Response to Referee 2

From the center of wind pressure to loads on the wind turbine: A stochastic approach for the reconstruction of load signals

Referee's comment (RC) in blue
Author's comment (AC) in black

The references to lines in the manuscript (e.g., 'L.80') are given with respect to the **new version** of the paper.
In gray: text from the revised version of the manuscript.

GENERAL COMMENTS

REFEREE:

[...] I feel there is still some confusion regarding the applicability of the method to fatigue or extreme loads. In fact, while evidence is provided on how the method may be applied to lifetime fatigue load estimation, it is not validated for extreme load prediction. I think most of the confusion lies in the fact that the authors sometimes refer to extreme loads caused by gusts, other times to extreme load extrapolation. While standards prescribe both scenarios to be checked, they are very different situations, and this is a bit confused in the way it is presented now. Also more explicitly distinguishing between fatigue and extreme loads in the text is recommended, see below for more details.

The comment on the fact that the method has been proposed for lifetime extreme load extrapolation has been only partially addressed. From the authors response throughout the paper and in the conclusion it is not clear if "Lifetime loads" are fatigue or extreme loads. The paper provides evidence that the method may indeed predict fatigue loads accurately, but evidence regarding extremes is not provided. Extreme lifetime loads (1yr or 50yr return period) are often difficult to predict with a simplified model as they may depend on a reduced number of cases. It is extremely difficult to predict which cases those may be due to the high non-linearity of the system. And thus discrepancies in these scenarios, which are often hard to tune for due to their scarcity, may cause differences in predictions.

I would thus recommend to clarify better if the discussion, and the procedure outlined in the conclusions to go from COWP to lifetime loads refers to fatigue or extreme loads. When referring to extreme loads I would recommend to either provide more evidence of the ability of the model to predict 50 or 1-year extreme loads or to clearly state that while the model may provide an interesting prospect in this regard, it is yet to be verified and validated.

Thank you very much for your comment. By re-reading our statements con-

cerning *extreme* wind and *extreme* loads, we realize, as you remarked, that they might lead to ambiguity. However, it should be noted that in our work, we do not refer to *extreme* loads as defined by the IEC (i.e., with a 50-year or 1-year return period). Within the framework of the CoWP, the designation 'extreme load' has been adopted to signify substantial load events that, with a given wöhler coefficient, drive the estimated Damage Equivalent Loads (DELs) [1]. The importance of these very large events, which can be reproduced by our proposed stochastic method, is grounded on their dominant contribution to the DEL without being categorized within the scope of an IEC extreme load scenario.

To reduce possible confusion with the term 'extreme', our text has been modified in the manuscript.

In the paper, we employ the term 'extreme wind events' to denote specific instances of localized gust-like structures, which result in very strong differences of the wind speed over the y-z plane (i.e., perpendicular to the predominant direction of the wind, as illustrated in Fig. D1). In order to differentiate these events from the extreme wind conditions defined by the IEC, we have modified lines 337-339, 366-368, and 498. In such instances, the term 'extreme wind' has been replaced by 'severe or very strong differences of the wind speed over the rotor plane'. As an example, L.337-339:

Over those intervals, significant differences in the wind speed are observed in the spatial domain (i.e., over the rotor plane).

As an additional aspect, we want to point out that the dynamic response of modern wind turbines with increased size gives additional relevance to wind structures over the rotor plane. Larger areas covered by the increased rotors likely include inhomogeneities (i.e., severe differences in wind speed) over the rotor. In this direction, the CoWP and the stochastic approach delineated in our paper have the potential to serve as a tool for describing and modeling IEC extreme scenarios.

The following lines have been added to the conclusions of the manuscript (L. 426-429):

The validity of this load estimation has been demonstrated in the context of the DELs. The dynamic response of modern wind turbines with increased size gives additional relevance to wind structures over the rotor plane. Larger areas covered by the increased rotors likely include inhomogeneities (e.g., severe differences in wind speed) over the rotor. In this direction, the CoWP and the stochastic approach delineated in our paper have the potential to serve as a tool for describing and modeling IEC extreme scenarios (i.e., with 50-year or 1-year return period). In this direction, the CoWP and the stochastic approach delineated in our paper have the potential to serve as a tool for describing and modeling IEC extreme scenarios (i.e., with 50-year or 1-year return period).

A new version of the manuscript is provided along with a diff file.

[1] Schubert, C., Moreno, D., Schwarte, J., Friedrich, J., Wächter, M., Pokriefke, G., Radons, G., and Peinke, J.: Introduction of the Virtual Center of Wind Pressure for correlating large-scale turbulent structures and wind tur- bine loads, Wind Energy Sci. Discuss. [preprint], 2025, 1–19, https://doi.org/ 10.5194/wes-2025-28, *in review*, 2025.