
Observation of fireworks to understand the nonlinear behavior of shock waves excited by explosions

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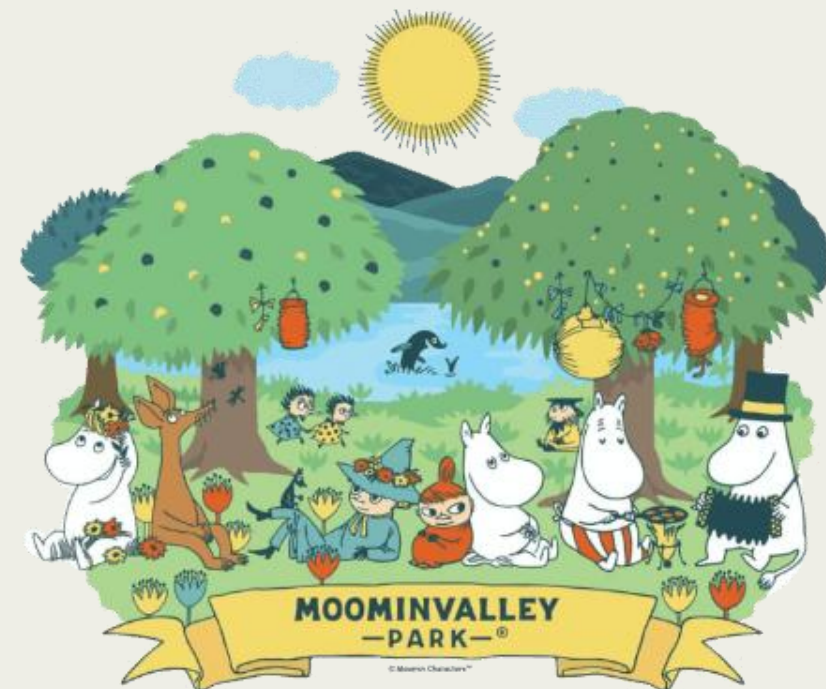
Japan Weather Association (JWA)



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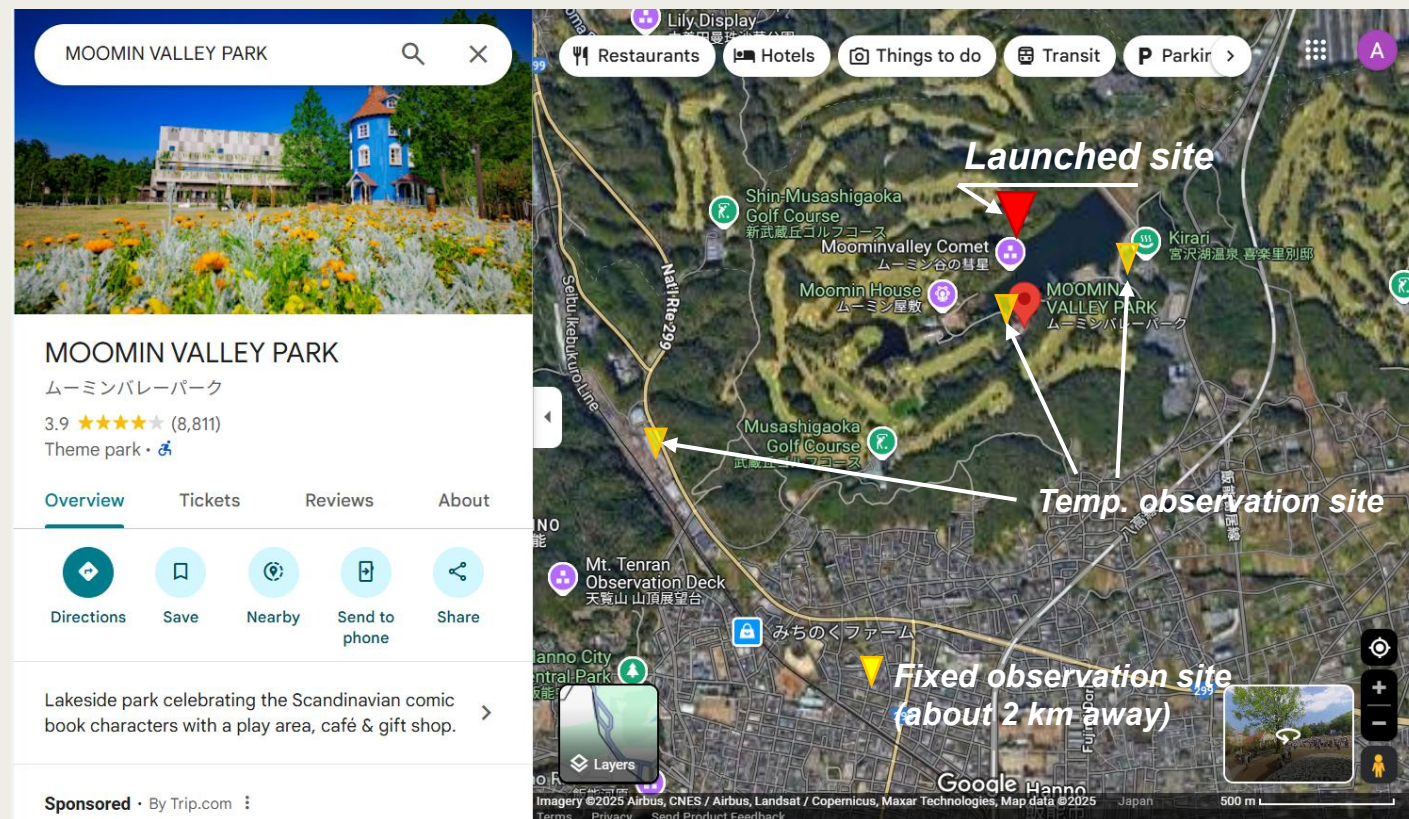
Introduction

- We attempted to **observe the infrasound signals generated by explosion events** to understand the actual state of waveform deformation and attenuation due to propagation.
- **The target event was fireworks** as part of theme park events.
- Taking advantage of the fact that such fireworks were regularly launched on every weekend of the holiday season, **observations were made by deploying a portable pressure sensor** near the launch site or several kilometers from the sound source.

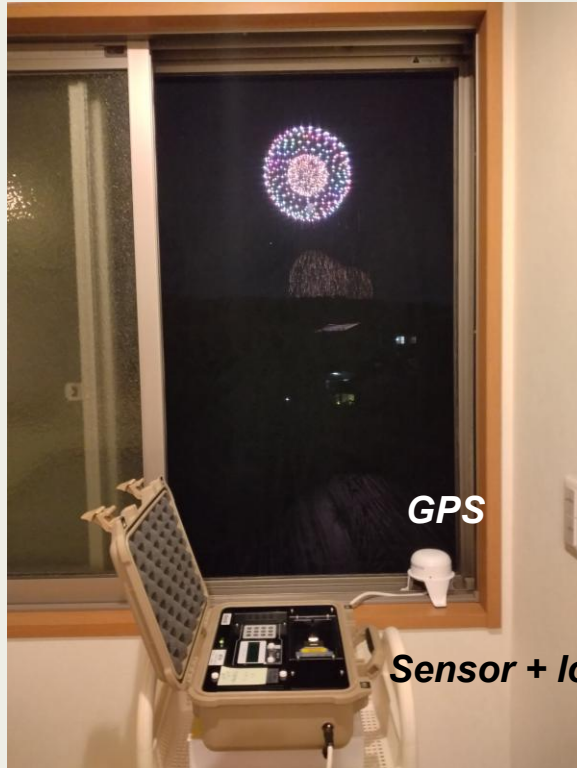


Observation of fireworks

- Observations were made by deploying a portable pressure sensor (*Paroscientific Digital Quartz Resonator sensor Model 6000-16B*) with a sampling frequency of 100 Hz and an IIR filter with a corner freq. of 22 Hz.
- Each observation was conducted at one or two locations.
- Observations were conducted in the summers of 2024 and 2025.



Observation of fireworks



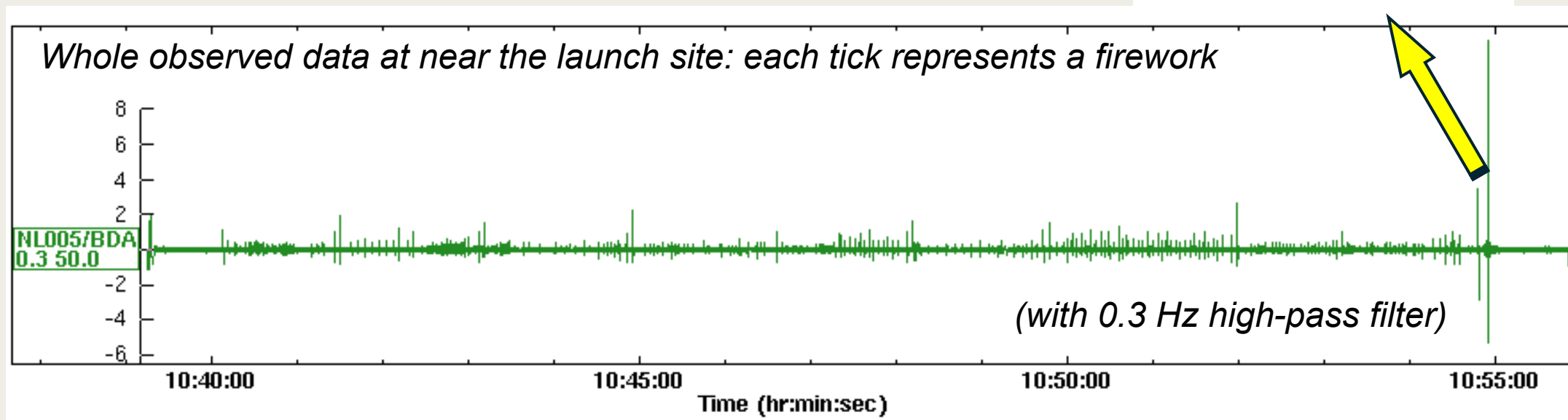
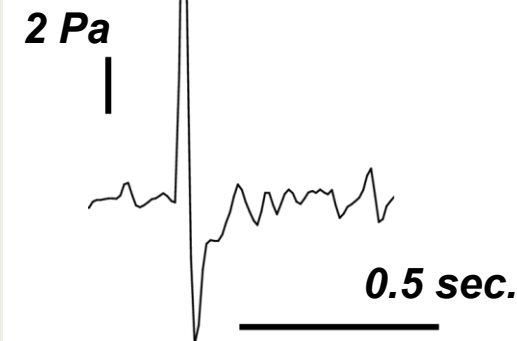
**Fixed observation site
(About 2 km away from the
launch site)**



**Temp. site deployed in the park
(A few hundred meters away
from the launch site)**

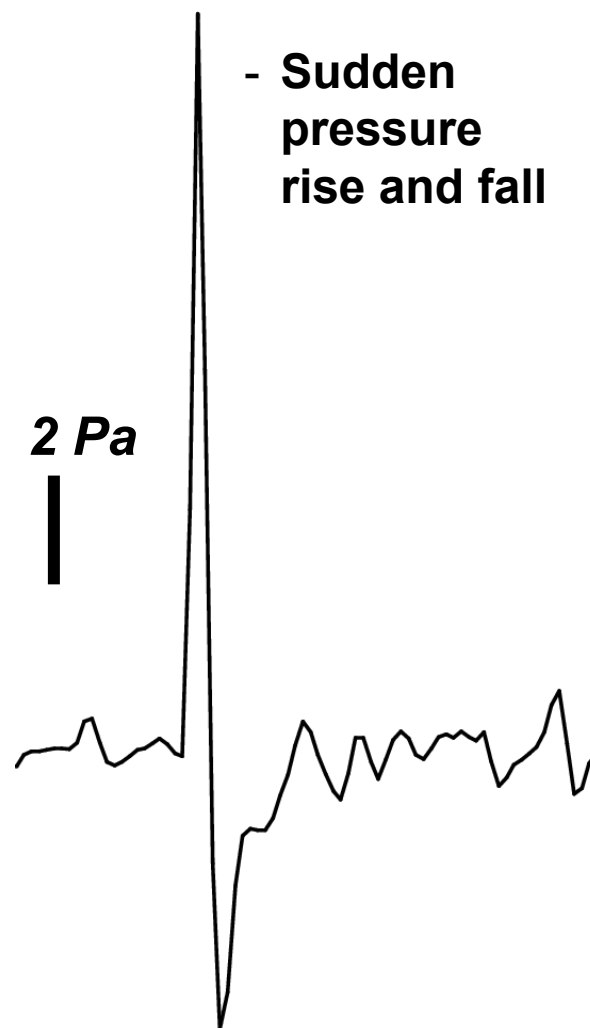
Observed data

- The fireworks lasted for 15 minutes, we got observed data of over 100 firework signals at few locations during a single session.
- Each waveform was picked up and these were compared each other.



Observed data / waveform groups

- The signal from an explosion should be a positive pressure, indicating expansion, followed by a negative pressure, indicating air entering the expanded space.
 - But the waveforms observed at near the launch site were classified into two groups based on their shapes.
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- *The shape of the waveform varies depending on the explosion size?*

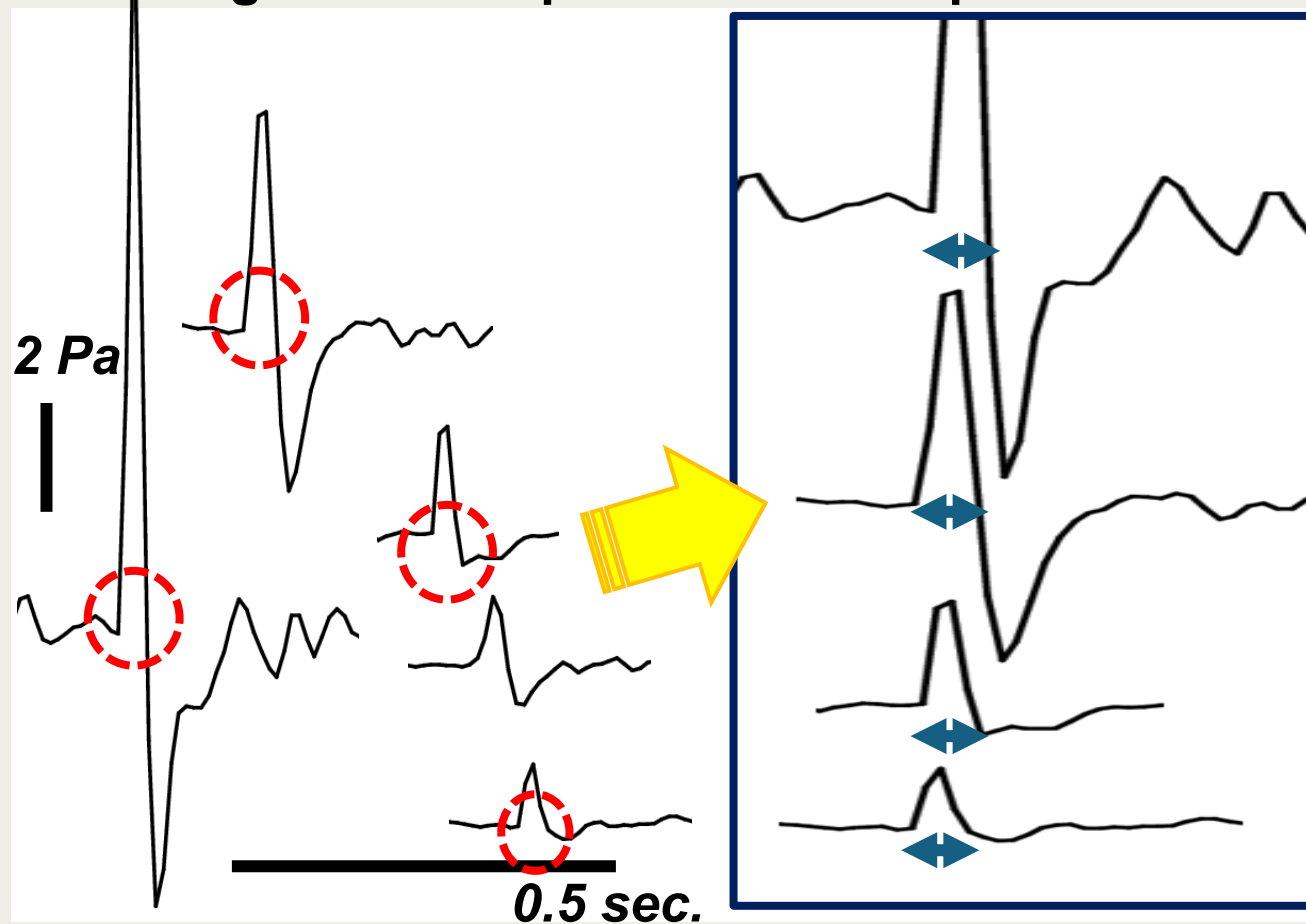


- Sudden pressure rise and gradual pressure drop/relaxation



Observed data / the time required for expansion caused by an explosion

- The duration of the initial positive pressure appears to be roughly the same regardless of the change in the amplitude of the explosion.

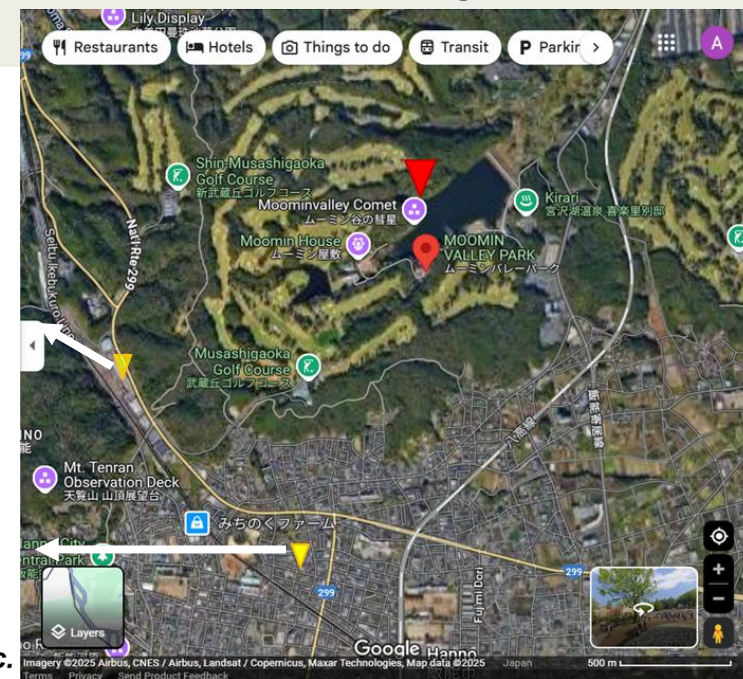
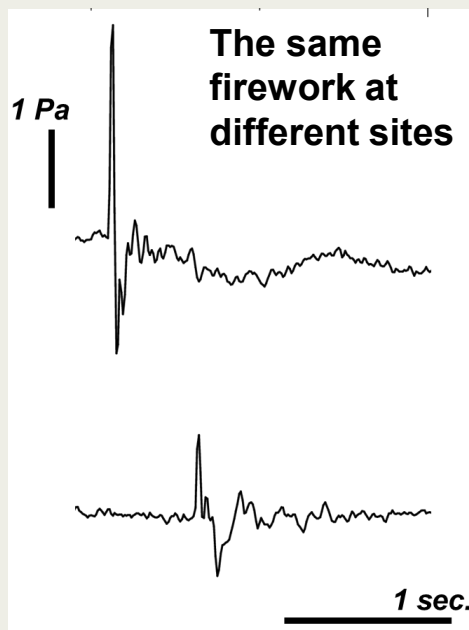
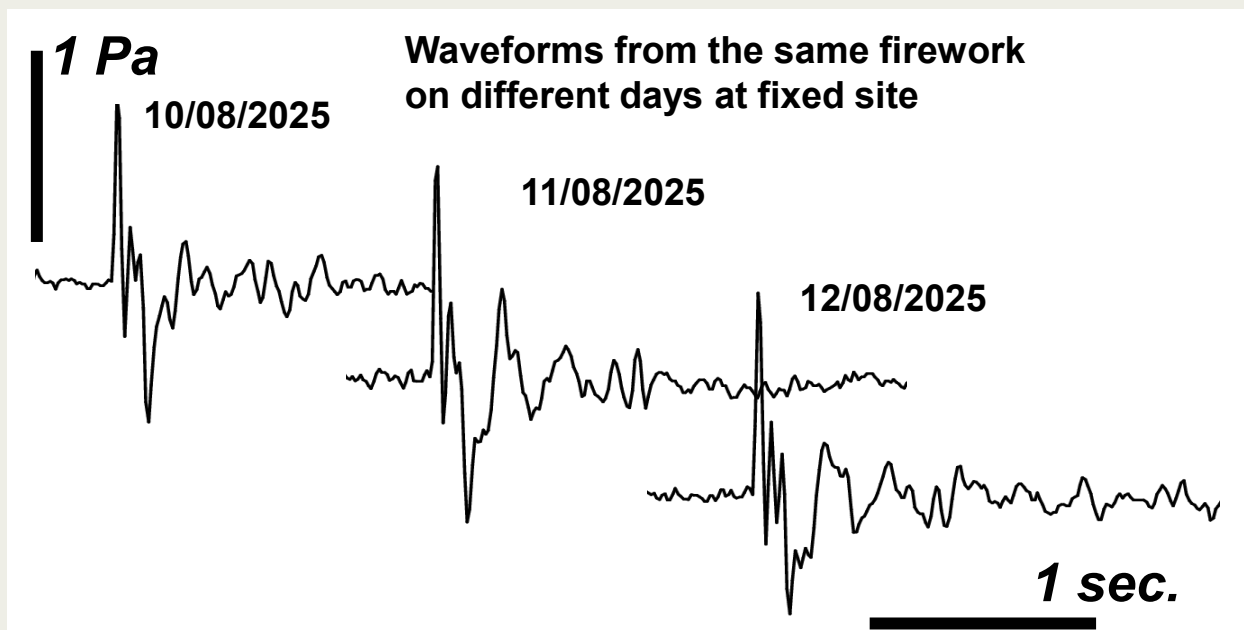


*This may indicate that **the time required for expansion due to a small explosion under atmospheric pressure remains almost same regardless of the size of the explosion.***

⇒ In other words, it shows that it is difficult to estimate the yields of explosions by using of the duration time of the initial positive pressure for small explosion...

Observed data / overall waveform shapes including the coda

- Overall waveform shapes including the coda observed at the same site are very similar but there are some differences between different sites.



- It goes without saying that the observed waveform is shaped by the surrounding environment of the observation site.



Concluding remarks

- We attempted to observe the infrasound signals generated by explosion events to understand the actual state of waveform deformation and attenuation due to propagation.
- Although the nonlinear deformation was not clearly observed, several distinctive characteristic phenomena were observed.
- We believe that the knowledge gained from this study can be applied analogically to the interpretation of waveform deformation due to shock wave propagation.
- And we believe that observing fireworks is suitable not only for understanding the characteristics of shock waves, but also for practicing infrasound observations.