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Interactive comment on "Structural monitoring for lifetime extension of offshore wind monopiles: Can strain measurements at one level tell us everything?" *by* Lisa Ziegler et al.

Anonymous Referee #2

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1 - General comments

Lifetime extension (LTE) of offshore wind turbine support-structures is a topic with increased attention for wind farm operators and owners. More and more offshore wind farms are gradually approaching their design lifetime. Hence, the discussion about cost-efficient lifetime evaluation methods is of high interest and relevance to the industry. The manuscript approaches this field of interest by applying a combination of strain gauge measurement data at one location only, statistical methods and data simulations in a fatigue damage analysis. The method incorporates elements of traditional LTE analyses (based on pure strain gauge measurements) with model-based

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simulations using statistical weather data. This combination ensures a close-to-reality analysis by using measurement data at the real asset, at the same time as it saves cost for extensive measurement campaigns by using simulation tools as a substitute. The manuscript is well written and recommended for publication subject to minor revisions.

The manuscript provides a good introduction to the approach itself and results obtained by evaluation of simulation data and predicted damage values. However, there is room for improvements by discussing several aspects in more detail:

- The analysis focuses on the prediction of fatigue damage values at mudline in the monopile. How critical is this location in the overall fatigue loading of the structure? Monopiles are commonly build by a pile structure with transition piece as connection to the tubular tower. How does the transition piece with grouting connection influence the ability to predict/transfer fatigue loading values from above to below the transition piece? Does other structural components influence the accuracy of the model in terms of prediction of values at other locations?

- Does the method include the possibility to evaluate fatigue of soil bearing capacity based on measured loads, or is this out of scope?

- What is the common practice for LTE analyses in the wind industry by today? How are such analyses performed for other offshore structures, e.g. oil and gas platforms? I'm aware of that loads on these structures are substantially different from what wind turbines experience. However, LTE is common practice in this area and experience from such analyses could potentially be transferred to the wind industry.

Several details of the performed analysis as well as technical solution are missing for an interested reader. Please address the following comments in a revised version:

- Include a matrix which shows load case combinations, or a reference to where the setup of the mentioned 'design basis and additional 1700 load cases' can be found.

- How does the technical solution of 'strain measurements at one level' look like? What

kind of strain gauges are required, how many and where are they placed? What kind of data do you extract from your simulation model at this level?

The manuscript shows fatigue damage prediction with very high accuracy (1-3%). To which extent will this accuracy be influenced by other potential errors as for example the fact that your simulation model must represent the real asset in detail? Degradation is mentioned in the discussion and needs to be accounted for in a measurement campaign. Noise of real world measurement data is another source of error and should be discussed and addressed in the approach.

2 - Specific comments

1 Introduction

- The BSH has a requirement that a CMS system has to be installed for at least 1/10 of the offshore wind turbines in a wind farm. Do you think the presented method could be a solution to fulfill such a requirement? Looked at it from a different angle, could an already installed support-structure CMS be used as input to your calculations and by this enable LTE calculations without additional sensor measurements?

- Traditional LTE analyses are for example based on strain gauge measurements for a certain period and statistical weather data. Do you know how many strain gauges need to be placed in traditional LTE measurement campaigns of monopiles? How large is the benefit for your solution, both in terms of reduced sensor costs as well as increased accuracy?

2 Methodology

- Please include the description of software programs used in the analysis (currently described in Section 3.1) in this section.

- SCADA-data are commonly recorded and are available for the lifetime of the asset. By retrofitting the proposed method in existing wind turbines, could historical SCADA-data in combination with experience from strain gauge measurements be used for an

evaluation of the fatigue damage experienced in the past?

3 Results and discussion

- It is not clear to the reader which number of neighbors you are ending up with, or which do you evaluate as sufficiently accurate. Figure 1 presents 4 neighbors on each side; Figure 10 presents 1 and 10 neighbors; and Table 1 and Figure 5 presents 1 and 15 neighbors. Please be more consistent on the data sets used and analyses performed to evaluate the sensitivity of the approach to different parameters.

- Have you evaluated to plot Table 1 as bar graph for better readability and direct comparison of the different approaches?

3 - Technical corrections

Page 1, line 19: 'better decisions', compared to what? Please rewrite.

Page 4, line 19: 'is predicted best', is resulting in highest accuracy? Please rewrite.

Page 5, figure 3: Please include grid lines in figure for better readability.

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