Rocket infrasound signatures recorded with smartphones

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Motivation

- Standardization of signal characteristics is a recurring problem in infrasound detection
- We are developing a suite of scalable multiresolution feature extraction algorithms for infrasound data processing
- Our main purpose is to facilitate reproducible and transportable characterization of diverse signatures captured by traditional and ubiquitous infrasound networks
- Next-generation technology (smartphones) provides prevalent detection networks with the power of crowdsourcing[2]
- We will apply these algorithms to rocket infrasound signatures recorded with smartphones

Introduction

- Fourier-based signal processing algorithms with fixed time windows are limited in resolution accuracy[1]
- We develop a standardized multiresolution framework based on the implementation of the Gabor limit to define a scaled set of frequencies and time windows for transient feature extraction
- Fractional octave bands generate narrow bandpassed filter banks to compensate for resolution imbalance[1]

References

[1]Garces *InfraMatics* **2013** Vol.2 No.2 p. 13-35
[2]Kong et al. *Sci. Adv.* **2016** 2(2):e1501055
[3] http://johnkrausphotos.com/launches/
[4] http://www.space.com/34007-nasa-launches-osiris-rex-asteroid-sampling-mission.html
[5] http://www.floridatoday.com/story/tech/science/space/2016/08/18/how-to-watch-deltaiv-rocket-launch-cape-canaveral-air-force-station-afspc6/88952130/
[6] http://www.floridatoday.com/story/tech/science/space/2016/08/14/live-spacex-falcon9-rocket-launch-landing-cape-canaveral-air-force-

Methods

Signal recording

- Several rocket launches from Cape Canaveral Air Force Station, FL were captured by an array of iOS devices running RedVox infrasound app

Figure 1. Sensor location relative to launch site

Data processing

- Algorithm development in IntelliJ IDEA interface using Python programming language
- Interpolation for the case of unevenly sampled barometer data
- Spectral decomposition with Fast Fourier Transforms
- Application of filter banks and computation of overlapping time windows in accordance with the Gabor limit
- Computation of physics metrics for each frequency bin

Filter banks on Atlas V rocket launch data (16/09/08)

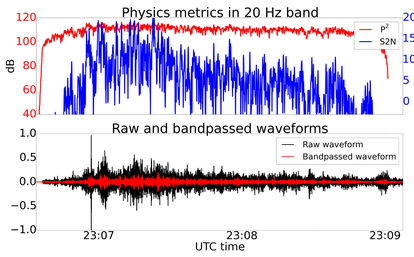

Figure 2. Bandpassed waveform and detection metrics for 17.78 - 22.39 Hz band (19.95 Hz center frequency).

Results

Falcon 9 rocket launch
2016 August 14, 5:25 GMT[6]

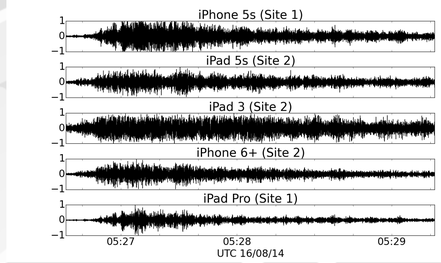

Figure 3. Microphone waveforms from all devices near Falcon 9 launch site.

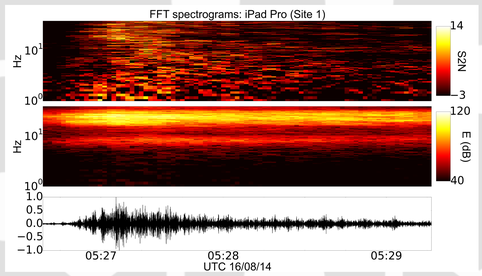

Figure 4. Fourier-based algorithm applied to Falcon 9 launch signature from iPad Pro .

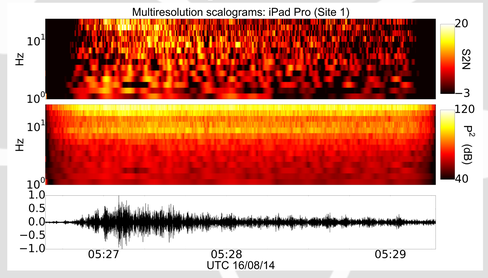

Figure 5. Multiresolution algorithm applied to Falcon 9 launch signature from iPad Pro.

Delta IV rocket launch
2016 August 19, 4:52 GMT[5]

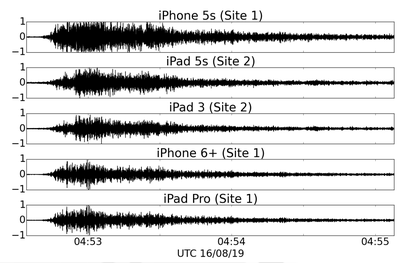

Figure 6. Microphone waveforms from all devices near Delta IV launch site.

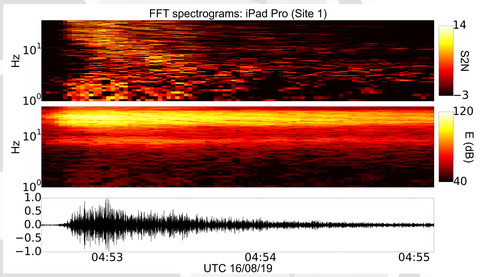

Figure 7. Fourier-based algorithm applied to Delta IV launch signature from iPad Pro.

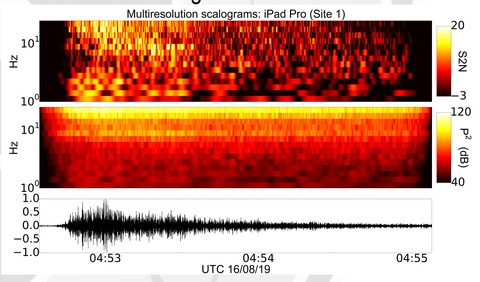

Figure 8. Multiresolution algorithm applied to Delta IV launch signature from iPad Pro.

Atlas V rocket launch
2016 September 8, 23:05 GMT[4]

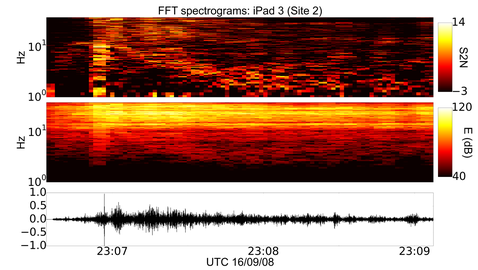

Figure 9. Fourier-based algorithm applied to Atlas V launch signature from iPad 3.

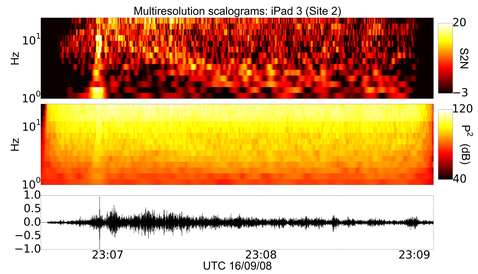

Figure 10. Multiresolution algorithm applied to Atlas V launch signature from iPad 3.

Figure 11. Delta IV rocket launch at 12:52 am EDT on August 19, 2016[3]

Conclusions and Future Work

- We have developed standardized and transportable multiresolution feature extraction algorithms which provide accurate characterization of rocket launch signatures recorded by smartphone networks
- We propose the application of these algorithms to:
  - Unevenly sampled barometer data
  - Other blast and supersonic data
  - Data acquired from soon-to-be-released RedVox infrasound app for Androids

This work was funded in-part by the Consortium for Verification Technology under Department of Energy National Nuclear Security Administration award number DE-NA0002534

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National Nuclear Security Administration