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Response to anonymous reviewer comment RC1

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Reviewer comments are marked with "RC1" and answers from the authors are marked with "A" in cursive. When applicable, we provided quotations of the modified sections from the manuscript to further illustrate the response. The modified sections that are quoted here are marked in ***bold****.*

We would like to warmly thank the reviewer for the extensive and qualitative feedback. We hope that the integration of the reviewer's feedback has improved the quality of the manuscript.

Reviewer Comment #1

RC1: Thank you very much for submitting this very interesting manuscript. The authors modelled current and future forest fire susceptibility in Brandenburg using a random forest approach. They analyzed variable importances of topographic, climatic, anthropogenic, soil and vegetation predictors, highlighting the influence of human factors for fire ignitions in Brandenburg. Overall, one strength of this article is the comprehensive description of methods and its well written nature. I very much enjoyed reading the study. Well done! So far, I only have only one major comment regarding the temporal selection of climatic variables, the rest is minor.

A: Thank you very much for the positive feedback on our manuscript and your careful examination. In the following, we will provide some explanatory comments in response to your comments.

RC1: Major comment: Over that whole manuscript I am wondering why only a selection of months (here June) was used to build your random forest models. I agree that human factors have a strong influence on fire susceptibility in Brandenburg and I can also follow your discussion on explaining the rather weak influence of climate variables given your analysis and missing extreme events in the data. However, in general, I miss more details/justification why the selection of only few summer months was done here. In the variable description the authors refer to a publication by He et al. (2022), which however, modelled Australian bushfires, thus the climate-fire-susceptibility relations might be different from those compared to forest fires in Brandenburg. Therefore, I kindly ask the authors at least to better justify the rather strong assumption to select only certain months for their analysis. I also kindly ask the authors to test if your random forest analysis yields very different results if you include all the months of the year (from Table 1 I assume that monthly resolution is given also for the future data). After all, I think including more months in your analysis is highly valuable, because this could also improve our predictive outcomes and messages you could convey for your future projections (as you discussed in section 4.2). I suspect the main reason why your future predictions are weakly diverging from the present day, might not only be due to a limited representation of extreme events in our future data, but rather the fact that the only changing variables in your predictions are climatic - and those have a fairly weak importance our RF-models.

A: We thank the reviewer for this detailed feedback. For Random Forest model training, we included forest fire data from all available months of all years for the analysis (2014 to 2022). Respectively, we included climatic data of all available months of the mentioned time period for the model training. The month of June was selected for model prediction exclusively. We decided upon this month after carefully assessing the forest fire data provided by the Lower Forestry Authority of the State of Brandenburg (2023), which showed that the majority of forest fire events occurred in the month of June based on the years of 2014 to 2022.

To clarify this matter, we modified the following section at the end of chapter 2.2 (ll. 92 f.):

"After analysing the monthly frequency of forest fires in the federal state of Brandenburg, the month of June was selected for the prediction of the four scenarios, since forest fire data showed the highest number of forest fires in this month between 2014 to 2022 (Lower Forestry Authority of the State of Brandenburg, 2023). ***For model training, we used all available forest fire events of all months between 2014 to 2022 and pre-processed monthly climatic data sets in accordance with the available forest fire data.****"*

Regarding your statement "I suspect the main reason why your future predictions are weakly diverging from the present day, might not only be due to a limited representation of extreme events in our future data, but rather the fact that the only changing variables in your predictions are climatic - and those have a fairly weak importance our RF-models.": *Thank you very much for pointing this out. We absolutely agree with this interpretation. Since the second reviewer expressed a similar criticism, we did some more research into available data and discovered the data set "Land Cover 2050 - Global" by Esri Environment (2021), which predicted global land cover change for the year of 2050. It was used to compute future proximity to urban settlements. The layer of future proximity to urban settlements was then used for the future prediction of forest fire susceptibility. For further explanations on this aspect, please refer to the answers to the second review comment RC2.*

Reference:

Esri Environment. (2021). Land Cover 2050—Global. https://hub.arcgis.com/datasets/esri::land-cover-2050-global/about

RC1: Minor comments: Line 5: Please shortly define fire susceptibility already in the abstract.

A: Thank you for this suggestion. We modified the abstract accordingly. This is the updated abstract:

"Preventing and fighting forest fires has been a challenge worldwide in recent decades. Forest fires alter forest structure and composition, threaten people's livelihoods, and lead to economic losses, as well as soil erosion and desertification. Climate change and related drought events, paired with anthropogenic activities, have magnified the intensity and frequency of forest fires. Consequently, we analysed forest fire susceptibility (FFS), which can be understood as the likelihood of fire occurrence in a certain area. We applied Random Forest (RF) machine learning (ML) algorithm to model current and future FFS in the federal state of Brandenburg (Germany) using topographic, climatic, anthropogenic, soil, and vegetation predictors. FFS was modelled at a spatial resolution of 50 metres for current (2014-2022) and future scenarios (2081-2100). Model accuracy ranged between 69 % (RF_{test}) and 71 % (LOYO), showing a moderately high model reliability for predicting FFS. The model results underscore the importance of anthropogenic parameters and vegetation parameters in modelling FFS on a regional level. This study will allow forest managers and environmental planners to identify areas, which are most susceptible to forest fires, enhancing warning systems and prevention measures."

RC1: Line 16: Consider to check the reference for the increasing number of fires in Germany. I guess it should be rather the study by Gnilke et al. from 2021 not 2022.

A: Thank you for pointing this out. We checked this again and you are right. The updated sentence is now as follows (ll. 14 f.):

"In Germany, very low precipitation has been occurring more frequently in the last six years, leading to an increased number of forest fires ***(Gnilke and Sanders, 2021)****."*

RC1: Line 54: Consider to check the reference Gnilke & Sanders 2021. I think here it should be rather the Gnilke et al. 2022 publication.

A: Thank you for pointing this out. We checked this again and you are right. The updated sentences are now as follows (ll. 51 ff.):

"Due to a high percentage of coniferous forest, this federal state has been particularly prone to forest fires in the past. Furthermore, remnants of old munitions at former military training sites have been causing forest fires in Brandenburg in 2018 and 2019 ***(Gnilke et al., 2022)****."*

RC1: Line 62: Could you please cite some of the few studies that you found, which have analyzed current and future FFS at a high spatial resolution?

A: Thank you for this useful suggestion. The studies mapping current forest fire susceptibility at smaller scales and relatively high spatial resolution are Ghorbanzadeh et al. (2019), Pourtaghi et al. (2014), Razavi-Termeh et al. (2020), and Suryabhagavan et al. (2016).

We checked this text passage and our references again but could not find any studies that modeled future forest fire susceptibility at a small scale and high spatial resolution. Accordingly we corrected the sentence in the manuscript as follows (ll. 60 ff.):

"To our knowledge, only few studies have analysed FFS at a high spatial resolution so far ***(Ghorbanzadeh et al., 2019; Suryabhagavan et al., 2016; Razavi-Termeh et al., 2020; Pourtaghi et al., 2015) and we do not know of any studies that modelled future FFS at a high spatial resolution.****"*

References:

Ghorbanzadeh, O., Blaschke, T., Gholamnia, K., & Aryal, J. (2019). Forest Fire Susceptibility and Risk Mapping Using Social/Infrastructural Vulnerability and Environmental Variables. Fire, 2(3), Article 3. https://doi.org/10.3390/fire2030050

Pourtaghi, Z. S., Pourghasemi, H. R., & Rossi, M. (2015). Forest fire susceptibility mapping in the Minudasht forests, Golestan province, Iran. Environmental Earth Sciences, 73(4), 1515–1533. https://doi.org/10.1007/s12665-014-3502-4

Razavi-Termeh, S. V., Sadeghi-Niaraki, A., & Choi, S.-M. (2020). Ubiquitous GIS-Based Forest Fire Susceptibility Mapping Using Artificial Intelligence Methods. Remote Sensing, 12(10), Article 10. https://doi.org/10.3390/rs12101689

Suryabhagavan, K. V., Alemu, M., & Balakrishnan, M. (2016). GIS-based multi-criteria decision analysis for forest fire susceptibility mapping: A case study in Harenna forest, southwestern Ethiopia. Tropical Ecology, 57(1), 33–43.

RC1: Line 79: I could not find A2 in the supplement. Maybe it should be S2 here.

A: This is absolutely true. We corrected this information accordingly. The updated sentence is now as follows (ll. 78 ff.):

“To represent the current state, the years of 2016 and 2022 were selected after carefully analysing the monthly precipitation sums and mean monthly air temperature of Brandenburg between 2014 to 2022 (see Fig. S 1 and ***S 2*** *in the* ***S****upplement).”*

RC1: Line 115: Here the authors state that climatic variables where aggregated to 3 months, but in line 90 is written that only June was selected. Please indicate which months were used to train the models. (see also my major concern) If only June was selected to built the RFs, I recommend to check if the peak fire season might be shifted under future climate conditions - and if so, shortly discuss this point in the discussion.

A: Thank you for your comment. Please refer to our answer provided to the “Major Comment”, where we provided an answer on this matter.

RC1: Line 320: I agree to the points you raised to explain the weak importance of climatic variables. However, I miss a discussion what would happen if more months (and therefore more intra-annual variability) were considered in your approach (see major concern). How would that change your results?

A: Considering the fact that we used data from all months of 2014 to 2022 for model training, we believe that it is not necessary to reflect on this here any further.

RC1: Line 369: I highly acknowledge that you outline forest fire prevention strategies in Brandenburg. Please add references for the lines 369 – 371.

A: Thank you for pointing out the lack of references here. We added those accordingly. This is the updated text passage (ll. 398 ff.):

“An effective forest fire prevention strategy in Brandenburg involves promoting the growth of mixed forests instead of the prevalent monocultural pine forests. In particular, increasing the percentage of broadleaf trees is needed ***(Ministry for Rural Development, Environment and Agriculture in Brandenburg, 2024; Gnilke et al., 2022)****.”*

References:

Gnilke, A., Liesegang, J., & Sanders, T. (2022). Potential forest fire prevention by management-An analysis of fire damage in pine forests. https://literatur.thuenen.de/digbib_extern/dn065237.pdf

Ministry for Rural Development, Environment and Agriculture in Brandenburg. (2024). Strategie des Landes Brandenburg zur Anpassung an die Folgen des Klimawandels. *https://mluk.brandenburg.de/sixcms/media.php/9/Klimaanpassungsstrategie-BB-Kurzfassung.pdf*