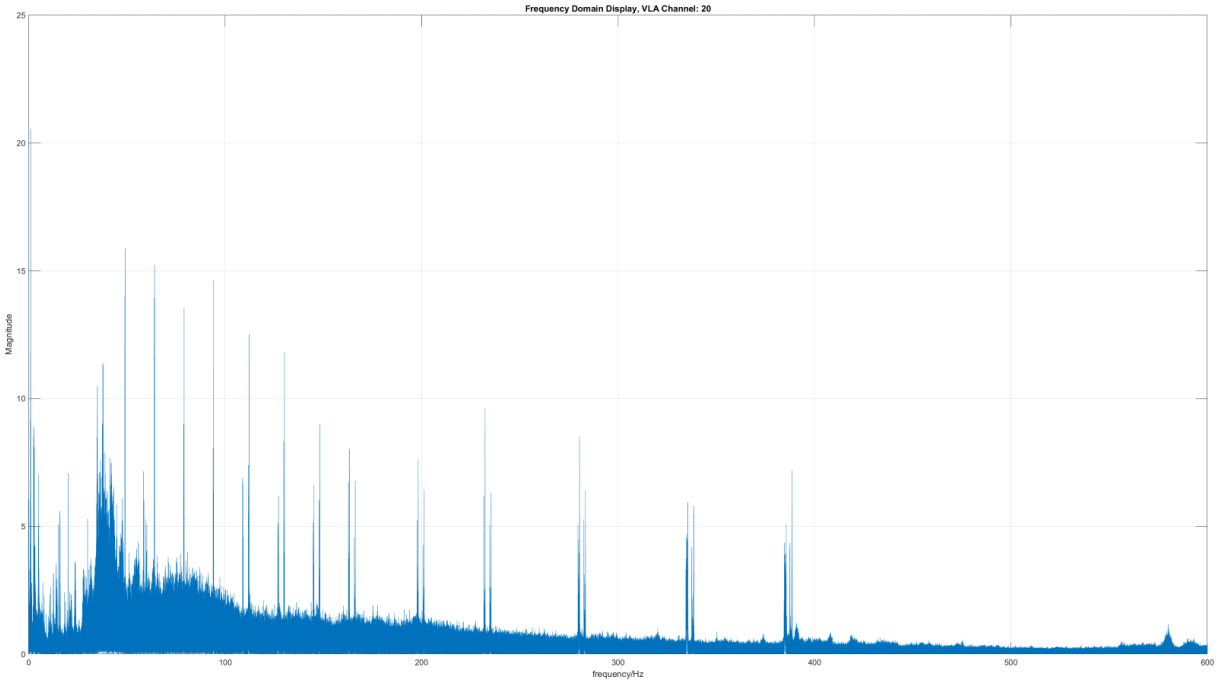

Time Domain Display, VLA Channel: 15
Magnitude
time/s
-0.023
-0.0235
-0.024
-0.0245
-0.025
-0.0255
-0.026
-0.0265
0
500
1000
1500
2000
2500
3000
3500
4000
4500

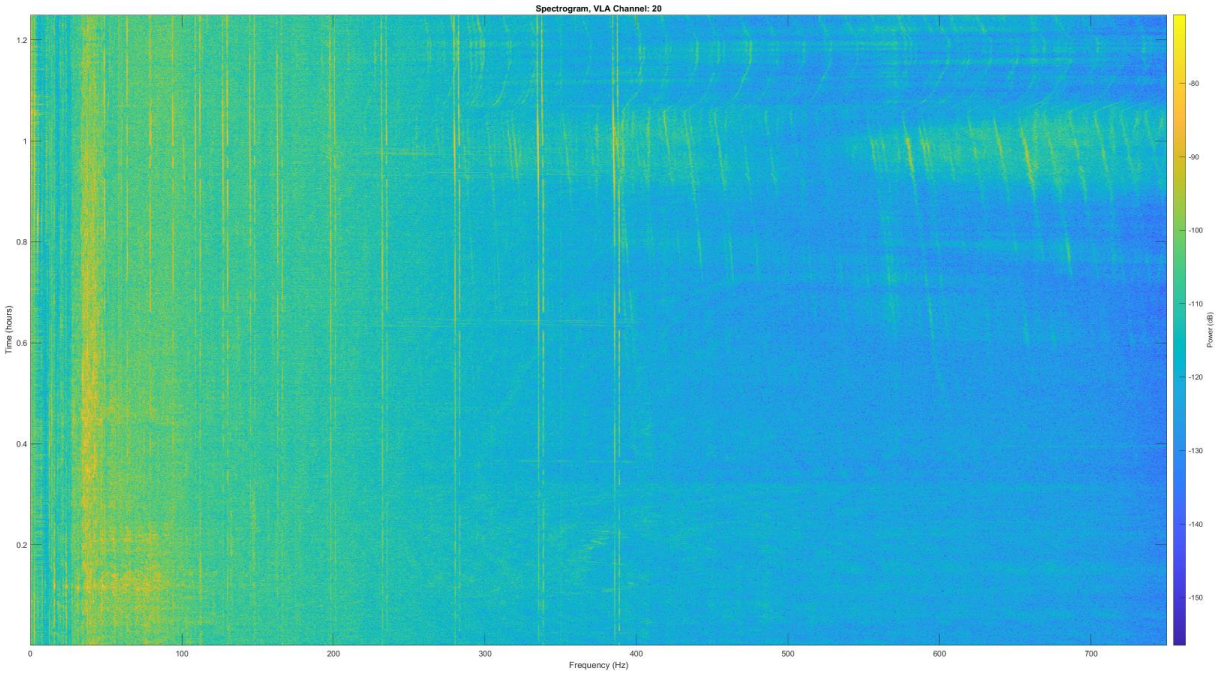

Frequency Domain Display, VLA Channel: 15
Magnitude
frequency/Hz
18
16
14
12
10
8
6
4
2
0
0
100
200
300
400
500
600


Spectrogram, VLA Channel: 15
Time (hours)
Frequency (Hz)
Power (dB)
1.2
1
0.8
0.6
0.4
0.2
0
100
200
300
400
500
600
700
-80
-90
-100
-110
-120
-130
-140
-150

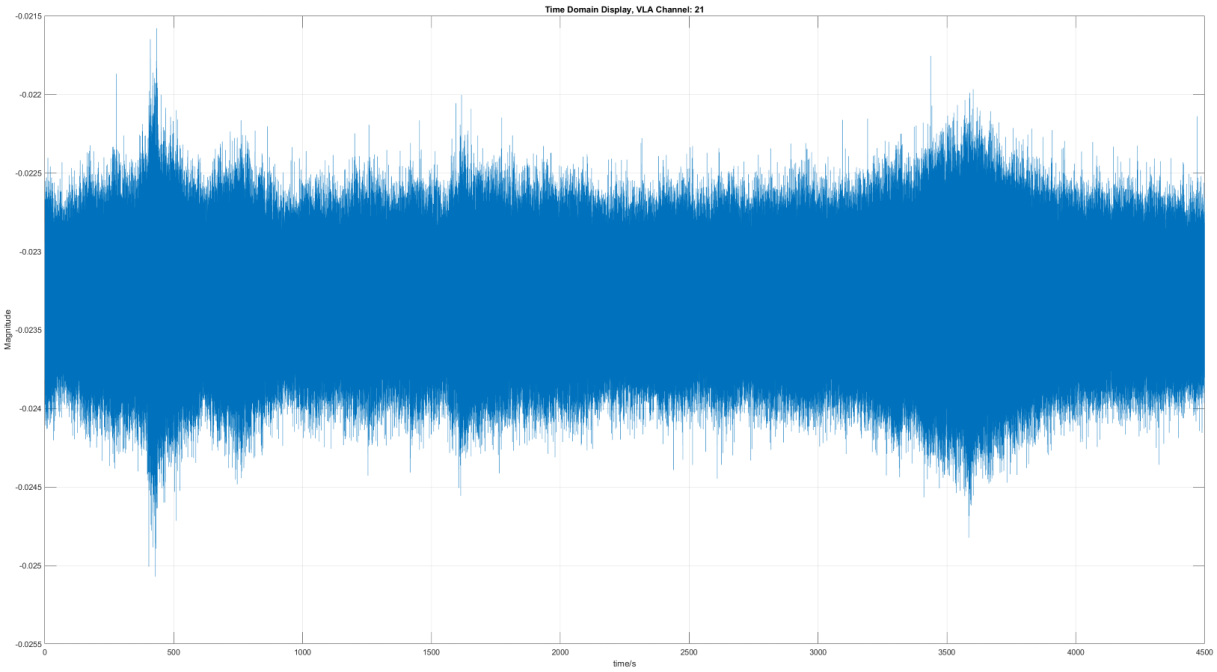
Channel 20:

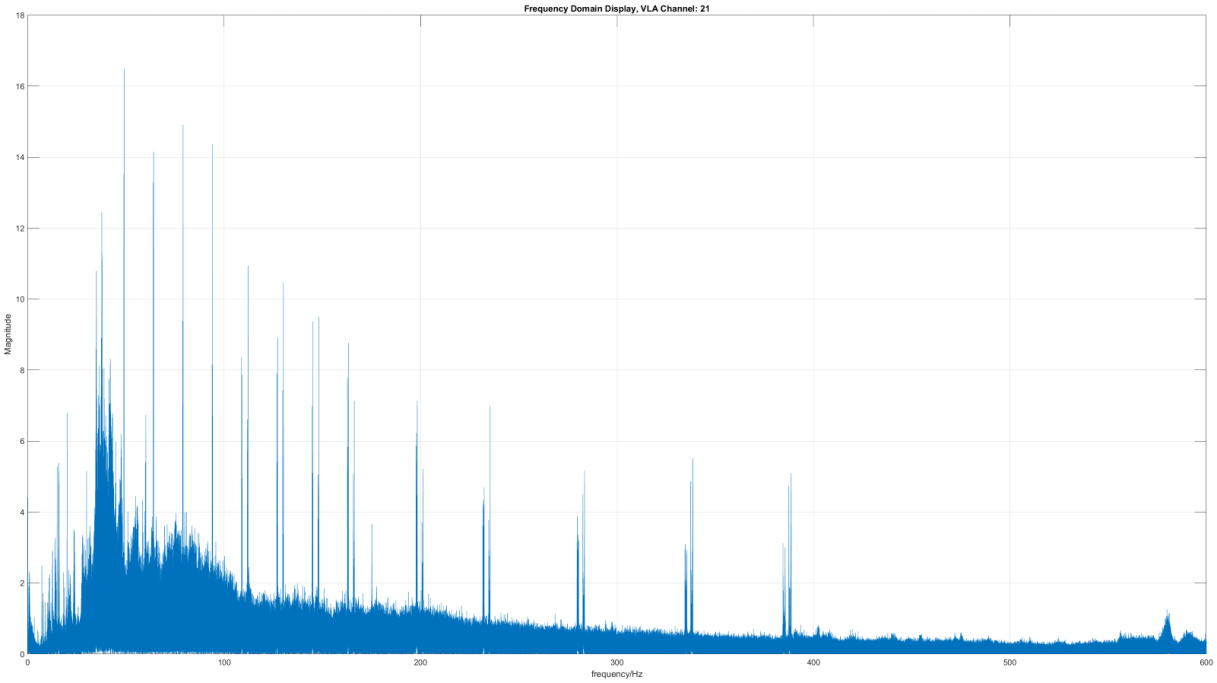

Time Domain Display, VLA Channel: 20
Magnitude
time/s
-0.022
-0.0225
-0.023
-0.0235
-0.024
-0.0245
-0.025
-0.0255
-0.026
0
500
1000
1500
2000
2500
3000
3500
4000
4500

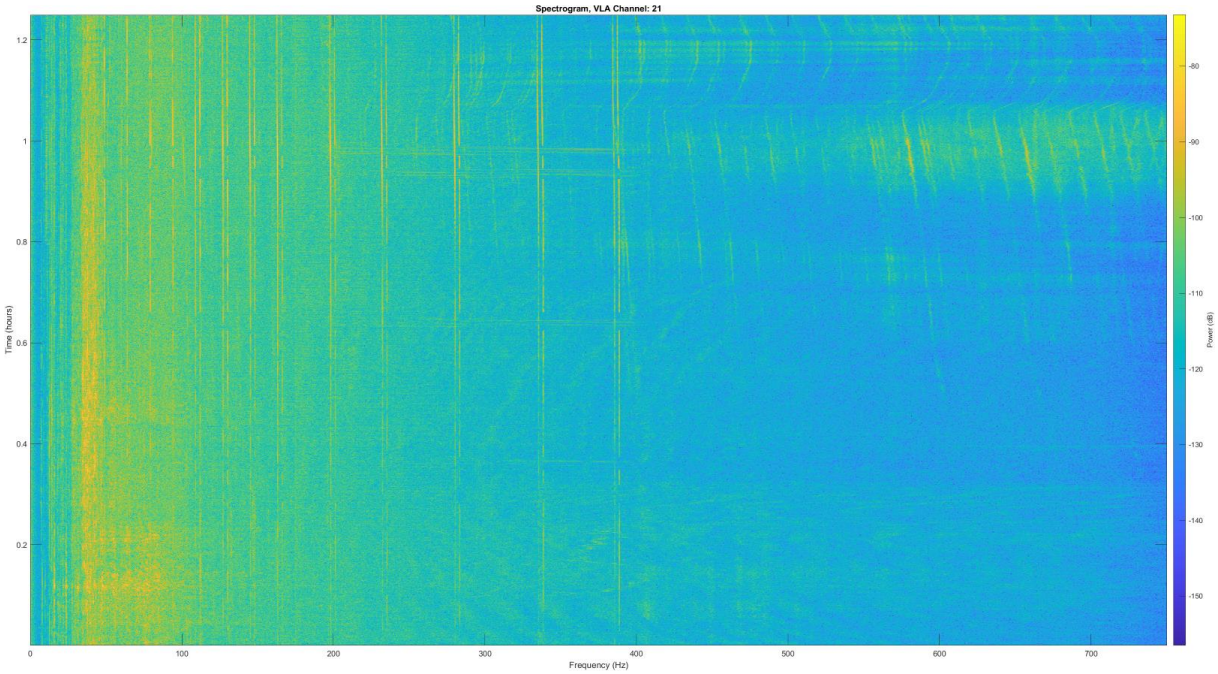

Frequency Domain Display, VLA Channel: 20
Magnitude
frequency/Hz
25
20
15
10
5
0
0
100
200
300
400
500
600


Spectrogram, VLA Channel: 20
Time (hours)
1.2
1
0.8
0.6
0.4
0.2
0
100
200
300
400
500
600
700
Frequency (Hz)
-80
-90
-100
-110
-120
-130
-140
-150
Power (dB)

Channel 21:


Time Domain Display, VLA Channel: 21
Magnitude
time/s
-0.0215
-0.022
-0.0225
-0.023
-0.0235
-0.024
-0.0245
-0.025
-0.0255
0
500
1000
1500
2000
2500
3000
3500
4000
4500


Frequency Domain Display, VLA Channel: 21
Magnitude
frequency/Hz
18
16
14
12
10
8
6
4
2
0
0
100
200
300
400
500
600



Evaluation

Based on the graphs generated, we can ascertain that the frequencies present in the “High Signal Level” set of the deep source are visibly present in the FFT and the spectrograms. Furthermore, the frequencies listed for the shallow source are also visibly present. However, the frequencies listed in the other tonal sets for the deep source are not present, and the same can be said for the noise frequencies. When we examine the FFT and spectrograms for VLA, we see faint presence of peaks at frequencies 175 and 350 on some spectrograms but not in others.

Moreover, we also see larger than expected power magnitudes at lower frequencies, the source of which is unknown. In VLA, this power magnitude is within comparable range when compared to the power of other visible frequencies. It is now important to understand how the detection of power at lower frequencies might affect future research, and what the source of this power might be. It is possible that the power detected at low frequencies might be from an unlisted noise source or from the ship itself (ship’s navigation system, etc.) – however, these are simply speculation.