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Noise Reduction Capability of the Trampoline Fabric Wind Dome

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ABSTRACT

Low frequency sound below 20 Hz, also known as infrasound, is generated by both natural and anthropogenic sources. Local surface winds also generate signals within this frequency band and can dominate signals. Effectively monitoring sources of interest requires filtering out the influence of wind. Recently, the National Center for Physical Acoustics developed a 1 m fabric dome made from trampoline material that can serve as a wind filter for temporary field deployments. We assess the performance of this new dome by quantifying its overall noise reduction and show that it is an acceptable wind filter for temporary infrasound field deployments.

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ACRONYMS AND TERMS

Acronym/Term	Definition
NCPA	National Center for Physical Acoustics
PSD	Power Spectral Density

1. INTRODUCTION

Infrasound, low frequency sound below 20 Hz, is generated by both natural and anthropogenic sources such as volcanoes, earthquakes, chemical explosions, and rocket launches. Local surface winds also generate pressure fluctuations within this frequency band and can often dominate signals recorded on infrasound sensors (Raspet et al., 2019). Therefore, effectively monitoring sources of interest requires filtering out the influence of wind. A number of wind noise reduction systems, or "filters", have been designed to decrease this effect and these have been studied extensively. The first was a 602 m long tapered pipe with 100 openings which decreased wind noise below 1 Hz but suffered from the limitation of being directional (Daniels, 1959). Most wind consist of metal rosette pipe arrays that work through spatial averaging (Hedlin and Raspet, 2003; Raspet et al., 2019). The pipe arrays perform very well, decreasing wind noise by up to 20 dB (Raspet et al., 2019). However, they are large, expensive, and difficult to deploy, making them not ideal for temporary or low cost field deployments. Porous hoses, typically used for landscaping, were used as an inexpensive alternative for some time, though Walker & Hedlin (2010) recommend against their use. Signals recorded using these porous hoses show differences in amplitude based on source-to-receiver geometry and frequency content (Howard et al., 2007). Another often-used inexpensive alternative is the porous wind dome. These have been shown to reduce wind noise by up to 25 dB depending on the fabric and size (Noble et al., 2014; Raspet et al. 2019). However, these domes require a large footprint to effectively reduce wind noise at lower frequencies (Raspet et al., 2019). Previous work by Albert et al. (2021) compared the wind noise reduction capability of porous hoses, a metal mesh dome, and placing a bucket over the infrasound sensor. The authors found the metal mesh dome both reduces wind noise and maintains waveform fidelity and recommend it for most temporary field deployments. They also strongly recommended against placing a bucket over the bare sensor as it does nothing to decrease noise. The National Center for Physical Acoustics (NCPA) recently developed a 1 m fabric dome made from trampoline material that can serve as a wind filter for temporary field deployments. As of the time of this writing, there are no publications on the performance of this new dome. Therefore, in this study we quantify the performance of the trampoline fabric wind dome and show it is an acceptable wind filter for temporary infrasound field deployments.

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2. EXPERIMENT AND METHODS

2.1. Experiment Setup

To analyze the performance of the trampoline wind dome, we deployed two co-located four-sensor infrasound arrays at the Facility for Acceptance, Calibration, and Testing (FACT) site on Kirtland Air Force Base near infrasound station FSA3 (Figure 1).

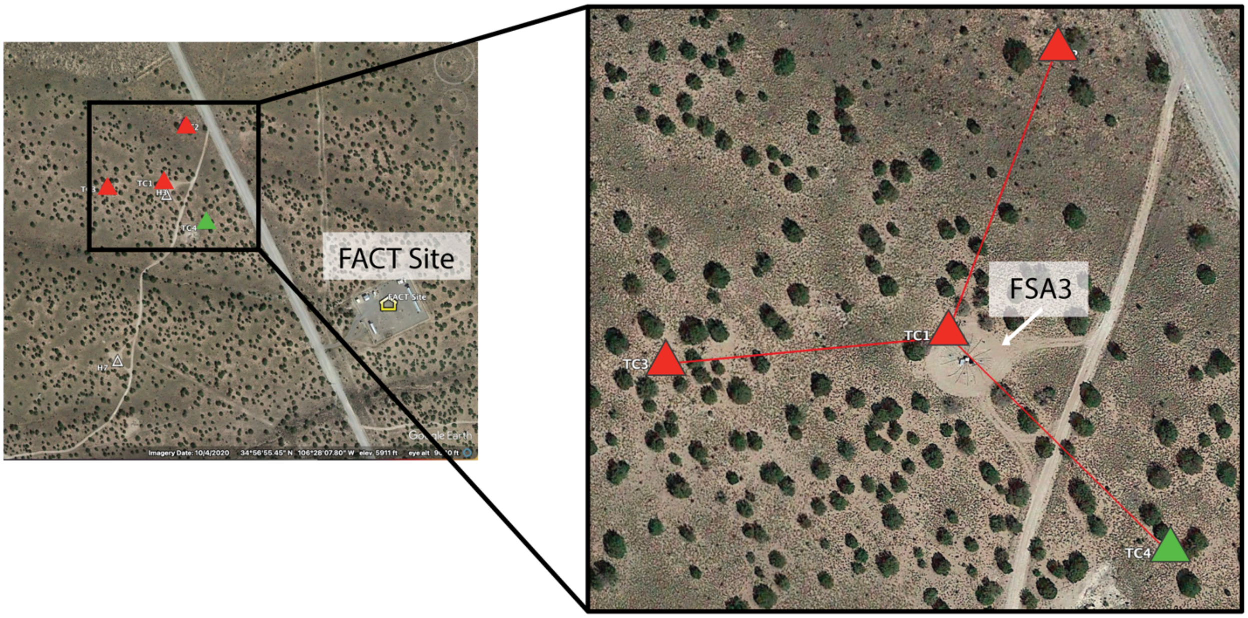

Figure 1. Locations of two co-located four-sensor infrasound arrays deployed for this study. Infrasound sensors are denoted by triangles. Only channel 4 on each array recorded data continuously for the entire time period between August 16, 2022 through January 9, 2023. This sensor is colored green. The sensors not used in the analysis are shown in red.

Each array consisted of Hyperion Technology Group IFS-3000 series infrasound sensors connected to a RefTek Systems Inc. RT-130 digitizer. One array had no wind noise reduction system, and the other array had 1 m diameter trampoline fabric wind domes covering each sensor. The trampoline fabric not only serves as a physical barrier to wind; the polypropylene basketweave mesh also provides protection from ultraviolet rays. Unfortunately, we ran into errors with both digitizers that caused them to fail often. However, channel 4 on each array continuously recorded data during the entire ~5 month experiment duration from August 16, 2022 through January 9, 2023. As such, this study focuses on comparing recordings from only one sensor in each array. A picture of the co-located infrasound sensors with and without the trampoline wind dome filter is shown in Figure 2. In situ wind speed data was taken from the Albuquerque International Sunport at a site ~1.6 km from the co-located infrasound arrays.

Figure 2. Co-located infrasound sensors with (right) and without (left) the trampoline fabric wind filter.

2.2. Methods

Following the method of Albert et al. (2021) data was first divided by wind speed intervals. Wind data was downsampled from the original sample rate of 10 Hz to 20 min/sample and the mean speed was used. The wind speed distribution suggested sufficient data to analyze data corresponding to wind speeds between 1 and 9 m/s. Because of this, we chose to focus on 1 m/s wind speed intervals between the 1 to 9 m/s range. This is a departure from the previous methods of both Albert et al. (2021) and Hedlin & Walker (2003) but was chosen as these intervals better represent the data.

After binning data by wind speed intervals, power spectral densities (PSDs) were calculated using a 20 min Hann window with 50% overlap (Hedlin & Walker, 2003; Albert et al., 2021). The average PSD was then taken for each wind speed interval and converted to decibels using $10\log(PSD)$. The reduction in overall wind noise was calculated by subtracting the mean PSD of the trampoline wind dome from the mean PSD of the bare sensor.

3. RESULTS AND DISCUSSION

The noise reduction of the trampoline fabric dome was then assessed for each wind speed interval and is shown in Figure 3. For all wind intervals and frequencies, the trampoline wind dome reduces overall noise to some extent, with maximum noise reduction values ranging from 4.8-11.5 dB. For most wind speed intervals, noise reduction peaks between 1-10 Hz. However, noise reduction peaks for wind speeds between 1-3 m/s are an exception. These two wind intervals contain the highest number of examples (2,879 for 1-2 m/s and 3,996 for 2-3 m/s). Therefore, it is likely that the abundance of PSDs may capture frequency content changes due to anthropogenic and/or physical diurnal as well as seasonal variations. As such, future studies may want to limit analyses to specific times of day or further divide data into temporal groups.

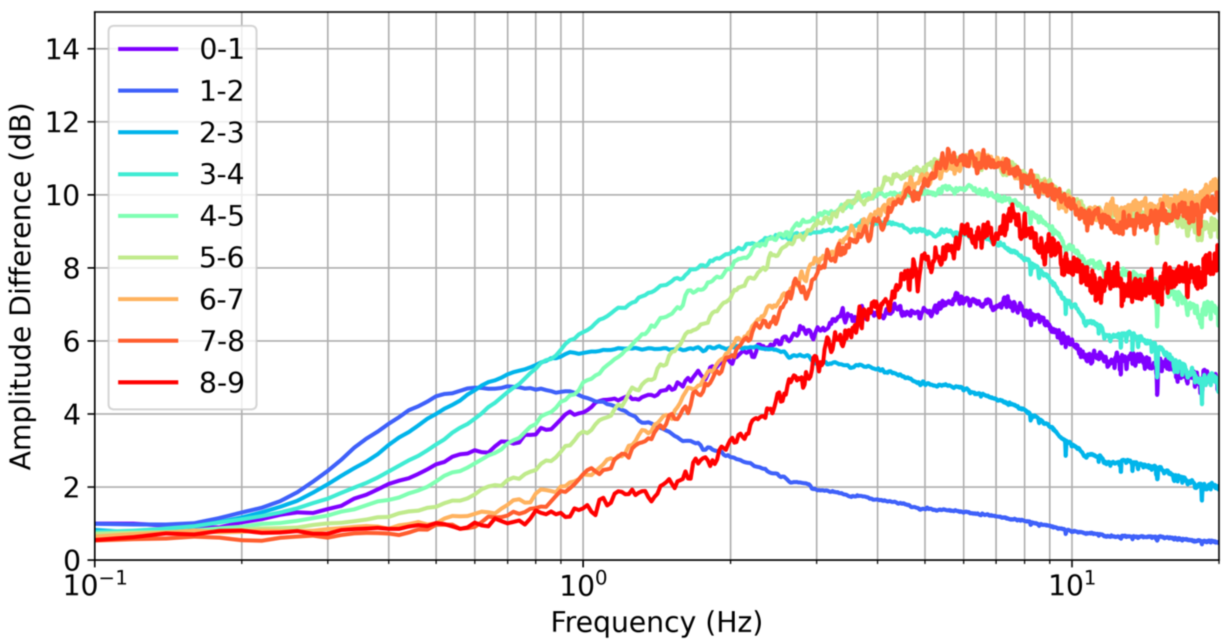

Figure 3. Overall noise reduction of the trampoline fabric wind dome for each wind speed interval and frequency. Maximum overall noise reduction ranges from 4.8-11.5 dB. For most wind speed intervals, peak noise reduction occurs between 1-20 Hz. This is not the case for 1-3 m/s, which may be due to the number of examples in these wind speed intervals.

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4. CONCLUSIONS

The 1 m trampoline fabric dome developed by NCPA can serve as a wind filter for temporary field deployments, but its performance had not previously been assessed. This study quantifies its performance by co-locating two 4-channel infrasound arrays with and without the trampoline fabric wind domes. As discussed in the previous section, the trampoline fabric wind dome reduces overall noise, with maximum values ranging from 4.8-11.5 dB. Due to its ease of deployment and effectiveness in reducing overall noise, we conclude that the trampoline fabric wind dome is an acceptable wind filter for temporary infrasound field deployments and recommend its use for future work.

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