Authors’ response to comments of associate editor

Journal:	Wind Energy Science
Title of paper:	Extreme wind turbine response extrapolation with Gaussian mixture model
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The authors would like to thank the associate editor for the comments and advice on the submission. The manuscript has been revised accordingly, and the detailed responses are provided below.

Overview: *This paper discusses the topic of wind turbine extreme load statistical extrapolation methods. By utilizing the Gaussian mixture model (GMM) as a multi-modal statistical model to fit the long-term distribution of load response under uncertain wind condition, the data aggregation first and fitting afterward (AFFA) method can be used to estimate the characteristic load with 50-year return period. The performance of the proposed method is validated against the existing methods through four cases: the maximum out-of-plane blade tip deflection, the maximum blade root out-of-plane bending moment, the maximum blade root in-plane bending moment, and the maximum tower base side-to-side bending moment. A comparison of the fitting first and aggregation afterward (FFAA) and AFFA approach is conducted, and the advantages of GMM in terms of both accuracy and flexibility is demonstrated. The paper is concise and well organized with most of the reviewers’ comments properly addressed. I would recommend this paper to be accepted on condition that the following minor issues are further addressed to improve the clarity and completeness of the paper:*

Response: Your review of the manuscript and providing valuable comments are appreciated. The issues highlighted are addressed, and changes have been made to the revised manuscript. (The line numbers in the changes sections are the number in the revised manuscript.)

Comment 1: *The discussion regarding Figure 5 is missing in the main body of the context.*

Response 1: Thanks for your comments.

Changes 1: The discussion regarding Figure 5 is updated at line 272:... can lead to varying results. GMM (LS) overcomes this limitation as LS is only used to determine the number of components and is not affected by the choice of quantiles. For example, in Fig. 5, the extreme load estimation for the maximum out-of-plane blade tip deflection is compared using Weibull(LS) with data above the 50th (legend as 50%) to 90th (legend as 90%) quantiles. Significant differences are observed when using different amounts of tail data for LS with Weibull distribution.

Fig. 5 is positioned closer to the text describing it.

Comment 2: *Regarding the Comment G.1 of Reviewer #2, in Line 68-71 of the revised manuscript, the authors claim that the tail distribution of a mixture probability distribution is likely to be dominated by only one of the distributions. This implies that the tail distribution of GMM might also be dominated by a single Gaussian distribution component since GMM is also a kind of mixture probability distribution. I am not sure this explanation is the true reason that the GMM outperforms other mixture distribution. Consequently, I recommend the authors discuss more about the advantage of GMM over other mixture distribution models or compare the performance of other mixture distribution models in Sections 3-5.*

Response 2: Thanks for your comments. The advantages of GMM over other mixture distribution models (e.g., the bi-modal distributions compared in Jung and Schindler (2017)) are listed as follows:

– Wind turbine extreme load responses can exhibit multiple modes, as illustrated in Figure 1 of the revised manuscript. When employing maximum likelihood estimation for the entire dataset, Weibull distribution struggles to accommodate distributions with more than one mode, as evidenced in Figure 1. Consequently, distributions like GEV-Weibull or Weibull-Weibull might not yield optimal performance in cases with multiple modes.

– The primary emphasis of the paper lies in load extrapolation, a scenario often extending beyond the available dataset, rather than on distribution modeling. The suitability of bi-modal distributions compared in Jung and Schindler (2017) for load extrapolation or estimating low failure probabilities has not been established.

– In Jung and Schindler (2017), various bi-modal distributions were presented, introducing the challenge of selecting an appropriate distribution when the true distribution of the underlying data remains unknown. As demonstrated in this manuscript, one of the advantages of GMM is its flexibility, mitigating prediction errors stemming from improper distribution selection.

Changes 2: In line 67: ...modelling an entire multimodal statistical population. However, the varying number of modes in wind turbine response distributions, sometimes exceeding two, poses challenges for both bi-modal distributions and fixed-component distributions. These challenges stem from mismatches in mode numbers during distribution fitting using the complete dataset. When relying solely on tail data for distribution fitting, the selection of appropriate mixture probability distribution components and their quantities remains a challenge (e.g., Weibull-Weibull, GEV-Weibull, GEV-Lognormal-Weibull).

Comment 3: *The word "sample" is used throughout the paper with various meanings, which is a bit confusing.*

Response 3: Thanks for your comments.

Changes 3:

In line 92, 130: data sample -> dataset

In line 107, 133, 154, 156, 161: sample -> dataset

References

Jung, C. and Schindler, D.: Global comparison of the goodness-of-fit of wind speed distributions, Energy Conversion and Management, 133, 216–234, https://doi.org/10.1016/j.enconman.2016.12.006, 2017.