General comment

The manuscript entitled "A statistical global burned area model for seamless integration into Dynamic Global Vegetation Models" by Blessing Kavhu and colleagues develops a Generalized Linear Model (GLM) with 19 predictors. The authors designed and tested 26 models using burned area data from the Global Fire Emissions Database version 5 (GFED5) and combinations of the selected predictors. Model 25 was chosen as the best-performing model, with an explained deviance of 0.568 and a Normalized Mean Error (NME) of 0.718. The authors identified key predictors such as Fire Weather Index (FWI), and Percentage Non-Tree Cover (PNTC), which strongly influence fire occurrence, and Human Development Index (HDI), Gross Primary Productivity Index (GPPI), and Population Density (PPN), which are negatively associated with fire occurrence. While the model demonstrates limited accuracy in predicting global annual burned area variability (Figure 5), it performs well in capturing global seasonal variability (Figure 8). The authors also discussed the comparison between predicted and observed data in terms of spatio-temporal variability at the GFED regional level.

In general, I have concern regarding the alignment of the manuscript's title with its methods and objectives. The current title suggests that the authors developed statistical models (GLMs) seamlessly integrated into Dynamic Global Vegetation Models (DGVMs). However, upon reviewing the manuscript, it becomes clear that the GLM was built independently of any DGVM, and the integration is only theoretically explained. According to my understanding, true integration with DGVMs requires a lot and long modification processes, testing within specific DGVM frameworks, reparameterization, new input-output verification, module integration, and validation process. The integration process involves technical adjustments such as modifying input data formats, calibrating modules, and ensuring compatibility with existing model components (e.g., physical, physiological, vegetation, or disturbance, and biogeochemical modules). Without actual implementation and demonstrated results, the claim of "seamless integration" remains unsupported. I suggest revising the title to reflect the study's scope and contributions more accurately. For example, the title could emphasize the development of a GLM, its evaluation of wildfire drivers, and its ability to predict spatio-temporal variability in burned area data.

Additionally, the study workflow needs to be presented more systematically. I recommend referencing workflows from published manuscripts in this field and ensuring that critical methodological details, such as data sources, temporal coverage of input data, and prediction periods, are clearly outlined. The abstract section is also not structurally strong enough, it should be rearranged. A clear and detailed workflow will greatly aid readers in understanding the study's methodology. Furthermore, the term "prediction" should be adjusted to "historical prediction" to reflect the study's temporal scope (2002–2018).

Overall, I recommend major revision before this manuscript can be considered for publication in Biogeosciences. Addressing the points mentioned above, along with detailed reviewers comments, will significantly enhance the manuscript's clarity and alignment with its objectives. Please find detailed comments below.

Detailed Comments

L1 "Statistical global burned area model"

Could you please specify what kind of statistical model that you used in this study?

The phrase is somewhat broad. Consider specifying the nature or methodology of the statistical model (e.g., linear, regression-based, machine learning, empirical, so on). This would make the title more precise and appealing to a specialized audience.

"Seamless integration into Dynamic Global Vegetation Models"

Could you please explain what does "seamless integration" means?

The term "seamless integration" is somewhat subjective and may overpromise ease of implementation. Consider replacing it with a more objective phrase or point out the advantages or novelty of this statistical model with existing burned area models that are widely used globally.

L11 The abstract structure is still weak and requires rewriting. Generally, an abstract should include, in sequence: the main problems identified by the authors, the solutions proposed to address these problems, the methodology applied in the study, and the objectives of the research. The results should be summarized, supported by numerical findings and validation metrics, and addition of standard deviations in the result. Additionally, the conclusions and key findings should be highlighted, and the abstract should conclude with a statement on the contribution of the study to the scientific field, which you have partially addressed in the first and final sentence of your current abstract.

L13 Is wildfire modeling challenging solely due to human behavior? What about natural dynamics, such as climate and other environmental variables, that also influence wildfires?

L14 Is the main goal of this study to demonstrate the relationship between biophysical and socioeconomic factors and wildfire dynamics, including monthly burned area? The manuscript title should clearly reflect the primary objective of your research.

L15 The sentence, 'We developed Generalised (Generalized?) Linear Models (GLMs) to capture the relationships between potential predictor variables that are simulated by DGVMs…' can be combined with the previous sentence, as both explain the objectives of this study. Combining them would improve the flow and cohesiveness of the text while reducing redundancy.

L18 What does the "final model" mean?

L23 To enhance the scientific rigor and clarity of the manuscript, I suggest including the r-values (correlation coefficients) for both positive and negative correlations between BA and the predictor variables. Reporting these values will provide a clearer understanding of the strength of these relationships. Additionally, where possible, p-values should be included alongside r-values to

indicate statistical significance (e.g., p < 0.05). To maintain the brevity of the abstract, p-values can be detailed in another section that elaborates on these findings.

L24 Before discussing the model predictions, could you please provide a comparison of your statistical model's performance with the benchmark dataset (GFED5) for burned area? Typically, in modeling, it is essential to first validate the model's performance using historical observation data before applying it to future predictions. This will help contextualize the model's accuracy and allow for a better understanding of its strengths and limitations in comparison to the established dataset.

L27 The use of 'R > 0.50' is vague. To strengthen this statement, please provide a range of correlation values or specific values for different regions. This will offer a clearer understanding of the model's performance across various areas and enhance the scientific rigor of the analysis.

L36 Please specify the year the data is from when mentioning the record fires in Australia and Canada, each burning more than 15 million hectares (Barnes et al., 2023; Jain et al., 2024). Additionally, it would be useful to include a comparison with the wildfires in Australia and Canada from the previous year. This will help strengthen the statement that 'climate change has led to more severe fire weather' by providing a clearer context of how fire severity has evolved over time.

L60 Please explain why the predictive skill of process-based models is often not yet satisfactory. If the explanation is similar to the next point, you may consider combining both sentences, as they both address the limitations of process-based models. This will improve the coherence and conciseness of the text.

L63 Please explain why statistical approaches are often used to evaluate human impacts on wildfires. Highlight the advantages of statistical methods.

L65 Please explain why the application of statistical models to ecosystems other than those used in their derivation is often not reliable. Highlight the limitations of statistical methods.

L88 "However, the integration of these techniques into DGVM is yet to be realized". Please check this article: https://doi.org/10.1029/2023MS003710. Son, et al., 2024 integrated of a Deep-Learning-Based Fire Model Into a Global Land Surface Model. I suggest reviewing the article directly to confirm the specifics of the DGVM's integration approach.

L90 If possible, please mention the DGVM name you are criticizing to provide clearer information. By specifying which DGVM you are referring to, readers will better understand the context of your critique and the gap in current modeling approaches.

L93 Please check this article: https://doi.org/10.5194/bg-21-4195-2024. Section 2.4 Model application. Nurrohman, et al., 2024 has integrated SEIB-DGVM with the SPITFIRE fire model and modified DGVM to produce monthly outputs using statistical downscaling methods. The method is able to capture monthly wildfire dynamics with results very similar to GFED4s benchmark data (Figure 5 in that article).

L94 Using up-to-date remote sensing datasets in the DGVM as input or validation dataset?

L95 Please clarify the integration between DGVMs and statistical models, DGVMs and remote sensing datasets, or both. The previous sentence discussed using remote sensing datasets for fire modeling, so it would be helpful to understand how these approaches are integrated and how each component contributes to enhancing the model's fire prediction accuracy.

L111 Figure 1: Please create a simple workflow legend that explains the definition of each shape. Additionally, clarify the meaning of the color differences (red and black). There are international standards for workflow/flowchart design, including how to select shapes, so please refer to them. You can also refer to published manuscript in Biogeoscience for example. To enhance readability, when mentioning external datasets or input data, include the dataset names along with the corresponding year ranges for the data you are using.

L111 I believe the small black boxes below the red tube shape are meant to describe each process, correct? For example, you used Pearson correlation in the correlation matrix, a quasi-binomial GLM, and so on. If this is the case, I recommend avoiding the use of shapes for these descriptions, as shapes can represent processes, data, or other meanings depending on the one selected. Instead, it would be clearer to provide descriptions below each process or explain them in a paragraph beneath Figure 1. This will enhance clarity and avoid redundancy in the diagram.

L115 Could you please clarify whether you used the entire burned area (BA) time range from the GFED5 dataset for your study, or just specific years such as 2002 and 2018?

L115 Please ensure that the abbreviation for the Global Fire Emissions Database is written uniformly as either "GFEDv5" or "GFED5" throughout the manuscript. Consistency in terminology helps maintain clarity and professionalism in scientific writing.

L124 At first, please directly explain the predictor variable you are using, then followed by the sentence "whilst" along with the reason why you use those predictors only. This structure will help clarify the rationale behind your choices and ensure a logical flow in your explanation.

L135 For Table 1, in the source column, I suggest adopting a consistent citation style for all the predictor data used. This means including either the author's name and publication year or the specific time when you accessed the dataset. Be sure to check the "how to cite" instructions for each dataset to provide the correct format. This will ensure clarity and credibility in referencing the data sources. Please check Table 1. Summary of predictor and fire response variables (Haas et al., 2022) https://doi.org/10.1088/1748-9326/ac6a69

L135 Ensure that the table header is repeated on all pages where the table appears, and apply this adjustment to other tables as well.

L155 Please check section 2.3 and 2.4. both have a same name "vegetation-related predictors"

L169 Could you please provide a more detailed explanation of the HDI data? This should include the data range, units (if applicable), and guidance on interpreting the HDI data used in your study. Since your results indicate that HDI predictors have a significant impact, this clarification is necessary to ensure that the discussion aligns with the proper interpretation of the HDI data.

L178 I suggest changing the structure of sections 2.3 to 2.6, to become sub-sections under section 2.2. Because it explains about predictor variables specifically, to simplify the reading flow. Example: 2.2. Predictor variables, 2.2.1. Vegetation-related predictors, ... 2.2.4. Weather-related predictors. 2.3. Data processing.

L190 You describe data processing in subsection 2.7, but this step is not included in Figure 1, the study workflow. I recommend adding data processing to Figure 1 for consistency. Additionally, to enhance clarity for readers, ensure that Section 2 provides a detailed and sequential explanation of the data and study processes, aligning with the workflow illustrated in Figure 1.

L200 "GPPI was originally defined as the Monthly Ecosystem Productivity Index (MEPI) in the study by Forrest et al. (2024)". After reviewing their work, I see that MEPI evaluates ecosystem productivity, including vegetation health and phenological states. Could you please clarify why you renamed MEPI to GPPI while using the same equation, and why it is referred to as the 'novel GPPI' (as mentioned in lines 20 and 533)?

L223 Figure 2. This correlation matrix is a part of your results, isn't it? According to Figure 1. Correlation matrix is classified as the first step of your study. If so, please move Figure 2 to the result section.

L229 Is it Figure A3 or Figure 3? Additionally, how many plots did you create ten or eight?

L229 In my opinion, it would be better not to mention the result image (Figure 3) in Section 2, as this section should focus solely on the data and methodology.

L236 What data did you use for model calibration and testing? Was it GFED5? Please include the calibration and testing process in Figure 1 for clarity.

L262 You can delete this sentence, as this information is described in the table caption. This paragraph could start with the sentence "The initial models ... so on"

L274 Could you please explain more details about the reason why you chose Model 25 instead of Model 24 or another model with better deviance and NME? If it is for the reason of future projection of RD data, we can refer to the deviance and NME values in the second, third and so on, because based on the explanation, these two variables are a reference for whether the model is good or not. If it is for simpler reasons, you better explain how the model is said to be simple, whether because there is no multiplication between predictor variables or other reasons.

L267 Could you please explain why you introduce polynomial terms for Percentage Tree Cover (PTC)?

L277 Could you please explain how the predictor formula in each model is determined, the reasons for summing or multiplying the predictors?

L287 Please change the exponent symbol (e) to $\times 10^x$

L302 Could you please explain what Larson and McCleary 1972 means? I checked the References and there is no citation information.

L303 (GPP) or (GPPI)?

L308 Please search additional references related to similar GLM modeling that have similar or lower explained deviance values than yours, and providing explanations to strengthen your results that the values are accepted.

L322 Please write the year of the observed burnt area (GFED5) and predicted burnt area datasets in Figure 4.

L330 Could you please explain the reason for adjusting the HDI predictor to be included, excluded, or constant? I don't see any explanation of this HDI setting in the methods section or in sub-section 2.5. Anthropogenic Influence Predictor.

L331 Please remove the title of Figure 5 "Internanual variability .." at the top of the graph, as it is already written in the figure caption.

L331 Please reduce the burnt area unit (y-axis) to be 2 digits, so that the digit is not too long by applying $\times 10^x$

L338 Please write the full name of the abbreviation SHAF, SHSA, NHAF, CEAS and so on (because it has not been explained before)

L345 Please clarify the figure caption to be understandable by the reader. Is it a interannual variability comparison of burnt areas between model projections and GFEDv5?

L345 Please clarify the figure caption to be understandable by the reader. Is it a interannual variability comparison of burnt areas between model projections and GFEDv5?

L355 To make it briefer, you can combine figure 6 and figure 7.

L367 Please remove image title above the graph "Global Seasonal Cycle" and adjust the y-axis not using "k", you can use $\times 10^x$

L372 Please delete the paragraph between section 4. Discussion and sub section 4.1. It's better to discuss the research result directly.

L378 I have not seen any explanation about what DGVM you used in this study and how you integrate your GLM with those DGVM, either in the methodology section or elsewhere. How can you state that this GLM is compatible in DGVM? To my current understanding, each DGVM has its own characteristics, starting from their programming language and the flow of how it reads specific input data (so it needs data handling / pre-processing to be integrated into each DGVM).

L423 Please provide cross-reference form figure that support this statement, so that readers can easily refer to specific figure. In addition, please provide more explanation why your model exhibits stronger performance in those regions including in the northern hemisphere.

L432 After this sentence, it is better to explain how this model contributes to novel insights into the factors that influence global fire trends, and after that you can compare with other studies.

L442 "This highlights the significant influence of HDI in projecting the purported negative global ire trend". If so, you can further discuss how the spatio-temporal variability of projected burnt area of each region (in this sub-section or other sub-section), how HDI affects the burnt area in the region. If the HDI data is the same as this source: https://hdr.undp.org/data-center/human-development-index#/indicies/HDI, then you can associate regions with low, medium, high and very high HDI.

L442 "The HDI is related to factors like advancements in fire control methods, surveillance, technology, and outreach strategies increasing awareness, particularly in response to the growing human technological developments". Can you add one or some references that supports this statement?

L450 In this sub-section, you can discuss how the interannual variability of your model in each GFED region (as shown in Figure A1), how your model performs compared to the observational data from GFED5.

L463 Please also discuss another DGVM that used SPITFIRE fire module, as SPITFIRE is an updated fire module from GlobFIRM. SPITFIRE has implemented full burned area calculations and considers natural ignition factors from lightning and ignition and fire suppression based on population density (Thonicke et al., 2010).

SPITFIRE effectively includes human fire suppression on other lands because human ignitions first increase and then decrease with increasing population density (Hantson et al., 2016).

Models that explicitly simulate the impact of human suppression on fire growth or burnt area (CLM, CLASS–CTEM, JSBACH–SPITFIRE, LPJ–GUESS–SIMFIRE–BLAZE) are better at representing the spatial pattern in burnt area compared to models which do not include this effect (0.85 and 0.93 respectively). (Hantson et al., 2020)

Please try to check the following papers that discuss FireMIP and DGVM used to simulate fire and burned biomass emissions resulting from forest fires.

Historical (1700–2012) global multi-model estimates of the fire emissions from the Fire Modeling Intercomparison Project (FireMIP) (Li et al., 2019)

The Fire Modeling Intercomparison Project (FireMIP), phase 1: experimental and analytical protocols with detailed model descriptions (Rabin et al., 2017)

The status and challenge of global fire modelling (Hantson et al., 2016)

L468 "The findings of this study exhibit robustness in capturing seasonal cycles ($R^2= 0.536$)," Could you please include a cross-reference an image that states this? To make it easier for readers to refer to the results you are discussing. Please apply throughout the rest of the section, when you mention the results of the study, include a cross-reference with a supporting figure or table.

L471 Could you please provide evidence to support this assertion that it is due to climatic conditions in those regions? You can compare seasonal fire patterns and climatic conditions in those regions and discuss the result in this sub-section.

L478 In my opinion, I think this paragraph is better presented at the beginning of sub section 4.5.

L478 Do you do future predictions of annual or seasonal burned area data globally?

L490 I suggest renaming this sub-section to "model limitation and excluded drivers". Include the explanation and discussion of "model shortcomings" in sub-section 4.7 to this section.

L500 "FAPAR is highly correlated with GPP." Please confirm, according to Figure 2. FAPAR correlation with GPP is 0.59, or do you mean FAPAR in general which includes FAPAR, FAPAR12 and FAPAR6?

L512 I suggest this sub-section be changed to 4.7. Recommendations (after you separate the discussion of shortcomings, as I suggested in L490). Or you could also combine section 5. Conclusions and Recommendations, to harmonize after you discuss the Conclusions, you can suggest recommendations regarding further studies.

L513 "The findings of this study offer valuable insights into the underlying drivers and patterns shaping global fire dynamics". The sentence does not explain the model shortcomings or recommendations. It seems better to put it in the Conclusion section. In addition, in this sub-section, please explain about recommendations only, you can discuss recommendations on how to solve the limitations or shortcomings of the current model, or further studies from this research.

L525 This first paragraph doesn't fit in the Conclusion section, it's more like an introduction, I suggest deleting this first paragraph.

L531 Make sure the Conclusion section explains the research objectives .The first two sentences have answered the first objective, but add how much the major predictors correlate with burnt area (BA).

L534 Explain the performance of the model when predicting BA compared to the GFED5 observational data -> state the evaluation value index that you used for validating the model before predicting, how do you state the model is suitable to be used to predict BA.

L536 Before the phrase "We hope", explain the third objective, explain how the model performance, including spatio-temporal, interannual and seasonal cycle of BA compares with GFED5 observational data.