Response to reviewer comments on “Storm damage beyond wind speed – Impacts of wind characteristics and other meteorological factors on tree fall along railway lines”.

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Preliminaries: We would like to thank the anonymous reviewers for their comments on our manuscript. We find the comments helpful and constructive. We think that they will help to improve the manuscript. In the following pages we set out in detail our responses to the comments and how we plan to act on them.

Review 1

This study assess the impact of several meteorological factors on tree fall risk along the German railway network. The results contribute to the understanding of the relative importance of different factors on the tree fall risk in Germany and they can be extrapolated by some extent to other countries as well, especially to those having similar climatic and environmental conditions. The manuscript has a clear structure and it is well written. However, I have a couple of general and a few more specific minor comments.

General comments

1. From line 70 onwards it is explained how much Deutche Bahn has recently spend money on vegetation management, but the number of tree fall events causing disruption in the railway service has remained high. The paragraph ends with justification that this kind of study can add value to the management of vegetation along the transportation routes. Can you comment your results from this viewpoint in the Discussion section? In which extent do you expect, that these results could be implemented to mitigate the wind-related damage?

Response:
To address these questions and elaborate on the aims of our study and the benefits of our results, we made several changes.
1. We changed the paragraph in the Introduction starting at line125 to:

> “We aim to develop a meteorology-based tree fall impact model, which is a first step toward a more complex predictive tree fall model. On the one hand, such a predictive model could be used to identify areas at risk and support management decisions, for example, which trees to cut down, especially when environmental and forest data are included at some point. On the other hand, the model can be applied to climate model data to identify future changes in tree fall risk. To accomplish this, we need to identify meteorological parameters and parameter combinations that impact tree fall risk alongside railway lines in Germany over the long term and across a large-scale area. We aim to deepen the understanding of tree fall risk and wind and to explore how far wind-related parameters like daily maximum gust speed, the gust factor, air density, wind load, the duration of strong wind speeds, or wind direction have an impact on tree fall. We also examine the impacts of other predictors related to meteorology

that have been included in previous studies, such as soil moisture, precipitation, snow, or soil frost. Additionally, we study legacy effects of dry and wet spells by including soil water volume and precipitation in antecedent time periods."

2. We added a paragraph to the Discussion section 6.3 (limitations):

> "This study aimed, among other things, to create a meteorological basis for a predictive tree fall model that can support decisions regarding the management of vegetation alongside transportation routes, as well as climate-resilient forests. However, local ecological information (soil, tree species, stand structure, etc.) is not taken into account. Thus, the results are not representative of every individual setting but rather for an average setting across Germany. Nonetheless, this work is a step towards future research on the topic of wind damage and tree fall."

3. We added an Outlook-paragraph to the Conclusion:

> "This work is a step towards future research on the topic of wind damage and tree fall. Firstly, it is the foundation for a predictive tree fall model, as it shows how to incorporate meteorological factors into such a model. Secondly, the model can be applied to climate model data to estimate changes in tree fall risk in future climate scenarios. We aim to elaborate on these goals in future research."

2. I understand that Figure 4 presents the most relevant results of this study. Here, one model parameter is varied in each plot while the others are fixed to a certain value. How these fixed values were defined?

Response:
The precise choice of values for these figures does not significantly impact the conclusions we draw from the results. We explored the data before our analysis and then picked values that seemed reasonable. We will add the following sentence to the Results, line 283:

> "For these plots, one model parameter is varied while the others are fixed to a certain value (detailed in the caption of Figure 4) that was determined during a previous data exploration. For the fixed values of $v_{max\ anom}$ and dur_{90} we picked 18 m/s and 5 hours, which represent values of a short but strong winter storm. 18 m/s are exceeded on about 0.5% of days and thus occur approximately two days a year. For $swvl_{anom}$ and pr_{90} we selected values that represent a dry situation, thus very low soil moisture and very low precipitation. For wind direction we picked a north-easterly wind. For the other variables (pr_365, ρ) we chose the average over the time period 2017-2021."

Can you also perhaps slightly elaborate, how the interaction of different variables has been taken into account here?

Response:
We describe the implementation of interactions in section 4.2, line 191 – 197 and line 226 - 229. We discuss the effect of the two interactions present in the model in section 6.2.
We will enhance the description of the method and effects of the implementation of the interaction terms by adding a paragraph to the Results in line 251:

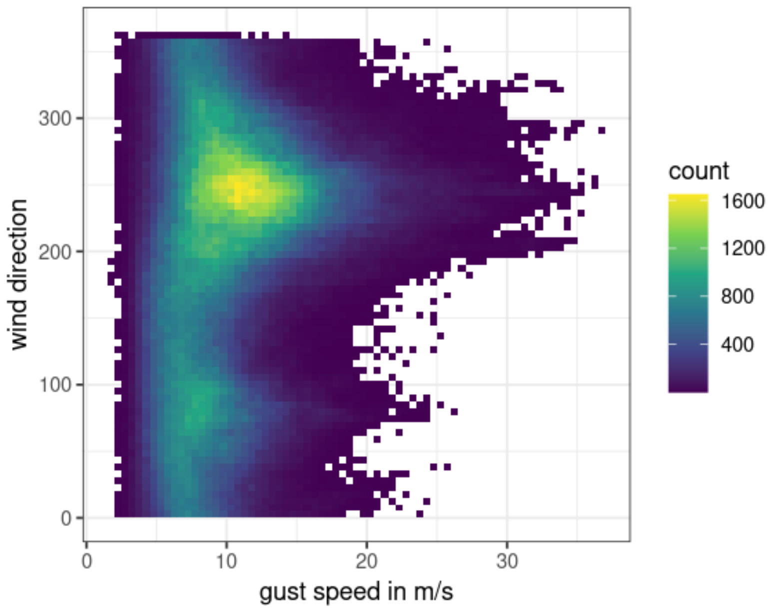
> „The terms v_{max_anom}: dur_{90} and v_{max_anom}:gf represent the interactions of gust speed with duration and gust factor. They serve to account for the fact that the individual parameters do not change tree fall risk independently. Their impact in the model becomes apparent mainly on days with relatively high wind speeds. See section 6.3 for further discussion of this effect“

We also added this sentence to the Methods, line 197:

„It [the interaction] represents how the effect of x_1 on the event probability changes with x_2 (and vice versa). A significant b_3 would indicate that the effect of x_1 on the probability is different at different levels of x_2.„

In general, the results presented in Fig. 4 seem as expected with the exception of the impact of wind direction on tree fall risk. As noted on lines 286-288, southeasterly winds seem to produce the smallest and northwesterly the highest risk. The impact of wind direction is furthermore discussed on lines 343-348 where the authors note that trees tend to adapt to local wind direction. As the predominant wind direction in Germany has probably some western component, it is interesting and unexpected for me that the northwesterly winds would cause the highest risk. Do you have any idea what could be the reason for this result? Could it even be just random noise due to the fact that very local features might dominate here.

Response:
We can think of two possible explanations: One is, like you are saying, that this might be a random effect. The other explanation is connected to uncertainties in ERA5 wind data and to the fact that that westerly winds are on average stronger (see the figure below where we plotted gust speeds against wind direction and which shows that the most extreme gust speeds occur for westerly winds). ERA5 is not a perfect representation of wind and sometimes underestimates the gust speeds. (We added a section about the shortcomings on ERA5 to 6.3. Please see our first response of Review 2 for more detail). Thus, in cases where ERA5 underestimates the real gust speeds but shows westerly winds the wind direction may become a proxy for stronger winds in the statistical model. However, it should be noted that the effect of the wind direction on tree fall risk is relatively small compared the effect of the wind speed itself. Furthermore, the effect of the wind direction only slightly exceeds the range of the confidence intervals.



We added a section to the Discussion to elaborate on this:

„In our model the influence of the wind direction on tree fall risk is relatively small compared to the effect of the wind speed itself. Nonetheless, it appears that westerly winds slightly increase tree fall risk. This seems counter-intuitive as this is the predominant wind direction in Germany. One would assume the trees adapt to this and thus wind direction would have either no effect or that easterly winds would increase tree fall risk. An explanation might be that westerly winds are on average stronger. ERA5 is not a perfect representation of local winds and sometimes underestimates gust speeds (Molina 2021). Thus, in cases where ERA5 underestimates the real gust speeds but shows westerly winds the wind direction might become a proxy for stronger winds.„

To return to interaction terms, a notable feature in Fig. 5 is that the model with no interaction terms for the gust factor yields generally higher tree fall risk than the model with interaction terms included. Can you comment on that?

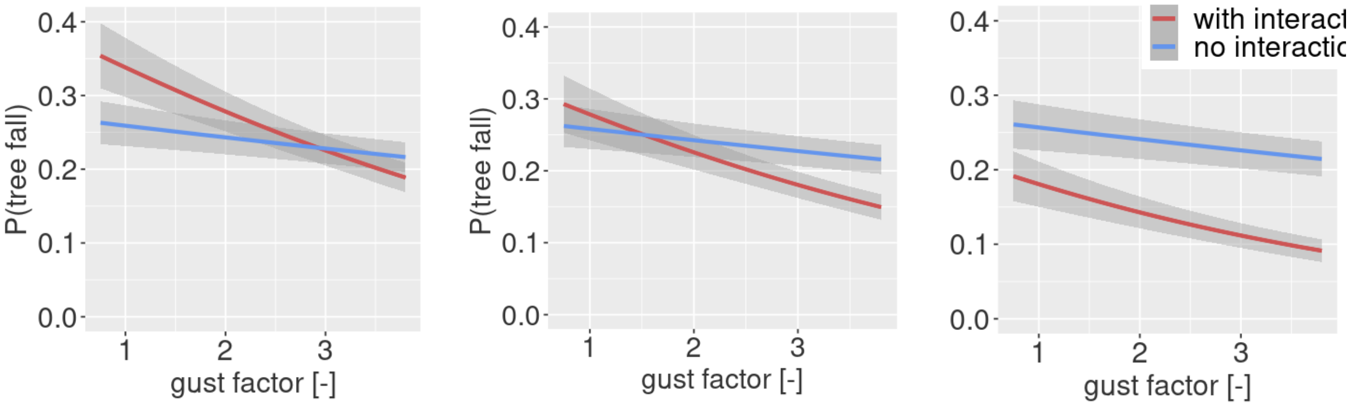
Response:

Interaction terms capture non-linear effects between predictors. This can lead to modified probability estimates that might be more realistic but can turn out to be lower. Both interaction terms in the model play a role here:

The introduction of the interaction with the gust factor changed the estimated coefficient and thus the relationship between the predictor and the target variable. The estimated coefficient of the gust factor is positive, but the estimated coefficient for its interaction with the gust speed is negative (see Table 1). The negative coefficient weakens the resulting probability.

2. The exact position of the curve is, in this case, among other factors, determined by the duration of strong wind speeds because of the second interaction (v_{max_anom}: dur_{90}).

In the figure below, you can see how the curve of the model with interaction terms (red) is shifted while the no-interaction-model (blue) changes only minimally. The durations in the figures are 20, 15 and 5 hours.



Specific comments

1. Line 51. The term "gust factor" is probably familiar for the readers with background from storm damage studies but not for all other readers. You could shortly explain it by a few words here, for example like this "A high daily gust factor (i.e., the ratio of gust wind speed to mean wind speed) decreases the risk" etc

Response:

We will follow the suggestion and add: „(the ratio of maximum daily gust wind speed to the mean daily gust speed)“ to line 51.

2. Line 64. I assume that here should read "losses" instead of "loses"

Response:

Thank you. We changed it.

3. Line 80. Please check this sentence, as it seems like some words are accidentally missing.

Response:
We changed the sentence to:

> "In recent years the interest in the topic has increased. A number of studies on tree fall hazards show that this problem is also present outside the German railway network (Bíl et al., 2017; Koks et al., 2019; Kučera and Dobesova, 2021; Szymczak et al., 2022)."

4. Line 138. Should it read "Monthly percentages" instead of "Yearly percentage" in the caption of figure 2?

Response:
We changed the caption to:

> "Percentage of tree fall events per month over a year alongside German railway lines for the period 2017-2021."

5. Line 145. I would estimate from the figure that approximately 28% of tree fall events occurred in December, January and February in total, so the claim that "the majority" of the events occurred within these months is clearly incorrect. Moreover, December is in fact the month with the third smallest number of tree fall events in the data, and the three months with the largest number of tree fall events are January, February and March. However, even these three months are far from producing "the majority" of the events.

Response:
We changed the section in line 145 - 147 to:

> "The highest monthly numbers tree fall events occur from January to March and from June to August. There is also a peak in October (Figure 2). Large-scale windstorms in winter and convective events in summer are influential drivers. The most extreme daily numbers of tree fall occur during the winter season and are connected to winter wind storm events (Figure 3)."

6. Line 149. Is there a reason why you use ERA5 data instead of a more finer resolution ERA5-Land data?

Response:
ERA5-Land provides only mean wind speed but not gust speed, which is more relevant for tree damages. Additionally, ERA5-Land seems to show no improvement regarding wind speed compared to ERA5. Fatolahzadeh Gheysarii et al. (2023) compared wind speed of ERA5 and ERA5-Land with observations in Canada and found ERA5 to perform slightly better. Clelland et al. (2024) did an evaluation for Siberia. They state: „ERA5-Land performs the best at lower WSPs [wind speeds], however ERA5 should be used for extreme high speeds, which are likely to be of most interest.„ We are not aware of an evaluation of ERA5-Land wind speeds for Europe.

7. Line 172. I assume that here should read "where" instead of "were"

Response:
Thank you. We changed it.

8. Line 242. Did you use a two-tailed z-test or t-test?

Response:
Thank you for pointing out this mistake. We changed the lines 242 and the caption of Table 2 to:

“with $p < 0.05$ based on the Student’s t-test”

9. Line 250. It is stated here that explanations for the different predictor abbreviations are given in Table Fehler: Verweis nicht gefunden. This apparently German table is referred several times thereafter. What table is this and where it can be found?

Response:
Something went wrong wit the cross references for the tables. We fixed the references in the text. In line 250 we refer to Table 1.

10. Line 305. I assume that here should read "limitations" instead of "limiation"

Response:
Thank you. We changed it.

11. Line 313. I assume that the word "and" is missing between the words "risk" and "improve"

Response:
Thank you. We changed it.

12. Line 415. I assume that here should read "The" instead of "Teh"

Response:
Thank you. We changed it.

13. Line 436. I would suggest to rephrase the caption of Figure 7 as follows: "Comparison of interaction effect. Gusty day: dur90 = 2 and gf = 5; sustained day: dur90 = 12 and gf = 2…"

Response:
Thank you. We changed it.

Review 2

General comments

The manuscript utilizes stepwise model selection to construct a logistic regression model, aiming to identify meteorological parameters, partially the wind and their combinations, and assess their impact on tree fall. The study proposes that high wind speeds (gust), especially in combination with wet conditions and a high air density, increase tree fall risk, and suggests relating meteorological predictors to local climatological conditions for the acclimation of trees to their local climatic conditions. The paper is the first time showing clearly that storm duration, gust factor and air density are important factors in calculating the risk of tree fall. Anyway, I am not convinced the regression results by using the wind ERA5 hourly dataset. The use of ERA5 as observational data may not be sufficient, as previous studies have shown its limitations in capturing historical near-surface wind speed over land (e.g. Dunn et al., 2023, BAMS). I strongly recommend the performance of ERA5 could be validated by the actual data (time series obtained from meteorological institutes). Otherwise, this is just a theoretical exercise from the perspective of reanalysis, so anyone could do that in this aspect. Thus, I have to reject the publication of this paper.

Response:
Thank you for the critical question regarding the discrepancies between reanalysis data and station-based measurements, which is a relevant aspect that needs to be discussed. While station-based wind measurements are certainly more accurate than reanalysis data at the specific location of the measurement, there are several reasons why reanalysis data is more appropriate for the purpose of our study:

- Previous studies provide validations of ERA5 with observational data and find high correlations between them. Molina at al. (2021) compare hourly 10 m wind speed from ERA5 with wind observations from 245 stations across Europe. They find that „Most of the stations exhibit hourly [Pearson corrrelation coefficients] ranging from 0.8 to 0.9, indicating that ERA5 is able to reproduce the wind speed spectrum range, from light to strong relative frequencies, for any location over Europe“. Minola et al. (2020) compare ERA5 with hourly near-surface wind speed and gust observations across Sweden for 2013–2017. They, too, find Pearson correlations of 0.8 and higher for daily maximum gust speeds. However, they do point out that „evident discrepancies are still found across the inland and mountain regions“ and that higher wind speeds and gust speeds display stronger negative biases. For another study we connected ERA5 gust speed data to German observational data from the DWD station network and found similar correlation values. We assume by Dunn et al., 2023, BAMS you are referring to Dunn et al. 2023 - Global and regional climate in 2022? This seems to be a study on climate indices in the year 2022 and not on the validity of ERA5 wind speed.
- Reanalysis wind speed data, including ERA5 data, has already been used successfully in several studies relating wind damage to wind speeds (Donat et al. 2001, Sarli et al. 2020, Trojand et al. 2022).
- There are at the moment 279 stations in Germany that measure gust speed. That is one station per 1280 km². The tree fall events are randomly distributed along the Germany railway network and a weather station is in many cases not nearby. This is problematic since gusts are a manifestation of small scale turbulences with high spatial variability and station-based gusts measurements may not be representative for a larger area. Thus, the observational data from the German weather station network is not feasible for our modelling approach.
- There are two potential applications of the models presented in this study: first, to use the models to translate wind forecasts of numerical weather prediction models into expected wind damages; second, to use the models to translate climate model output to wind damages

to assess potential impacts of climate change on tree fall risk. In both cases the wind data would be retrieved from simulations of numerical atmospheric models. Therefore, it is reasonable to also train and test the performance of the model based on atmospheric model data.

Based on these arguments we think ERA5 is the most appropriate data set for the purpose of our statistical modelling approach.
To justify the selection of ERA5 as input data and to point out its limitations we added the following sections to the Discussion (line 455):

„While evaluations of ERA5 gust speeds with observational data point out some limitations they also find the data in general to be a good representation of local measurements. Molina (2021) compare hourly 10 m wind speed from ERA5 with wind observations from 245 stations across Europe. They find that „Most of the stations exhibit hourly [Pearson correlation coefficients] ranging from 0.8 to 0.9, indicating that ERA5 is able to reproduce the wind speed spectrum range [...] for any location over Europe“. Minola (2020) compare ERA5 with hourly near-surface wind speed and gust observations across Sweden for 2013–2017. They, too, find Pearson correlations of 0.8 and higher for daily maximum gust speeds. However, they do point out that „evident discrepancies are still found across the inland and mountain regions“ and that higher wind speeds and gust speeds display stronger negative biases.“

We also gather from this review that the aims of our study and the benefits of our results were not made clear. We therefore made further changes in the text:

1. We changed the paragraph in the Introduction starting at line 125 to:

“We aim to develop a meteorology-based tree fall impact model, which is a first step toward a more complex predictive tree fall model. On the one hand, such a predictive model could be used to identify areas at risk and support management decisions, for example, which trees to cut down, especially when environmental and forest data are included at some point. On the other hand, the model can be applied to climate model data to identify future changes in tree fall risk. To accomplish this, we need to identify meteorological parameters and parameter combinations that impact tree fall risk alongside railway lines in Germany over the long term and across a large-scale area. We aim to deepen the understanding of tree fall risk and wind and to explore how far wind-related parameters like daily maximum gust speed, the gust factor, air density, wind load, the duration of strong wind speeds, or wind direction have an impact on tree fall. We also examine the impacts of other predictors related to meteorology that have been included in previous studies, such as soil moisture, precipitation, snow, or soil frost. Additionally, we study legacy effects of dry and wet spells by including soil water volume and precipitation in antecedent time periods.”

2. We added a paragraph to the Discussion section 6.3 (limitations):

“This study aimed, among other things, to create a meteorological basis for a predictive tree fall model that can support decisions regarding the management of vegetation alongside transportation routes, as well as climate-resilient forests. However, local ecological information (soil, tree species, stand structure, etc.) is not taken into account. Thus, the results are not representative of every individual setting but rather for an average setting across Germany. Nonetheless, this work is a step towards future research on the topic of wind damage and tree fall.”

3. We added an Outlook-paragraph to the Conclusion:

“This work is a step towards future research on the topic of wind damage and tree fall. Firstly, it is the foundation for a predictive tree fall model, as it shows how to incorporate meteorological factors into such a model. Secondly, the model can be applied to climate model data to estimate changes in tree fall risk in future climate scenarios. We aim to elaborate on these goals in future research."

Specific comments

1. Overall, the English level of the manuscript is a little poor and makes it hard to fully understand all the results and discussion, I suggest inviting an English native speaker to revise it thoroughly. Also, the depth of the text is very shallow and reveals a lack of scientific and technical maturity from the authors to properly conduct this research.

Response:
Unfortunately, the review does not specify where the text lacks depth and scientific maturity. We gave the text to test readers once again, including native English speakers with scientific background, and adapted the language and content where there was criticism.

2. The abstract needs to be rewritten, there exist so many grammar and logic errors.

The review does not point out the specific grammar and logic errors. We gave the abstract to test readers to account for the criticism and changed in the following way:

> "Strong winter wind storms can lead to billions in forestry losses, disrupt train services, and require millions of Euros to be spent on vegetation management alongside the German railway system. Therefore, understanding the link between tree fall and wind is crucial.
> Existing tree fall studies often emphasize tree and soil factors more than meteorology. Using a tree fall dataset from Deutsche Bahn (2017-2021) and meteorological data from ERA5 reanalysis and RADOLAN radar, we employed stepwise model selection to build a logistic regression model predicting the risk of a tree falling on a railway line in a 31 km grid cell. While daily maximum gust speed (the maximum wind speed in a model time step at 10 m height) is the strongest risk factor, we also found that the daily duration of strong wind speeds (wind speeds above the local 90th percentile), precipitation, soil water volume, air density, and the precipitation sum of the previous year increase tree fall risk. Using interaction terms between maximum gust speed and the duration of strong wind speeds, as well as gust factor (the ratio of maximum daily gust wind speed to the mean daily gust speed), improves the model performance and makes the impact of duration and gust factor visible. Days with a low gust factor and a longer duration of strong winds show a higher tree fall risk. Therefore, our findings suggest that high and prolonged wind speeds, especially in combination with wet conditions (high precipitation and high soil moisture) and high air density, increase tree fall risk. Incorporating meteorological parameters linked to local climatological conditions (through anomalies or in relation to local percentiles) improved the model accuracy. This indicates the importance of taking tree adaptation to the environment into account."

Defines gust and strong wind at the first instance.

We will follow the suggestion and also elaborate on other terms introduced in the Abstract. We changed the correspondent section to:

> „While daily maximum gust speed (the maximum wind speed in a model time step at 10 m height) is the strongest risk factor, we also found that daily duration of strong wind speeds (wind speeds above the local 90th percentile), precipitation, soil water volume, air density and the precipitation sum of the previous year increase tree fall risk. A high daily gust factor (the ratio of maximum daily gust wind speed to the mean daily gust speed) decreases the risk."

3. The introduction section needs to be restructured. Modifications can be made on various places, including but not limited to Ⅰ. the first to third paragraphs can be condensed into a single paragraph, Ⅱ. the fourth paragraph is not quite relevant to the manuscript's topic, Ⅲ. The correction method in the sixth paragraph can be moved to the data and methods section.

Response:
We condensed the first and third paragraph into one. We also shortened the section starting at line 70 to:

> „In 2018, Deutsche Bahn increased its budget for vegetation management to enhance storm safety, now spending approximately 125 million Euros annually (DB, 2023). And yet the cost of tree fall remains in the order of millions of Euro per year (Messenzahl, 2019). With 68% of railway tracks lined by trees and forests, ongoing management is necessary. Since 2018, over 1,000 workers have been employed to monitor and maintain railway vegetation (DB, 2023). Despite these efforts, there was an average of 3,062 tree fall incidents per year from 2017 to 2021, causing service disruptions and infrastructure damage."

We do not agree with the notion about the fourth paragraph (line 95 - 110). Here we present the state of knowledge in this research area. We point out the lack of meteorological predictors in previous studies and how wind speed and meteorology are considered in the studies which do take a deeper look on the relationship of tree and forest damage and wind. To make this more clear we changed the section starting at line 95 to:

> „Additionally, previous studies mainly analyse the impact of tree, stand and soil related factors on wind-induced damages but often exclude metrology. Those which consider meteorological predictors often focus on the relationship between tree damage and mean or maximum wind speeds (Schindler et al., 2009; Jung et al., 2016; Morimoto et al., 2019). Yet, there are some other meteorological predictors which are considered in previous works and which we will consider as well:"

We do not know what is meant by correction method. To our understanding we do not describe any correction methods in the introduction.

4. Line 62: What is high wind speed? A daily peak gust or maximum wind in a day or the biggest mean wind? Please clarify it at the beginning of the article to help readers understand.

Response:
This sentence is merely meant as an introduction to the topic. We changed the sentence to „Strong wind speeds are a major factor leading to tree fall and are therefore a threat both to the railway service and forestry. " as this wording is more in alliance with our later wording. In Table 1 and 2, we define what strong wind speed is in the context of our work, namely the exceedance of the local 90th percentile of gust speed.

5. Lines 70-72 missing a reference to support your point.

Response:
The reference is given in line 72-73 (DB, 2023), We moved it to the end of the sentence in line 73 to make it more apparent.

6. Line 74: 68%

Response:
Thank you. We changed it.

7. Line 79: Please clarify your topic, what you are going to investigate in this study.

Response:
The topic and aim of our investigation are first introduced in the Abstract (line 45) and then again at the end of the Introduction (line 125). As stated above we made several changes to clarify our topic and aim. This section (line 62 to 84) of the introduction is meant to motivate our research.

8. Line 83: change “connection” to “relationship”.

Response:
Thank you. We changed it.

9. Line 84: Have you done this in this study? If not, please remove these kinds of words.

Response:
We removed the sentence and changed line 82:
„Such research aids the management of vegetation alongside transportation routes as well as the development of climate resilient forests.“

10. Line 191: The method on how to introduce and calculate interaction terms seems unclear. I recommend further elucidation on the methodology or criteria used to establish the logistic regression model.

Response:
We describe the implementation of interactions in section 4.2, line 191 – 197 and line 226 - 229. We discuss the effect of the two interactions present in the model in section 6.2.
Perhaps the method and effects of interactions are not completely clear. Therefore we added this paragraph to the Methods, line 197:

> „It [the interaction] represents how the effect of x_1 on the event probability changes with x_2 (and vice versa). A significant b_3 would indicate that the effect of x_1 on the probability is different at different levels of x_2.„

We modifierd line 226 – 229:

> „We assume gust speeds to be the key predictor but interactions with other predictors that influence a trees vulnerability are likely. Therefore, we added interaction terms between daily maximum gust speed and each other model predictor in the same stepwise approach. Again, we only kept the interaction term if it improved the model’s BSS.“

We also added this section to the Results in line 251:W

> „The terms v_{max_anom}:dur_{90} and v_{max_anom}:gf represent the interactions of gust speed with duration and gust factor. Gust factor and duration of strong wind speeds change tree fall risk but their impact in the model only becomes apparent on days with relatively high wind speeds. See section 6.3 for further discussion of this effect.“

Additionally we added a third criteria to the model selection process:

> „3. The predictor has to be significant with $p < 0.05$ based on the Student’s t-test.”

11. Line 203-204: Please give more details on what specifically the reference model is when combining the trained model with it.

Response:
We added a sentence in line 204:.

> „[...] where *BS* is the modelled Bier Score and BS_{ref} is the score of a reference model, in this case a model that simply assumes the long term average tree fall probability in each grid cell, computed individually. This mean probability is used as the forecast probability *f* in BS_{ref} and compared to the outcome *o*.“

12. Line 222: The rationale of the first criteria used for model selection appears unclear. I recommend further explanations.

Response:

We changed this to:

> "1. There must be exactly one predictor from each predictor class in the model (see Table 2 for full list of predictors and classes)."

We elaborate on the predictor classes in line 210.

13. Line 249: The relationship between the equation 9 and each grid cell is unclear. It's uncertain whether the equation is derived from spatially averaged data or from data for each grid cell, and whether it's adapted to individual grid cells. I suggest more detailed instructions.

Response:
We added the following to line 252 to elaborate on this:

> „This model predicts the tree fall risk for each grid cell using the meteorological variables of each cell as input."

14. Line 441-442: The manuscript suggests that incorporating additional information such as tree, soil, or stand data could significantly influence the model results, potentially raising concerns about the robustness of the conclusions. Please provide further clarification on whether the identification of parameters, their combinations, and their impact on tree fall would be altered significantly as a result.

Response:
As these additional parameters are not available to us we cannot make a statement on how exactly they would alter the tree fall risk or if theses changes would be significant.

We made changes to this paragraph to elaborate on this issue:

> „Many studies have pointed out the influence of tree, stand and soil factors on wind damage vulnerability (Mayer et al., 2005; Kamo et al., 2016; Kabir et al., 2018; Díaz-Yáñez et al., 2019; Hart et al., 2019; Gardiner, 2021; Wohlgemuth et al., 2022). Such data is unfortunately not available for the scope of our study. Thus, model results could vary if such information were to be incorporated. For example the tree fall risk according to this model might vary at the same gust speed level for trees standing on sandy soils compared to loamy soils or for solitary trees compared to trees in a forest. However, our results show clear evidence for the importance of specific meteorological predictors in tree fall and storm damage modelling."

15. Line 4: The term "gust speed" is used for the first time in the abstract and I suggest providing a definition.

Response:
We will follow the suggestion and also elaborate on other terms introduced in the Abstract. We changed the section to:

> "While daily maximum gust speed (the maximum wind speed in a model time step at 10 m height) is the strongest risk factor, we also found that daily duration of strong wind speeds (wind speeds above the local 90th percentile), precipitation, soil water volume, air density and the precipitation sum of the previous year increase tree fall risk. A high daily gust factor (the ratio of maximum daily gust wind speed to the mean daily gust speed) decreases the risk."

16. Line 103: The symbols "t" and "T" are unfamiliar in the study, and I recommend a specific description.

Response:
We changed this to:

“In other works the gust factor is defined as the ratio of the maximum short-term averaged wind speed over a shorter duration t_s to a long-term averaged wind speed over a longer duration t_l (Ancelin, Courbaud and Fourcaud, 2004; Gromke and Ruck, 2018). The exact durations of t_s and t_l then need to be adapted to the specific research questions.”

17. Line 145: The statement "The majority of tree fall events occur in December, January and February" appears to be inconsistent with Figure 2. Please verify this discrepancy.

Response:
We changed the section in line 145 - 147 to:

“The highest numbers tree fall events occur from January to March and from June to August. There is also a peak in October (Figure 2). The most extreme daily numbers of tree fall occur during the winter season and are connected to winter wind storm events (Figure 3).”

18. Line 172: The word "were" appears to be grammatically incorrect.

Response:
Thank you. We changed it.

19. Line 193-194: The word "haven" appears to be grammatically incorrect.

Response:
Thank you. We changed it.

20. Line 231: The word "ore" appears to be grammatically incorrect.

Response:
Thank you. We changed it to „or“.

21. Line 250: The sentence "Table Fehler: Verweis nicht gefunden" seems to contain an error. The same error appears to be present in the later sections of the manuscript.

Response:
Something went wrong wit the cross references for the tables. We fixed the references. In line 250 we reference Table 1.

22. Line 281-282: The sentence "improved the model's BSS" is not significantly agree with the sentence "The BSS of this model remains 0.069" and may cause misunderstanding. I recommend reviewing and revising it.

Response:
Thank you for pointing out this mistake. Here we mean that after removing the non-significant predictors the BSS remains at the same value. We changed this sentence and moved it to line 274:

“After removing the three non-significant predictors the BSS remains 0.069.”

23. Figure 4-7: For enhanced readability, I recommend adding the corresponding standardized coefficients separately to each figure.

Response:
We do not think adding the standardized coefficient of the varied variable will help the comprehension of the figures and might even be misleading as in each plot all predictor coefficients lead to the modelled result and not just the coefficient of the parameter on the x-axes. If a reader is interested in the exact coefficient of each predictor they may find it in Table 1.

24. Line 447: The line seems empty and unnecessary. Please remove it.

Response:
Thank you. We changed it.

25. Line 449: The font of "maximum" in the definition of $vmax$ seems irregular and warrants revision.

Response:
Thank you. We changed it.

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