Authors' Response to Reviews

Reviewer A

We would like to express our gratitude to reviewer A for his/her constructive comments, which have helped us improve the clarity and completeness of our work. We have carefully considered each of the reviewer's comments and have made an effort to incorporate additional information addressing these points where appropriate. The reviewer's comments primarily focus on what additional information could be added to help readers better understand the relationships between human activity and seismic noise.

We have made an effort to investigate certain aspects, but we encountered some objective difficulties along the way. For example, we attempted to investigate a potential correlation between changes in seismic noise and city populations, but such a correlation appears to be negligible, with only a general trend observed. Another example concerns the correlation of seismic noise changes at the regional scale with mobility data. However, Google does not provide suitable regional data for Greece, making a reliable comparison challenging.

Below we provide detailed, point-by-point responses to address each suggestion.

The reviewers' original comments appear in blue italicized text, followed by our responses in plain text.

Pages and lines numbers correspond to the revised manuscript version, with changes highlighted.

This is a review comment to the manuscript entitled "The impact of COVID-19 lockdown measures on high-frequency seismic ambient noise in Greece: Utilizing strong-motion seismograph networks for human activity monitoring in urban environments" by Giannopoulos et al., submitted to Seismica. Authors investigated seismic noise level in Greece during COVID-19 pandemic, and observed noise reduction during lockdown. Such observations have been made by previous studies including global and regional ones as cited in the manuscript, and authors added national scale observation in Greece. Although their basic observation is rigid, some additional investigation will be helpful for readers to understand relationships between human activity and seismic noise. My comments are listed below, which should be addressed before publication.

1. Noise reduction is various frequency band

Authors observed noise reduction in various frequency band as shown in Figure 3 and concluded that 10-30 Hz is most influenced by human activities. Can authors quantitatively describe how much the noise reduction varies according to the frequency range? For example, the amount of noise reduction in 4-20 Hz and 20-45 Hz are well correlated?

A quantitative description of noise reductions across various frequency ranges is provided in Tables R1 and R2, below. Table R1 shows the percentage changes in seismic noise at the specific stations shown in Figure 3 of the manuscript, while Table R2 summarizes national-scale daily median changes across the different frequency ranges. The 50-90 Hz range is excluded, as it is not applicable to all instruments. In addition, Figure R1 (similar to Figure 8 of the manuscript) visualizes the temporal percentage changes across these frequency ranges. We created these figures and tables to provide a clearer visualization of the discussion.

Table R1: Percentage changes in seismic noise for different frequency ranges at the stations depicted in Figure 3 of the manuscript. Cells shaded in dark and light green indicate the smallest and second lowest observed reductions, respectively.

	4-14 Hz		**4-20 Hz**		**5-25 Hz**		**10-30 Hz**		**20-45 Hz**	
	LD1	LD2	LD1	LD2	LD1	LD2	LD1	LD2	LD1	LD2
NOAC	-14.2 %	-9 %	-15.3 %	-9.8 %	-19.1 %	-11 %	-31.9 %	-22.8 %	-33.9 %	-21 %
PATG	-40.9 %	-32.3 %	-41 %	-32.2 %	-41.5 %	-33 %	-37.8 %	-30 %	-41.3 %	-28.4 %
OREA	-22.1 %	-0.4 %	-23.9 %	-1.8 %	-24.3 %	-2.4 %	-27.1 %	-8.6 %	-31.6 %	-12.9 %

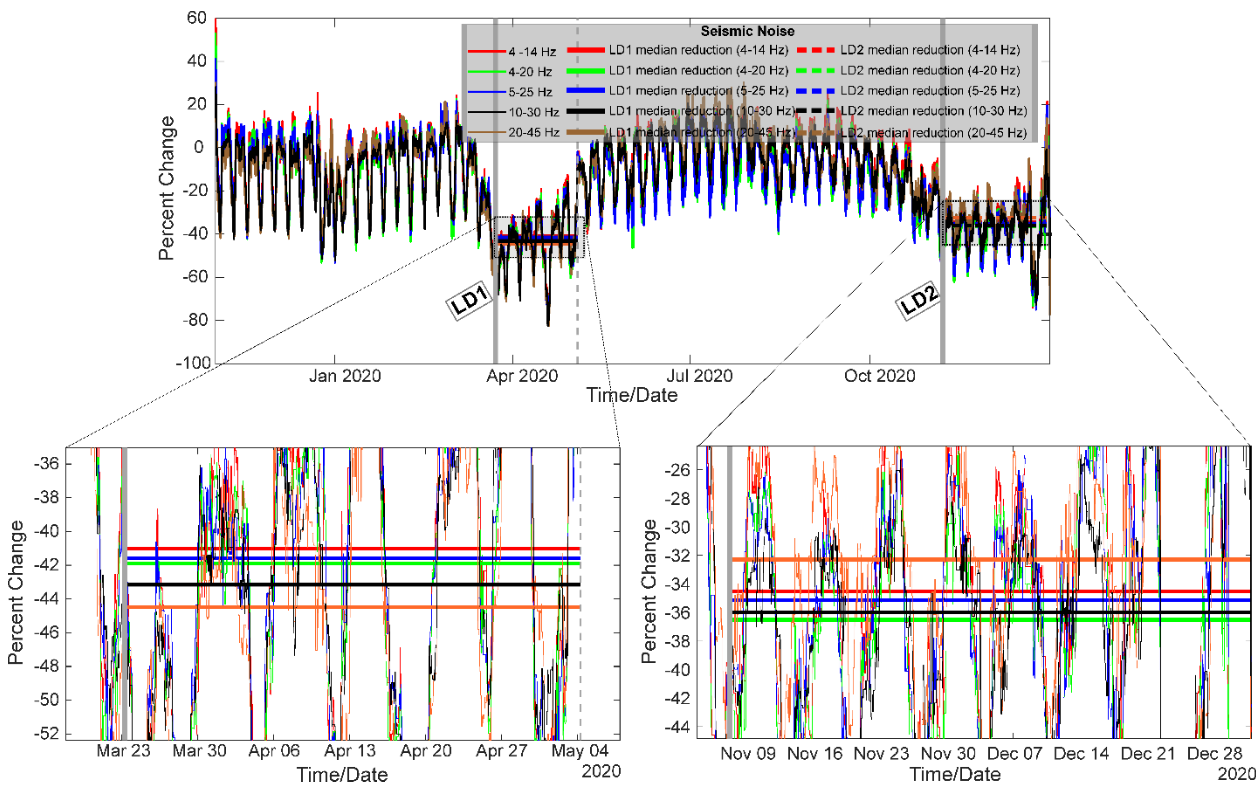

Figure R1: An overplot of the temporal percentage changes in the national-scale daily median observed across different frequency ranges.

Table R2: Percentage changes in the national-scale daily median in seismic noise for different frequency ranges. Cells shaded in dark and light green indicate the smallest and second lowest observed reductions, respectively.

	4-14 Hz		**4-20 Hz**		**5-25 Hz**		**10-30 Hz**		**20-45 Hz**	
	LD1	LD2	LD1	LD2	LD1	LD2	LD1	LD2	LD1	LD2
Percent Change	-41 %	-34.5 %	-41.9 %	-36.5 %	-41.6 %	-35.1 %	-43.2 %	-36 %	-44.5 %	-32.3 %

From the above, it can be concluded that, when examined on a national scale, reductions in seismic noise observed across the studied frequency ranges demonstrate a positive correlation, with notably similar patterns. However, as would be expected, variations between frequency bands can be evident at individual stations. These variations are possibly influenced by local factors, such as differences in citizens' mobility affecting the frequency content of the noise near the stations. The presence of narrow spikes in the temporal variations of the HiFSAN data, though less frequent, could affect the overall percentage changes.

At a national scale, the lockdown effects are adequately captured across all frequency ranges. Although the differences among the ranges are not substantial, the largest reduction (44.5%) during the first lockdown was observed in the 20-45 Hz frequency band, while the largest reduction (36.5%) during the second lockdown was observed in the 4-20 Hz band. The second-largest reductions during both the first and second lockdowns observed in the 10-30 Hz range, with decreases of 43.2% and 36%, respectively. The selection of an optimum frequency band for the analysis and presentation of the results becomes somewhat more challenging, especially when considering also the presence of two lockdowns.

Therefore, following the reviewer's valid observation, we acknowledge that the conclusion in the manuscript stating that "10-30 Hz is most influenced by human activities" is not entirely accurate, as the lockdown effects are adequately captured by other frequency bands as well.

For this reason, we have revised our earlier statement to clarify our reasoning for focusing on the 10-30 Hz band, while also noting the variations successfully captured by the other frequency ranges.

The main reason for choosing the 10-30 Hz frequency range is to present and visualize the results more effectively, in line with the approach followed by the majority of previous studies on this topic.

We believe it is appropriate to include the current additional Figure R1 and Tables R2 in the supplementary material, allowing readers to review the variations observed in the other frequency ranges.

The specific changes we made following this comment are as follows:

1. **Page 13, Lines 11-14**: The following text has been deleted: "Although the frequency range of the lockdown effects on seismic noise may vary among different stations, we observed that the 10-30 Hz frequency range was mostly influenced by human-related seismic noise for the majority of the stations, exhibiting more evident reductions in HiFSAN. Therefore, our analysis focused on the 10-30 Hz band."

   Page 13, Lines 14-20: The following text has been added, replacing the previously deleted one: "The lockdown effects on seismic noise are effectively captured across all studied frequency ranges, as shown in Fig. 3. However, individual station examples may reveal variations among frequency ranges, likely influenced by local factors such as the frequency content of anthropogenic noise specific to each station, or other site-specific characteristics beyond the scope of this study. To better facilitate the presentation and visualization of the results, we focused our analysis on the 10-30 Hz frequency range. Additional results regarding the variations in seismic noise across other frequency ranges are provided in the supplementary material."
2. Figure S1, presenting the temporal percentage changes in the national-scale daily median observed across different frequency ranges, has been added to the supplementary material.
3. Table S1, detailing the percentage changes in the national-scale daily median of seismic noise across different frequency ranges observed during both lockdowns, has been added to the supplementary material.

2. Noise reduction patterns in different cities

Authors showed examples in Figure 4 that different cities responded differently to two lockdown periods. Are there any interpretations about the cause of their differences? For instance, seismic stations (City Hall) surrounded by local residential area did not show significant reduction, whereas seismic station in business town showed large reduction, etc.

I'm also curious about single noise reduction for either LD1 or LD2 observed in several stations. What kind of social response to lockdown did result in such seismic noise reduction? Do authors have any interpretations?

It could be also interesting to show a map of stations categorized by the noise reduction types presented in Figure 4 and to discuss their spatial relation with the regional characteristics (residential area, business town, population of city, etc.).

Attempting to address the question, "why different cities responded differently during lockdowns?" and provide additional context for the discussion, we compiled a table (Table R3) detailing the type of building in which the stations are installed and the population of the respective area.

Since the vast majority of seismic stations used in this study are city-based, located either in the centers of their respective towns or within the limits of their urban environments, it is challenging to determine whether a station is specifically located in a business district or a residential area.

Considering our dataset, a more efficient approach is to examine if there is any relationship between noise reductions and population size. For this reason, we visualized the relationship between the percentage reduction in seismic noise and the city's population, separately for the two lockdowns (Figure R2).

Despite the fact that the population of most cities is significantly below 100.000, with a median population of about 8.000, applying a common linear regression to the data shows that there is a positive correlation between the percentage reduction in seismic noise and the population (the larger the population, the greater the observed noise reduction). While the strength of this linear relationship is understandably weak due to the nature of the data, the overall trend remains observable. This general trend is observed in both lockdowns, with the notable difference, which has already been discussed, that the percentage reduction during the first lockdown is larger than that of the second.

So, a possible explanation for the differences observed among cities could be the assumption that higher population is associated with higher baseline levels of human activity, which are subsequently more significantly suppressed during the lockdowns. Therefore, areas with larger populations tend to exhibit more pronounced reductions in seismic noise when human mobility and activity decrease. Despite the fact that the correlation coefficients indicate weak or no correlation between the noise reduction and population (see Figure R2), a comment regarding this observation has been added to the manuscript.

As in the previous comment, we believe it is appropriate to also include the current additional Table R3 and Figure R2 in the supplementary material allowing readers to access this information.

Table R3: List of seismic stations used in the present study. The type of building, the name, and the population of the town/city where the stations are located are presented.

Stations	Town/City	Building type	Population*
DRPA.HL	Drapetsona	Town Hall	13.815
LVRA.HL	Lavrio	Town Hall	10.046
YDRA.HL	Hydra Island	Monastery	2.070
NOAC.HL	Athens	Facilities of NOA	643.452
ATH5.HI	Athens	Greek Parliament	643.452
KLV1.HI'	Kalavrita	Town Hall	1.702
LCHA.HL	Lechaina	Town Hall	2.993
MSL1.HI	Messolonghi	Regional Administration Building	13.965
PATC.HL	Patras	Regional Administration Building	173.600
PATG.HL	Patras	Power Supply Company	173.600
RIOA.HL	Rio	Town Hall	5.430
ZARA.HL	Zacharo	Town Hall	3.172
ARS1.HI	Argos	Town Hall	21.891
KIAA.HL	Kiato	Town Hall	9.907
MNVA.HL	Monemvasia	Town Hall	1.626
MTHA.HL	Methoni	Town Hall	.587
NPLA.HL	Naflio	Town Hall	14.532
NPS1.HI	Neapoli	Local Health Center	2.787
PYL1.HI	Pylos	Town Hall	2.568
AIDA.HL	Aidipsos	Town Hall	4.123
DLFA.HL	Delfi	Town Hall	867
KYMI.HL	Kymi, Evia Island	Municipal Kiosk	2.888
LAM2.HI	Lamia	Regional Administration Building	47.529
ARG2.HI	Argostoli, Cephalonia Isl.	Regional Administration Building	10.982
KRK1.HI	Corfu, Corfu Island	Town Hall	30.737
SMHA.HL	Sami, Cephalonia Island	Town Hall	1.078
VAS2.HI	Vassiliki, Lefkada Island	Local Health Center	407
GINA.HL	Giannouli	Town Hall	8.165
SOFA.HL	Sofades	Town Hall	6.269
TRKA.HL	Trikala	Town Hall	62.064
VOL2.HI	Volos	Regional Administration Building	85.803
ARTB.HL	Arta	Town Hall	24.079
JAN.HL	Ioannina	Center for Social Welfare	64.896
MTVA.HL	Metsovo	Town Hall	2.337
PRGA.HL	Parga	Town Hall	2.489
AMYA.HL	Amyntaio	Town Hall	4.348
LMS2.HI	Laimos	Town Hall	176
DRA2.HI	Drama	Hospital	44.257
MMAA.EG	Thessaloniki	Museum	309.617
NASA.HL	Naoussa	Town Hall	18.049
OREA.HL	Oraiokastro	Town Hall	23.626
PLG.HL	Polygyros	Traffic Education Park	7.779
PLN1.HI	Chaniotis	Town Hall	938
SHTA.EG	Thessaloniki	School for the blinds	309.617
STC.EG	Stivos	Community Building	502
ALXA.HL	Alexandroupolis	Museum	59.723
KOMA.HL	Komotini	Regional Administration Building	54.165
SFL1.HI	Soufli	Local Health Center	3.770
THS1.HI	Prinos, Thasos Island	Local Health Center	1.330
TRGA.HL	Dikaia	Town Hall	557
XANC.HL	Xanthi	Town Hall	58.760
EFSA.HL	Agios Efstratios Island	Town Hall	257

KRL1.HI	Karlovasi, Samos Island	University	7.363
LMN1.HI	Myrina, Lemnos Island	Town Hall	6.190
PRK.HL	Agia Paraskevi, Lesvos Isl.	Municipality building	2.053
SKY1.HI	Skyros Island	Town Hall	3.052
ASTA.HL	Astypalaia Island	Town Hall	1.376
KLNA.HL	Kalymnos Island	Hospital	17.752
KSL.HL	Kastelorizo Island	Municipality building	584
KSS1.HI	Kasos Island	Citizen Service Center	1.223
MILA.HL	Milos Island	Town Hall	902
NAX1.HI	Naxos Island	Town Hall	8.897
NISR.HL	Nisyros Island	Monastery	1.048
RDI1.HI	Rhodes, Rohodes Island	Town Hall	56.440
RODB.HL	Rhodes, Rohodes Island	School of Tourism Education	56.440
THRA.HL	Thira Island	Town Hall	1.516
AGNA.HL	Agios Nikolaos, Crete	Telecommunication Company	13.605
CH01.HI	Chania, Crete	Regional Administration Building	54.559
CHNB.HL	Chania, Crete	Town Hall	54.559
HERG.HL	Heraklio, Crete	Town Hall	156.842
RTHF.HL	Rethymno, Crete	Municipality building	35.763
SIT2.HI	Siteia, Crete	Town Hall	11.166

*Population of the municipality where the seismic stations are located. Population data are derived from the 2021 Population-Housing Census conducted by the Hellenic Statistical Authority (https://www.statistics.gr/documents/20181/17286366/APOF_APOT_MON_DHM_KOIN.pdf/41ae8e6c-5860-b58e-84f7-b64f9bc53ec4).

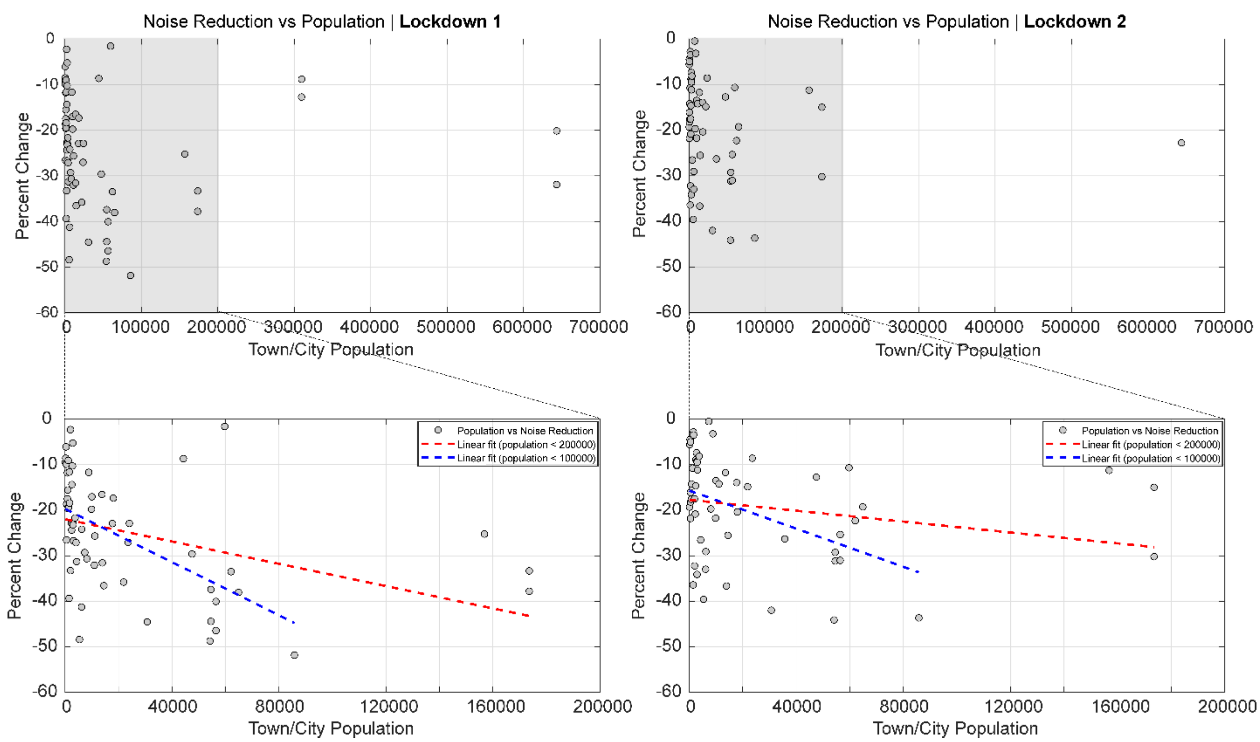

Figure R2: The percent changes in HiFSAN are plotted against the population of each respective city. The regression lines depict the linear relationship between the percent reductions and population size. The correlation coefficients (R) are -0.06 for LD1 and -0.13 for LD2, indicating a weak or negligible correlation between the two parameters.

Regarding, the single noise reductions observed in a few stations for either LD1 or LD2, this likely reflect the varying levels of citizens' mobility within the vicinity of the seismic stations during each lockdown period. Specifically, this could include human activity changes both within the buildings housing the seismic stations and in the surrounding areas. For example, stations located in buildings that for some reasons continued to operate partially during one lockdown but not the other, or those situated near areas with differing patterns of essential activity, could exhibit such variations. While detailed local mobility data are unavailable for precise comparisons, it is cautious to attribute these reductions to the general relationship between mobility and seismic noise variations observed during lockdowns.

We acknowledge the reviewer's suggestion of including a map categorizing the noise reduction types presented in Figure 4 of the manuscript. However, since the large majority of the reductions are linked to decreases observed during both lockdowns (despite differences in percent variation), this reflects a consistent response to restrictions in human activity across various regions and stations. As such, we believe that an additional map may not provide significantly new insights on this matter. Furthermore, we have added a comment to the manuscript following Figure 4 to emphasize that the most frequently observed pattern is associated with reductions during both lockdowns, making this observation clearer to readers. Also, in response to Comment 3, which somewhat related with the current comment, we included an additional map in the manuscript depicting the differences between two lockdowns.

The specific changes we made following this comment are as follows:

1. **Page 17, Lines 2-3**: The following text has been added: "Notably, the vast majority of stations in the current analysis exhibit similar patterns, demonstrating reductions during both lockdowns."
2. **Page 17, Line 3**: "some" has been replaced with "a very few".
3. **Page 17, Lines 6-10**: We added the following text: "This observation likely reflects varying levels of anthropogenic activity within the vicinity of the seismic stations during each lockdown period. This could include mobility changes both within the buildings housing the seismic stations and in the surrounding areas. For example, stations located in buildings that for unknown reasons continued to operate partially during one lockdown but not the other, could exhibit such variations."
4. **Page 23, Lines 1-7**: We added the following text: "A possible explanation of the varying responses of different cities during the lockdowns could be differences in population size. Although there is no strong statistical relationship between noise reduction and population size (see supplementary

material), a general trend suggests that cities with larger populations are typically associated with higher baseline levels of human activity, which tend to be more significantly suppressed during lockdowns. As a result, areas with larger populations are more likely to exhibit pronounced reductions in seismic noise as human mobility and activity decrease during the lockdowns."

5. Table S2, which lists the building type, name, and population of the town/city where the stations are located, has been added to the supplementary material.

6. Figure S2, illustrating the relationship between seismic noise reduction and population, has been included in the supplementary material.

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3. Noise reduction during two lockdowns

In Figure 6, authors presented spatial distributions of noise reduction for two lockdowns. Please also provide a correlation plot of the amount of noise reduction during two lockdowns. Related to my comment #2 above, is there any interpretations about the spatial variations of noise reduction and regional characteristics?

We appreciate the reviewer's suggestion, as such a plot can effectively visualize interesting information and could indeed be a useful addition to the manuscript. Following the reviewer's comment, we included an additional figure in the manuscript, which is also presented below as Figure R3. Figure R3 provides a correlation plot of the noise reductions observed during the two lockdowns, along with a map view showing the spatial distribution of the differences in percent reductions.

The correlation plot illustrates both the quantitative distribution of percent reductions during the two lockdowns and the positive linear relationship between the two parameters. It is also visually evident that the reduction in seismic noise levels observed during the second lockdown is smaller compared to the first one.

The differences in percent reduction between the two lockdowns show how reductions during the first compare to the second lockdown for each station. Positive values (warm colors) indicate that the first lockdown had a greater reduction than the second one, while negative values (cool colors) indicate that the second lockdown had a greater reduction than the first one. Evidently, the differences were calculated only for the stations where reductions were observed during both lockdowns.

Regarding the interpretation of potential spatial variations in seismic noise reductions, no specific pattern is observed beyond what was previously mentioned in our response. A potential interpretation primarily relates to the fact that larger noise reductions appear to be associated with cities that have larger populations. Additionally, based on the map in Figure R3(e), it is evident that in larger cities, with populations exceeding 100000, the reduction observed during the first lockdown is greater than that of the second lockdown. In smaller cities, most stations follow the same trend, but some, exhibit grater reductions during the second lockdown. This observation will be incorporated into the manuscript.

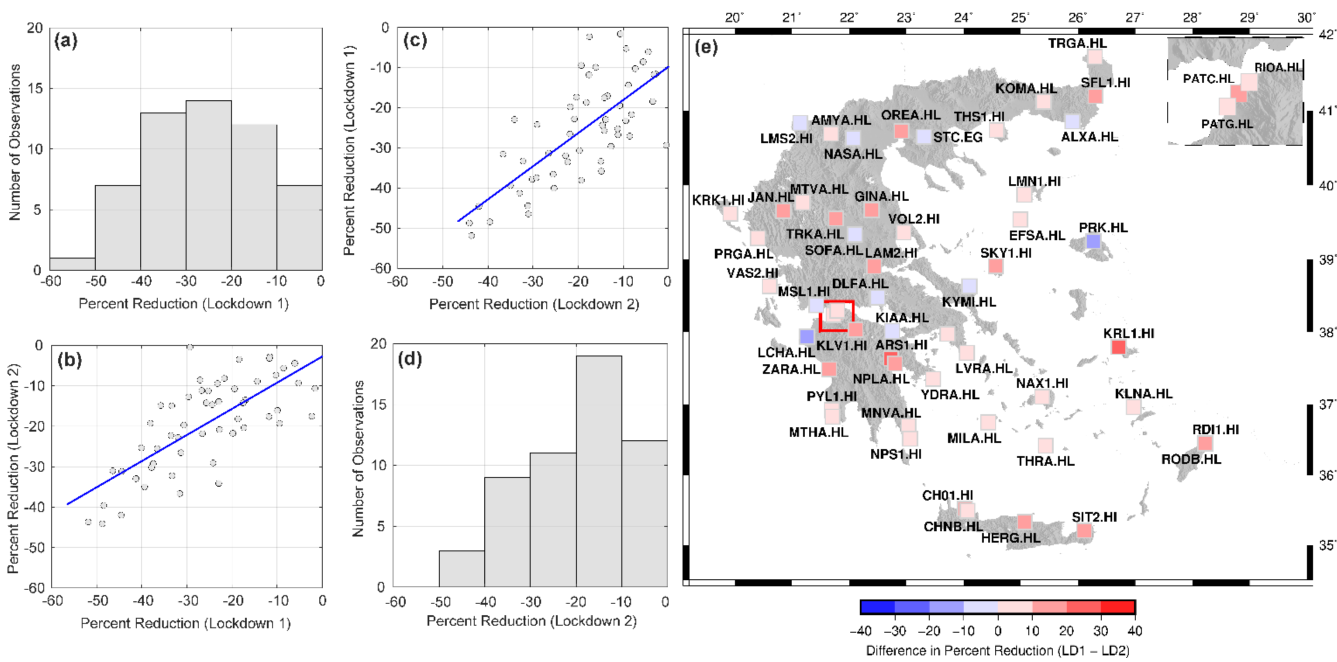

Figure R3: Correlation analysis of percent reductions in seismic noise during the two lockdowns and their differences, as visualized in a map view. (a, d) Histograms showing the distribution of percent reductions for each lockdown. (b, c) Scatter plots with regression lines illustrating the linear relationship between the percent reductions observed in the two lockdowns. The correlation coefficient (R) is 0.73, indicating a strong positive relationship. (e) Map view showing the differences in percent reductions between the first and second lockdown at each station. Warm colors (positive values) indicate greater reductions during the first lockdown, while cool colors (negative values) indicate larger reductions during the second lockdown. The differences were calculated only for stations where reductions were observed during both lockdowns.

The specific changes we made following this comment are as follows:

1. **Page 24, Lines 6-17 and Page 25, Lines 1-4:** The following text has been added: “Figure 7 examines the relationship between noise reductions during LD1 and LD2, showing a correlation plot (Fig. 7a-

d) and a map of the spatial distribution of percent reduction differences between the two lockdowns (Fig. 7e). The percent reductions of LD1 compared to those of LD2 show a positive linear relationship, with a correlation coefficient of 0.73. This suggests a consistent trend across stations, although noise reductions during the second lockdown are generally smaller than those observed during the first. Exceptions to this general trend are clearly visible in the map of Fig.7e, where positive values (warm colors) indicate greater reductions during the first lockdown, and negative values (cool colors) indicate larger reductions during the second lockdown. While no distinct spatial patterns emerge, a general trend is evident. In larger cities with populations exceeding 100,000, reductions during the first lockdown tend to be more pronounced compared to those of the second. For instance, this is observed at stations such as NOAC (Athens), OREA (Thessaloniki), PATC, PATG, RIOA (Patras), and HERG (Heraklion). In smaller cities, most stations follow the same trend, but some, such as LCHA (Lechaina) and SOFA (Sofades), exhibit grater reductions during the second lockdown. As previously noted, while the correlation between noise reduction and population size lacks strong statistical support, we cautiously observe that business cities with larger populations tend to experience greater reductions in seismic noise levels, particularly during the first lockdown."

2. An extra figure has been added to the manuscript as Figure 7.

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4. Comparison with Google mobility data

Authors compared seismic noise reduction with Google mobility data in Figure 8. Although this comparison was made in national scale only, are there any regional differences? As Google provided regional ("Decentralized Administration") scale data, it might be worth comparing regional seismic noise reduction and mobility data.

We greatly appreciate the reviewer's suggestion, which we had indeed considered during the early stages of the manuscript, as it would be particularly very interesting in the Greek context as well. Greece is divided into 13 administrative regions (1. Attica, 2. Central Greece, 3. Peloponnese, 4. Western Greece, 5. Ionian Islands, 6. Thessaly, 7. Epirus, 8. Western Macedonia, 9. Central Macedonia, 10 East Macedonia and Thrace, 11 North Aegean, 12 South Aegean, and 13. Crete). However, Google provides regional mobility data based on 7 regions (1. Attica, 2. Epirus combined with Western Macedonia, 3. Central Macedonia combined with Eastern Macedonia and Thrace, 4. Peloponnese combined with Western Greece and Ionian Islands, 5. North Aegean combined with South Aegean, 6. Thessaly combined with

Central Greece and 7. Crete.). These "decentralized regions" provided by Google differ significantly from Greece's administrative regions, making a meaningful comparison between seismic noise and mobility data impractical, as the Google data combines multiple administrative regions into a single category. Additionally, 5 out of the 7 regions' mobility data provided by Google contain gaps in several mobility categories. The corresponding Community Mobility Report for COVID-19 can be accessed here: https://www.gstatic.com/covid19/mobility/Region_Mobility_Report_CSVs.zip. As a result, any comparison between noise reduction and mobility data is necessarily limited to the national scale already presented in Figure 10 (numbered as 8 in the initial manuscript).

Nevertheless, based on the concept of 'Decentralized Administration' mentioned in the reviewer's comment, we consider it appropriate to include an extra figure (Figure R4), in addition to Figure 6 of the manuscript, which illustrates the median noise reduction at the administrative region level for each lockdown.

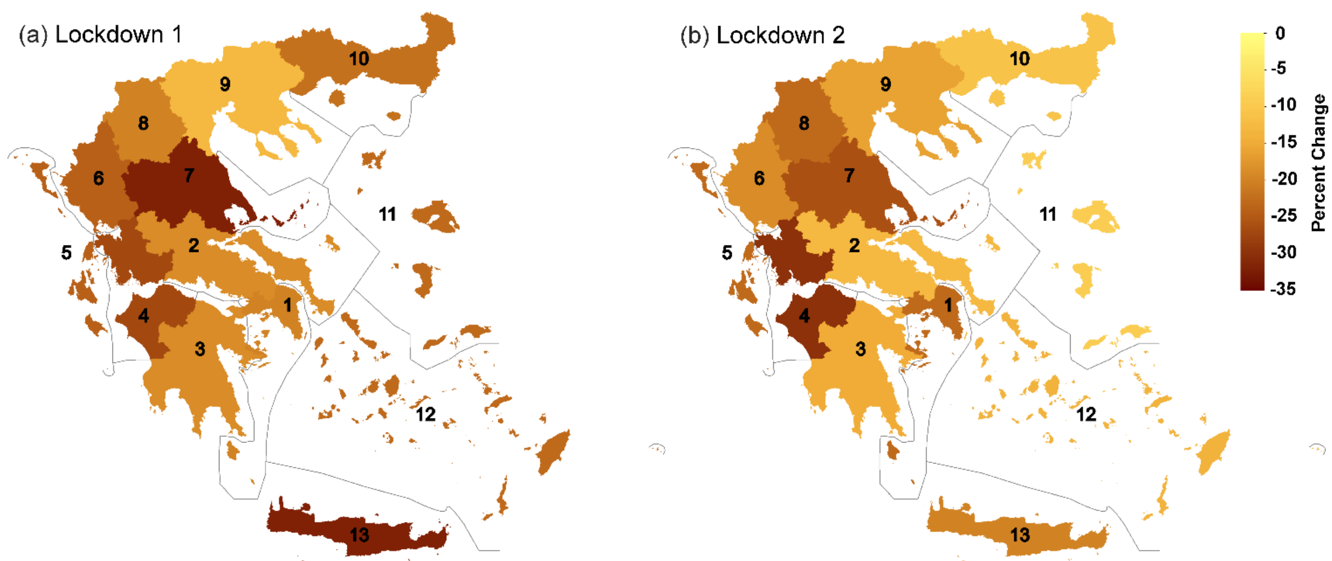

Figure R4: Median percent changes in HiFSAN during (a) the first lockdown and (b) the second lockdown, across the 13 administrative regions of Greece. Median values were calculated based on the noise reductions per station presented in Figure 6. The numbers on the maps correspond to the respective administrative regions of Greece: 1. Attica, 2. Central Greece, 3. Peloponnese, 4. Western Greece, 5. Ionian Islands, 6. Epirus, 7. Thessaly, 8. Western Macedonia, 9. Central Macedonia, 10 East Macedonia and Thrace, 11 North Aegean, 12 South Aegean, and 13. Crete.

The specific changes we made following this comment are as follows:

1. **Page 26, Lines 3-19:** The following paragraph has been added: "Greece is divided into 13 decentralized administrative regions. Using Figure 6, which depicts the percent reductions in seismic noise per station, we grouped the stations spatially by their respective administrative regions to calculate and display the median percent reduction for each region. Figure 8 illustrates the median percent reduction in HiFSAN across the 13 administrative regions of Greece during both lockdowns. At the regional level, trends similar to those observed at the individual station level can be noted. Overall, the most significant reductions in seismic noise were recorded during the first lockdown in the majority of the regions (9 out of 13). Specifically, greater percent reductions during the first lockdown were observed in Central Greece, Peloponnese, Ionian Islands, Thessaly, Epirus, East Macedonia and Thrace, North Aegean, South Aegean, and Crete. In contrast, Attica, Western Greece, Western Macedonia and Central Macedonia exhibited median noise reductions that were approximately 3% higher during the second lockdown compared to the first. Comparing these seismic noise reduction data with mobility data could provide valuable insights into interpreting these variations. However, Google's mobility data are available for only 7 decentralized regions, which differ significantly from Greece's 13 administrative regions, complicating a direct comparison between seismic noise and mobility patterns. Furthermore, the mobility data for 5 of these 7 regions contain gaps across several categories, limiting their utility. Consequently, such a comparison is feasible only at the national level and is presented in Section 3.3."
2. An extra figure has been added to the manuscript as Figure 8.

Additional changes made in the manuscript:

1. A Greek version of the abstract has been included in the manuscript.
2. "Covid-19" has been replaced with "COVID-19" throughout the manuscript.
3. Table 1 has been moved to appear between the second and third paragraphs of the Introduction section.
4. Page 8, Lines 19-20: The following text has been added: "A list of the specific type of building where the stations are installed is provided in the supplementary material."
5. Caption of Figure 1: "labeled" has been replaced with "labelled".
6. Page 11, Line 13: "4-20 Hz," has been added in the parentheses.

7. Caption of Figure 2: “strong motion” has been added in the caption’s text.
8. Page 13, Line 4: The abbreviation “P.P.C.” has been deleted as it is not used in the following text.
9. Page 13, Line 5: “capturing” has been replaced with “presenting”.
10. Page 21, Line 7: 3.2.3 Subsection’s title “HiFSAN percentage changes per station” has been changed to “HiFSAN percentage changes per station and administrative region”.
11. Caption of Table 2: “strong motion” has been added in the caption’s text.
12. Numbering of initial Figures 7 and 8 changed to 9 and 10 in the revised manuscript, respectively.
13. Page 34, Lines: 13-18: Based on the first reviewer’s comment the sentence “These reductions were particularly prominent at frequencies above 4 Hz, characteristic of anthropogenic seismic noise, and were more pronounced in the 10 - 30 Hz frequency band.” has been revised as follows: “These reductions were particularly prominent at frequencies above 4 Hz, characteristic of anthropogenic seismic noise, and were evident across all studied frequency bands, including the 10-30 Hz range, which was the primary focus of the current study to facilitate result visualization.”
14. Page 35, Lines 1-6: The following paragraph has been added to the Conclusions section: “Although the same restriction measures were implemented during both lockdowns, the reduction in seismic noise levels was more pronounced during the first lockdown than the second. This observation aligns with Google mobility data, which show higher levels of human mobility during the second lockdown. A plausible explanation for this difference is that citizens may have been less motivated to strictly follow the restriction measures during the second lockdown, leading to increased mobility. This behavioral shift is reflected in both the mobility and seismic data.”

Reviewer B

We would like to sincerely thank Reviewer B for the careful reading of our manuscript and for the constructive comments and suggestions, which have helped us to further improve the clarity and completeness of our work.

We have carefully considered each of the reviewer's points. All recommendations have been implemented, except for the suggestion to split Figure 10 into multiple panels. We kindly prefer to retain Figure 10 in its original form, for reasons explained below.

Below we provide detailed, point-by-point responses to address each comment and suggestion.

The reviewers' original comments appear in blue italicized text, followed by our responses in plain text.

Pages and lines numbers correspond to the second version of the revised manuscript, with changes highlighted.

Giannopoulos et al., have produced a detailed study of urban noise across a strong-motion sensor network in Greece, focusing on the effects of the COVID-19 lockdowns on the noise amplitudes. The comparison of two different lockdowns (LD1 & 2) is particularly interesting, and I thought the comparison of the two lockdowns across the network (Figure 7) was a particularly good addition. The paper is well-written, and the authors should be commended for the clarity of their explanations.

Please note that I was not the original reviewer. I acknowledge the work undertaken by the authors to produce a comprehensive, detailed response to the original review; in my opinion these responses address the main points of the previous reviewer. The additional points below are relatively minor, and should be considered recommendations rather than essential changes. Hopefully they will be useful to the authors. After revisions or rebuttals of these points the paper I expect I would be able to recommend to the editor that the paper is suitable for publication in Seismica.

Main Points:

Fig.4 c & d: LMS2 / MNVA – These two stations do not show the strong weekly variations of other stations (e.g., AMYA, ARTB, Fig 4 a & b). This is an indicator that the stations are not sensitive to the periodic anthropogenic sources that relate to population movements; in my (limited) experience stations that do not show the weekly variations are often sensitive to meteorological effects that can vibrate *buildings (e.g., Groos, J. C., and J. R. Ritter (2009), Time domain classification and quantification of seismic noise in an urban environment, Geophys. J. Int. 179, no. 2, 1213–1231) or vibrations due to air-conditioning systems. On Pg17, (L11-12) it may be useful to a reader to point out that MNVA does not exhibit the (strong) weekly variations and is therefore not anticipated to see strong evidence of the lockdown signals due to this specific site effect?*

We agree with the reviewer's comment. The absence of strong weekly cycles could indicate limited sensitivity to anthropogenic noise, which may explain the lack of clear lockdown signatures. This is a useful observation and we have included such a comment on this in the manuscript, as recommended.

The specific change we made following this comment is as follows:

Page 17, Lines 12-15: The following text has been added: "Compared to stations AMYA and ARTB, stations LMS2 and MNVA do not exhibit clear, typical week-long cycles of seismic noise levels. This could suggest that these stations are less sensitive to periodic anthropogenic sources related to population movements, which may explain why the lockdown effects are less evident or entirely absent in such cases."

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pg23. L1 to 3: 10 to 30Hz, guided by the previous review the authors have considered a correlation with population size, for which they find no strong statistical evidence. Because they are studying high-frequency data (10-30Hz), the seismic wavelengths are likely to be short (a few hundred metres maximum) and the seismic sources themselves (e.g., traffic) are likely to be radiating at relatively low power. Therefore, it is likely that the noise generation effects are very local; i.e., within a few hundred metres of the station (this is alluded to later when looking at mobility data). Perhaps a single sentence indicating that population is a large-scale effect while high-frequency noise is likely a local effect might be a useful addition here?

We agree with the reviewer's comment. We also consider that the observed seismic noise reductions during lockdowns are more directly linked to immediate human activity near each station rather than overall population metrics. For instance, a station in a busy district of a small town may exhibit higher noise levels than a station within a quiet district of a densely populated city. Based on the reviewer's comment, we have added a sentence noting that while population size is a large-scale factor, high-frequency noise is mainly a local effect.

The specific change we made following this comment is as follows:

Page 23, Lines 7-10: The following text has been added: "The lack of a strong statistical relationship between noise reduction and population size, however, may be attributed to the fact that while population size is a broad-scale factor, high-frequency seismic noise (10–30 Hz) is predominantly influenced by local sources, such as nearby traffic, within a few hundred meters of each station."

Fig.10 – the figure quality throughout the manuscript is excellent, but this graph is a difficult to interpret because it is so busy (lots of lines that obscure one another). Would splitting it into a couple of panels lead to easier comparisons?

We appreciate the reviewer's suggestion and acknowledge that Figure 10, as a single-panel figure, presents a lot of information, which may make it visually dense. However, despite this drawback, we believe that maintaining it in its current form offers more advantages. Similar visualizations have been used in previous studies that compare seismic noise with mobility data, making this approach familiar to readers in the topic. Additionally, splitting the figure into multiple panels could make direct comparisons between the different mobility trends more challenging, which is one of the key strengths of this visualization. Considering these factors, we kindly prefer to retain Figure 10 as a single-panel figure.

Fig.10 – the authors argue in the text that the median noise is predominantly controlled by workplace activity, however in Figure 10 (particularly in Sept. and Oct. 2020) the lowest noise occurs at times of highest workplace mobility. Am I interpreting this correctly? If so, why is this (it appears to be counter to my expectation)? I note that I do not believe the mobility data to be flipped, as workplace mobility is very low on 28th Oct (Ohi Day) as one might expect.

We sincerely appreciate the reviewer's comment, as it brings attention to an insightful observation. Indeed, this pattern is noticeable not only in September and October 2020 but also during the late spring and summer months. Since our primary focus in this study was on periods affected by lockdown restrictions, this trend did not receive our attention. Notably, outside lockdown periods, workplace mobility appears elevated during weekends, which is somewhat unexpected.

Following a thorough review of both the seismic noise and the mobility dataset provided by Google, we found no apparent errors. Thus, the mobility data from Google indeed exhibit this pattern during the aforementioned periods.

With some caution, a possible explanation for this pattern, could be that, since this trend primarily occurs during the tourist season, the workplace mobility data provided by Google may unknowingly capture other types of movement, throughout the whole country, that might not strictly fall under workplace-related activities.

This observation does not affect the overall picture and the conclusions regarding the impact of lockdown measures on seismic noise. However, we consider it appropriate to add a brief comment in the discussion section of the manuscript acknowledging the reviewer's observation and providing a possible interpretation.

The specific change we made following this comment is as follows:

Page 33, Lines 4-9: The following text has been added: "While the overall trend between mobility data and seismic noise is generally consistent, a closer look at periods outside the lockdowns, particularly during the tourist season, reveals unexpectedly high workplace mobility during weekends. A possible explanation is that Google's workplace mobility data may unknowingly capture other types of movement across the country that do not strictly correspond to workplace-related activities."

Pg33, L1-2: is this adoption of self-protection measures also observable in the mobility data? If so, perhaps add one sentence to indicate this?

Indeed, the adoption of self-protection measures is reflected in the relevant mobility data, which exhibit a similar decreasing trend to that observed in the noise data. We have added a sentence to highlight this observation in the manuscript.

The specific change we made following this comment is as follows:

Page 33, Lines 14-16: The following sentence has been added: "The adoption of self-protection measures is also evident in the mobility data, which show a similar decreasing trend to that observed in the noise data (Fig. 10)."

Minor Points / Typographical Errors:

pg2 L6 (pg. 19 L. 9 and pg.31 L.20) 'horizontal lockdowns'. I do not understand this phrase, and it does not appear to be widely used in the literature. What is 'horizontal' about the lockdowns? Is there a more common term for what the authors are trying to describe?

We appreciate the reviewer's comment and acknowledge that the term "horizontal lockdowns" may not be immediately clear. The phrase was a direct translation from the corresponding Greek expression, which, as the reviewer correctly points out, is not widely used in English-language literature.

Our intention was to describe lockdown measures that were applied uniformly across various sectors and regions, rather than targeting specific areas or industries. We have replaced "horizontal lockdowns" with the term "nationwide lockdowns".

The specific changes we made following this comment is as follows:

Instead of "horizontal lockdowns", we now use the term "nationwide lockdowns" to describe the uniform, broad application of restrictions across various sectors and regions. There were three replacements throughout the manuscript: 1^{st} → Page 2, Line 6, 2^{nd} →Page 19, Line 11 and 3^{rd} → Page 32, Line 7.

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pg6 L4 'Seismology' doesn't need upper case

Done.

pg6 L12 The authors are correct that most noise below 1Hz has natural causes, although several authors have pointed out that trains can generate low-frequency seismic vibrations seen across distances of tens of kilometres (e.g., Sheen, D.-H. et al (2009). Low frequency cultural noise, doi: 10.1029/2009GL039625; or Table 3 of Green et al., (2017), doi: doi.org/10.1785/0220160128

We agree with the reviewer's comment. A brief reference to such an example, which falls outside the principal categorization of seismic noise sources, has been added to the manuscript.

The specific change we made following this comment is as follows:

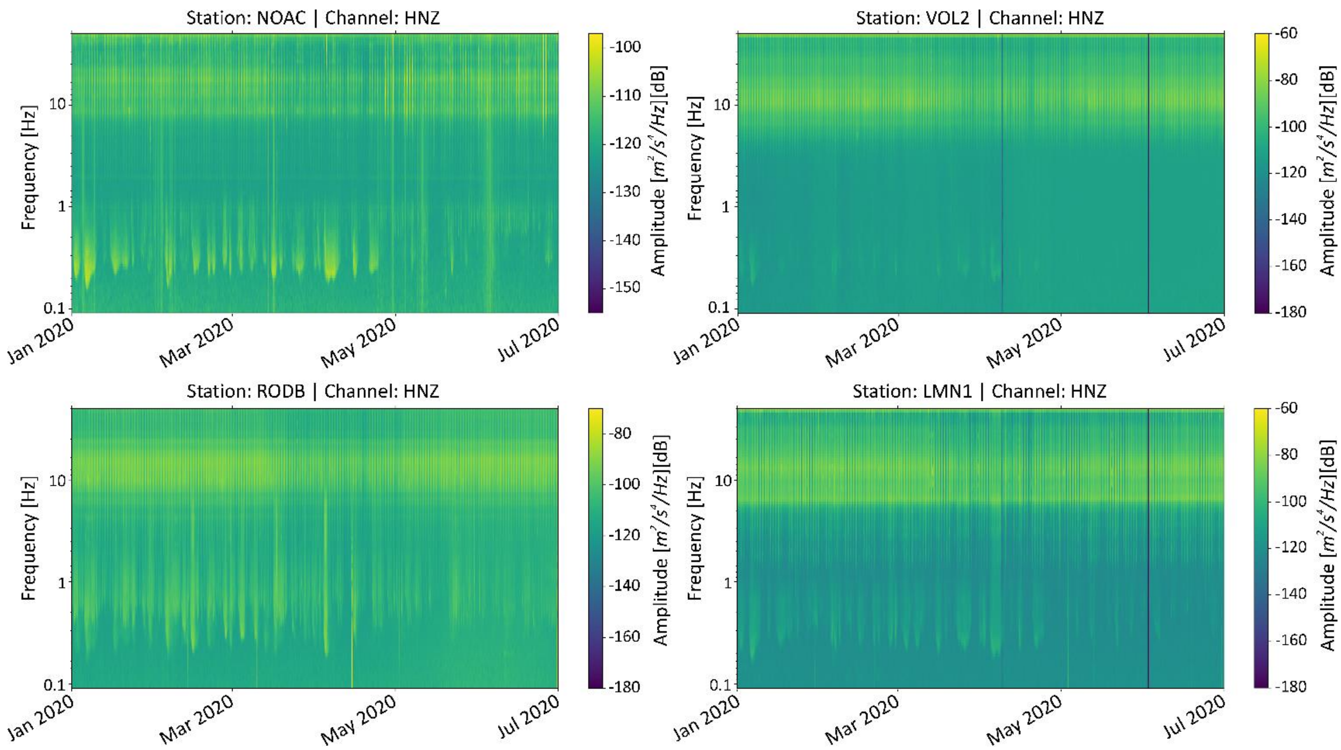
Page 7, Lines 3-6: The following text has been added: "There are, however, cases of seismic noise sources that fall outside this primary categorization. For example, low-frequency seismic background noise (0.01–0.05 Hz) observed at broadband seismic stations has been shown to strongly correlate with railway schedules (Sheen et al., 2009)."

Fig.2: the scaling of the spectrograms could be improved. Currently it is difficult (to this reader) to see the details. I note that the colorbar extends to -180dB; if this minimum value was restricted to -130 or -140dB it is likely that the contrast between low power / high power regions would be considerably easier to see.

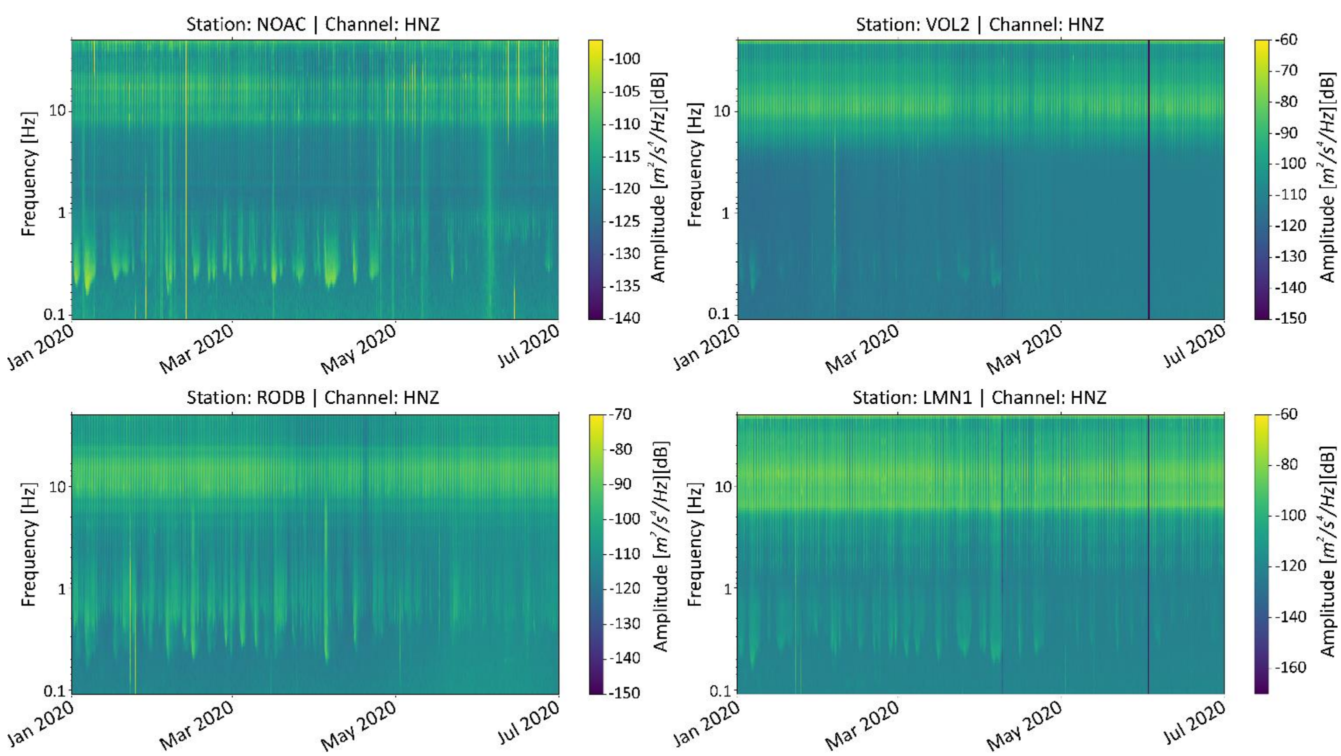
We agree that the visibility of details in the spectrograms is limited. This is largely due to the fact that the data were acquired exclusively from strong motion sensors, which typically exhibit a narrower dynamic range compared to broadband instruments. As a result, the overall amplitude variability is limited, and specific features such as the secondary microseism are more difficult to detect. Our main focus was on the high-frequency part of the spectrum.

Following the reviewer's comment, we made an additional effort to enhance the spectrograms by adjusting the scaling. Although the improvement is modest due to the inherent limitations of the dataset, we believe the revised figure offer slightly better contrast.

Previous version



Updated version



The specific change we made following this comment is as follows:

An updated version of Figure 2 has been added in the manuscript.

pg14. L3 the term 'free-field' is usually reserved for particular (theoretical) seismological conditions (for example where the field is not influenced by interactions with ground surfaces etc.). Suggest replacing 'free-field' with 'rural' in this case (if I understand the sentence correctly).

We agree with the reviewer's comment.

The specific change we made following this comment is as follows:

Page 14, Lines 10-11: The term "free-field" was replaced with "rural".

Fig.5. I presume the normalisation has been achieved by dividing through by the maximum amplitude observed at a particular station within the time period studied; it would be useful if the authors explicitly stated this. If this is the case, how successful is the normalisation for stations such as LMS2 and MNVA (Fig 4c and d), which have significant outliers as their maximum values (is this accounted for somehow?).

We appreciate the reviewer's comment. The normalization in Fig. 5 was indeed achieved by dividing each time series by the maximum amplitude observed at each respective station over the study period. Following the reviewer's comment, this has now been explicitly stated in the manuscript.

In our case, no special treatment was applied regarding the presence of individual outliers, such as the one observed at station MNVA. Instead, in order to mitigate the potential influence of such values, we consistently used the median in both the visual representation of the data and the calculation of percentage changes. In practice, all percentage changes reported in the manuscript are based on median values derived from two distinct time periods (e.g., pre-lockdown and during lockdowns), which effectively reduces the impact of any extreme values. This is stated in the section 3.2.3.

The specific change we made following this comment is as follows:

Page 18, Lines 11-12 and **Page 19, Line 1**: The following text has been added: "The normalization was performed by dividing the amplitude values of each station's time series by the respective maximum value observed during the study period."

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pg25 L1: 'greater' not 'grater'

Done.

pg.31 L6 (in Fig 10 caption): 'milestone' not 'millstone'

Done.

pg.35 L11 Green & Bowers (2008) paper – although this is related to an unusual source, it wasn't particular focused on an urban environment. Did the authors mean to reference Green et al., (2017) which looked specifically at broadband noise in London (https://doi.org/10.1785/0220160128) ?

We agree with the reviewer's comment. Indeed, the reference to Green et al. (2017) is more appropriate in the context of our discussion on "human-related activities within urban environments".

The specific changes we made following this comment are as follows:

Page 36, Line 7: The reference to Green & Bowers (2008) has been replaced with Green et al. (2017) in the manuscript.

The corresponding changes have also been made in the reference list. The reference of "*Green, D. N., and Bowers, D. (2008). Seismic raves: tremor observations from an electronic dance music festival. Seismol. Res. Lett. 79, 546–553. doi: 10.1785/gssrl.79.4.546*" was replaced with "*Green, D. N., Bastov, I. D., Dashwood, B. and Nippress S. E. J., 2017. Characterizing Broadband Seismic Noise in Central London. Seismological Research Letters 2016; 88 (1): 113-124. doi: https://doi.org/10.1785/0220160128*".

Additional changes made in the manuscript:

1. Page 2, Line 7: To avoid repetition from the previous sentence, the word "nationwide" has been replaced with "national".
2. The affiliation of the person you helped us with the creation of Fig. 8 was added in the acknowledgements.