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High Altitude Balloon-borne Acoustic Detection of the October 2020 Large Surface Explosion Coupling Experiment (LSECE)

Silber, E. A.[1], Bowman, D.[1], Weiss, C.[1]
[1]Sandia National Laboratories, Albuquerque, New Mexico

Background

- Natural and anthropogenic impulsive atmospheric events, e.g., explosions, can generate low frequency (f < 20 Hz) acoustic waves, also known as infrasound. Due to low attenuation at very low frequencies, infrasonic waves can travel over very long distances before reaching ground-based sensors [1]. However, the Earth's atmosphere is dynamic, and it changes on very short time-scales – this has an adverse effect on our ability to accurately model airwave propagation.
- Over the past few years, it has been demonstrated that high altitude balloons can serve as floating, yet robust platforms for deploying infrasound sensor payloads for the purpose of event detection and source localization [2,3] (Figure 1). One of the advantages of such platforms is relatively low local noise, allowing for better signal detection compared to surface-based sensors [2].
- Balloon borne infrasound monitoring has gained momentum in recent years, with
- Controlled explosion experiments provide important ground-truth data that can be utilized for the purpose of infrasound signal and source identification, and the development and improvement of detection and propagation algorithms.

Figure 1: High altitude balloon launch. The balloon is shown as it is starting to ascend. Payload is attached via paracord.

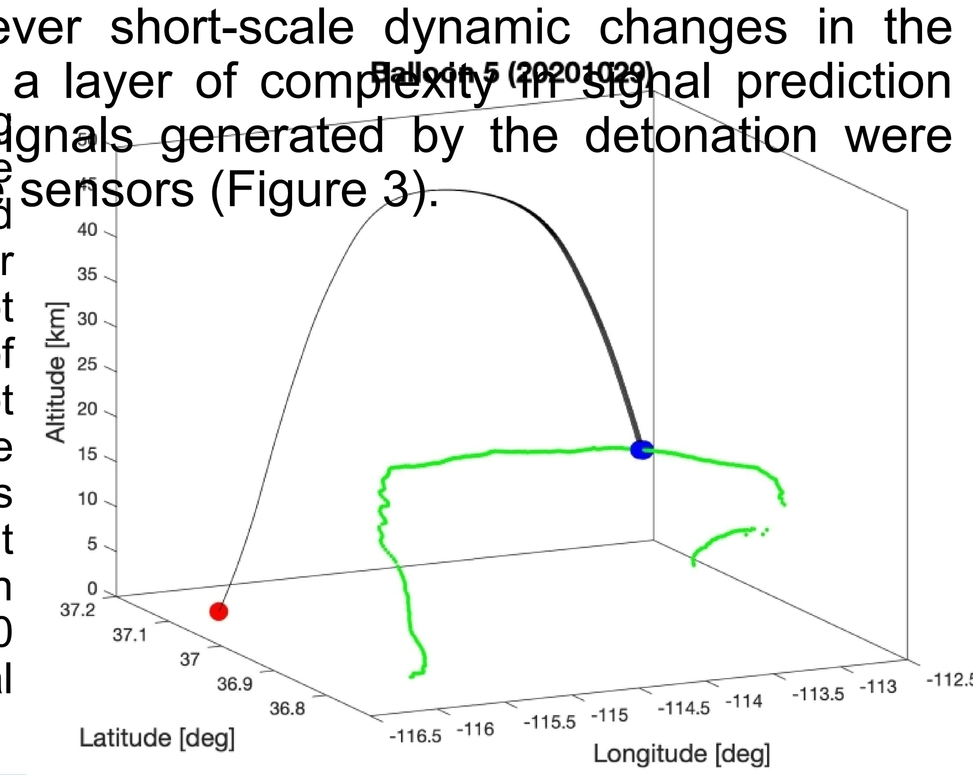
Experiment

- The Large Surface Explosion Coupling Experiment (LSECE), consisting of two one-ton (TNT equivalent; 1 TNT = 4.184 x 10^9 J) explosions, was performed at the Nevada National Security Site in October of 2020 with the aim to use all available sensing modalities (e.g., seismic, infrasound) to obtain well-characterized ground-truth data. The detonations occurred at the same location but two days apart, one in early morning (Oct 27, dubbed Artemis) and the other one in afternoon (Oct 29, dubbed Apollo), in order to obtain ground-truth under different atmospheric conditions.
- High altitude balloons (Figure 1) were deployed on both days, carrying infrasound sensor payload, consisting of prototype condenser microphones and GEMs [4].

Results

- Three balloons (#3-5) were in flight during the Apollo detonation on Oct 29. The continuous motion of the balloons impedes a typical stationary sensor array processing approach that is generally applied to quickly and efficiently search for the signals; therefore propagation modeling using the open source GeoAc raytracing package [5] with a G2S model atmosphere [6] aided in this task. The G2S model provides atmospheric parameters (e.g., temperature, wind speed and direction) for a given location, date, and time.
- Predicted ray propagation paths for all three sensors exist (Figure 2); however short-scale dynamic changes in the atmosphere add a layer of complexity in signal prediction and detection. Signals generated by the detonation were found on all three sensors (Figure 3).

Figure 2: Raytracing results showing possible ray paths associated with signal detection for Balloon #5. The red dot represents the point of detonation, the blue dot is the balloon, and the green line represents the balloon flight trajectory. The balloon cruising altitude is ~20 km. The horizontal source-receiver distance was 176 km.



Results (cont'd)

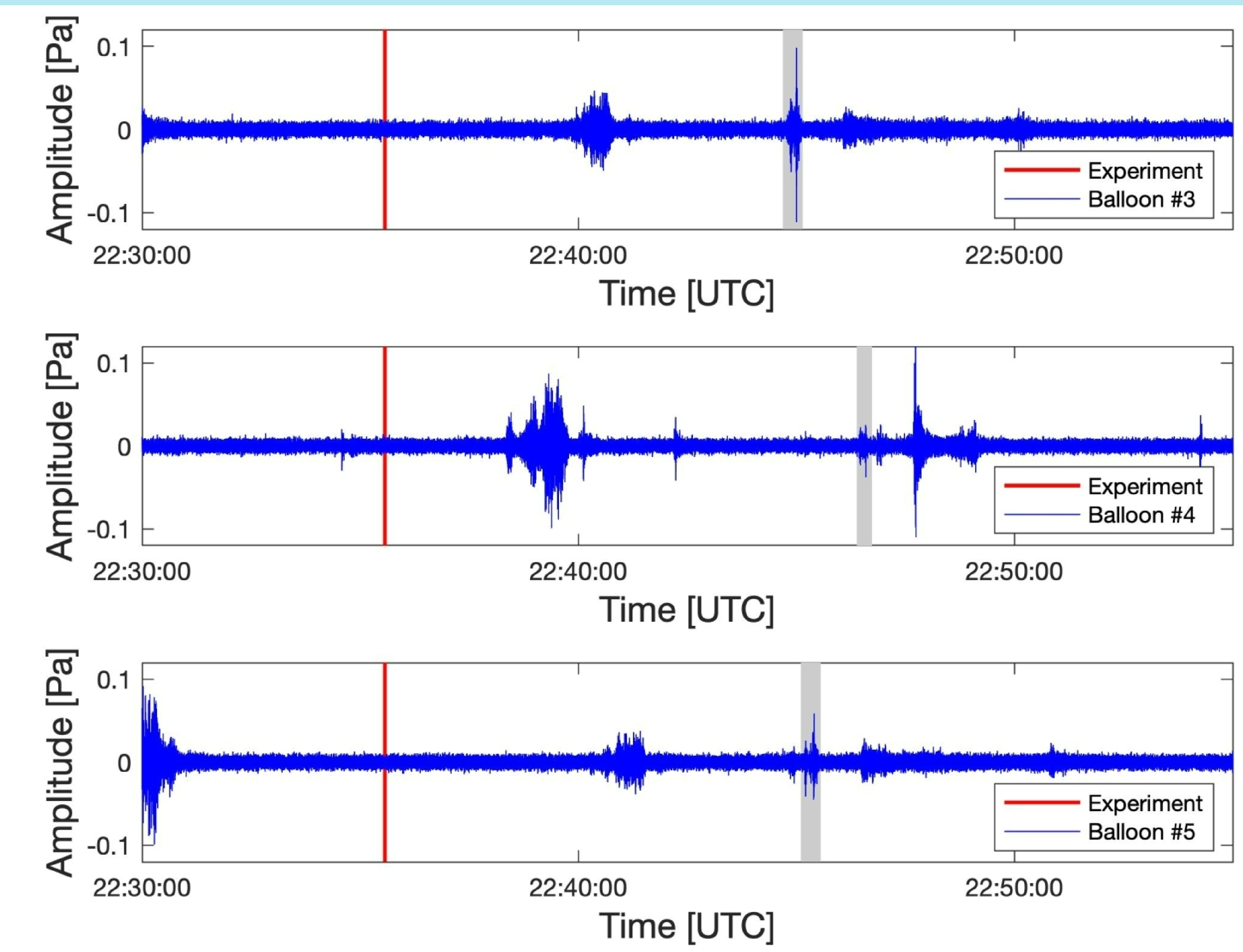


Figure 3: Time series of filtered waveforms (high pass) for the three balloons in flight on that day. The red vertical line represents the moment of detonation, and the grey shading is associated with the signal arrivals 9 -10 min later on all three sensors. The high-altitude acoustic environment is rather complex, and many detected signals remain poorly characterized.

Summary

- Infrasound sensors carried by high altitude balloons detected the signals generated by the LSECE controlled detonation experiment. The local acoustic environment at these altitudes might be more complex than previously thought.
- Work is underway to develop an algorithm for high altitude drifting platforms that will enable event detection when ground truth is not available.

References

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