

Research Article

Quantifying Contributions of Biomass Burning to Air Quality in Africa

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Abstract

One of the major sources of tropospheric ozone (O₃) precursors such as nitrogen oxides (NO_x), carbon monoxides (CO), and non-methane volatile organic compounds (NMVOCs) is biomass burning. The emissions from the burning not only affect air quality and climate locally, but also on a continental to hemispheric scales through long-range transport. We used NASA's Global Modeling Initiative Chemistry and Transport Model (GMI-CTM), to quantify the changes in surface ozone over Northern Sub-Saharan Africa (NSSA: 0 – 20N, 20W – 55E), as triggered by biomass burning from different regions. During the winter months (i.e., January), most of the burning is concentrated in the NSSA region while in summer it shifts southward outside the NSSA region. Our analysis reveals that out of the total contribution to surface ozone from biomass burning emissions in the NSSA region, 92% is due to NSSA biomass burning while the remaining 8% is from outside the NSSA. In fact, most (~75%) of the 8% comes from outside the African continent because little to no biomass burning occurs in Africa outside of the NSSA region during this time of year. However, during the summer months (i.e., July), most of the contribution to NSSA surface ozone (96%) is due to burning from outside NSSA. Only 10% of the 96% comes from outside the African continent because during this time most of the burning is from outside the NSSA but within the African continent. In spring (i.e., April) approximately equal percentages of contributions come from within and outside the NSSA region.

Keywords

Air Quality, Biomass Burning, Surface Ozone, Northern Sub-Saharan Africa, Chemistry and Transport Model

1. Introduction

Biomass burning is one of the most significant anthropogenic and natural disturbances affecting atmospheric composition in tropical and subtropical regions. The combustion of

vegetation through agricultural waste burning, land clearing, and wildfires releases substantial quantities of trace gases and aerosols into the atmosphere [59], with far-reaching implications for

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air quality, human health [30, 48], and climate [4, 7, 9]. Through long-range transport emissions from biomass burning do not only affect local surroundings but also regional and even continental [68] and hemispheric scales [10]. Africa accounts for approximately 50% of global biomass burning emissions, making it a critical region for understanding the atmospheric impacts of combustion-related pollution [45, 61].

Surface ozone, a secondary pollutant formed through photochemical reactions involving NO_x , CO, and NMVOCs in the presence of sunlight, poses significant threats to human health [26], vegetation [2, 18, 40], and ecosystems [19, 41, 50]. While stratospheric ozone protects life on Earth from harmful ultraviolet radiation, tropospheric ozone at ground level acts as a respiratory irritant and contributes to the formation of photochemical smog [33]. Understanding the sources and transport pathways of ozone precursors is essential for developing effective air quality management strategies and assessing the regional and global impacts of biomass burning [17].

The spatial and temporal distribution of biomass burning in Africa exhibits strong seasonal patterns driven by climatic conditions, vegetation types, and land management practices [23]. During the Northern Hemisphere winter, burning activity concentrates in the Sahelian zone and northern savanna regions, while summer months see a southward shift of burning activity to southern Africa [45, 47]. This seasonal migration creates complex patterns of atmospheric transport and chemical transformation that influence air quality across the continent and beyond [1, 37, 38].

This study employs the NASA Global Modeling Initiative Chemistry and Transport Model to quantify the relative contributions of biomass burning emissions from different geographical regions to surface ozone concentrations in Northern Sub-Saharan Africa. By conducting sensitivity simulations with emissions from specific regions systematically removed, we provide new insights into the spatial origins of ozone pollution and the importance of long-range transport in determining regional air quality [13, 64]. These findings have important implications for understanding source-receptor relationships [12], attributing responsibility for transboundary pollution, and informing regional cooperation on air quality management.

2. Methods

2.1. Study Region

Northern Sub-Saharan Africa (NSSA) is defined in this study as the region bounded by 0–20°N latitude and 20°W–55°E longitude. This domain encompasses different vegetation classes including savanna, grassland and cropland, spanning multiple countries across West, Central, and East Africa [42]. Figure 1 shows the vegetation classification in both NSSA and SHA (Southern-Hemisphere Africa) adopted from the studies [35].

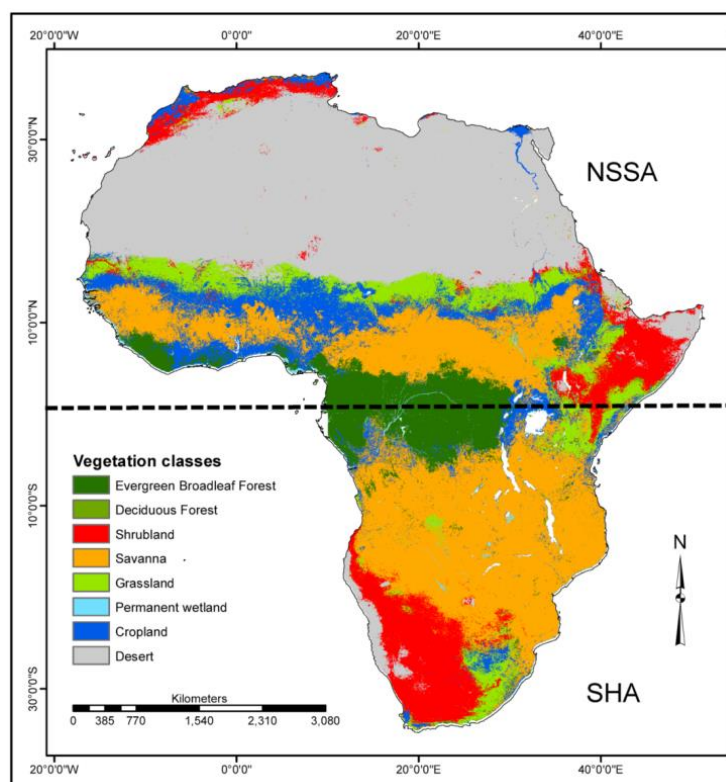


Figure 1. Vegetation classification in both NSSA and SHA (Southern-Hemisphere Africa) adopted from the studies [35].

Both regions experience strong seasonal variations in precipitation, vegetation cover and fire activity, making it an ideal natural laboratory for investigating the impacts of biomass burning on atmospheric chemistry [29].

Figure 2 shows 13-year timeseries of fire counts (black) and

land surface temperature (red) derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) [24, 27] over the NSSA region (bottom panel) compared with the whole continent (bottom panel). The MODIS fire counts, and land surface temperature is from 2001 to 2013.

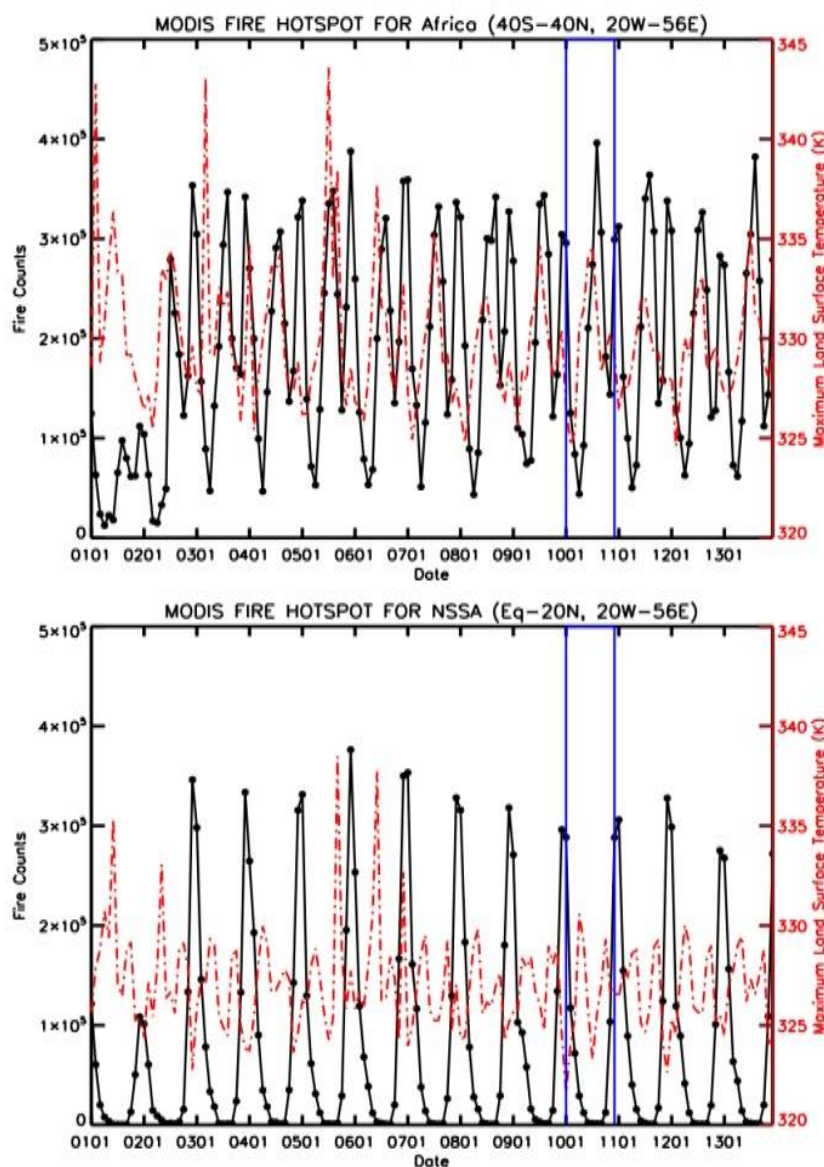


Figure 2. Monthly (2001-2013) comparison of fire counts (black) and land surface temperature (red) over the NSSA region (lower panel) and the entire African continent (upper panel), derived from MODIS observations.

2.2. Model Description

The Global Modeling Initiative Chemistry and Transport Model (GMI-CTM) combines a state-of-the-art representation of atmospheric chemistry with meteorological fields to simulate the distribution and transformation of trace gases [14, 53]. The model employs a comprehensive tropospheric-strato-

spheric chemical mechanism [16] that includes detailed representations of NO_x -hydrocarbon-ozone chemistry, with particular emphasis on processes relevant to biomass burning plumes [71]. The GMI-CTM is driven by assimilated meteorological data from NASA Global Modeling and Assimilation Office (GMAO) that provide realistic representations of atmospheric circulation, temperature, humidity, and other variables affecting chemical processes [44]. The model resolution

allows for adequate representation of regional-scale transport patterns while maintaining computational efficiency for multi-year simulations. Cloud convection, boundary layer mixing, and wet and dry deposition processes are parameterized following established schemes that have been validated against observations [34, 43]. Although, the GMI-CTM is a well known CTM that has been used in many atmospheric investigations it has its known limitations similar to other CTMs, some of these known uncertainties have been discussed elsewhere including uncertainties in spatial resolution [72], transport process [73], meteorological inputs [74] and chemistry [71].

2.3. Biomass Burning Emissions

Biomass burning emissions for the GMI-CTM are derived from the Global Fire Emissions Database (GFED) version 4, which combines satellite-based fire detection products from MODIS with biogeochemical modeling to estimate emissions [23, 28, 62]. The temporal distribution of emissions follow seasonal cycle of fire activity detected from space [60], capturing the characteristic north-south migration of burning across the African continent throughout the year. Spatial patterns are resolved at $0.25^\circ \times 0.25^\circ$ resolution and then re-gridded to the model grid scale, allowing for realistic representation of emission hotspots and their evolution over time.

The emission inventory includes all major ozone precursor species: NO_x (emitted as NO with subsequent rapid conversion to NO_2), CO, and a comprehensive suite of NMVOCs [3-5].

Table 1 shows the regional and global distribution of biomass-burning emissions used in the simulations. Approximately 50% of global biomass emissions originate from Africa, with the NSSA region contributing 30–40% of the continent's total.

Emission factors account for combustion efficiency variations related to fuel moisture content, fire intensity, and vegetation characteristics specific to different African biomes [67]. Temporal profiles incorporate diurnal variations in fire activity based on satellite overpass times and known patterns of agricultural burning practices [45]. Table 1 shows the regional and global breakdown of the biomass emissions used in the simulations. Biomass emissions from Africa account for about 50% of the global biomass emissions, with the NSSA region accounting for 30% - 40% of the emissions from Africa.

Table 1. Regional and global biomass emissions implemented in the simulations.

	GLOBAL / Tg	AFRICA / Tg	NSSA / Tg
CO	561	250.3	84.3
CH_2O	10.6	4.3	1.45
CH_4	27.6	9.7	3.32

	GLOBAL / Tg	AFRICA / Tg	NSSA / Tg
CH_4O	15.6	6.4	2.19
CO_2	12400	6240	2100
NOX	19.0	9.4	3.18
OC	27.3	12.3	4.16
BC	3.6	1.7	0.60
VOC	46.7	21.0	7.13

2.4. Simulation Design

To quantify the contribution of biomass burning from different regions to surface ozone in NSSA, we conducted a series of sensitivity simulations following the methodology of the studies [1, 13]. In fact, four sensitivity simulations were initiated. (1) The baseline simulation which included biomass emissions from all regional sources around the globe at their full magnitudes. (2) Perturbed simulation with biomass emissions switched off from all regions around the globe. (3) Perturbed simulation with biomass burning in the NSSA region switched off. (4) Perturbed simulation with no biomass emissions from Africa (40N-40S, 30W-60E).

By comparing surface ozone concentrations between the baseline simulation and each sensitivity experiment, we isolate the contribution from each source region. The differences between any two simulations represent the ozone that can be attributed to the emissions removed in one simulation but present in the other. This approach accounts for non-linear chemical interactions and transport processes that cannot be captured by simple emission inventory analysis [17, 65, 66].

Simulations were run for 12 months in 2010 to ensure robust statistics and to capture seasonal variability in meteorology and fire activity. Results are analyzed on a monthly basis to reveal seasonal patterns in source contributions, with particular focus on representative months for winter (January) and summer (July) conditions. Spatial analysis examines both regional averages and geographical patterns of source contributions across the NSSA domain.

2.5. Analysis Method

Surface ozone concentrations are extracted from the lowest model layer (approximately 0-100 m above ground level), representing conditions relevant to human exposure and ecosystem impacts. Statistical analysis includes calculation of monthly mean concentrations, absolute and relative contributions from different source regions, and assessment of spatial variability across the NSSA domain. Uncertainty estimates account for interannual variability but do not include structural model uncertainties or emission inventory errors, which represent important caveats to the quantitative results [51].

3. Results

3.1. Seasonal Distribution of Biomass Burning

The African continent exhibits pronounced seasonal patterns in biomass burning activity that follow the migration of the Intertropical Convergence Zone (ITCZ) and associated precipitation patterns [45, 47]. During boreal winter months, particularly January (left column of Figure 3), fire activity concentrates in the northern savannas and Sahelian regions, corresponding closely with the NSSA study domain. This period follows the end of the rainy season when vegetation has dried sufficiently to support combustion, and agricultural practices including crop residue burning and land clearing are most prevalent [39, 70].

Fire counts and emission magnitudes peak in December through February across the NSSA region, with hotspots in the Guinea and Sudan savanna zones [23]. The spatial extent

of burning during this period spans from Senegal and Mauritania in the west through Mali, Burkina Faso, Nigeria, Chad, and Sudan in the center and east.

Fire radiative power measurements indicate that these fires release substantial energy and produce emission plumes that are transported both horizontally and vertically into the free troposphere [24, 67].

Fire activity during boreal winter (January) concentrates in the northern savannas and Sahelian regions, corresponding closely with the NSSA study domain (left column in Figure 3).

As the year progresses into spring months such as April, biomass burning activity begins its southward migration. During this transitional period, significant fire activity occurs both within the NSSA region and in equatorial and southern African regions [61]. The Guinea coast experiences continued burning while fire activity increases in Central African countries and begins to accelerate in southern Africa. This distributed pattern of emissions creates complex source-receptor relationships as NSSA air quality becomes influenced by both local and remote burning.

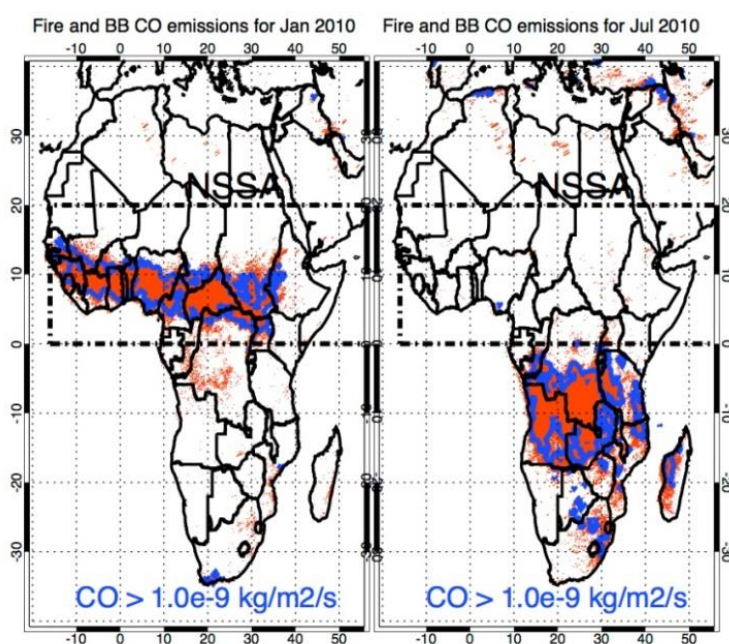


Figure 3. MODIS fire hotspots distribution (red) over Africa in January (left) and July (right) for the year 2010. The blue contours denote locations where biomass CO emissions are greater than $1.0e^{-9}$ kg/m²/s. The burning is associated with high emissions of CO.

By boreal summer, particularly July, the spatial distribution of African biomass burning shifts dramatically southward (right column of Figure 3). Fire activity in the NSSA region diminishes to minimal levels as seen in the upper right panel of Figure 3, the region experiences its rainy season causing an increase in vegetation index (green contour). Simultaneously, burning intensifies across southern Africa (lower right panel of Figure 3), including Angola, Zambia, Zimbabwe, Mozambique, and South Africa [15, 61]. This represents the peak fire

season for the Southern Hemisphere, with emission magnitudes comparable to those observed in northern regions during winter. The seasonal reversal creates a natural experiment for evaluating long-range transport influences on NSSA air quality.

3.2. Monthly Comparison of Simulated and Observed Surface Ozone

Comparison between modeled surface ozone (red and green)

and observed ozone from ozone sondes (back) at stations in Nairobi (right) and La Reunion (left) are shown in Figure 4.

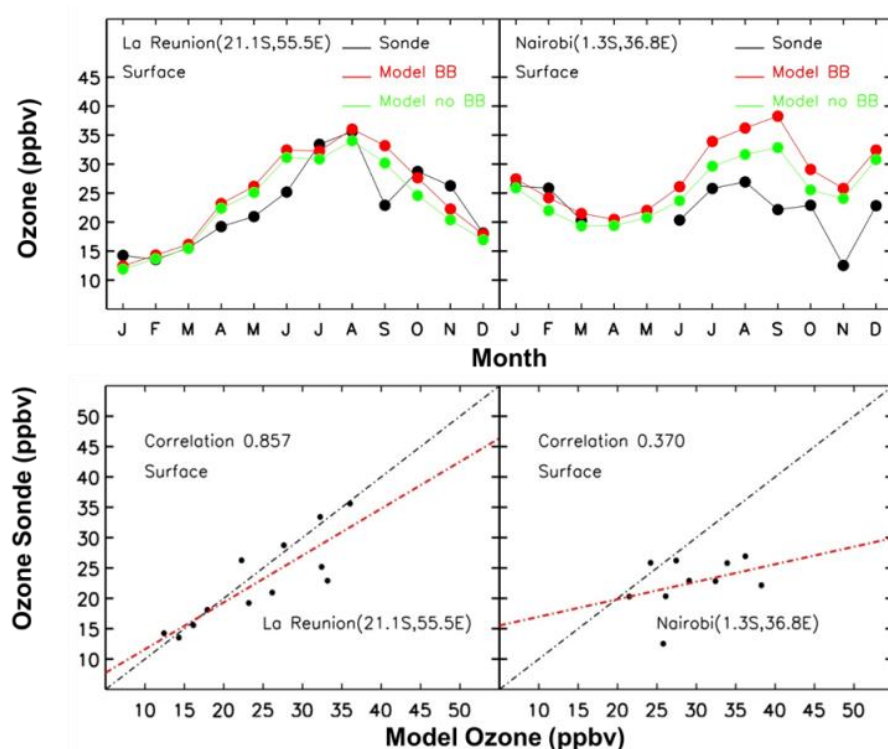


Figure 4. Modeled (red and green) and observed ozone (black) comparison at stations in Nairobi (right column) and La Réunion (left column). The upper row shows the monthly for 2010 while the bottom row shows the scatter comparison.

Baseline simulation (run 1) is in red while perturbed simulation with no BB (run 2) is green. The comparison reveals that the model overestimates surface ozone at both stations especially during the burning season. The best agreement in terms of correlation between the model and observation is obtained at La Reunion (0.85) than Nairobi (0.37). This in part is due to less burning in La Reunion compared to Nairobi.

3.3. Spatial Distribution of Surface Ozone Due to Regional Biomass Burning

January (left column) and July (right column) ozone distribution due to regional biomass burning is shown in Figure 5.

Upper row shows ozone due to all regional BB sources around the globe (difference between baseline and simulation 2), Middle row is due to BB from NSSA region (difference between baseline and simulation 3) and bottom row is due to BB from outside the NSSA region (difference between simulation 2 and 3).

Allowing BB emissions from all regions (upper row) reveal two peaks, one in the NSSA region during January, when biomass burning activity concentrates within the NSSA region and the other south of the equator during July when burning activities shift southwards. NSSA induced emissions only

(middle row) show elevated ozone concentrations across much of the NSSA domain in January, with peak values exceeding 40 ppbv in regions experiencing the most intense burning and favorable photochemical conditions. July represents a dramatic reversal in source-receptor relationships for NSSA surface ozone. During this month, the NSSA region experiences minimal local biomass burning due to the West African monsoon and associated rainfall [29]. Surface ozone concentrations due to NSSA BB show smaller values compared to January, typically less than 2.5 ppbv in the NSSA region although, there is a global maximum concentration of 376 ppbv outside Africa, reflecting both reduced precursor emissions and different meteorological conditions including increased cloudiness and higher humidity [46].

The spatial pattern is different seasonally when one looks at the impact of BB emissions from outside the NSSA region (bottom row). In this case the surface ozone peaks in July outside the NSSA region in the south where there is intense burning and less than 2.5 ppbv in January (although global maximum is 20.7 ppbv outside Africa) when there is less burning outside the NSSA region. The spatial pattern of ozone enhancement correlates strongly with emission hotspots, modified by meteorological factors including solar radiation, temperature, and wind patterns [38, 46].

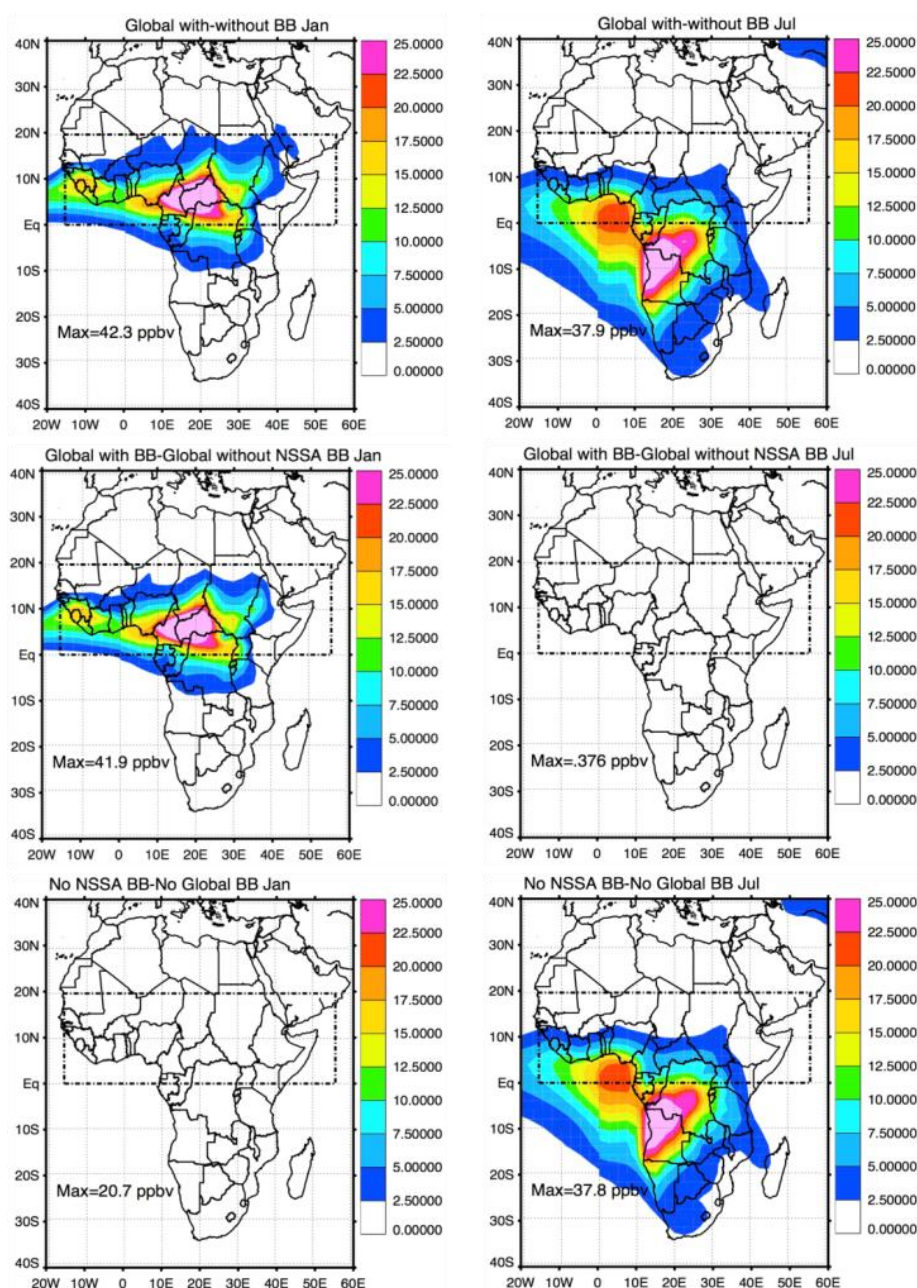


Figure 5. Spatial distribution of simulated surface ozone attributable to regional biomass burning for January (left column) and July (right column). The maximum numbers shown are global maximum concentrations.

3.4. Monthly Evolution of NSSA Average Ozone Due to Regional BB

Figure 6 shows the monthly BB induced surface ozone averaged within the NSSA region due to BB emissions from all source regions (black), NSSA region (blue), outside NSSA region (green) and outside Africa (red). Obviously, impact of global BB emissions on surface ozone in the NSSA region (black) show two peaks, one during northern summer and a much stronger during winter. Most of the winter contribution is due to local burning (blue), in fact, 92% of it comes from within the NSSA region. This dominant contribution reflects both the

proximity of emissions to receptors and the efficiency of photochemical ozone production in the tropical environment characterized by intense solar radiation and favorable temperature conditions [25, 49]. The remaining 8% of biomass-burning-attributable ozone originates from emissions outside the NSSA region (green). Detailed analysis of this external contribution reveals a surprising finding: approximately 75% of this 8% comes from sources outside African continent entirely (red). During this period, minimal biomass burning occurs south of the NSSA boundary due to the rainy season in those regions.

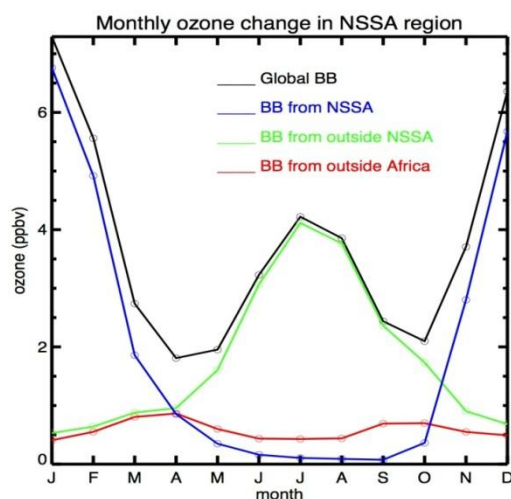


Figure 6. Monthly mean biomass-burning-induced (BB) surface ozone averaged over the NSSA region, with contributions attributed to all source regions (black), the NSSA region (blue), regions outside NSSA (green), and regions outside Africa (red).

Consequently, intercontinental transport from South America (particularly the Amazon Basin and Cerrado regions experiencing burning during their summer season) and from Southeast Asia accounts for most of the external contribution [1, 52]. Long-range transport of ozone precursors and ozone itself from these distant sources occur through several pathways. Upper-tropospheric transport following deep convection in emission regions can carry pollution across ocean basins, with subsequent descent and mixing into the surface layer over NSSA [11, 31, 64]. The overall magnitude of external contributions remains modest in absolute terms during winter but represent an important baseline pollution level that cannot be controlled through local emission reductions alone.

Using the maximum and minimum values, during summer, about 92% - 96% of biomass-burning-attributable ozone in NSSA originates from sources outside the region (green). Although robust, this overwhelming dominance of external contributions again demonstrates the importance of long-range transport for determining air quality during the local wet season. The geographical origin of these external contributions differs from the winter pattern. Due to intense biomass burning occurring across southern Africa during this period, our analysis shows that up to 90% of the external contribution to NSSA ozone originates from within the African continent [15, 54, 36]. Only about 10% comes from intercontinental sources, primarily Southeast Asia which coincides with their fire season. The intra-continental transport from southern to northern Africa involves several meteorological mechanisms that facilitate the long-range movement of pollutants [22]. Low-level transport plays a limited role due to the barrier effects of equatorial convection and precipitation. More important are mid-tropospheric circulation patterns that can carry biomass burning plumes northward along the eastern side of the continent [8]. The East African Highlands and associated topographic channeling create preferred pathways for pollution transport.

Additionally, biomass burning plumes injected into the free troposphere through pyro-convection can be transported horizontally over long distances before mixing downward into the boundary layer over NSSA [11, 20, 21].

4. Discussion

4.1. Implications for Air Quality Management

The strong seasonal variation in source contributions to NSSA surface ozone has important implications for air quality management strategies [6]. During winter months when local emissions dominate, regional efforts to reduce biomass burning through improved agricultural practices, fire management, and public awareness campaigns could achieve substantial benefits for local air quality [39, 69]. Up to 92% local contribution in January indicates that emission reductions within NSSA would translate nearly proportionally into ozone improvements during this critical season.

However, summer months present a different challenge. With up to 96% of biomass-burning-attributable ozone originating from outside NSSA, local emission controls would have minimal impact on air quality during July. Instead, regional cooperation across multiple African countries would be essential for addressing summer ozone pollution [1]. The finding that up to 90% of external contributions come from within Africa (rather than intercontinental sources) is actually encouraging from a policy perspective, as it suggests that continental-level coordination could meaningfully address the transboundary pollution issue.

The transitional spring period represents an intermediate case where both local and regional approaches contribute value. Air quality management during April would benefit from combined strategies addressing both local NSSA emissions and coordinated actions with southern and central African countries. This distributed source attribution complicates policy development but also provides flexibility in targeting the most cost-effective emission reduction opportunities regardless of their specific location.

From an international policy perspective, these results highlight the need for transboundary cooperation on biomass burning management. Especially, when World Health Organization (WHO) has stated that most of the African countries do not have ozone standards but few who have exceeds WHO standard of $100 \mu\text{g}/\text{m}^3$ for 8-hour (e.g. Kenya, Senegal and South Africa use $120 \mu\text{g}/\text{m}^3$) [63]. WHO recommends strengthening national standards toward WHO targets, alongside improved monitoring using existing frameworks such as the African Union's policies on environmental protection and climate change to enhance specific provisions for fire management cooperation [32]. Regional economic communities including ECOWAS (Economic Community of West African States), EAC (East African Community), and SADC (Southern African Development Community) could play important

roles in facilitating collaborative approaches to reducing biomass burning emissions.

4.2. Comparison with Previous Studies

Our findings regarding the dominant role of local sources during winter months align with previous observational [55–58] and modeling studies of West African air quality. Field campaigns including AMMA (African Monsoon Multidisciplinary Analysis) and DACCWA (Dynamics-Aerosol-Chemistry-Cloud Interactions in West Africa) have documented elevated ozone during the dry season and identified biomass burning as a primary driver [29, 38]. Our quantitative attribution of 92% to local sources provides new specificity to these earlier findings.

The summer season dominance of external contributions, particularly from southern African biomass burning, has been suggested by previous work examining long-range transport patterns [54], but the magnitude of the contribution quantified here (96% from outside NSSA with 90% of that being intra-continental) represents a more precise estimate than previously available. Satellite observations of carbon monoxide plumes and trajectory analysis have indicated transport from southern to northern Africa during boreal summer [15], and our modeling results provide quantitative ozone attribution consistent with those transport patterns.

Previous modeling studies have generally focused on specific seasons or shorter time periods [1, 13], while our year-round analysis reveals the full seasonal cycle of source contributions. Some earlier work emphasized intercontinental transport influences [52, 64], but our results indicate that intra-continental African transport is actually more important on an annual basis. This finding likely reflects improvements in emission inventories for African biomass burning [62] and enhanced model representation of intra-continental transport processes.

The spring transition period with approximately equal contributions from local and external sources has received less attention in previous literature, which has tended to focus on the more dramatic winter and summer extremes. Our identification of this transition period as a distinct regime for source attribution provides new insights relevant to understanding year-round air quality variations and planning seasonal emission reduction strategies.

5. Conclusions

This study has quantified the contributions of biomass burning from different geographical regions to surface ozone in Northern Sub-Saharan Africa using the NASA Global Modeling Initiative Chemistry and Transport Model. The key findings reveal dramatic seasonal variations in source-receptor relationships that have important implications for air quality management and policy development.

During winter months (January), local NSSA biomass burning dominates, contributing 92% of total biomass-burning-attributable ozone in the region. External contributions amount to only 8%, with most of this originating from intercontinental sources outside Africa. This local dominance indicates that regional emission reduction efforts would be highly effective during the dry season when ozone concentrations are highest and population exposures are the greatest.

Summer months (July) present a strikingly different situation, with 96% of biomass-burning-attributable ozone originating from outside NSSA. More importantly, 90% of this external contribution comes from within Africa, primarily from southern African biomass burning that undergoes long-range transport northward. This finding highlights the critical importance of continental-scale cooperation for addressing summer ozone pollution in NSSA.

These results demonstrate that effective air quality management in Africa requires approaches tailored to seasonal source patterns and geographical contexts. No single strategy will address year-round ozone pollution; instead, integrated approaches combining local emission reductions with continental-scale cooperation offer the greatest potential for protecting population health and environmental quality. The findings also underscore the importance of transboundary collaboration in addressing air pollution in Africa, where meteorological transport patterns create strong linkages between emissions in one region and impacts in others.

Future work should focus on reducing uncertainties in emission inventories and chemical mechanisms, conducting targeted observational campaigns to validate model predictions, and developing detailed health impact and economic analyses to support policy development. By continuing to advance scientific understanding of biomass burning impacts on African air quality, the research community can provide the evidence base needed for effective policy action to protect the hundreds of millions of people affected by this critical environmental challenge.

Abbreviations

O ₃	Ozone
NO ₂	Nitrogen Oxide
CO	Carbon Monoxides
NMVOC	Non-Methane Volatile Organic Compounds
GMI	Global Modeling Initiative
CTM	Chemistry and Transport Model
NSSA	Northern Sub-Saharan Africa
SHA	Southern-Hemisphere Africa
MODIS	Moderate Resolution Imaging Spectroradiometer
GMAO	Global Modeling and Assimilation Office
GFED	Global Fire Emissions Database
ITCZ	Intertropical Convergence Zone
BB	Biomass Burning

ppbv	Parts Per Billion by Volume
WHO	World Health Organization
ECOWAS	Economic Community of West African States
EAC	East African Community
SADC	Southern African Development Community
AMMA	African Monsoon Multidisciplinary Analysis
DACCIWA	Dynamics-Aerosol-Chemistry-Cloud Interactions in West Africa
NASA	National Aeronautics and Space Administration

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Author Contributions

Richard Damoah: Conceptualization, Data curation, Formal Analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing

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Chibuike Chiedozie Ibeuchi: Formal Analysis, Writing – review & editing

Kwabena Fosu-Amankwah: Formal Analysis, Writing – review & editing

Kofi Asare: Formal Analysis, Writing – review & editing

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Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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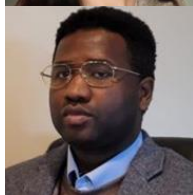
Biography



Richard Damoah is Assistant Professor in the Climate Science Division at Morgan State, International Research Associate at the Latin American Technical University in El Salvador and the Director of All Nations University Space Systems Technology Laboratory in Ghana. He has more than 20 years' experience in chemistry climate modeling, radiative transfer modeling, trajectory modeling, pollution measurement and data analysis with strong programming skills. Before joining Morgan Dr. Damoah had worked at (1) NASA Goddard Space Flight Center in Maryland as Associate Research Scientist under the GESTAR program, (2) University of Waterloo in Ontario, Canada as Research Fellow and (3) University of Edinburgh in UK as a Postdoc. Dr Damoah graduated with Bsc in Physics at University of Cape-Coast in Ghana, Msc in Environmental Physics at University of Bremen in Germany and PhD in Natural Sciences specializing in Air Pollution Transport Modeling, at Technical University of Munich also in Germany.



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Chibuike Chiedozie Ibebuchi is an Assistant Professor in the Department of Mathematics at Morgan State University. He earned his Ph.D. in Climate Science from University of Wuerzburg, Germany, where his doctoral research focused on climate modelling, climate variability and change, and synoptic-scale weather patterns. His academic training also includes a Master's degree in Hydrosience and Engineering; and a Bachelor's degree in Applied Mathematics. At Morgan State, Dr. Ibebuchi's work centers on synoptic climatology, climate variability and change, and the integration of machine learning and artificial intelligence into environmental science. He is also actively engaged in disaster risk management research, aiming to improve resilience and adaptation strategies in vulnerable communities. His teaching and mentorship emphasize

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Dr. **Kwabena Fosu-Amankwah** is a meteorology and climate scientist specializing in aerosol remote sensing, air-quality assessment, and climate–environmental monitoring in sub-Saharan Africa. He is a Postdoctoral Researcher in the Climate Science Division at Morgan State University, USA, and a Lecturer and Researcher in the Applied Physics Department at C.K. Tadam University of Technology and Applied Sciences, Navrongo, Ghana. He holds a PhD in Meteorology and Climate Science and an MSc in Environmental Science from the Kwame Nkrumah University of Science and Technology, and a BSc in Physics from the University of Cape Coast. His current work focuses on

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Dr. **Kofi Asare** is a Research Scientist and Manager of the Remote Sensing and Climate Centre at the Ghana Space Science and Technology Institute. He holds a PhD and MPhil in Geography with specialization in climate science, Earth Observation (EO), and environmental analysis. His research interests include climate modelling, satellite-based climate and air quality monitoring, hydrometeorological extremes, crop yield modelling, land-use and land-cover dynamics, and climate–health interactions. His current work contributes to the development of EO-driven decision-support systems. He is committed to advancing EO applications for climate resilience and sustainable development in West Africa.

Research Field

Richard Damoah: Air Quality, Climate Change, Atmospheric Pollution, Air Pollution Transport, Atmospheric Trajectory Modelling.

Xiaowen Li: Atmospheric Physics, Satellite Meteorology, Cloud-Resolving Simulation, Urban Study.

Chibuike Chiedozie Ibebuchi: Synoptic Climatology, Climate Variability, ML/AI applications in Environmental Science, Disaster Risk Management.

Kwabena Fosu-Amankwah: Atmospheric Remote Remote Sensing, Air Quality, Climate Science, Meteorology, Data Science, Energy, Agriculture and Food Security.

Kofi Asare: Climate modelling, Remote Sensing, Air Quality, Climate Change, Agriculture and Food securing, Climate and Health.