Response to Reviewers and Editor

Title: Influence of biogenic NO emissions from soil on Atmospheric chemistry over Africa: a regional modelling study

Author(s): Yao et al.
MS No.: acp-2024-3179

The authors would like to express their gratitude to the editor and the reviewers for their constructive and insightful comments, which have contributed to improving our manuscript. We have carefully addressed all concerns raised and implemented the necessary revisions accordingly. In response to the reviewers' comments, we have thoroughly revised the manuscript for clarity, improved grammatical structure, and refined the scientific phrasing to align with standard terminology in atmospheric sciences. Additionally, all acronyms have been explicitly defined upon their first appearance. References and DOIs have been properly formatted and moved to the reference section where necessary. In general, we have modified the summary of the manuscript by defining all acronyms at their first occurrence, correcting the distinction between NO_2 concentrations and emissions, and rephrasing the sentence discussing differences in model accuracy to ensure clarity and consistency. In the introduction, we have clarified sentence structures, reduced redundant use of "significant," properly defined BioNO, AMMA, and ICTP RegCM5 acronyms, and improved the logical flow of environmental factors influencing BioNO emissions. Additionally, we removed unnecessary DOIs from the text and adjusted verb tenses for consistency. In Section 2.1, we have ensured consistency in referring to the model as RegCM5, defined the MOLOCH and OI_WK acronyms, corrected terminology such as “fine particle,” and addressed grammatical errors. Additionally, we expanded the discussion on the CBM-Z chemical mechanism. In Section 2.2, we have removed redundant sentences to improve clarity and conciseness. We also corrected the sentence structure to ensure coherence and defined the WFPS acronym. In Section 2.3, we have specified the spatial resolution of the model as 30 km × 30 km with 35 vertical levels. Additionally, we have provided a clear description of the model domain, detailing its geographical extent and the rationale for its selection. In Section 3, we have corrected the subscripts for O_3, NO_2, and HNO_3, clarified the reference to “used here as reference,” removed redundancy in LAERO’s participation description, relocated DOIs to the reference section, and corrected the definition of ERA5. In Section 6, we have clarified whether CAMS and GEOS-Chem simulations account for BioNO emissions to improve comparisons with RegCM5. A land-use map has been added as supplementary material to contextualize the distribution of savannas and grasslands. The numbering of figures has been adjusted to maintain logical order, and the reference to Figure 7 has been properly formatted. The discussion of Figure 9 now directly compares BASE and BIONO columns of NO_2 from RegCM5 with OMI observations. Additionally, bias values for CAMS and GEOS-Chem models have been included in Tables 5, 6, and 7 for a more comprehensive comparison.

Below, we provide a point-by-point response explaining how we have addressed each of the referees’ comments. Note that our responses to the comments are in blue. We are confident that this second review stage has improved the manuscript. We look forward to the referees’ opinion of the revised article, and to the editor’s decision.

With our best regards, and our deepest gratitude to the referees and editor.

On behalf of all the co-authors

Sincerely yours
Eric Martial Yao and Fabien Solmon

REFEREES' REPORTS:

REFEREE RC1

General Comment : *This work evaluates the impact of soil nitric oxide emissions (BioNO) on regional air quality over Africa using the RegCM5 regional climate model. The authors applied a revised chemistry scheme within the model, and also used updated BioNO emissions developed from an artificial neural network (ANN). The authors find that by incorporating BioNO, evaluation of model chemical output against observations is improved across various time scales and for multiple chemical species. This manuscript contains numerous grammatical errors and typos, particularly related to poor sentence structure, incorrect verb tense, and missing articles (e.g. "a" or "the"), and there are an abundance of acronyms which are not defined throughout the manuscript. Additionally, there are many instances of phrasing and terminology that deviate from the conventional language typically used in atmospheric science / ACP publications. While not necessarily incorrect, using unconventional language can make the text feel less polished and can be distracting. These grammatical errors and text issues unfortunately detract from the manuscript quality, making it difficult to assess the overall quality of this work objectively. I have suggested some edits in the line by line comments, however I encourage the authors to more thoroughly go through the entire manuscript to correct remaining grammatical errors and to carefully revise the manuscript to improve clarity and readability for an ACP audience before resubmitting. I do find the model evaluation of surface NO_2, O_3 and HNO_3 concentrations against observations to be worthwhile.*

Author's response: We have carefully revised the entire text to address grammatical errors, correct typos, and improve sentence structures. We also ensured the consistent use of articles and proper verb tenses throughout the manuscript. All acronyms have now been clearly defined upon their first mention. In addition, we revised phrasing and terminology to align with the conventional language typically used in atmospheric science and ACP publications, following the reviewer's guidance. These modifications have considerably improved the clarity and readability of the manuscript. Furthermore, the entire manuscript has been thoroughly reviewed by a native English speaker to ensure linguistic accuracy and fluency. We greatly appreciate the reviewer's positive remark regarding the model evaluation of surface NO_2, O_3, and HNO_3 concentrations against observations.

Specific Comment 1 : *The word "significant" is used numerous times in this manuscript, when the sentiment is being conveyed that something is substantial, or noteworthy. I encourage the authors to reduce the use of "significant" and "significantly" in such cases, as these words should be reserved for the context of statistical significance, as opposed to*

something that is notable. Consider using words such as: notable, noteworthy, considerable, or substantial.

Author's response: We have carefully reviewed the manuscript and replaced all instances where "significant" and "significantly" were used in a non-statistical context with more appropriate terms such as "notable," "considerable," or "substantial."

Specific Comment 2 : *There are many website links and DOIs that are included within the body of the text, which need to be included in the reference section with only an appropriate citation within the body of the text. Refer to other ACP papers for an example of appropriate citations.*

Author's response: In accordance with ACP formatting guidelines, we have removed all direct links and DOIs from the main text and properly cited them in the reference section. In the body of the text, we now refer to these sources using standard in-text citations.

Specific Comment 3: *Section 2.2 describing the BioNO parameterization requires attention. In equation 2, how are each of the weights determined? What do the variables S1, S2, and S3 represent? Why does each of S1, S2 and S3 contain a summation cross differing values, e.g. 1 to 7, 8 to 23, and then 17 to 23? What do the subscripts on the weights represent? This is not explained, causing the various equations feel arbitrary. Additionally, why are hyperbolic tangents used to represent this process in equation 1? This is not a common approach when modeling soil NO emissions. Why not use a more common, and newer, approach, e.g. Hudman et al., (2012), which is cited within this manuscript? There needs to be a clearer description of this parameterization and justification for decisions that were made, as the soil emissions and subsequent impacts appear to be the focal point of this manuscript.*

Author's response: We have updated Section 2.2 to incorporate these following explanations and ensure clarity regarding the parameterization process (based on the description given in Delon et al., 2007):

- The weights (wi) in the Artificial Neural Network (ANN) equations are determined through a supervised training process. Initially, these weights are assigned random small values to ensure that no input variable dominates the model from the start. The network is trained using a backpropagation algorithm, which iteratively adjusts these weights to minimize the error between the predicted NO fluxes and observed values. In each iteration, the network calculates the prediction error, propagates this error backward through the network, and updates the weights accordingly. This process

continues until the error is minimized, ensuring that the final weights reflect the true influence of each input variable on NO emissions.

- The tanh (hyperbolic tangent) function is employed as the activation function in the network. It introduces non-linearity, which is essential for capturing the complex interactions between environmental variables and NO emissions. The tanh function also normalizes intermediate outputs to a range between -1 and 1, stabilizing the learning process and preventing extreme values from skewing the results.
- The sub-equations (S1, S2, S3) structure the network into separate layers, each designed to capture different aspects of the relationships between environmental variables and NO emissions. Although they all use the same input variables (x1 to x7, representing factors like WFPS, soil temperature, pH, etc.), they apply different weights in each sub-equation. This design allows the network to explore multiple combinations of the inputs and better capture non-linear dependencies. Each sub-equation acts as a filter, emphasizing specific patterns or interactions among the variables. The outputs of these sub-equations are then combined using the tanh function to produce the final normalized NO flux.
- The use of this ANN approach, instead of models like Hudman et al. (2012) approach, which was developed at a global scale, was chosen for its ability to model complex and non-linear relationships directly from empirical data. This is particularly valuable in regions like Africa, where in situ measurements of BioNO are limited. The ANN allows the model to adapt to diverse environmental conditions and better generalize across the domain.

Author's changes in manuscript: *Modified Line 186 to 198*

Specific Comment 4: *While section 2 describes some general details about the RegCM5 model, no details are provided about the specific model domain for this study. Is the model being run for all of Africa, or a subset? Or is the model run globally, and only a subset is being shown to focus on Africa? A clearer description is needed. This could be added to section 2.3.*

Author's response: We have revised Section 2.3 to include a detailed description of the model domain used in this study. We clarified that the model is not run globally but focuses solely on a specific domain of Africa.

Author's changes in manuscript: *Modified Line 208 to 213*

Line-by-Line Technical Correction – Line 4 (Abstract): *I would change "atmospheric NO_2 emissions" to "atmospheric NO_2 concentrations". Also, please define NO_2, e.g. nitrogen dioxide (NO_2). Please define all acronyms at their first instance before using an acronym.*

Author's response: We have replaced "NO_2 emissions" with "NO_2 concentrations". Additionally, we have defined NO_2 as "nitrogen dioxide (NO_2)" upon its first mention and reviewed the manuscript to ensure all acronyms are properly introduced when first used.

Line-by-Line Technical Correction – Line 6 (Abstract) : *Please define INDAAF acronym.*

Author's response: As mentioned in our response to the previous comment regarding acronyms, we have now defined INDAAF (International Network to study Deposition and Atmospheric chemistry in Africa) upon its first mention in the abstract.

Line-by-Line Technical Correction – Line 9 (Abstract): *The sentence starting with "Large differences are however…" is a run-on sentence, and the wording is confusing. Please rephrase. This sentence also appears to contradict the claim in the previous sentence that model accuracy has been improved.*

Author's response: We acknowledge that the original sentence was overly complex and could lead to misinterpretation. We wanted to say while the integration of BioNO emissions improves the overall model performance particularly for NO_2, HNO_3, and O_3 seasonal cycles, it does not eliminate all discrepancies. To clarify this point and avoid confusion, we have rephrased the sentence to distinguish between the general improvements in model accuracy and the specific biases that still remain, especially regarding surface ozone concentrations. This also resolves the run-on sentence issue.

Author's changes in manuscript: *Modified Line 10 to 12*

Line-by-Line Technical Correction – Line 16 & 17: *"… a significant source of gaseous and particulate emissions, affecting the regional…."*
"…, there are also a significant…"

Author's response: We have revised the sentences to avoid redundancy and improve the flow. The first occurrence of "significant" was replaced with "major", and the second with "substantial" to maintain the intended meaning while enhancing readability.

Author's changes in manuscript: *Modified Line 17 to 20*

Line-by-Line Technical Correction – Line 22: *"… (Referred to as BioNO) …"*

Author's response: We have corrected "referred as" to "referred to as" to adhere to proper English usage.

Author's changes in manuscript: *Modified Line 23 to 24*

Line-by-Line Technical Correction – Line 23: *"… (Ludwig et al., 2001) and above-canopy emissions estimates range from 4.7 – 26.7 Tg N* yr^{-1}*…"*

Author's response: To improve the clarity and structure of the sentence, we have reformulated it slightly to ensure smooth reading and clear attribution of the reference.

Author's changes in manuscript: *Modified Line 24 to 26*

Line-by-Line Technical Correction – Lines 27-32: *I would reorganize these sentences, to first list the large variety of environmental factors that influence BioNO, and then following with the description of precipitation and soil moisture. While soil emissions are heavily influenced by precipitation and soil moisture, I don't find it accurate to lead with the idea that emissions "primarily" depend on soil moisture. This is just one of numerous important factors.*

Author's response: We have reorganized the sentences as suggested, starting with a comprehensive list of environmental and physical factors that influence BioNO emissions, followed by a focused discussion on soil moisture and precipitation. Regarding the emphasis on soil moisture, we agree that it is one of several important factors influencing soil NO emissions. However, in tropical regions, such as those studied here, soil moisture plays a dominant role in controlling seasonal variations in BioNO fluxes, primarily due to the well-documented pulse effect following the onset of rainfall (Johansson et al., 1988; Yienger and Levy, 1995; Meixner and Yang, 2004), essentially because soil temperature variation is low. To reflect this, we have nuanced the statement to highlight soil moisture as a key driver in tropical soils while acknowledging the influence of other environmental factors.

Author's changes in manuscript: *Modified Line 28 to 37*

Line-by-Line Technical Correction – Line 33: *Remove "however"*

Author's response: We have removed "however" from the sentence to improve the clarity and flow of the text.

Author's changes in manuscript: *Modified Line 38*

Line-by-Line Technical Correction – Line 40: *"… used a neural network-based…"*

Author's response: We have added the article "a" before "neural network-based" to maintain correct grammatical structure.

Author's changes in manuscript: *Modified Line 45 to 46*

Line-by-Line Technical Correction – Lines 41–42: *Does "lower equatorial Africa's troposphere" refer to equatorial Africa's lower troposphere, or does this refer to Africa's troposphere at lower latitudes? The wording is confusing.*

"… troposphere on 6 August 2006 during the AMMA…" Please define the AMMA acronym."

Author's response: Our intention was to refer to the lower troposphere over Equatorial Africa, focusing on the atmospheric layer closest to the surface where BioNO emissions influence NOx and O_3 production. We have revised the sentence to clarify this and avoid confusion. This revised phrasing aligns with the description provided in Delon et al. (2008). We have also defined the acronym AMMA upon its first mention as "African Monsoon Multidisciplinary Analysis" to ensure clarity.

Author's changes in manuscript: *Modified Line 47 to 48*

Line-by-Line Technical Correction – Line 48: *"… resulting in a 10% decrease…"*

Author's response: We have corrected "an 10%" to "a 10%" to ensure proper grammar.

Author's changes in manuscript: *Modified Line 53*

Line-by-Line Technical Correction – Lines 49–50: *"… regional climate systems to study the impact of present and future…."*

Author's response: We have revised the sentence to clearly emphasize that the focus is on studying the impact of present and future climate change and variability on BioNO emissions.

Author's changes in manuscript: *Modified Line 54 to 55*

Line-by-Line Technical Correction – Line 52: *"…in the chemical environment…"*

Author's response: To improve clarity, we have modified "chemical environment" to "the chemical environment" to specify the context and avoid ambiguity.

Author's changes in manuscript: *Modified Line 56*

Line-by-Line Technical Correction – Line 58: *"I recommend starting a new paragraph with the sentence 'One goal of the present study…'"*

Author's response: We have started a new paragraph with the sentence "One goal of the present study…" to improve the structure and readability of the text.

Author's changes in manuscript: *Modified Line 64*

Line-by-Line Technical Correction – Line 59: *"Please define ICTP RegCM5"*

Author's response: We have defined the acronym ICTP RegCM5 upon its first mention as "International Centre for Theoretical Physics Regional Climate Model version 5 (ICTP RegCM5)" to ensure clarity.

Author's changes in manuscript: *Modified Line 64 to 65*

Line-by-Line Technical Correction – Lines 70–73: *"This sentence referring to the shared scientific goals should not be in the introduction of the manuscript. This would be more appropriate to include in an acknowledgements section. Additionally, DOIs should not be included within the body of text in a manuscript. They should be included in the references section with a relevant citation."*

Author's response: We had already included detailed acknowledgements for both the INSA and INDAAF projects in the Acknowledgements section. To avoid redundancy, we have removed the sentence from the introduction and maintained the information in the Acknowledgements section. Additionally, we have ensured that all DOIs are correctly placed in the References section.

Line-by-Line Technical Correction – Line 74: *"… Sections 2 and 3 will provide", to be consistent with verb tense later on in the paragraph.*

Author's response: To ensure consistency in verb tense throughout the paragraph, we have changed "provide" to "will provide".

Author's changes in manuscript: *Modified Line 77*

Line-by-Line Technical Correction – Line 80: *"Is the model referred to as RegCM5, or RegCM5-CHEM? I see references to both, without a clear description. I recommend choosing one for consistency."*

Author's response: The model used in this study is RegCM5, which inherently includes the atmospheric chemistry module. To maintain clarity and consistency throughout the manuscript, we have specified the term "RegCM5" as the full model with online chemistry activated, rather than using the term "RegCM5-CHEM". We have clarified this in Section 2.1.

Author's changes in manuscript: *Modified Line 83*

Line-by-Line Technical Correction – Lines 82 and 94 :

Line 82: "Please define MOLOCH"
Line 94: "Please define OI_WK"

Author's response: We have now defined both MOLOCH and OI_WK upon their first mention in the manuscript to improve clarity.

- MOLOCH has been defined as *"MOdello LOCale in H coordinate (MOLOCH), a non-hydrostatic dynamical core developed by CNR-ISAC (Davolio et al., 2020)"*.
- OI_WK has been defined as *"Optimal Interpolation Weekly (OI_WK) sea surface temperature dataset"*.

Author's changes in manuscript: *Modified Line 85*

Author's changes in manuscript: *Modified Line 97 to 98*

Line-by-Line Technical Correction – Line 101: *"I believe this is supposed to say 'fine particle', not 'fine particles'."*

Author's response: We agree with the suggestion and have corrected "fine particles" to "fine particle" to ensure grammatical accuracy and consistency.

Author's changes in manuscript: *Modified Line 120*

Line-by-Line Technical Correction – Lines 107–109: *"This sentence contains numerous grammatical errors."*

Author's response: We have revised the sentence to correct grammatical errors and improve clarity.

Author's changes in manuscript: *Modified Line 126 to 128*

Line-by-Line Technical Correction – Line 122: *"Use 'degree' instead of 'deg'."*

Author's response: We have replaced "deg" with "degree" to maintain consistency with formal writing standards.

Author's changes in manuscript: *Modified Line 141*

Line-by-Line Technical Correction – Lines 142 & 144: *"This sentence appears to be repeated, the same as line 139." & "It appears that a new sentence begins in the middle of a different sentence here"*

Author's response: We have removed the repeated portion from line 142 to avoid duplication, and a new sentence begins correctly.

Author's changes in manuscript: *Modified Line 158 to 163*

Line-by-Line Technical Correction – Line 165: *"Please define WFPS."*

Author's response: We have defined WFPS upon its first mention as "Water-Filled Pore Space (WFPS)" to ensure clarity.

Author's changes in manuscript: *Modified Line 182 to 183*

Line-by-Line Technical Correction – Line 175: *"I suggest 'The model has a spatial resolution of 30 km x 30 km, with 35 vertical…'"*

Author's response: We have revised the sentence to improve clarity

Author's changes in manuscript: *Modified Line 206*

Line-by-Line Technical Correction – Line 179: *"Add subscripts for O3, NO2 and HNO3."*

Author's response: We have added subscripts to O_3, NO_2, and HNO_3 to follow standard chemical notation.

Author's changes in manuscript: *Modified Line 215 to 216*

Line-by-Line Technical Correction – Line 196: *"This line says 'used here as reference'. What is this referring to? Should there be a reference to a figure perhaps? Also, it is not clear what 'duplicates means' is referring to."*

Author's response: We have clarified the phrase "used here as reference" by specifying that it refers to the baseline dataset used for model evaluation. We have also revised "duplicates' means" to "average of these duplicate samples" for clarity. The duplicate samples refer to the two passive samplers exposed at each INDAAF site to ensure reproducibility, as described in Ossohou et al. (2023), with monthly concentrations calculated from the arithmetic mean of these duplicates.

Author's changes in manuscript: *Modified Line 230 to 235*

Line-by-Line Technical Correction – Line 198: *"The sentence states that LAERO participated bi-annually, and then later specifies twice yearly, which is redundant."*

Author's response: We have revised the sentence to remove the repetition and improve clarity.

Author's changes in manuscript: *Modified Line 236 to 238*

Line-by-Line Technical Correction – Line 200: *"References to other work/studies should not be done by including a link within the body of the text. Same for DOIs."*

Author's response: We have removed all direct links from the body of the text and included them in the references section following the journal's guidelines.

Line-by-Line Technical Correction – Line 210: *"ERA5 does not stand for 'European Environment Agency version 5'."*

Author's response: We have corrected the definition of ERA5, which stands for "ECMWF Reanalysis v5" (produced by the European Centre for Medium-Range Weather Forecasts), and updated the text accordingly.

Author's changes in manuscript: *Modified Line 247 to 249*

Line-by-Line Technical Correction – Line 241: *"Remove 'somehow'."*

Author's response: We have removed "somehow" to improve clarity and maintain a more objective tone.

Author's changes in manuscript: *Modified Line 281*

Figure Comment: *"I recommend removing the underlying emissions data from this figure, as those results do not get discussed at any point. I recommend modifying this figure to be a simpler introduction to the model domain, with a rectangle denoting the extent of the model domain, as well as the INDAAF points, to show where measurements were taken. Otherwise, there is no introduction to the model domain."*

Author's response: We understand the importance of providing a clear introduction to the model domain and have addressed this concern in the following ways:

1. **Clarifying the Model Domain in Figure 1:**
   The current Figure 1 already represents the full extent of the model domain used for the simulations, without any cropping during post-processing. To make this clearer, we have updated the figure legend to explicitly state that the displayed area corresponds to the entire model domain. Details about study are already provided in Section 2.3. The INDAAF measurement sites are also shown to provide context for the locations of observational data used in the study.
2. **Retention of Emissions Data in the Figure 1:**
   While we understand the suggestion to simplify the figure, we believe that retaining the emissions data is important for contextualizing the spatial distribution of anthropogenic and biomass burning NO emissions within the model domain. These emissions are directly relevant to the discussions in the manuscript, particularly when interpreting model results over regions where biomass burning or anthropogenic activities predominate. For instance, statements such as *"In the biomass burning regions, these differences are less visible"* and *"Both the model and the satellite data show high concentrations of NO_2 in areas such as the Sahel and forest regions, where biomass burning plays a significant role"* rely on the spatial distribution of these emissions.

3. **Updated Figure and Legend:**
   We have therefore chosen to retain the emissions data in Figure 1 while ensuring that the figure serves both purposes: Introducing the model domain and measurement sites and Showing the spatial distribution of emissions that are discussed later in the manuscript.

Author's changes in manuscript: *"Figure 1. Annual anthropogenic and biomass burning NO emissions (averaged over 2010–2013) and INDAAF measurement site locations, showing the full extent of the model domain used in the simulations. Measurement sites include Banizoumbou (Ba), Katibougou (Ka), Djougou (Dj), Lamto (Lam), Bomassa (Bom), and Zoétélé (Zoe)."*

Author's changes in manuscript: *Modified Line 399 to 400, 405, 435-437 and 491 to 492.*

REFEREE RC2

Comment 1: *The Delon et al. (2007) methodology for estimating biogenic NO emissions was developed based on measurements from sites characterized as wet agricultural soils in temperate climates and dry grassland soils in tropical climates. These measurements were mostly taken during the warm season. How do the climatic conditions and land-use types in the Delon et al. (2007) study compare to those in the manuscript? Are there inconsistencies, and if so, how might they impact the estimated BioNO emissions for the study area?*

Author's response: The study of Delon et al. (2007) was based on data from semi-arid and temperate environments, where soil moisture fluctuates significantly between dry and wet periods, but also between two episodes of rain during the wet season in dry savannas (i.e. soil can dry rapidly if two rain events are distant). In contrast, our study focuses on a broader range of ecosystems, including tropical forests, savannas, and arid regions. The land-use types covered in our study include dense forests with persistently high soil moisture, seasonally dry savannas where soil moisture varies strongly, and arid zones with very low nitrogen availability and limited microbial activity.

In our model, BioNO emissions are larger in semi-arid and savanna regions (as shown in Figure 5), where nitrogen availability, soil pH, and moisture variability favor microbial NO production. In forested areas, emissions remain lower due to canopy inhibition (based on a Canopy Reduction Factor application) and the absence of strong moisture pulses. These results are consistent with known drivers of BioNO emissions in Delon et al. (2007) approach.

The ANN algorithm used in this study was originally trained on data from semi-arid and temperate climates. While it captures NO emissions well in regions with strong moisture variability (like Sahel), its performance in tropical forests is influenced by the persistently high soil moisture in these areas. The lack of strong wet-dry cycles in forests means that the pulse effect is less relevant, which can affect the accuracy of BioNO estimates in these environments where our confidence is lower. Considering that these processes are well described in the literature (i.e. pulses in semi arid landscapes and lower emissions with lower variability in more humid forested regions), we can assume that the model correctly reproduces the expected spatial distribution. However, our results highlight the need for further calibration using additional datasets from forested regions.

Comment 2 : *Lines 139–145 contain repetitive sentences and should be rephrased for clarity and conciseness.*

Author's response: We have addressed this redundancy by restructuring and rephrasing the text for better clarity. The revised version removes the repetition and ensures a more concise formulation (see Lines 158-163)

Comment 3 : *It is unclear whether the CAMS chemical reanalysis and GEOS-Chem simulations account for BioNO emissions. Clarifying this would make the comparison with RegCM5 results more explicit.*

Author's response: Both CAMS chemical reanalysis and GEOS-Chem model include BioNO emissions. CAMS incorporates soil NO emissions from the POET (Granier et al., 2005), using a prescribed climatology rather than interactive calculations.

GEOS-Chem accounts for BioNO emissions using the Hudman et al. (2012) parameterization, which dynamically simulates emissions based on environmental conditions such as soil moisture, temperature, and nitrogen inputs.

This clarification has been added to the manuscript.

Author's changes in manuscript: Modified Line 409 to 412

Comment 4: ***Lines 369–370****: The manuscript states, "This is especially apparent in transitional ecosystems such as savannas and grasslands." Where are these land-use types located within the study area? The authors should consider providing a land-use map as a supplementary file for readers unfamiliar with the geography and land-use distribution in Africa.*

Author's response: We agree that providing a clearer representation of land-use types within the study domain would enhance the reader's understanding. To address this, we included a land-use classification map as a supplementary file, highlighting the main ecosystems (forests, savannas, grasslands, and arid regions).

Author's changes in manuscript: Modified Line 409 to 412, and included Figure S1 in a supporting information file.

Comment 5: *Lines 371–372: Figure 9 is discussed after Figure 6. The figures should be numbered in the order of their appearance in the manuscript.*

Author's response: We have adjusted the figure numbering to maintain a logical sequence. Figure 9 has been moved to become Figure 7, Figure 7 has become Figure 8, and Figure 8 has become Figure 9. This ensures that figures are now introduced in the correct order as they appear in the text.

Comment 6: *Line 374: The reference to Figure 7 should be correctly formatted in parentheses.*

Author's response: We have corrected the formatting of the Figure 7 (now Figure 8) reference to ensure consistency with the manuscript's citation style.

Comment 7 : *Figure 8: It would be more straightforward to compare and discuss the Base and BioNO columns of NO_2 simulated with RegCM5 against those from OMI and OMI/Aura satellite data.*

Author's response: We agree with the reviewer that a more direct comparison between the BASE and BIONO simulations with OMI/Aura satellite NO_2 columns would improve clarity. To address this, we have proposed in the review process to include in the manuscript modified Figure 9.

Author's changes in manuscript: Modified Line 430 to 446, and modified Figure 9

Comment 8: *Tables 5, 6, and 7: Bias values for CAMS and GEOS-Chem models should also be included for a more comprehensive comparison.*

Author's response: We appreciate the reviewer's suggestion to include bias values for CAMS and GEOS-Chem for a more comprehensive comparison. We have proposed to now include the biases from both CAMS and GEOS-Chem in the manuscript and updated Tables 5, 6 and 7.

Author's changes in manuscript: Modified Line 468 to 470, 489 to 491, 476 to 477, 524 to 525 and 597 to 601.

Comment 9: *Line 412 No correlation values are presented in Figure 11. The authors should either include them in the figure or adjust the text accordingly.*

Author's response: However, the primary objective of Figure 11 is to illustrate how the BioNO emissions improve the NO_2 simulations by bringing them closer to the 1:1 line, rather than to quantify the correlation between observed and simulated values. The visual comparison already suggests that with BioNO, the points shift towards the first bisector, indicating a better agreement between model results and observations. This improvement is already quantified in the tables through bias reduction metrics (Red/Inc)

Comment 10: *Expand the discussion on the CBM-Z chemical mechanism. While computationally efficient, it may oversimplify NO_x-VOC interactions, affecting the accuracy of NO_2 oxidation and the formation of secondary pollutants such as HNO_3 and O_3.*

Author's response: While CBM-Z is indeed computationally efficient, it also includes a number of improvements from earlier mechanisms such as CBM-IV, making it suitable for regional to global-scale applications. The mechanism explicitly represents important long-lived VOCs, peroxy radical interactions, and isoprene chemistry, which are key in controlling NO_x oxidation and secondary pollutant formation, including HNO_3 and O_3. However, we acknowledge that, as a lumped-structure mechanism, CBM-Z may simplify certain NO_x-VOC interactions, potentially affecting the accuracy of secondary pollutant formation. We have now expanded the model description section to reflect these strengths and limitations, with relevant references. In addition, one should keep in mind that biogenic and anthropogenic VOC emissions are affected by potentially large uncertainties over Africa and the cost/benefits of a more detailed scheme should also be put in this context.

Author's changes in manuscript: Modified Line 104 to 118**.**

Comment 11: *The overestimation of O_3 in RegCM5 results—could this be linked to overestimated chemical boundary conditions from CAMS, which, as shown in Figure 17, also overestimates O_3?*

Author's response: The overestimation of O_3 in RegCM5 are indeed influenced by CAMS boundary conditions, as Figure 17 shows that CAMS itself tends to overestimate O_3 at certain sites. This suggests that some biases in the simulated O_3 concentrations might be inherited from the chemical reanalysis. However, our analysis (as mentioned in the text) indicates that other factors also could play a significant role in this overestimation. Vertical transport and mixing processes are crucial for determining surface O_3 concentrations (e.g. monsoonal circulation during JJA), contributing to the observed biases. Differences in chemical regimes and dry deposition also impact the model's performance (transition from NOx-limited to VOC-limited) specially in the vicinity of sources.