Response to Comment RC2

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

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?*

The authors would like to sincerely thank the reviewer for his/her constructive feedback and valuable suggestions to improve the clarity and quality of the manuscript.
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.*

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.*

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.

Revised Text in Manuscript (Lines 409-412) : "Indeed, CAMS includes BioNO emissions … using the Hudman et al. (2012) scheme. "

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.*

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).

Revised Text (Lines 415-416):
“*This is especially apparent in transitional ecosystems such as savannas and grasslands (see supplementary Figure S1).*”

We proposed in the review process to include Figure S1 in a supporting information file, as follow

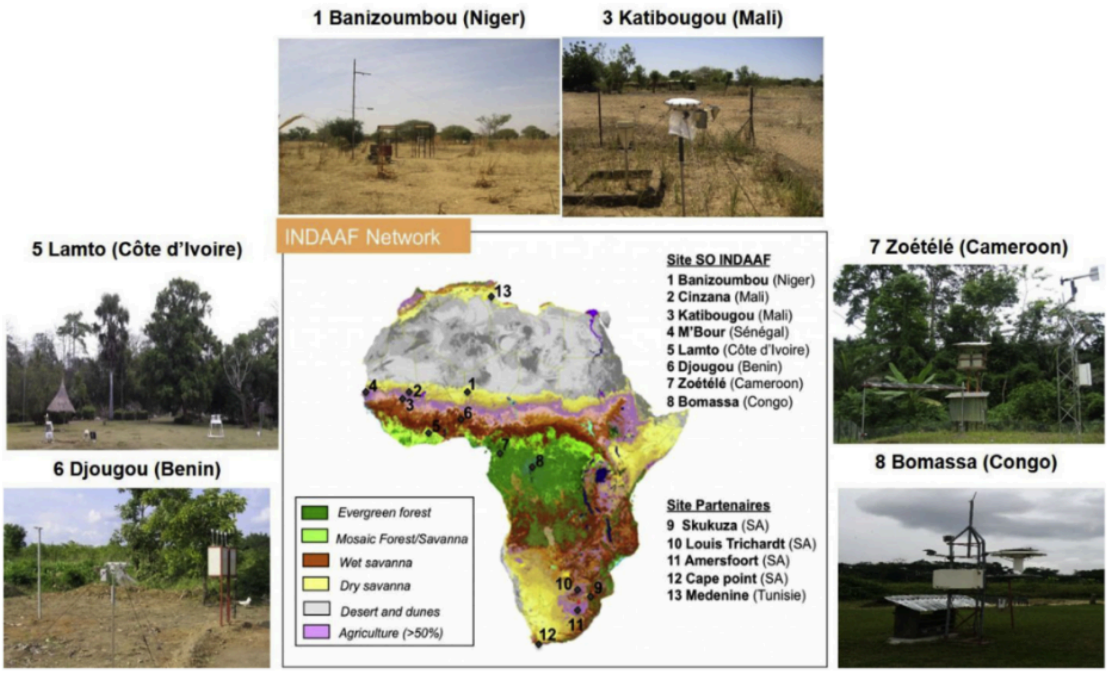


Figure S1. Land-use distribution in Africa and the location of INDAAF measurement sites. Zoom-in on the vegetations at the study stations: (1) Banizoumbou, (3) Katibougou, (6) Djougou, (5) Lamto, (8) Bomassa, and (7) Zoétélé.

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.*

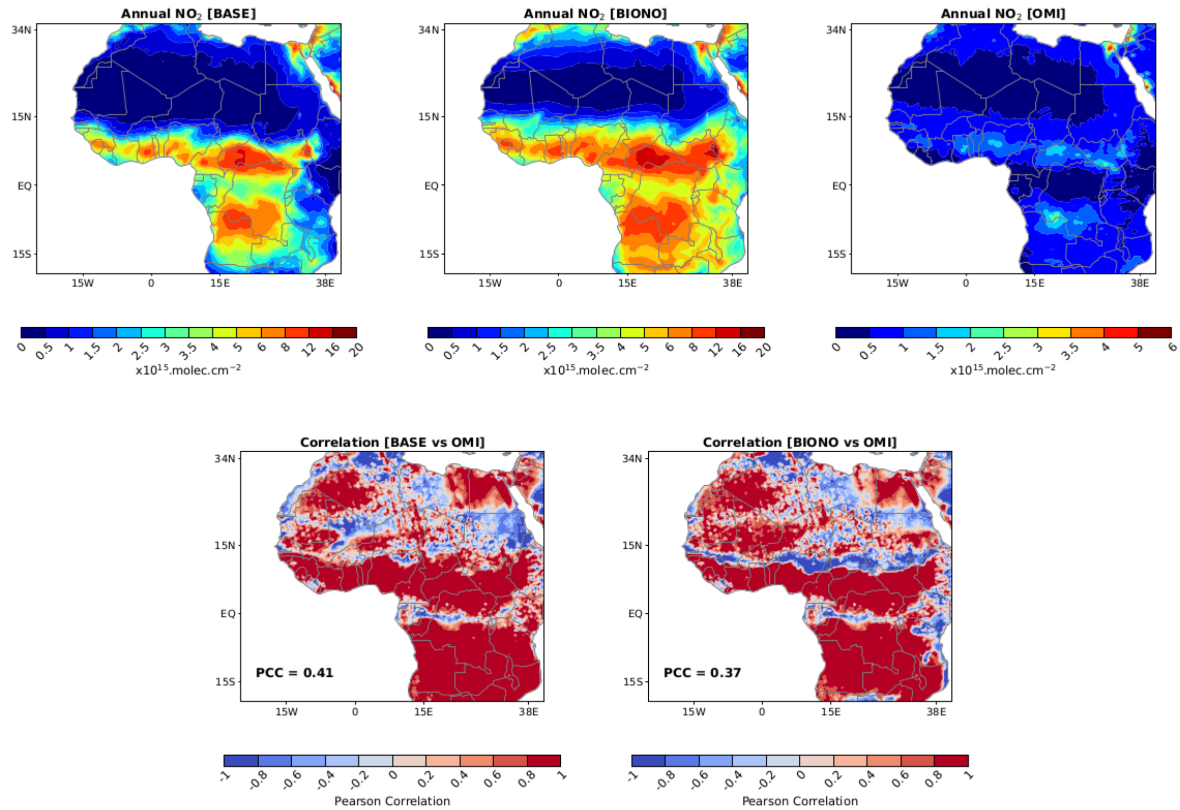
We have adjusted the figure numbering to maintain a logical sequence. Figure 9 has been moved to become Figure 7, Figure 7 has become Figure 8, and Figure 8 has become Figure 9. This ensures that figures are now introduced in the correct order as they appear in the text.

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

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.*

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 as follow:



Revised Text (Lines 430-446): "The comparison between RegCM5 simulations … large-scale processes dominate."

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

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 as follow:

Table 5. BASE, BIONO, CAMS and Geos-Chem Biases (ppb) for NO_2. The Reduced/Increased (Red/Inc) biases given by BIONO run is in %. Ba: Banizoumbou, Ka: Katibougou, La: Lamto, Dj: Djougou, Bo: Bomassa, Zoétélé: Zo

			Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Savannas	**Ba**	BASE[a]	-0.47	-0.67	-0.48	-2.01	-2.86	-4.62	-3.28	-2.04	-2.15	-4.97	-1.92	-0.72
		BIONO[b]	-0.43	-0.63	-0.47	-1.84	-2.62	-3.94	-0.48	3.53	0.97	-4.26	-1.85	-0.68
		Red/Inc[c]	-7.42	-6.45	-2.38	-8.38	-8.39	-14.65	-85.46	73.17	-54.86	-14.27	-3.48	-5.57
		CAMS[d]	0.33	0.27	0.74	-0.47	-1.86	-3.85	-2.73	-1.47	-1.52	-4.21	-0.33	0.44
		Geos-Chem[e]	-0.19	-0.33	-0.44	-2.04	-2.84	-4.54	-3.29	-2.17	-2.39	-5.16	-1.37	-0.33
	Ka	BASE	-0.64	-0.41	-1.54	-2.4	-2.42	-3.02	-1.3	-1.52	-1.13	-1.47	-2.53	-1.27
		BIONO	-0.03	0.19	-0.74	-1.26	-1.03	-1.06	2.25	2.72	1.28	0.08	-1.36	-0.63
		Red/Inc	-95.2	-54.71	-51.67	-47.51	-57.57	-65.08	73.2	79.12	13.22	-94.44	-46.41	-50.69
		CAMS	-0.26	-0.21	-1.4	-2.34	-2.4	-3.06	-1.38	-1.58	-1.18	-1.82	-2.45	-0.88
		Geos-Chem	0.50	0.24	-1.30	-2.29	-2.47	-3.08	-1.40	-1.66	-1.33	-1.96	-2.31	-0.25
Wet Savannas	**La**	BASE	0.25	-0.84	-1.07	-0.76	-0.31	-0.36	-0.22	-0.35	-0.35	-0.27	0.21	0.51
		BIONO	0.95	-0.13	-0.46	-0.09	0.35	0.27	0.26	0.12	0.28	0.64	1.05	1.26
		Red/Inc	286.37	-84.14	-57.09	-87.57	11.55	-24.72	20.15	-64.49	-18.37	137.2	406.76	146.79
		CAMS	0.16	-0.60	-0.83	-0.65	-0.26	-0.31	-0.17	-0.27	-0.24	-0.31	0.05	0.00
		Geos-Chem	-0.15	-0.69	-0.97	-0.80	-0.34	-0.38	-0.23	-0.28	-0.24	-0.36	-0.02	-0.04
	Dj	BASE	1.59	-0.16	-0.54	-0.64	-0.4	-0.45	-0.2	0.4	0.66	0.95	-0.09	0.84
		BIONO	2.86	1.18	0.58	0.48	0.77	1	1.62	2.06	2.4	2.15	0.99	2.28
		Red/Inc	79.95	656.78	8.14	-25.51	91.97	121.09	716.21	410.01	264	126.18	1052.96	171.61
		CAMS	-0.32	-1.41	-1.56	-1.62	-1.31	-1.23	-1.23	-0.54	-0.56	-0.55	-1.76	-0.90
		Geos-Chem	0.99	-1.22	-1.43	-1.55	-1.22	-1.13	-1.13	-0.47	-0.56	-0.55	-0.87	1.02
Forests	**Bo**	BASE	-0.80	-1.37	-1.17	-1.33	-1.64	-1.56	-0.98	-1.15	-1.12	-0.82	-0.55	0.16
		BIONO	0.20	-0.41	-0.23	-0.45	-0.77	-0.71	-0.13	-0.35	-0.39	-0.08	0.41	1.19
		Red/Inc	-75.32	-69.82	-80.71	-66.58	-52.96	-54.28	-86.47	-69.38	-65.42	-90.82	-24.59	649.99
		CAMS	-2.15	-2.04	-1.65	-1.64	-1.88	-1.86	-1.34	-1.41	-1.18	-0.91	-0.98	-1.26
		Geos-Chem	-1.94	-1.93	-1.54	-1.57	-1.82	-1.78	-1.20	-1.28	-1.12	-0.85	-0.90	-0.97
	Zo	BASE	0.88	-1.04	-0.82	-0.74	-0.54	-0.45	0.03	-0.30	-0.36	-0.37	0.05	1.14
		BIONO	1.65	-0.19	0.13	0.21	0.35	0.26	0.60	0.18	0.30	0.40	1.00	1.99
		Red/Inc	87.84	-81.28	-83.92	-71.35	-35.02	-41.79	2046.86	-41.26	-17.48	7.11	1769.01	74.47
		CAMS	-0.53	-1.79	-1.25	-0.93	-0.67	-0.66	-0.25	-0.47	-0.5	-0.51	-0.45	-0.59
		Geos-Chem	2.12	-0.87	-0.77	-0.78	-0.57	-0.52	-0.07	-0.32	-0.39	-0.45	-0.30	0.80

[a] Bias with BASE simulation
[b] Bias with BIONO simulation
[c] Reduction/Increase Bias by BioNO emissions
[d] Bias with CAMS reanalysis
[e] Bias with Geos-Chem model

Table 6. BASE, BIONO, CAMS and Geos-Chem Biases (ppb) for HNO_3. The Reduced/Increased (Red/Inc) biases given by BIONO run is in %. Ba: Banizoumbou, Ka: Katibougou, La: Lamto, Dj: Djougou, Bo: Bomassa, Zoétélé: Zo

			Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Savannas	Ba	BASE[a]		-0.02	-0.05	-0.25	-0.47	-1.36	-0.95	-0.91	-0.51	-0.46	-0.03	-0.05
		BIONO[b]		0.01	-0.04	-0.23	-0.45	-1.32	-0.87	-0.79	-0.36	-0.38	-0.01	-0.04
		Red/Inc[c]		-67.9	-12.35	-6.06	-4.02	-2.75	-8.47	-13.07	-29.26	-18.24	-68.23	-22.09
		CAMS[d]		0.14	0.00	-0.23	-1.20	-0.86	-0.84	-0.41	-0.27	0.18	0.12	
		Geos-Chem[e]		0.95	0.43	0.74	0.71	-0.24	-0.32	-0.48	-0.02	0.41	0.91	0.49
	Ka	BASE		-0.68		-0.45	-1.18	-1.73	-0.41	-1.01	-0.54	-0.32	-0.14	0.02
		BIONO		-0.64		-0.40	-1.13	-1.67	-0.30	-0.90	-0.44	-0.23	-0.08	0.05
		Red/Inc		-5.75		-10.28	-4.31	-3.51	-25.82	-11.12	-19.24	-29.46	-43.56	148.94
		CAMS		-0.58		-0.22	-1.05	-1.67	-0.38	-1.00	-0.52	-0.24	0.04	0.18
		Geos-Chem		0.20		0.99	-0.23	-1.11	-0.12	-0.85	-0.30	0.30	1.04	0.95
Wet Savannas	La	BASE	-0.07	-0.53	-0.66	-0.52	-0.36	-0.45	-0.16	-0.12	-0.13	-0.19	-0.21	-0.03
		BIONO	0.03	-0.47	-0.63	-0.51	-0.34	-0.42	-0.12	-0.06	-0.09	-0.17	-0.17	0.05
		Red/Inc	-62.64	-10.56	-4.79	-3.34	-4.56	-5.77	-25.28	-47.81	-31.76	-12.32	-20.27	53.7
		CAMS	-0.21	-0.50	-0.60	-0.48	-0.33	-0.43	-0.30	-0.34	-0.16	-0.18	-0.22	-0.14
		Geos-Chem	1.50	0.18	-0.14	-0.18	-0.15	-0.32	-0.17	-0.21	-0.06	-0.05	0.14	1.23
	Dj	BASE	0.26	-0.27	-0.39	-0.80	-0.68	-0.41	-0.30	-0.54	-0.35	-0.41	-0.27	-0.08
		BIONO	0.36	-0.20	-0.35	-0.77	-0.65	-0.36	-0.23	-0.48	-0.31	-0.34	-0.17	0.01
		Red/Inc	38.57	-26.36	-10.94	-4.56	-5.10	-12.64	-23.90	-10.38	-11.09	-16.50	-37.03	-84.93
		CAMS	0.56	0.04	-0.13	-0.65	-0.60	-0.38	-0.29	-0.53	-0.33	-0.32	-0.03	0.60
		Geos-Chem	3.71	1.74	0.91	0.03	-0.04	0.06	-0.06	-0.34	-0.09	0.15	1.25	2.90
Forests	Bo	BASE	-0.27	-0.42	-0.54	-0.45	-0.37	-0.24	-0.34	-0.35	-0.41	-0.17	-0.43	-0.16
		BIONO	-0.23	-0.40	-0.52	-0.44	-0.36	-0.24	-0.33	-0.34	-0.41	-0.17	-0.42	-0.13
		Red/Inc	-13.69	-4.99	-2.27	-1.25	-1.57	-2.68	-2.60	-1.98	-0.43	-0.52	-2.67	-19.02
		CAMS	-0.18	-0.42	-0.52	-0.44	-0.36	-0.18	-0.27	-0.30	-0.41	-0.16	-0.37	-0.00
		Geos-Chem	1.64	0.16	-0.14	-0.20	-0.16	0.14	0.29	0.04	-0.22	-0.05	-0.02	2.30
	Zo	BASE	0.05	-0.38	-0.26	-0.26	-0.25	-0.44	-0.10	-0.26	-0.18	-0.09	-0.27	-0.13
		BIONO	0.09	-0.36	-0.24	-0.26	-0.24	-0.43	-0.09	-0.25	-0.17	-0.09	-0.26	-0.09
		Red/Inc	84.56	-4.46	-4.67	-2.39	-1.46	-1.22	-7.70	-2.93	-2.48	-1.86	-4.61	-31
		CAMS	-0.03	-0.36	-0.23	-0.24	-0.23	-0.41	-0.08	-0.24	-0.17	-0.08	-0.23	-0.19
		Geos-Chem	2.67	0.58	0.24	-0.01	-0.07	-0.25	0.03	-0.13	-0.07	0.04	0.38	2.89

[a] Bias with BASE simulation
[b] Bias with BIONO simulation
[c] Reduction/Increase Bias by BioNO emissions
[d] Bias with CAMS reanalysis
[e] Bias with Geos-Chem model

Table 7. BASE, BIONO, CAMS and Geos-Chem Biases (ppb) for O_3. The Reduced/Increased (Red/Inc) biases given by BIONO run is in %.Ba: Banizoumbou, Ka: Katibougou, La: Lamto, Dj: Djougou, Bo: Bomassa, Zoétélé: Zo

			Month											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dry Savannas	**Ba**	BASE[a]	29.19	29.69	34.20	20.44	7.01	-2.46	-1.29	-1.06	6.64	12.16	28.46	26.72
		BIONO[b]	29.15	29.94	35.02	22.24	9.04	-0.41	-1.00	-1.98	9.28	14.56	29.08	26.87
		Red/Inc[c]	-0.16	0.83	2.40	8.78	28.84	-83.38	-22.87	86.79	39.70	19.67	2.16	0.54
		CAMS[d]	25.22	29.07	35.16	30.02	15.19	3.99	2.12	1.69	11.05	14.96	24.78	23.53
		Geos-Chem[e]	30.10	33.26	33.00	31.91	21.16	13.62	9.63	6.82	15.19	21.68	32.61	28.59
	Ka	BASE	30.44	26.04	29.86	19.01	-2.64	-9.84	12.94	1.97	7.22	13.00	20.23	29.63
		BIONO	29.93	25.80	29.53	19.42	-1.23	-8.80	13.35	2.25	10.11	15.59	20.23	29.34
		Red/Inc	-1.68	-0.93	-1.09	2.17	-53.40	-10.53	3.19	14.00	40.03	19.91	-0.03	-0.97
		CAMS	25.85	23.27	31.97	24.73	-2.33	-10.77	12.30	0.16	7.59	12.99	17.71	25.86
		Geos-Chem	33.50	20.24	39.04	36.18	11.03	1.06	17.34	2.52	11.76	22.53	31.00	32.96
Wet savannas	**La**	BASE	20.45	11.04	7.34	3.78	7.05	15.40	26.23	28.72	24.33	11.89	10.63	14.54
		BIONO	20.77	11.56	8.83	5.70	7.74	15.43	26.18	28.83	23.80	12.02	11.66	15.22
		Red/Inc	1.56	4.72	20.40	50.89	9.80	0.19	-0.21	0.38	-2.17	1.15	9.68	4.65
		CAMS	21.40	12.74	9.60	9.48	10.08	14.54	19.02	17.06	13.27	13.14	11.67	14.96
		Geos-Chem	32.79	18.14	14.09	14.23	10.85	11.18	14.53	14.41	12.81	12.16	15.58	27.52
	Dj	BASE	24.57	15.22	5.51	-2.63	-1.98	2.01	11.17	11.83	6.95	5.58	9.82	17.57
		BIONO	24.17	15.12	6.36	-0.58	-0.52	2.46	10.28	10.73	6.93	7.39	10.61	17.25
		Red/Inc	-1.64	-0.63	15.52	-78.09	-73.72	22.54	-7.94	-9.33	-0.25	32.48	8.10	-1.87
		CAMS	35.55	27.40	18.09	10.03	7.28	7.30	11.79	10.33	11.14	16.93	23.48	33.12
		Geos-Chem	41.37	33.38	22.38	17.30	13.17	11.57	13.37	13.34	14.42	19.23	33.01	32.54
Forest	**Bo**	BASE	17.38	11.39	6.39	4.63	7.74	12.04	15.46	14.91	5.08	1.96	5.80	17.08
		BIONO	17.86	12.20	8.32	6.27	8.16	11.66	15.08	14.57	5.02	3.11	7.57	17.83
		Red/Inc	2.77	7.12	30.28	35.51	5.45	-3.15	-2.44	-2.30	-1.16	58.58	30.44	4.39
		CAMS	15.00	7.01	1.46	2.09	4.02	9.73	14.20	13.15	6.12	4.94	4.56	13.71
		Geos-Chem	47.03	22.99	17.44	13.10	14.00	18.42	29.07	23.27	15.65	12.21	20.40	51.97
	Zo	BASE	18.57	6.10	5.01	4.23	2.64	9.56	19.67	23.05	13.45	4.61	4.24	14.92
		BIONO	19.14	6.69	6.31	6.08	3.57	9.65	19.40	23.04	13.02	5.33	6.11	15.39
		Red/Inc	3.09	9.70	26.07	43.94	35.60	0.91	-1.34	-0.07	-3.20	15.57	44.12	3.21
		CAMS	24.77	13.25	9.37	8.52	9.10	18.48	24.52	19.57	13.30	13.02	9.74	19.89
		Geos-Chem	49.95	25.61	19.73	12.08	9.12	13.48	20.70	18.95	14.30	14.05	23.98	52.49

[a] Bias with BASE simulation
[b] Bias with BIONO simulation
[c] Reduction/Increase Bias by BioNO emissions
[d] Bias with CAMS reanalysis
[e] Bias with Geos-Chem model

Revised Text:

Lines 468-470: ***"****Even though this reduction lowers the bias, it remains high and is also observed in the CAMS reanalysis (-3.85 ppb) and the state-of-the-art model (GEOS-Chem : -4.54 ppb) for the same month and site (See Table 5)."*

Lines 489-491: *"Similarly, GEOS-Chem model also displays positive biases in the dry season of wet savannas, particularly in Djougou, where the bias reaches 0.99 ppb in January.*

This suggests that the overestimation could be a systematic issue across models, potentially due to uncertainties in emissions or local photochemistry."

Lines 476-477 : "*GEOS-Chem also underestimates NO2 concentrations in these sites, with biases reaching -1.94 ppb in January at Bomassa, which are comparable to the BASE (-0.80 ppb) and CAMS (-2.15 ppb) biases.*"

Lines 524-525: *"This underestimation is also observed in CAMS and GEOS-Chem models, particularly for June, where CAMS and GEOS-Chem biases reach -1.67 ppb and -1.11 ppb, respectively … "*

Lines 597-601: *" A comparison with CAMS and GEOS-Chem shows that … regional ozone dynamics."*

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.*

We appreciate the reviewer's comment. 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.*

We appreciate the reviewer's suggestion to expand the discussion on the CBM-Z chemical mechanism. 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.

Revised text (Lines 104–118): *"CBM-Z builds upon the widely used CBM-IV mechanism (Gery et al., 1989) … more complex chemical scheme."*

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?*

We thank the reviewer for this insightful comment. 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.