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

Nobuo Arai, Takayuki Otsu, and Makiko Iwakuni

Japan Weather Association (JWA)

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CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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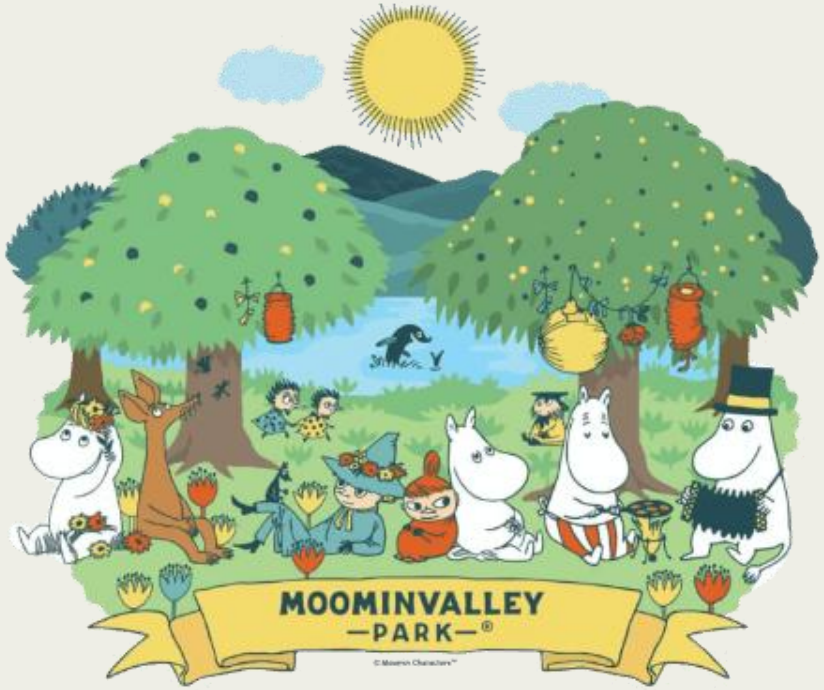
Introduction

- 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.



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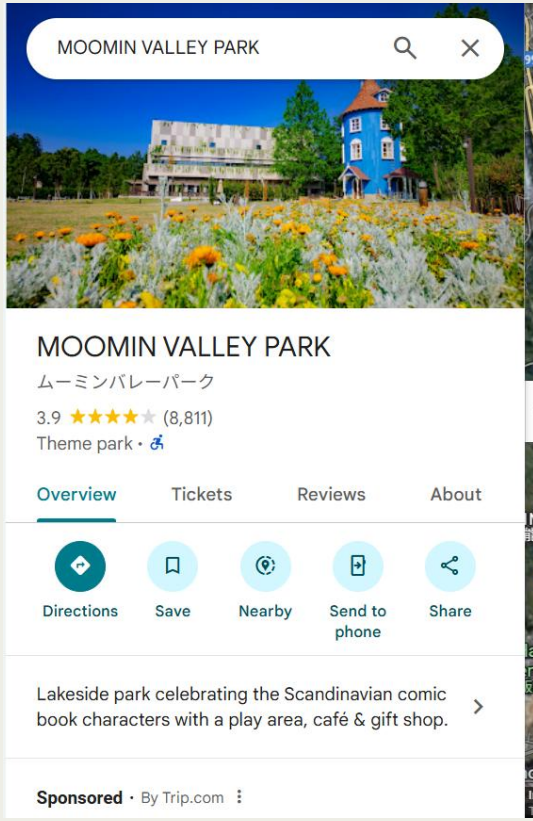
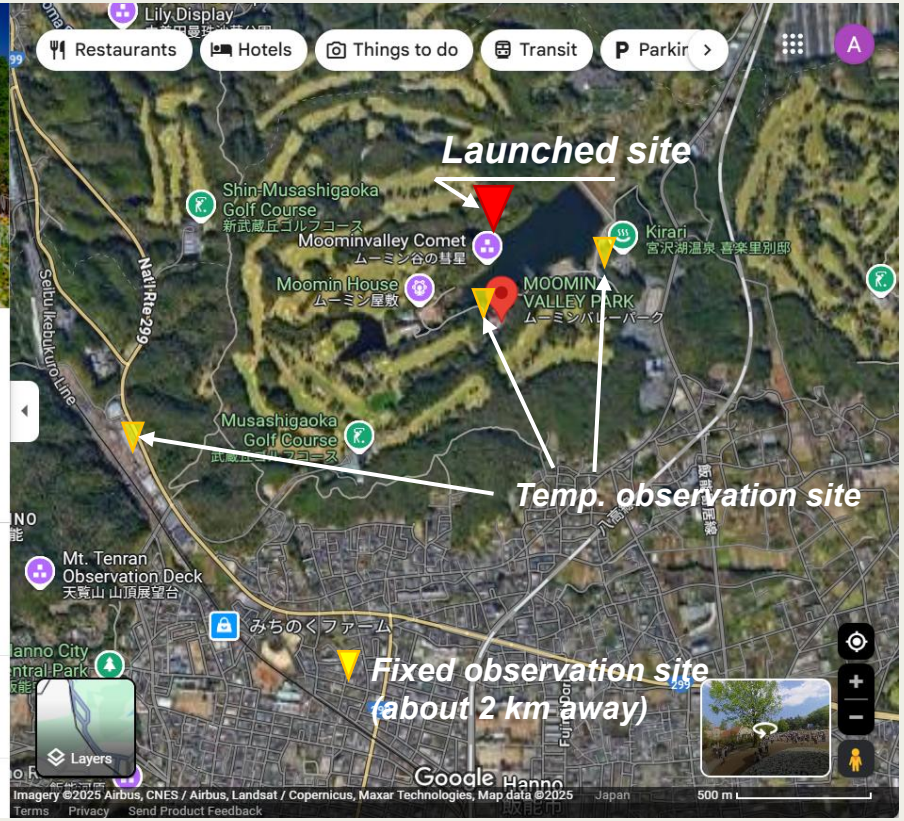
Observation of fireworks

- 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.





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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

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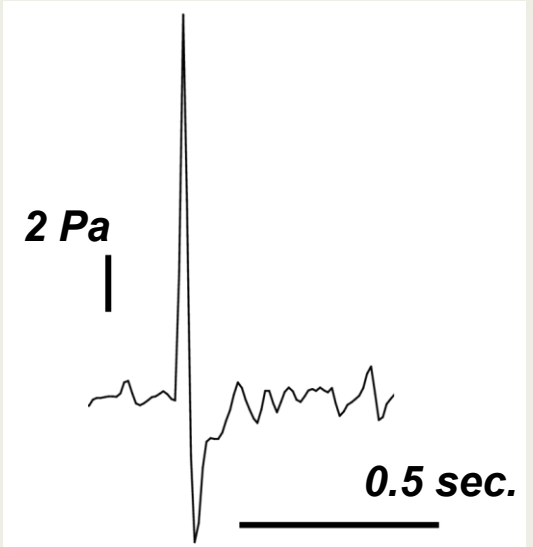
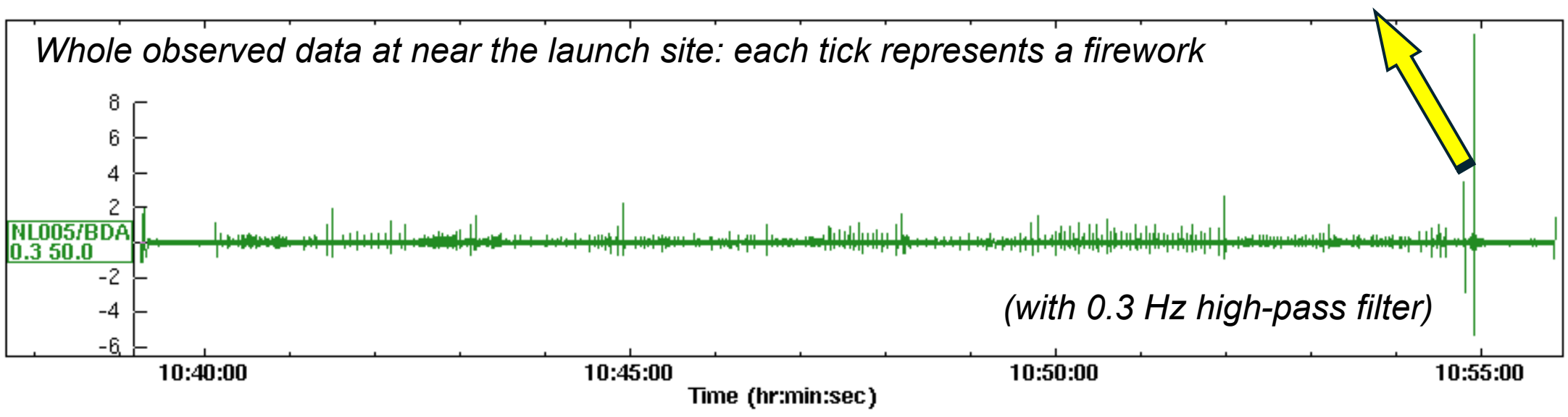
Observed data

- 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.





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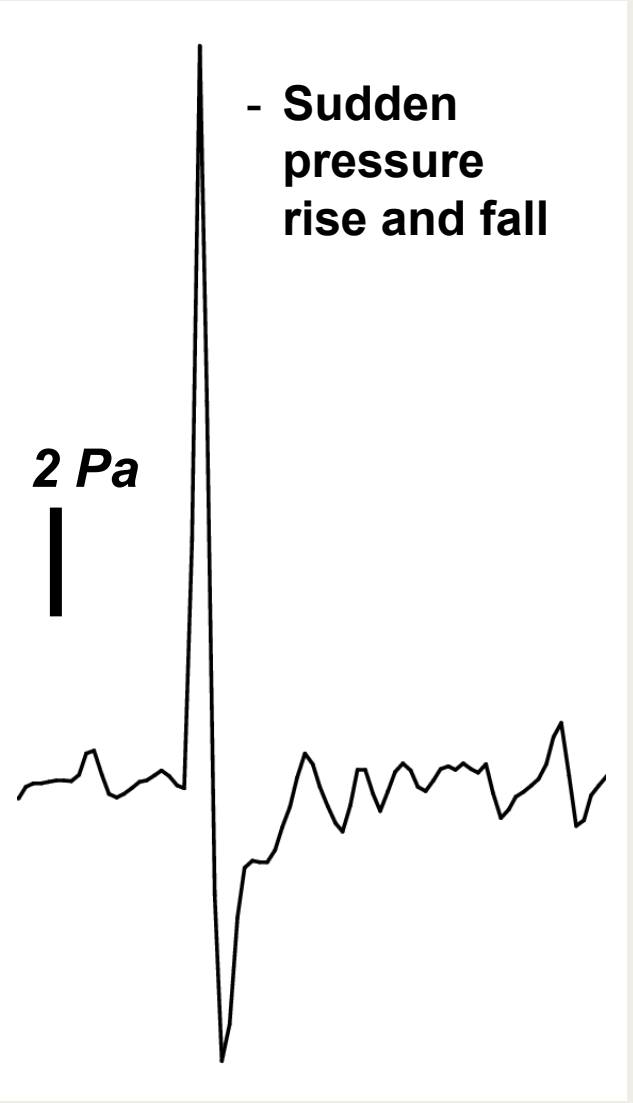
Observed data / waveform groups

- **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**.
- ***The shape of the waveform varies depending on the explosion size?***



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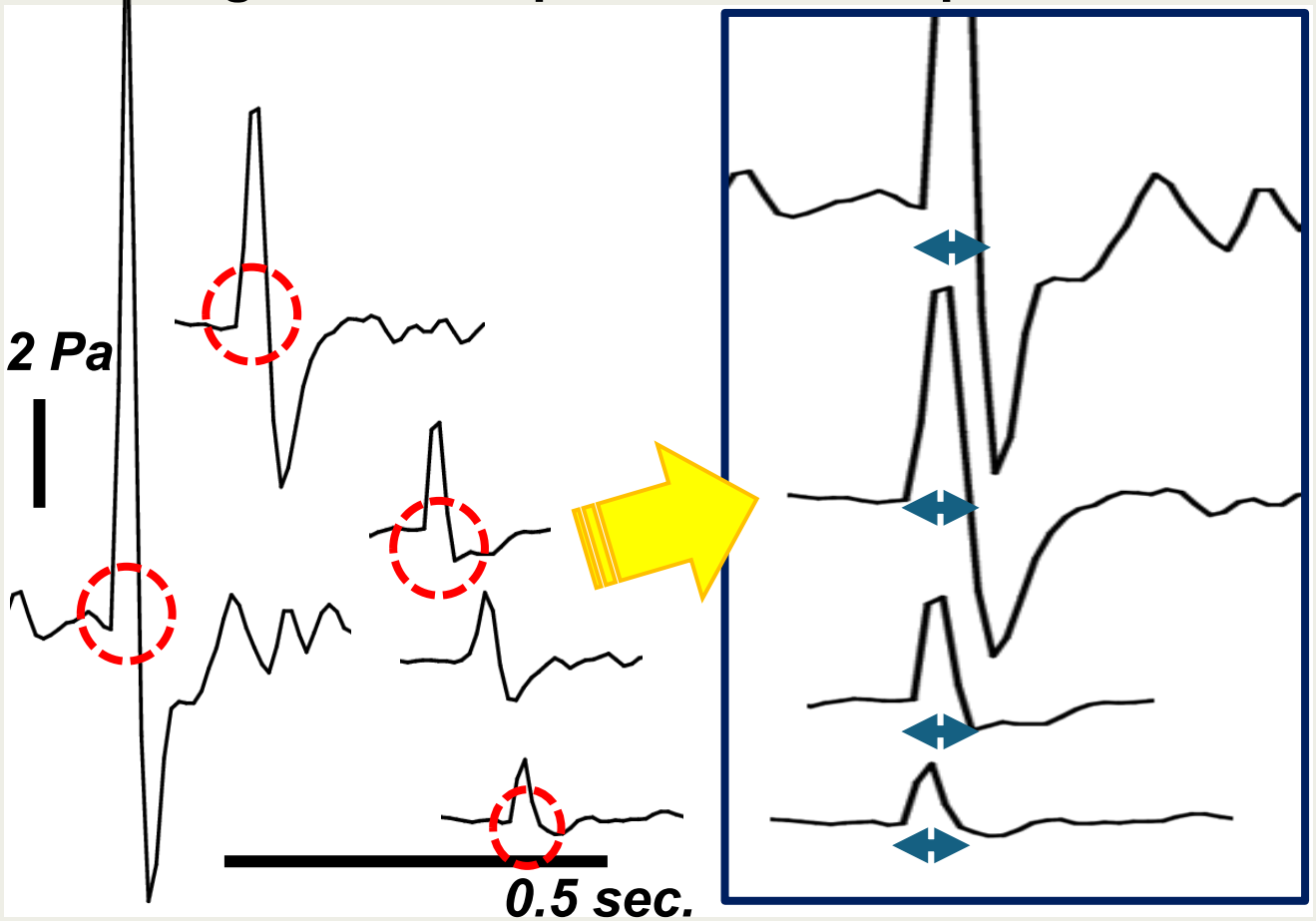
Observed data / the time required for expansion caused by an explosion

- **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…***

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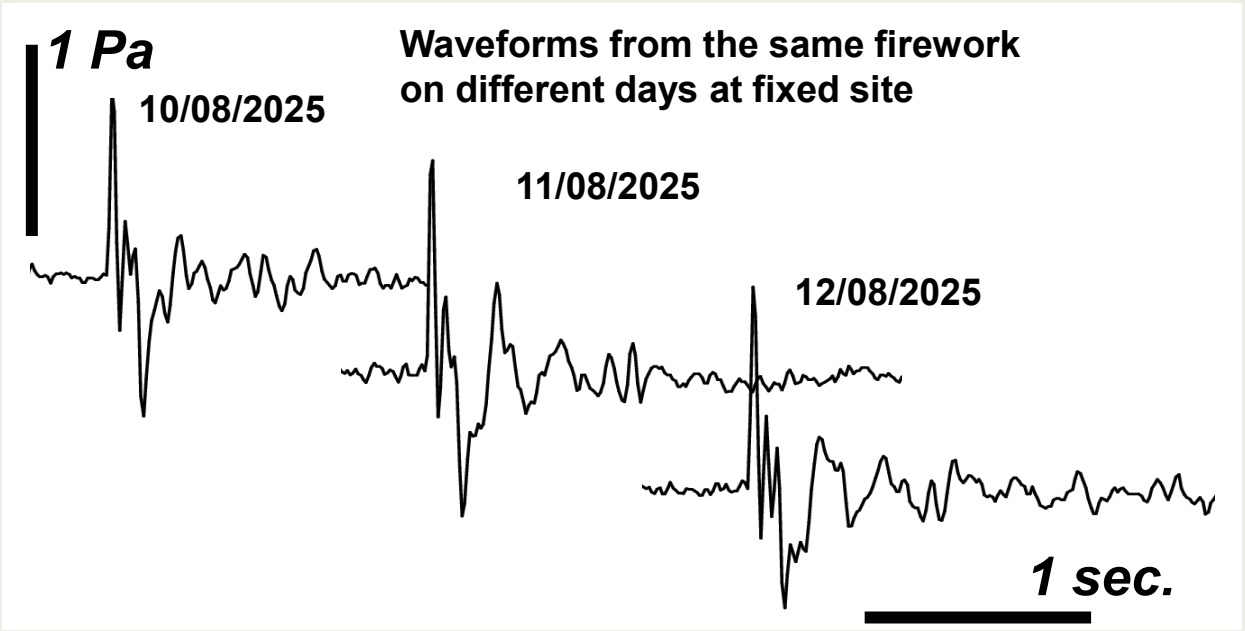
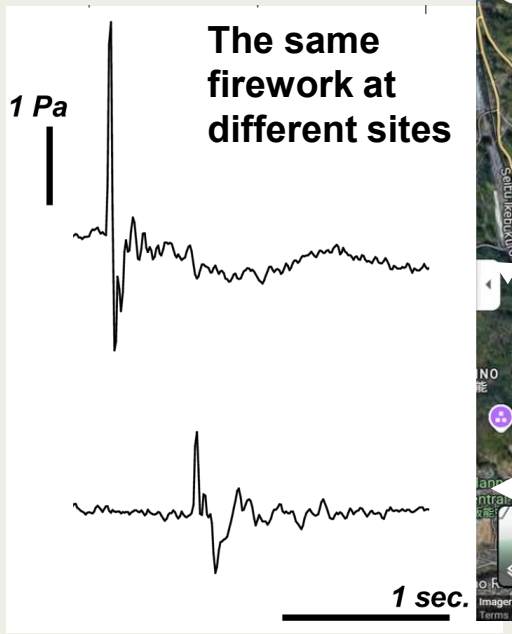
Observed data / overall waveform shapes including the coda

- **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.**

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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.

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