# Comment on se-2021-21 by Anonymous Referee #1

We sincerely thank the referee for the valuable comments which will help to improve the paper. Please find a point-by-point response to the comments. Our responses are in red. Actual changes to the text are marked as *italic* font.

On behalf of all authors, Yours sincerely,

Fabian Limberger

**Comments by Anonymous Referee #1:**

The work is quite interesting, it is also well written (with some small exceptions, as page10).

> The description on page 10 will be improved in the revised manuscript. It should be clearer after these changes.

The authors propose a way to model the seismic motion produced by the operation of wind turbines. They show the importance of phase shift due to the presence of more than one wind turbine, and propose a method to remove it. However, the main problem in the manuscript is the lack of discussion of the effect that more wind farms would have in both: the observed and the modeled motion.

> Yes, the focus of this paper is on the "phase-shift-elimination" method which can be used to estimate the amplitude field around a simulated windfarm. At the moment we cannot reliably estimate the impact of wind parks A and B but there are good reasons to assume that, for the considered distance range (max 4 km), the measured amplitudes are dominated by the wind turbines in Uettingen. Lower-frequency signals from other windfarms may have a stronger impact and this is partially discussed already. We will improve on the discussion during the revision. However, the detailed analysis of the contribution of neighboring windfarms on the measured amplitudes is beyond the scope of this paper. To consider their effects additional field data from an optimized station layout are required. We are currently preparing for field measurements to estimate this influence, but the results will not affect the general idea of the presented method.

The spectral analysis and their observations are consistent with previous works. However, in their results they mention “The remaining (sharp) peaks show no systematic dependence which is an indication that their origin is not related to the WTs.” To what could it be related? Could these peaks be related to the other two existent windfarms? Which are in some cases, closer than the Uettingen WF to the recording stations (i.e., stations 4 km away).

> The sharp peaks show no systematic distance dependence. Neither to the Uettingen wind farm nor to the neighboring windfarms. The amplitudes of these minor peaks show no correlation with the rotation rate of the wind turbines, or the wind speed. This indicates that the source which is causing these sharp peaks is probably not related to the operation of the wind farms. Therefore, these peaks were not analyzed in detail because amplitudes are small compared to the analyzed major peaks.

When the authors analyze the amplitude decay with the distance between 300 and 4000 m there are some stations with discrepancies with the fitting power law, which the authors explain as an effect of the near field for stations ~ 300 m away from the WF and as local anthropogenic noise for the stations at more than 3 km distance (which actually had been removed). So again the question would be: could

these effects be due to the other two wind farms? For the farther stations, which would be the role of the eastern wind farm with six wind turbines?

> With the averaging process we can remove only transient signals. Towards the end of the profile (F15 - F19) we are relatively close to the northeastern windfarm. However, the stations are also close to a heavily used highspeed railroad line. Both could explain the elevated PSD amplitudes which we observe in this region. This will be analyzed by future measurements. So far, we observe at these stations a general elevated noise level rather than an increase of single PSD peaks. This may be an indication, that the source is not the neighboring windfarm.

On the discussion, the authors mention shortly the effect that short measurements (shorter as 6,5 weeks) can have on the estimation of b values, because of the presence of transients and earthquake events. On section 2.1 the authors mention they removed the local transients, but they don't explain how they managed with earthquake events. The authors should clarify if they removed these signals or how they managed with them.

> Earthquake signals were not removed explicitly before averaging the PSD spectra. Keeping in mind that we used several thousands of single PSD spectra, we think that the influence of the (relatively few) earthquakes on the average amplitudes should be negligible. Furthermore, we removed 75% of the largest amplitudes (outliers) before calculating the average. This also reduces the influence of transient signals on the average amplitude calculation.

The discussion of the authors is good and complete, and they focus on the problems they solve. The authors show the important role that three aleatory wind turbines would have in the motion, but the role of the nearby wind farms (with even six turbines) is just shortly mentioned. Please discuss in more detail.

> The discussed comments on the additional wind farms will be included in the discussion of the revised article in more detail. We will add the following text to the discussion in line 346 after "…targeted three WTs in Uettingen (Fig. 1)":
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> *This could lead to an overestimation of the signal amplitudes, especially in the far field of the WF Uettingen. However, since we observe peaks at identical frequency in the near and far field of the WF, it is reasonable to assign these signals mainly to the wave field produced by the WTs in Uettingen. Signals from various WFs can generally be distinguish using e.g. mitigation analysis (Friedrich et. al., 2019). However, the detailed analysis of the effect of additional WFs around Uettingen is beyond the scope of this study but should be considered in future analysis.*

Would it be possible to identify which signals are really coming from the Uettingen WF and which from the other wind farms, in order to identify the origin and obtain an even better model?

> In ongoing analyses, we are working on the cross correlation of signals measured along the profile to identify signals that are emitted by the WTs in Uettingen. Generally, there are other approaches to distinguish signals from various wind farms (e.g. Friedrich et. al., 2019). But this is beyond the scope of our article, which focuses on the aspects of using an analytical approach to model the radiation patterns of a wind farm.

Figures 12 and 13 are discussed in the text before figures 10 and 11, it would be better to change the order. Figures 10 and 11 need a color scale for the modeled radiation patterns. The caption of figure 13 should be improved.

We agree with the comment on the order of the figures 10-13 and will change the order in the revised manuscript. Furthermore, we will add the color scale to figure 10 and 11.

The caption of figure 13 is improved to:

*Figure 13: Two-layer model derived by fitting observed and modeled amplitude decays. The best model parameters (cS and QS) for the two layers are found by performing a grid search to optimize the fitting of amplitude decays of signals < 4 Hz and > 4 Hz separately. The depths of the layer interfaces are obtained by assuming a penetration depth of surface waves of λ/3. The transition between layer 1 and layer 2 is somewhat obscure due to the lack of amplitude decays related to signals between frequencies of 3.5 and 4.85 Hz.*