— This is a pre-print of a non-peer reviewed article entitled "Did Seattle go silent during the Superbowl" which will shortly be submitted for review. Author: Ben Fernando, bfernan9@jh.edu. —

Non-peer reviewed **Report** submitted to SEISMICA

Did Seattle go silent during the Superbowl?

Benjamin Fernando * [1]

[1]Department of Earth and Planetary Sciences, Johns Hopkins University, Baltimore, MD, 21211

Author contributions: *Conceptualization*: BF. *Formal Analysis*: BF. *Writing - Original draft*: BF.

Abstract Large-scale cultural events such as sports games and music concerts are known to cause localised seismic excitation above background noise levels. In this paper we investigate whether a comparable far-field 'quietening' could be observed during Superbowl LX (February 8, 2026) in the city of Seattle, hometown of the Seattle Seahawks, as people stayed indoors to watch the game. We find that a number of stations in metropolitan Seattle and other urban or semi-urban areas of Washington state experienced their quietest Sunday afternoon in the last year in some or all of the 1-40 Hz frequency band which we examined. Comparable behaviour is not identified at stations in uninhabited areas of Washington. These results support the hypothesis that at least parts of Seattle and the wider state were comparatively 'silent' during Superbowl LX.

Non-technical summary During a sports game or concert, fans celebrating in a stadium may produce 'human earthquakes' that can be detected locally. This has been known for some time. However, very little work has been done on exploring whether such cultural events affect the seismic noise far from the stadium; i.e. whether people avoid noisy activities such as driving to watch the game. We analyse seismic data from Seattle and other areas of Washington state during Superbowl LX on February 8, 2026. We find that a number of stations, especially in metropolitan Seattle and Spokane, experience their quietest Sunday in the last year in some frequency bands. This supports our hypothesis that significant cultural events can in fact have a seismic impact far from their origin.

1 Introduction

It is well-accepted that cultural activities often have a seismic impact. In particular, large stadium-based gatherings such as sport games and music concerts have been shown to produce appreciable increases in recorded seismicity (Malone et al., 2015; Díaz et al., 2017; Caplan-Auerbach et al., 2023). Occasionally, individual events (such as the scoring of a goal) can be detected seismically via the vibrations that resulting crowd celebrations induce (Lorenzo, 2010; Denton et al., 2018; Vidale, 2011).

*Corresponding author: bfernan9@jh.edu

However, studies thus far have focussed on the seismic impacts of crowd activity within or near stadia, i.e. on a local level. For the largest cultural events, there are presumably wider-ranging effects as well.

As an example, during high-profile televised sporting events we could reasonably expect that people in locations far from the stadium (e.g. in other cities) may change their behaviour as a result of the event; for example staying inside to watch it.

Such changes in behaviour may hence result in a decrease in the amplitude of anthropogenic seismic noise, if 'loud' activities such as driving and construction are avoided (e.g. Lecocq et al. (2020); Nimiya et al. (2021)). At sites where the anthropogenic noise is a dominant component of the overall seismic noise (most likely in urban areas), this may hence result in an appreciable decrease in seismic noise during said cultural activity.

1.1 Superbowl LX

The Superbowl, the annual championship game featuring the two most successful teams in American Football, is one of the most significant events in the US cultural calendar (Real, 1975; Hopsicker and Dyreson, 2017). Superbowl LX was held on the night of Sunday, 8 February 2026 (Sunday night - Monday morning UTC) in Santa Clara, California, with the Seattle Seahawks defeating the New England Patriots 29-13.

Unlike the previous three Superbowls, the LX edition involved a team based in a city (Seattle) with a high density of seismic instrumentation. As such, this iteration of the competition enables us to perform a more detailed study of whether the seismicity recorded in Seattle also changed as a result during the game, despite it occurring more than a thousand kilometres away.

2 Data

2.1 Station selection

In this study, we make use of data from the Pacific Northwest Seismic Network, managed by the University of Washington (University of Washington, 1963). This network is extensive, and includes stations in both the state of Washington and nearby Oregon. It includes instruments in urban, semi-urban, and rural settlements; as well as in remote areas.

We consider four stations in metropolitan Seattle and four in smaller settlements of varying sizes elsewhere in Washington (Spokane, Port Angeles, La Conner, and Ozette), as well as two in remote areas (Mount St Helens and Hurricane Ridge in the Olympic National Park). These are shown in Fig. 1.

It should be noted that the seismic environment at each of these stations is likely to be different. Aside from the impact of actual tectonic earthquakes, the background 'noise' is generated by a variety of sources. These include the ocean microseism (generally stronger closer to the coast), anthropogenic activity (stronger closer to industrial activity or transport corridors), and other environmental processes, such as wind (Longuet-Higgins, 1950; Ardhuin et al., 2011; Larose et al., 2015; Díaz et al., 2022). The actual amplitude of any of these signals is also modulated by their distance from the noise source and local geology, including the site response Field and Jacob (1993). Hence, should any seismic 'quietening' be experienced around the time of the Superbowl, there is no reason to expect that this would be uniform across all stations. By choosing a selection of stations, from downtown Seattle to more remote areas, we aim to elucidate these inter-station differences and hence their possible causes.

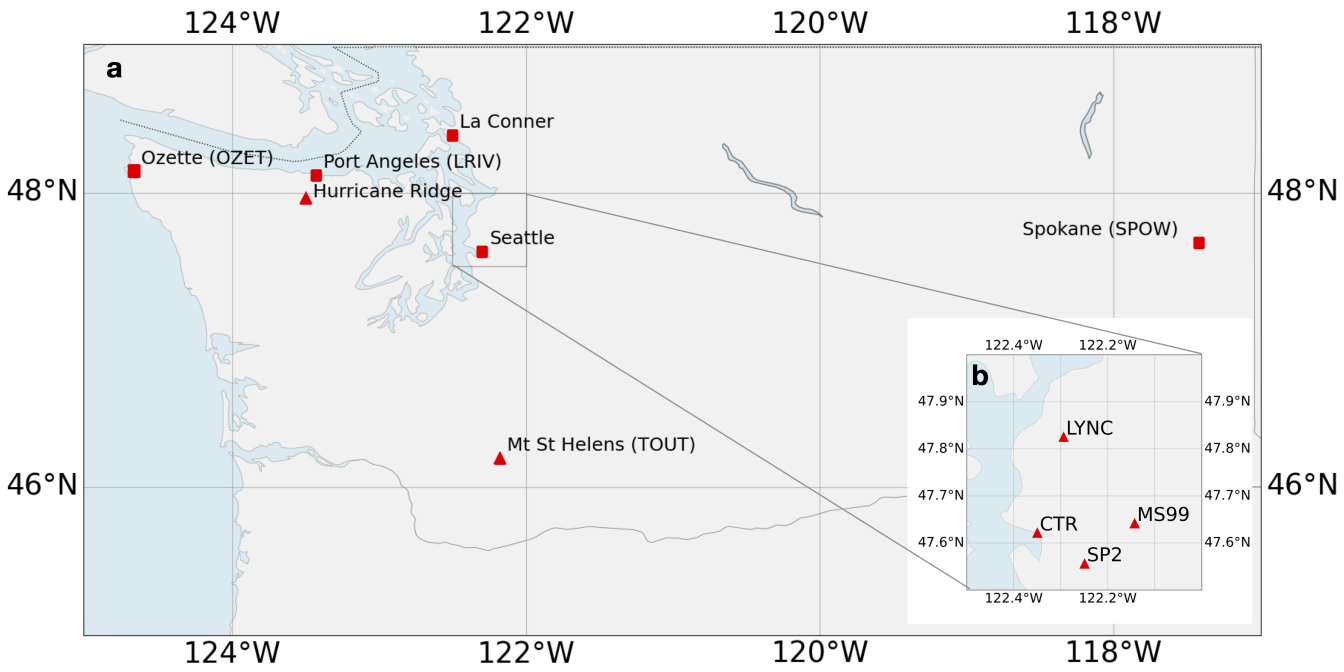

Figure 1 A map of the stations considered in this study. Those in inhabited areas are denoted by red squares, those in uninhabited areas are shown with red triangles. **a)** shows an overview of locations in Washington State, **b)** shows an inset of stations considered within metropolitan Seattle

2.2 Baseline

Because we are investigating whether the background seismic noise levels were lower during the Superbowl (rather than searching for signals of crowd activity which are already spatially and temporally localised), it is important to establish a baseline. We do this by considering data from all previous Sunday afternoons local time (Sunday nights/Monday mornings UTC) back as far as the Sunday after the last Superbowl in February 2025. This includes weeks where the anthropogenic seismic noise was likely lower for other reasons, e.g. during the weeks of Thanksgiving and Christmas/New Year.

Our window ranges from 30 minutes before kickoff to approximately 30 minutes after the final whistle (i.e. from 15:00 PST/23:00 UTC to 20:00 PST/04:00 UTC) such that the full range of gameplay is considered.

We focus on vertical-component data from the PNSN, and process via a four-corner prefilter (corners at 0.005, 0.01, 45.0, and 49.0 Hz) followed by instrument response removal. This frequency range encompasses that used in similar past studies (e.g. (Lecocq et al., 2020), and enables us to exclude the ocean microseisms whilst still capturing high-frequency anthropogenic noise. The use of 40 Hz as an upper limit also enables direct comparison across stations whose sampling rates are only 100 sps (i.e. well below the Nyquist of 50 Hz and away from the corners of our pre-filter). Note that the strong-motion seismometers on the PNSN record acceleration, so an integration is performed at this stage to output velocity.

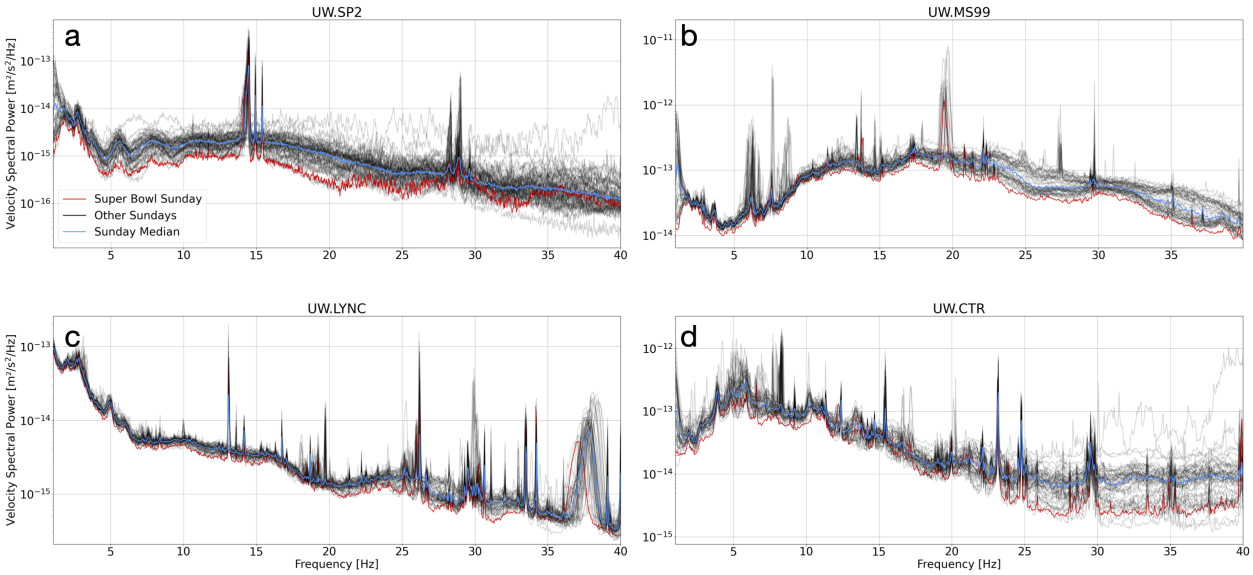

Figure 2 Vertical-component probabilistic power spectral densities for four stations located in metropolitan Seattle: **a)** SP2, located in Seward Park, **b)** MS99 located at Microsoft in Redmond, **c)** LYNC in Lynchwood, and **d)** CTR, located downtown. In each panel, each black line is the PPSD for a non-Superbowl Sunday. The blue line is the median of all Sundays, including the Superbowl Sunday. The red line is the Superbowl Sunday (February 8, 2026).

3 Results

3.1 Metropolitan Seattle

Fig. 2 shows probabilistic power spectral densities between 1 and 40 Hz for four stations in metropolitan Seattle (one downtown and three suburban). At each station, Superbowl Sunday was the quietest Sunday afternoon of the year in at least one frequency band (e.g. between 10 and 14 Hz at SP2 and between 15 and 20 Hz at MS99). In all cases, Superbowl Sunday was significantly quieter than the median noise in almost all frequency bands. The difference in which bands are quietest between the various stations likely reflects the fact that both the anthropogenic and the environmental (non-anthropogenic) noise are not constant across the network; and nor are the site responses.

3.2 Farther afield

Fig. 3 shows PPSDs for eight stations farther afield: a mixture of settlements of differing sizes (**a-d**), uninhabited areas in Washington (**e-f**), and two stations in urban areas outside Washington for comparison (**g-h**).

In panels **a-b** (semi-urban areas outside Seattle and Spokane, respectively), Superbowl Sunday is again observed to be quieter than every other Sunday in the preceding year in almost all frequency bands. In **c-d**, located farther from major centres (around 5 km from the edge of Port Angeles and in the hamlet of Ozette, respectively), smaller deviations from the median are observed. At UW.LRIV, Superbowl Sunday is quieter than most, but not all Sundays in the 1-10 Hz band, and closer to the median noise above 10 Hz. At UW.OZET, Superbowl Sunday is not appreciably quieter in any frequency band.

At stations in uninhabited areas (panels **e-f**), no appreciable difference is observed between Superbowl Sunday and other Sundays. This is as expected, given that the noise in these locations is expected to be predominantly environmental rather than anthropogenic. Note the enormous variability of the PPSD at UW.HURR, likely due to

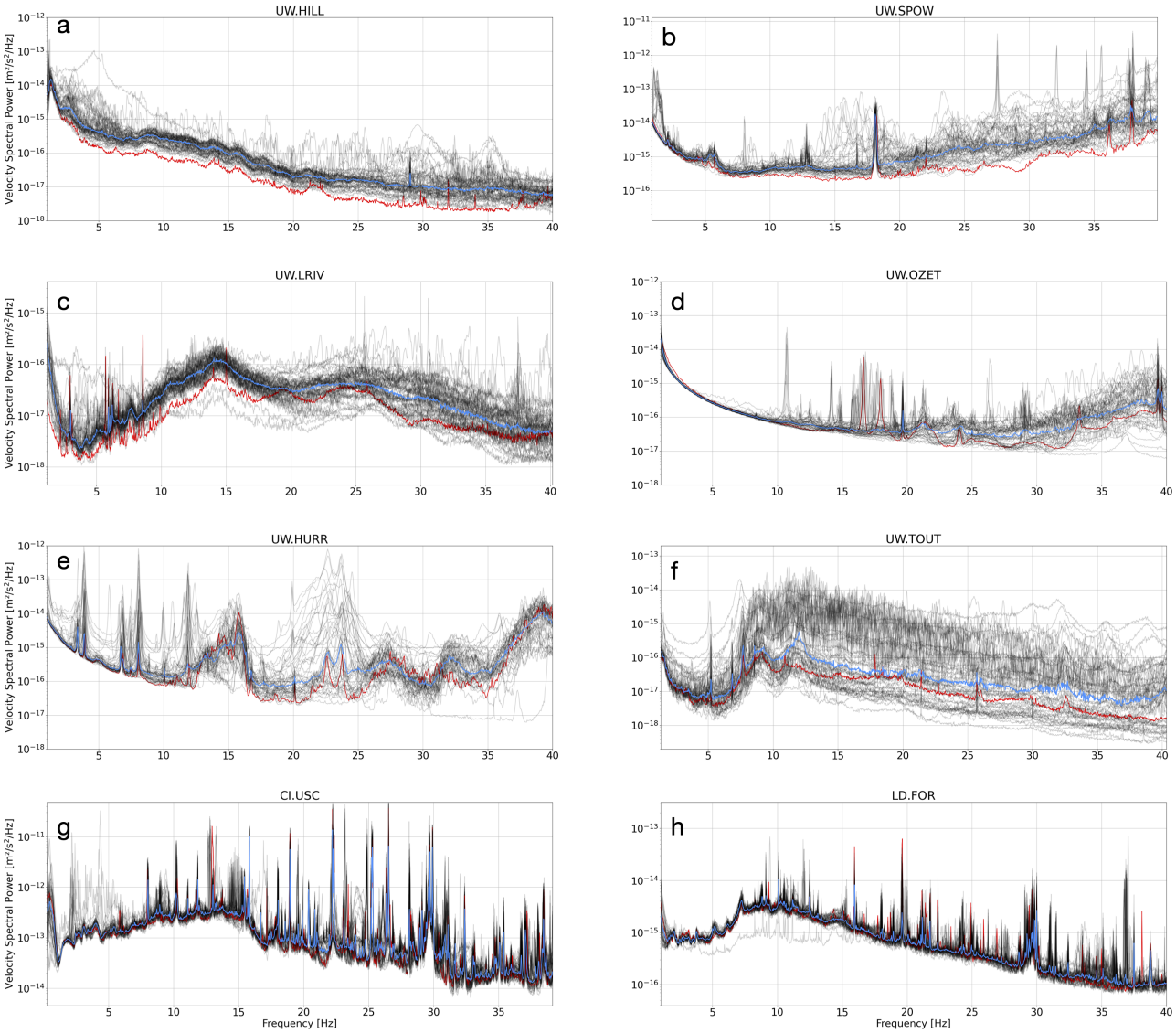

Figure 3 PPSDs for eight stations farther afield from Seattle: **a)** UW.HILL in the semi-rural area of La Conner, **b)** UW.SPOW on the edge of metropolitan Spokane in eastern Washington, **c)** UW.LRIV a few kilometres outside Port Angeles, **d)** UW.OZET in the small hamlet of Ozette on the Olympic Peninsula, **e)** UW.HURR on the uninhabited Hurricane Ridge in the Olympic National Park, **f)** UW.TOUT on the uninhabited slopes of Mount St Helens; and for external comparison two stations other non-Washington major cities: CI.USC at the University of Southern California in Los Angeles in **g)** and LD.FOR in Fordham, New York City in **h)**.

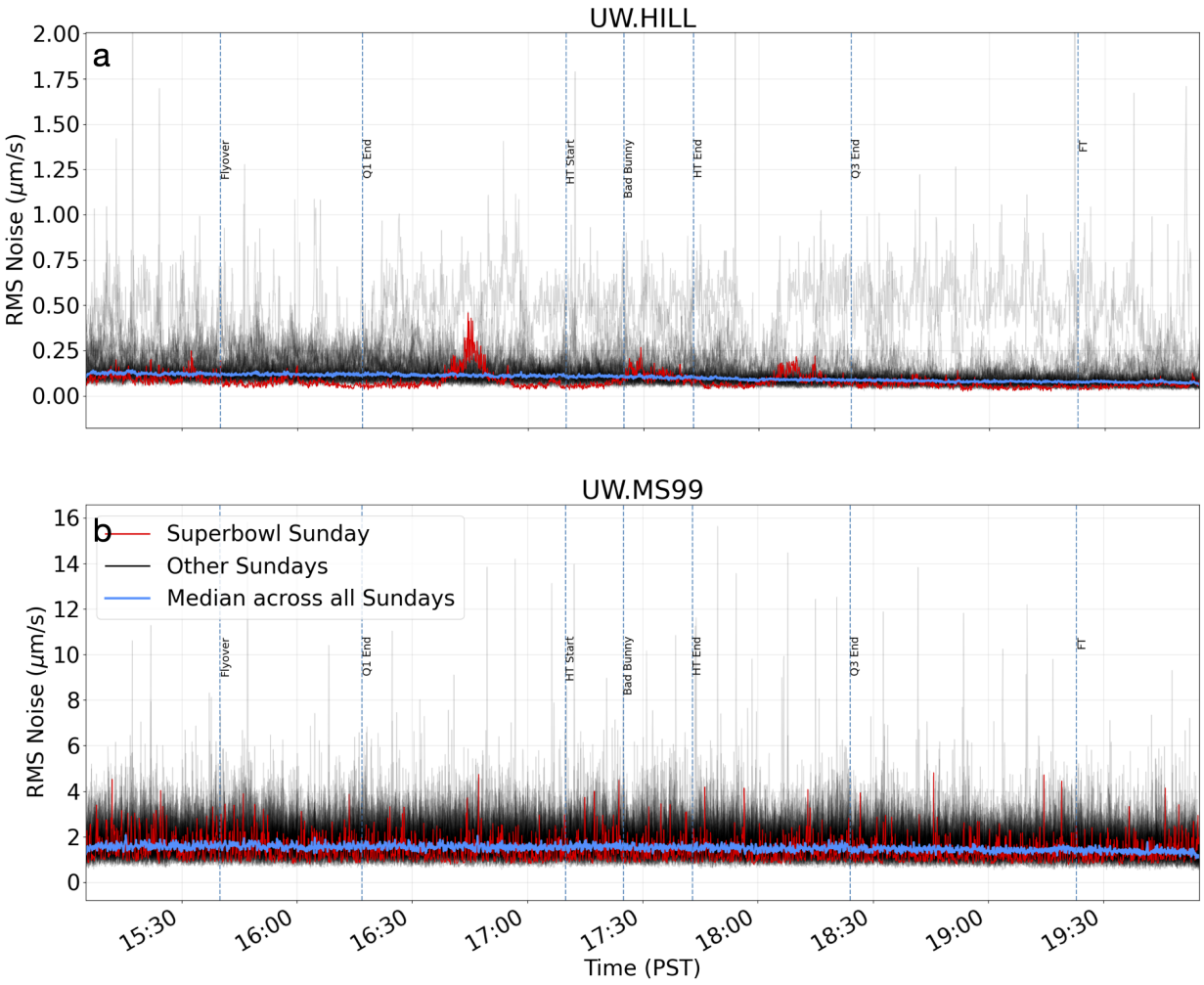

Figure 4 Time-resolved noise levels at stations **a)** UW.HILL and **b)** UW.MS99. Major events including the flyover/kickoff, end of each quarter, half-time, and full-time are shown; along with the timing of Bad Bunny's show. No particular trends are apparent.

substantial variations in wind speed on Hurricane Ridge.

For illustrative purposes only, we also show urban data from the centres of the United States' two other largest metropolitan areas, Los Angeles and New York City in panels **g**-**h**. The noise is also unchanged (and not particularly variable from week to week) at these two stations. A similar pattern of unchanged noise is seen at stations in other population centres; however as these are not the subject of this study we present only the two shown above here.

3.3 Time-resolved seismic noise variation

We also consider whether any time-resolved variations in noise are appreciable at the stations in metropolitan Seattle, which as previously discussed we expect to the most sensitive to anthropogenic noise. Data for two exemplar stations are shown in Fig. 4. Beneath its inherent variability, no appreciable trends in the noise over time are seen at UW.MS99 (noting that statistically, we expect any one day to be more variable over time than the median, as is seen). At UW.HILL the background is more variable, showing some temporally-localised increases on Superbowl Sunday. One of these appears to line up with the start of Bad Bunny's performance; but we consider that this is likely a coincidence given that similar increases occur in the middle of the second and third quarters.

4 Discussion

We observed that a number of stations in urban and semi-urban areas of Washington recorded an appreciable decrease in background seismic noise during the 2026 Superbowl. However, this correlation does not necessarily imply causation. Determining causation is significantly more challenging in this study, where we see only an absence of noise, as compared to past work which focussed on excesses of seismic energy caused by spatially and temporally localised crowd activity (e.g. (Vidale, 2011; Malone et al., 2015)).

. Previous studies of cultural events have not suffered from this problem as they have instead focussed upon excesses of seismic energy as compared to the background, i.e. spatially and temporally localised seismic signals whose origin can be identified and ascribed to a particular event.

Nonetheless, there is still clear evidence that supports the hypothesis that this quietening is indeed due to the Superbowl, including:

- Numerous stations in metropolitan Seattle recorded their quietest Sunday afternoon of the entire previous year in some part (or all of) the 1-40 Hz frequency band studied in this paper, indicating that this effect is real and that the afternoon of Superbowl LX was indeed especially quiet;

- That this effect was more pronounced at the studied stations close to population centres centres, supporting the hypothesis that this quietening is due to a decrease in anthropogenic activity;

- That no significant difference from the median Sunday noise levels was observed at stations in uninhabited areas, similarly indicating that this quietening was not primarily due to weather or other environmental factors;

- That no significant quietening was observed at urban stations in other areas of the country, indicating that this was not a nationwide phenomenon.

We explicitly note that not all stations in urban areas of Washington experienced this quietening, i.e. it is not correct to say that the entire city of Seattle was quieter than on any other Sunday in the previous year. This is as expected — the dominant source of noise depends on the station and frequency band considered, and not all sources of anthropogenic noise are expected to be affected equally by cultural events.

4.1 Conclusions

Our results indicate that it was indeed quieter at many locations in Seattle (and in some other urban and semi-urban areas of Washington state) during the Seahawks' appearance in Superbowl LX. This is one of the first indications that the seismic impacts of sporting or cultural events extend beyond the area local to the stadium where the event is being held. More detailed studies, for example across multiple Superbowls and multiple cities, can hence be used to provide insight into human behavioural changes during such events.

Acknowledgements

Data and code availability

Data for the Pacific Northwest Seismic Network, hosted by the University of Washington, are available via IRIS/EARTHSCOPE or the Northern California Earthquake Data Center. See University of Washington (1963). For data from the Southern California or Lamont-Doherty (New York) networks see California Institute of Technology and United States Geological Survey Pasadena (1926) and (Lamont Doherty Earth Observatory (LDEO), Columbia University, 1970) respectively.

Processing and visualisation undertaken in this paper made use of the NumPy (Harris et al., 2020), SciPy (Virtanen et al., 2020), ObsPy (Beyreuther et al., 2010), CartoPy (Met Office, 2010 - 2015), and Matplotlib (Hunter, 2007) packages.

Competing interests

The authors declare no competing interests.

References

Ardhuin, F., Stutzmann, E., Schimmel, M., and Mangeney, A. Ocean wave sources of seismic noise. *Journal of Geophysical Research: Oceans*, 116(C9), 2011.

Beyreuther, M., Barsch, R., Krischer, L., Megies, T., Behr, Y., and Wassermann, J. ObsPy: A Python toolbox for seismology. *Seismological Research Letters*, 81(3):530–533, 2010.

California Institute of Technology and United States Geological Survey Pasadena. Southern California Seismic Network, 1926. doi: 10.7914/SN/CI.

Caplan-Auerbach, J., Marczewski, K., and Bullock, G. Beast Quake (Taylor's Version): analysis of seismic signals recorded during two Taylor Swift concerts. *Research Square Pre-print*, 2023.

Denton, P., Fishwick, S., Lane, V., and Daly, D. Football quakes as a tool for student engagement. *Seismological Research Letters*, 89(5): 1902–1907, 2018.

Díaz, J., Ruiz, M., Sánchez-Pastor, P. S., and Romero, P. Urban seismology: On the origin of earth vibrations within a city. *Scientific reports*, 7(1):15296, 2017.

Díaz, J., DeFelipe, I., Ruiz, M., Andrés, J., Ayarza, P., and Carbonell, R. Identification of natural and anthropogenic signals in controlled source seismic experiments. *Scientific reports*, 12(1):3171, 2022.

Field, E. and Jacob, K. The theoretical response of sedimentary layers to ambient seismic noise. *Geophysical research letters*, 20(24): 2925–2928, 1993.

Harris, C. R., Millman, K. J., Van Der Walt, S. J., Gommers, R., Virtanen, P., Cournapeau, D., Wieser, E., Taylor, J., Berg, S., Smith, N. J., et al. Array programming with NumPy. *nature*, 585(7825):357–362, 2020.

Hopsicker, P. and Dyreson, M. Super bowl sunday: A national holiday and a global curiosity, 2017.

Hunter, J. D. Matplotlib: A 2D graphics environment. *Computing in Science & Engineering*, 9(3):90–95, 2007. doi: 10.1109/MCSE.2007.55.

Lamont Doherty Earth Observatory (LDEO), Columbia University. Lamont-Doherty Cooperative Seismographic Network, 1970. doi: 10.7914/SN/LD.

Larose, E., Carrière, S., Voisin, C., Bottelin, P., Baillet, L., Guéguen, P., Walter, F., Jongmans, D., Guillier, B., Garambois, S., et al. Environmental seismology: What can we learn on earth surface processes with ambient noise? *Journal of Applied Geophysics*, 116:62–74, 2015.

Lecocq, T., Hicks, S. P., Van Noten, K., Van Wijk, K., Koelemeijer, P., De Plaen, R. S., Massin, F., Hillers, G., Anthony, R. E., Apoloner, M.-T., et al. Global quieting of high-frequency seismic noise due to COVID-19 pandemic lockdown measures. *Science*, 369(6509):1338–1343, 2020.

Longuet-Higgins, M. S. A theory of the origin of microseisms. *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences*, 243(857):1–35, 1950.

Lorenzo, J. M. Seismology in Sport. *Seismological Research Letters*, 81(3):526–529, 2010.

Malone, S., Hall, K., Simmons, L., and Vidale, J. How to recognize a “beast quake” and a “dance quake”. *Seismological Research Letters*, 86 (3):1006–1008, 2015.

Met Office. *Cartopy: a cartographic Python library with a Matplotlib interface*. Exeter, Devon, 2010 - 2015. https://cartopy.readthedocs.io.

Nimiya, H., Ikeda, T., and Tsuji, T. Temporal changes in anthropogenic seismic noise levels associated with economic and leisure activities during the COVID-19 pandemic. *Scientific reports*, 11(1):20439, 2021.

Real, M. R. Super bowl: Mythic spectacle. *Journal of communication*, 25(1):31–43, 1975.

University of Washington. Pacific Northwest Seismic Network - University of Washington, 1963. doi: 10.7914/SN/UW.

Vidale, J. E. Seattle “12th man earthquake” goes viral. *Seismological Research Letters*, 82(3):449–450, 2011.

Virtanen, P., Gommers, R., Oliphant, T. E., Haberland, M., Reddy, T., Cournapeau, D., Burovski, E., Peterson, P., Weckesser, W., Bright, J., et al. SciPy 1.0: fundamental algorithms for scientific computing in Python. *Nature methods*, 17(3):261–272, 2020.