This paper is addressing the minimization of the overall power fluctuations for different wind farm portfolios. In general, the proposed method has the potential for publication in WES. I have the following comments:

Thank you very much for taking the time to evaluate our manuscript. Your comments are much appreciated.

In this file, the black colored text is your comments to the manuscript. We have done our best to response/answer all your comments, which is given as green colored text.

Because both reviewers are asking to get more explanation on why we have focused on the 2-3 h fluctuations and not other frequency ranges, this has been elaborated on in the text. In addition, one additional subsection is included, discussing potential smoothing effect at other frequency ranges (subsection 4.5, see the end of this document).

- The 5th and 95th percentiles of the step change function of wind power time series are used as statistical variability metrics in this paper, which from my point of view represent the range of power fluctuations. It could be more descriptive if the authors were also looking at mean and standard deviation.
  Thank you for this comment. The standard deviation is added. However, the mean is excluded, as the mean of the step change function is approximately zero. This is because the power production is always between zero and rated power, thus averaging over hourly increases/decreases for longer periods adds up to approximately zero. Two year of hourly data equals 17520 data points, and the maximum mean value would thus be $\pm 6*10^{-5}$ MW per $MW_{installed}$ (1 MW per $MW_{installed}$ divided by 2*24*365).

- This paper should be restructured to improve its readability.
  The manuscript is now restructured. All but one of your suggestions are applied.
  * The Section Introduction needs to improve. Please follow this sequence: problem definition and motivation for research in this field, literature review, and the main contributions of this research.
  This sequence is applied to the Introduction
  Subsection "A note on ignoring the wind farm smoothing effect" could move to the introduction as the paper assumptions.
  This subsection is moved to the end of the introduction.
  The Section “Data” could merge with the Section "Result".
  Although the suggestion is appreciated, the Sections “Data” and “Result” are still separate, so the reader can more easily locate what data has been used for the study.
  Optimization theory in Subsection “Optimization of wind farm capacities” is better to move to Section "Method".
  Thank you. The optimization theory is moved to the end of the Section “Method”

(in addition, the description of the optimization is also changed according to your comment further down).

- There are language errors and typos, e.g., constrain instead of constraint in pg 8 line 162.

Thank you. We have corrected multiple language errors in the revised version of the manuscript, including the error you mention here.

- Illustrated PSD in Fig. 5 is a little confusing. What are the time step and the time interval for the PSD analysis performed in this figure?

All PSD are generated with the same method. For clarification, the following description is added to the end of section **Method > Spectral Analysis**:

"The length of the chunks is a compromise between the accuracy of the PSD estimates (smaller chunks, i.e., more chunks) and the frequency resolution and the lowest resolvable frequency (longer chunks). In this study, a length of 256 data points is chosen (10 days and 16 hours), giving a number of 135 overlapping chunks for two-year hourly time series. The PSD estimates will therefore be generated for frequencies between (256 h)$^{-1}$ (Thus, including PSD estimates for the 3-4 day period of the time scale of migratory low-pressure systems at mid and high latitudes) and the Nyquist frequency of (2 h)$^{-1}$, with a resolution of (256 h)$^{-1}$."

The wording of the caption and label in Fig. 5 are also changed a little bit

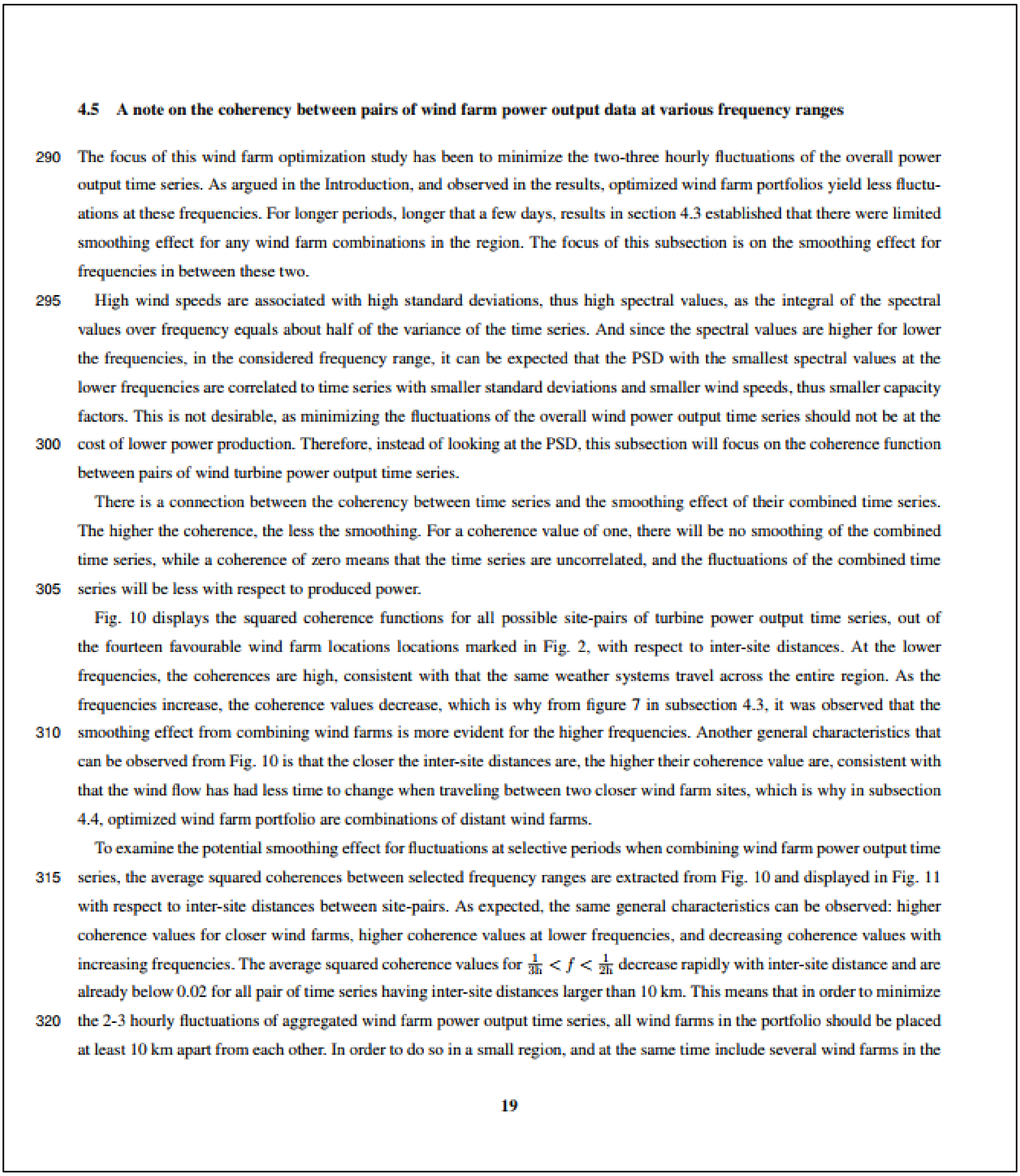
- Could the authors bring more details into the mathematical presentation of the optimization objective function represented by eq.2? The PSD of which function is going to be minimized in the specified frequency range.

  Yes. One additional equation is added, describing the power output time series of wind farm portfolios (Eq. (2) in the re-submitted manuscript). It is the PSD of this equation, which is used to derive an optimized portfolio, being the portfolio where the fluctuations of the total wind power output time series are minimized for frequencies between (3 h)$^{-1}$ and (2 h)$^{-1}$. The section describing the optimization has been changed accordingly in the re-submitted manuscript, as an attempt to improve the description.

- Have the authors tested different frequency ranges, and why is the frequency range (2h)-1 (3h)-1 chosen for the optimization?

  The focus is mainly on frequencies between (3 h)$^{-1}$ and (2 h)$^{-1}$. Arguments for why these frequencies are considered are added to the: Abstract, Introduction, Method > Spectral Analysis, and Discussion

We did not test other frequency ranges. However, we have added a subsection, see below, discussing this topic in more details.



4.5 A note on the coherency between pairs of wind farm power output data at various frequency ranges

The focus of this wind farm optimization study has been to minimize the two-three hourly fluctuations of the overall power output time series. As argued in the Introduction, and observed in the results, optimized wind farm portfolios yield less fluctuations at these frequencies. For longer periods, longer that a few days, results in section 4.3 established that there were limited smoothing effect for any wind farm combinations in the region. The focus of this subsection is on the smoothing effect for frequencies in between these two.

High wind speeds are associated with high standard deviations, thus high spectral values, as the integral of the spectral values over frequency equals about half of the variance of the time series. And since the spectral values are higher for lower the frequencies, in the considered frequency range, it can be expected that the PSD with the smallest spectral values at the lower frequencies are correlated to time series with smaller standard deviations and smaller wind speeds, thus smaller capacity factors. This is not desirable, as minimizing the fluctuations of the overall wind power output time series should not be at the cost of lower power production. Therefore, instead of looking at the PSD, this subsection will focus on the coherence function between pairs of wind turbine power output time series.

There is a connection between the coherency between time series and the smoothing effect of their combined time series. The higher the coherence, the less the smoothing. For a coherence value of one, there will be no smoothing of the combined time series, while a coherence of zero means that the time series are uncorrelated, and the fluctuations of the combined time series will be less with respect to produced power.

Fig. 10 displays the squared coherence functions for all possible site-pairs of turbine power output time series, out of the fourteen favourable wind farm locations locations marked in Fig. 2, with respect to inter-site distances. At the lower frequencies, the coherences are high, consistent with that the same weather systems travel across the entire region. As the frequencies increase, the coherence values decrease, which is why from figure 7 in subsection 4.3, it was observed that the smoothing effect from combining wind farms is more evident for the higher frequencies. Another general characteristics that can be observed from Fig. 10 is that the closer the inter-site distances are, the higher their coherence value are, consistent with that the wind flow has had less time to change when traveling between two closer wind farm sites, which is why in subsection 4.4, optimized wind farm portfolio are combinations of distant wind farms.

To examine the potential smoothing effect for fluctuations at selective periods when combining wind farm power output time series, the average squared coherences between selected frequency ranges are extracted from Fig. 10 and displayed in Fig. 11 with respect to inter-site distances between site-pairs. As expected, the same general characteristics can be observed: higher coherence values for closer wind farms, higher coherence values at lower frequencies, and decreasing coherence values with increasing frequencies. The average squared coherence values for $\frac{1}{3h} < f < \frac{1}{2h}$ decrease rapidly with inter-site distance and are already below 0.02 for all pair of time series having inter-site distances larger than 10 km. This means that in order to minimize the 2-3 hourly fluctuations of aggregated wind farm power output time series, all wind farms in the portfolio should be placed at least 10 km apart from each other. In order to do so in a small region, and at the same time include several wind farms in the portfolio, most of the spatial area in the region has to be utilized. Although comparable less, the average squared coherence for $\frac{1}{9\mathrm{h}} < f < \frac{1}{6\mathrm{h}}$ also decrease rapidly with inter-site distances, reaching a value around 0.05 for an inter-site distance of 30 km. This means that there are still possibilities for a maximum smoothing effect of 6-9 h hourly fluctuations for optimized wind farm portfolios consisting of a few wind farms, having in mind that the largest inter-site distances are around 90 km.

The squared coherence values for $\frac{24}{3\mathrm{h}} < f < \frac{1}{16\mathrm{h}}$ and $\frac{1}{72\mathrm{h}} < f < \frac{1}{48\mathrm{h}}$ decrease comparably more slowly with frequency, and the values are scattered. The lowest squared coherence values for $\frac{24}{3\mathrm{h}} < f < \frac{1}{16\mathrm{h}}$ and $\frac{1}{72\mathrm{h}} < f < \frac{1}{48\mathrm{h}}$ are 0.16 and 0.36, respectively. Although, a smoothing effect at these frequencies should be observed for combinations of two time series with low coherence values, combining more that a couple of wind farms in a wind farm portfolio is assumed to have limited smoothing effect for the these frequency ranges in the given region. And optimized wind farm portfolios consisting of more than a couple of wind farms are speculated to be determined by the standard deviation of the power output time serious at the expense of the total power production, rather than the combination of wind farms with low coherence values. The trend of the decrease of the squared coherence values with inter-site distance is is observable. By extrapolating, it is expected that optimized wind farm portfolios consisting of multiple wind farms could have a high daily smoothing effect at larger regions without the expense of total power production.

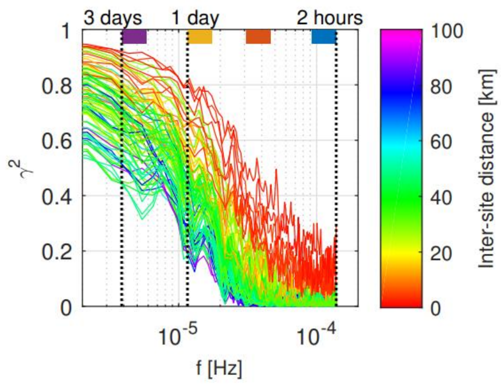


Figure 10. Squared coherence functions for all possible site-pairs out of the fourteen turbine power output time series, placed at the favourable wind farm locations marked in Fig. 2 (a total of 91 pairs). The colors of the coherence functions represent the distances in km between site-pairs, see colorbar. The four colors marked at the top of the figure are added to mark the frequency ranges considered in Fig. 11.

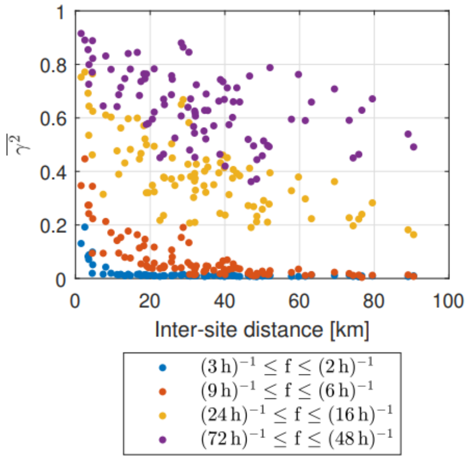


Figure 11. The average squared coherence for frequencies between (3 h)$^{-1}$ and (2 h)$^{-1}$ (blue color), (9 h)$^{-1}$ and (6 h)$^{-1}$ (red color), (24 h)$^{-1}$ and (16 h)$^{-1}$ (yellow color), and (72 h)$^{-1}$ and (48 h)$^{-1}$ (purple color), with respect to inter-site distance for all site-pairs considered in figure 10. The considered frequency ranges are marked in figure 10.