Responses to the reviewers' comments

Dear editor,

We sincerely thank you for the opportunity to revise our manuscript entitled *"Societal Impact of COVID-19 Crisis on the Ambient Seismic Noise in Metropolitan France"*. We are grateful for your insightful feedback and those of the reviewers, which helped to improve the quality of our work. Following the first reviewer's suggestions, we extended our analysis to the post-COVID-19 period in order to further explore potential changes in human mobility after the restriction phases in France. We have also provided detailed responses to all comments below and made the necessary revisions to the manuscript. In addition, we have improved and clarified certain points in the manuscript, correcting spelling mistakes and clarifying some sentences. We hope this revised version meets the requirements for publication in Seismica.

Best regards,
Flavien Mattern, on behalf of the authors

Reviewer C

> *The submitted paper Societal Impact of COVID-19 Crisis on the Ambient Seismic Noise in Metropolitan France studies the impacts of the COVID19 pandemic on noise levels on seismic stations across France. The main difference between this study is the spatial and temporal extent studied: all of france, reaching back to 2019 for a reference, and including all the lockdowns. Given this paper comes after a long series of covid and seismology papers, I would recommend to include the aftermath in 2022,2023. For example, has society accepted working from home, even well after covid, and can you see this in the data? This would really be interesting, and (as far as I know) new.*
>
> *The figures and text are clear and concise.*
>
> *While the reference noise level of 2019 may be more statistically sound than what all the other papers referenced in this area used, I am not sure which results found in this paper are new and provide a novel insight on the topic.*

Response : We would like to thank the reviewer for these comments. With regard to the novelty of our work, we would like to raise the following points:

- The literature mainly describes the effects of lockdowns in urbanised areas, where the effects of mobility restrictions are expected to be significant. Here, we add a new dimension by extending the analysis to a whole country, taking into account the environment of the stations, whether they are located in rural or urban areas. We show that, although the effects of mobility restrictions are strongest in urban areas, they are nonetheless significant in rural environments and that very local effects around the stations can be measured.
- Our analysis has enabled us to study the precise effects of lockdowns and curfews, the latter of which have not been widely studied in the literature, to our knowledge.

- Some studies have made the link with mobility indicators (e.g. Lecocq et al., 2020; Diaz et al., 2020; Giannopoulos et al., 2025). However, to our knowledge, there is no detailed analysis (with time-of-day precision) of road traffic that links observations to seismological data.

Following the reviewer's suggestion, we propose extending our analysis to include the years 2022 and 2023, in order to study the post-Covid-19 response in terms of seismic noise levels. This would effectively add a new dimension to the paper that has not yet been explored. We updated Figures 4, 6 and 9, which have been added to the Supplementary Material (Figures S2, S3 and S4, respectively) to ensure that the figures remain accessible and not overly complicated in the manuscript. We have retained 2 elements from the extension of the analysis to 2023:

- Recurrent decreases in noise levels can be seen at the end of the years 2021 and 2022 in November and December (and a slight increase in 2023) in Figures S2 and S3, which seems to be associated with temperature changes relative to the reference year 2019 (Figure S5). Temperature variations are distributed by the French government portal and produced by Météo France[1] .It is mostly visible for rural than urban stations with higher drop amplitudes for rural stations (Figure S5).
- Possible effects of human mobility after the phases of restrictions are observable on ambient seismic noise level, in particular through decreases in noise level in the evening and at night, also visible through road traffic.

These aspects are detailed in the Discussion section with a new sub-section : "4.4 Seismic noise level during the post-COVID-19 period".

[1]Temperature data : https://www.data.gouv.fr/datasets/donnees-climatologiques-de-base-quotidiennes/

A few spurious comments:

1. The definition of rural could means an average of 15000 people (200 people per km^2, 75 km^2) live within 5 km of the seismometer. While I understand one has to define rural somewhere, I would like to note that this means a decent-sized town is within range for a rural station, and human activity may be significant.

Response : In order to determine whether our definition of urban and rural stations has a significant impact on our results, we adapted the definition of an urban station by using population data for cities in metropolitan France (available on the French government website[2]). We define now an urban station if, within a radius of 5 km, there is a population density of more than 200 inhabitants/km² or a city with more than 5,000 inhabitants (the second criterion being new). This new, more restrictive definition brings the total number of stations to 44 urban and 83 rural (compared with 41 and 86, respectively, previously). Only three stations are affected by the new definition and there are no significant changes to our results. We therefore believe that the definition presented in our manuscript is appropriate.

[2]Population data : https://www.data.gouv.fr/fr/datasets/donnees-sur-les-communes-de-france-metropolitaine

2. I have been mesmorized by the 40% increase in noise in the early hours of August/September 2020, compared to 2019. I am wondering if this could be the Tour de France? The time of day is wrong for the caravan of vehicles, maybe, but it would be very cool if you could see this in the seismic data too. The fact that the 2020 Tour de France was moved to later in the year, would mean it stands out with respect to 2019, when the Tour de France would be in the normal June-July months.

Response : We thank the reviewer for this comment. We agree that there was a significant increase in road traffic of almost 40% around 6 am in September 2020 (29/08/2020 - 20/09/2020), as can be seen in Figure 9b. Interestingly, this increase has not been observed in seismic noise (cf. Figure 6 of the revised manuscript). To identify whether this increase is linked to the Tour de France 2020, we did the following test. We kept the road traffic using only stations that are located more than 50 km from the Tour de France route (Figure R1a that shows the route of the Tour de France in red). This represents 11 of the 24 stations used in Figure 9 of the revised manuscript. We reproduced below Figure 9b of the revised manuscript with these 11 stations only (see Figure R1b). These 11 stations are far enough away to not measure any direct effects of the Tour de France route, such as caravans of vehicles or road traffic disturbances near the route. We do observe the same increase of almost 40% around 6am in September 2020, which suggests that 1) this is not associated with the Tour de France, and 2) this phenomenon is rather a general trend throughout metropolitan France. Two possible explanations can be proposed: 1) a post-heatwave effect. In fact, a period of intense heatwave was observed in Northern France in August 2020 (a drop in traffic is indeed observed at the same time of the day in August, i.e. ~6hr). This would indicate a resumption of activity after the heatwave; 2) the back-to-school effect (01/09/2020), which could have been more marked as it was the first post-covid school year. Other explanations also need to be explored, as it is astonishing to have traffic overactivity without a signature in the seismic noise.

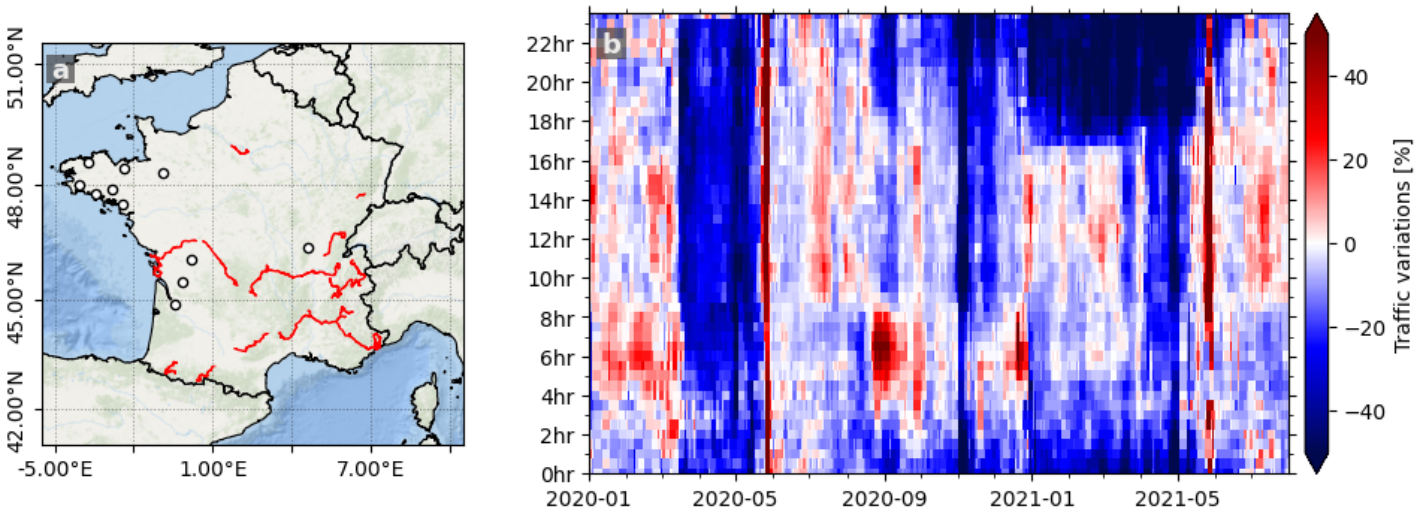

Figure R1 - a) Map of the Tour de France route in 2020 in red (accessed online from https://www.velowire.com/article/1069/fr/le-parcours-du-tour-de-france-2020-sur-open-street-maps-et-dans-google-earth--profils-d-etapes-et-itineraires-horaires.html). The considered traffic stations are indicated by the white circles. They represent the 11 traffic stations included among the 24 in Figure 9 of the revised manuscript, located more than 50 km from the Tour de France route. b) Median traffic variation with respect to the hour of the day. The reference traffic level is specific to each half-hour of the day in relation to the year 2019. Only the 11 stations mentioned in a) are taken into account.

Reviewer E

This manuscript by Mattern et al. analyses in detail the effect of the Covid-19 lockdowns and curfews on seismic noise in France. Although the paper does not produce novel results as such, I can see it has been very thoughtfully put together. The writing is truly excellent and the figures themselves are very nice - easy to understand and novel at the same time. I like the use of population density data that allows this study to take a deeper dive into the seismic noise changes. This work will be an excellent contribution to the more regional set of studies on the seismic noise reduction in 2020-21.

Response : We thank the reviewer for his very positive comments on our manuscript. Concerning the novelty of our results, we have detailed this aspect in response from point 1 of reviewer C.

I have just a couple of very minor comments / questions:

- *Figures 2, 3, and 8 could be a bit bigger.*

Response : We enlarged Figures 2, 3 and 8 to make them easier to read.

- *Figure 4 caption – please state what the curfew names (i.e., "20h", "18h") mean exactly.*

Response : We added a sentence to describe the meaning of the coloured periods in the legend of all the figures concerned (Figures 4, 6, 9 and 10).

- *~10 stations (top of Fig. 4b) showed seismic noise increases during the first lockdown. Can the authors speculate on what might have caused this?*

Response : We thank the reviewer for this comment. We would like to mention that, as a result of our systematic analysis of metropolitan France, it is possible that some stations are behaving differently from the general trend. All the stations measuring this increase are located far from urban centres, as they are not considered as urban from our definition. We believe that this observation should be understood in the context of the station's immediate environment. To support this, we looked in detail at the immediate environment of the stations concerned, some examples of which are given in Figure R2. For example, some of the stations are located next to a dam (e.g. FR.RSL; FR.SMPL), or close to a torrent (e.g. FR.OGAG; FR.OGCE; FR.ENAUX). These few examples explain why some stations may record these increases during lockdowns phases, although they are not specific to the restriction phases of COVID-19. We added a sentence in the manuscript to comment on this observation.

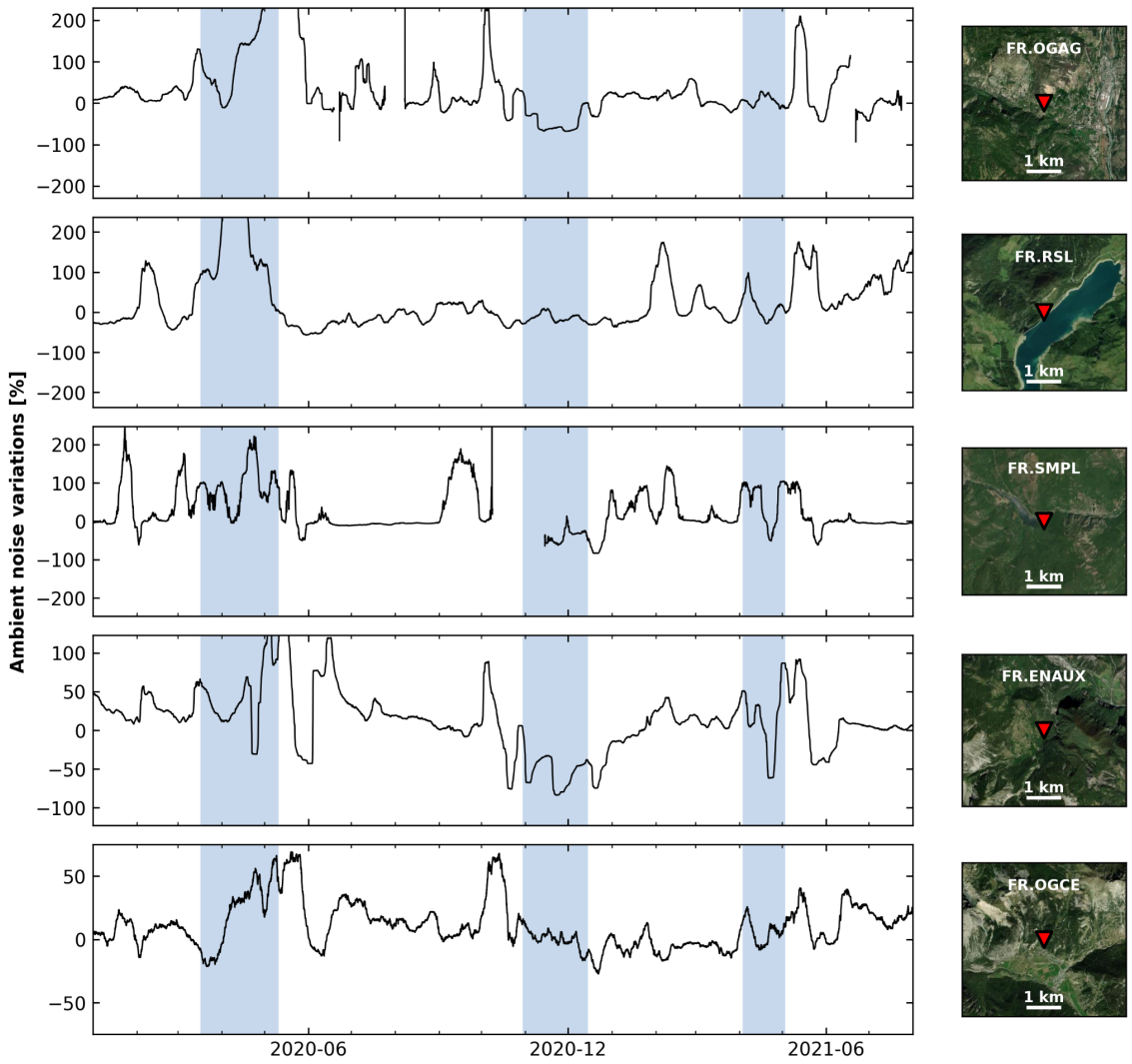

Figure R2 - (Left) Ambient seismic noise variations for 5 different stations measuring an increase in seismic noise level during the first lockdown. The three french lockdowns are indicated by the blue background. (Right) Satellite images in the station environment.

References

Diaz, J., Ruiz, M., & Jara, J. A. (2020). Seismic monitoring of urban activity in Barcelona during COVID-19 lockdown. Solid Earth Discussions, 2020, 1-20.

Giannopoulos, D., Evangelidis, C., & Sokos, E. (2025). 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. Seismica, 4(1).

Lecocq, T., Hicks, S. P., Van Noten, K., Van Wijk, K., Koelemeijer, P., De Plaen, R. S., ... & Xiao, H. (2020). Global quieting of high-frequency seismic noise due to COVID-19 pandemic lockdown measures. Science, 369(6509), 1338-1343.