Acoustic Monitoring, Localization and Character of a Prescribed Burn in Florida

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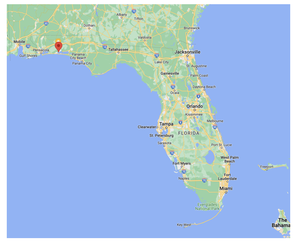
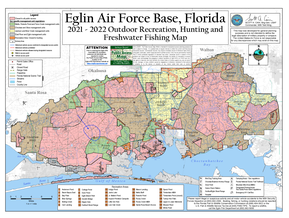
Abstract

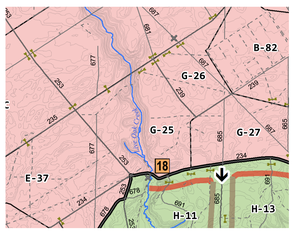
- Audible pressure perturbations are known to originate from wildland fires.
- We present evidence that acoustic infrasound was recorded during a prescribed fire, and detailed location and intensity can be monitored with beam forming acoustics.
- Numerous researchers from a broad range of disciplines monitored prescribed burns conducted at Eglin Airforce Base, FL, March, 2023. Single-unit infrasonic sensors and a six-element array were deployed outside the burn unit to capture acoustic signals emanating from the burn.
- The array was configured as a hexagon with distance between opposite elements of 10 m aperture.
- A separate network of dual-band radiometers was deployed in the burn unit to track the fire's evolution.
- Array analysis results show a coherent broadband signal with frequencies between 2 and 100 Hz emanating from the burn unit, although the major signal is 1-15Hz.
- (High accuracy locations of concurrent helicopter rotors at 10-15 Hz suggest the method is reliable.) Estimated azimuths of the fire follow the ignition pattern with delays of several minutes between the ignition time and the production of sound.
- We expect that infrasound amplitude variation reflects combustion intensity and may be associated with fuel source variability.

Florida





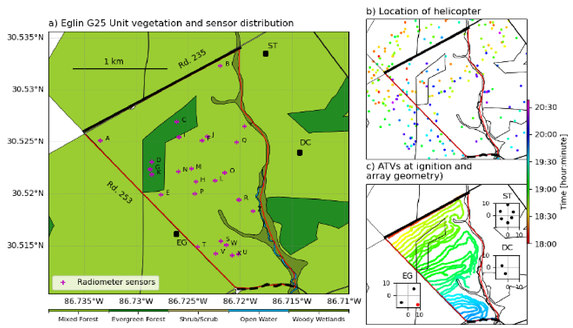
Eglin Prescribed Burn Target



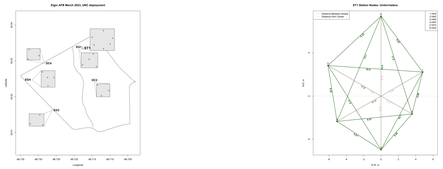
BeamForming0

- Beam Forming at Eglin
- Multichannel Node Arrays
- Typical Separation: 10 m
- Use InfraBSU and Chaparral Microphones
- Recording at a variety of Sample Rates: 100-2000 Hz
- Recording on RefTek and Nanometrics DAS's

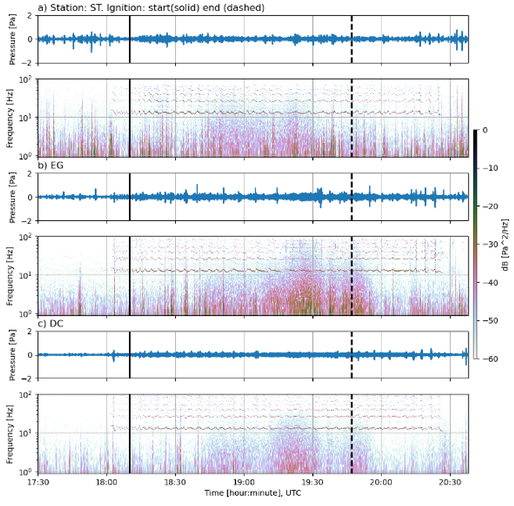
Fig 1a: Fire Plan and Station Configuration



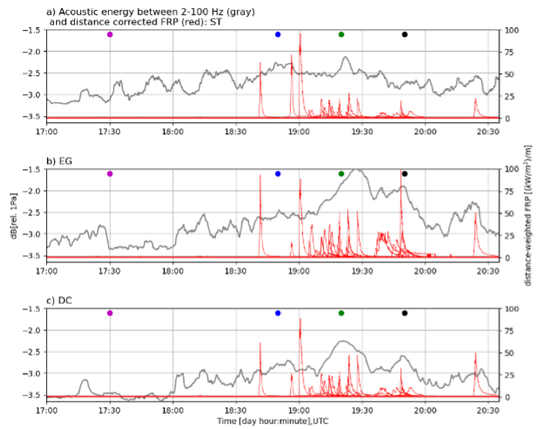
Station Configurations



3 Spectrograms: ST1 EG3 DC2



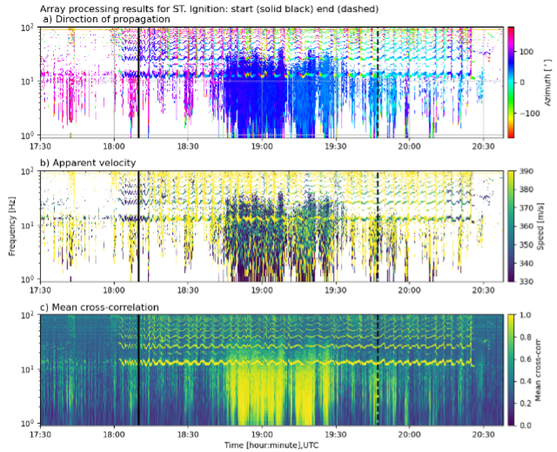
3 Spectrogram Analysis: ST1 EG3 DC2



The time evolution of acoustic energy of the broadband signal across the sensor network. The acoustic power is computed by integrating the modified power spectral density (PSD), which is the PSD with helicopter noise removed. In the three plots, the acoustic power is shown in decibels that are relative to 1 Pa. The fire-radiated power (FRP) data are shown (in red lines) for all sensors, divided by the distance to the sensor.

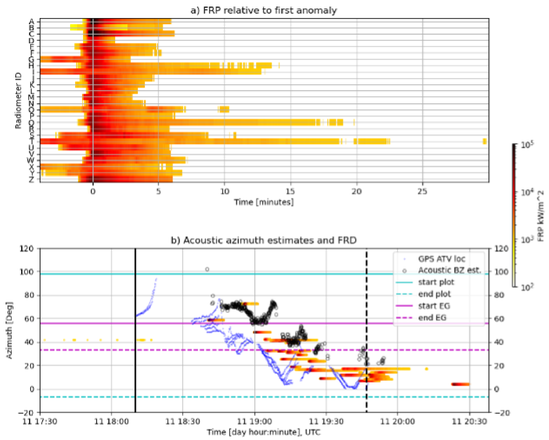
BeamForming ST1

- Beam Forming Station ST1: 6
- Extract Angle, Estimate Power and Velocity



a. Estimated azimuth direction of incoming wave.
b. Estimated apparent speed of the acoustic wave across the array.
c. Mean cross-correlation of the array nodes vs. frequency. Oscillating high values are helicopter noise and associated higher harmonics.

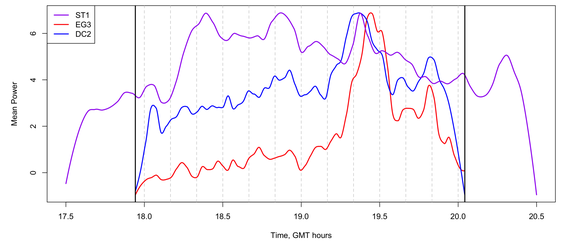
Correlations



Top Power waveforms from FRD sensors during: burn listed alphabetically to correspond to map location (FIG. 1a).

Bottom
- Black circles: average of peak-power azimuths at Station ST1, 2-10 Hz.
- FRD signals plotted versus time to show correspondence to azimuth estimates.
- Horizontal cyan solid/dashed lines: azimuths for top and bottom of burn unit.
- Solid/dashed magenta lines: start and end of the evergreen forest (FIG. 1a).
- Blue dots: azimuth-time location of ATVs during ignition.

Temporal Evolution



Comparison of time evolution of power at three stations showing (slight) delay of peak power as fire passes stations.

Eglin Prescribed Fire

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