Dear Editor Dr. James Lee,

Thank you very much for handling our manuscript. Please find below our itemized responses to the reviewers' comments and a marked-up manuscript. We have addressed all the comments raised by the reviewer and incorporated them in the revised manuscript.

Thank you for your consideration.

Sincerely,
Haolin Wang et al.

Reviewer #2

Comment [2-1]: This study tested how diurnal variation of fire emissions in Africa impact tropospheric ozone using GEOS-Chem. The issues below need to be addressed before it can be published.

Response [2-1]: We thank the reviewer for the comments on our study. Below, we provide a point-by-point response to the reviewer's comments and summarize the changes that have been made in the revised manuscript.

Comment [2-2]: Line 16: "GFED and GFAS" add full name.

Response [2-2]: We thank the reviewer for pointing this out. We have revised the text.

Comment [2-3]: Line 22: "reduce surface ozone biases (−1.54 to +9.09 ppbv vs. −1.58 to +9.13 ppbv)" This change is very small. Is it statistically significant? Otherwise please remove this statement.

Response [2-3]: We thank the reviewer for bringing this up.

We now state in the text: "Simulations with real hourly-resolved emissions produce comparable surface ozone biases (−1.54 to +9.09 ppbv vs. −1.58 to +9.13 ppbv) and marginally higher correlations with TROPOMI nitrogen dioxide (r = 0.80–0.89) and OMI ozone (r = 0.80–0.94). Although the statistical improvements are limited, the geostationary-driven approach reveals pronounced regional ozone differences and mechanistic insights into the role of diurnal fire variability"

Comment [2-4]: Title: "Using Geostationary-Derived Sub-Daily FRP Variability vs. Prescribed Diurnal Cycles" reads awkward. Using FRP Variability for what? Also Geostationary-Derived should be Geostationary-Satellite-Derived. Please revise.

Response [2-4]: Thank you for pointing it out.

We have revised the title as follows: "Using Geostationary-Satellite-Derived Sub-Daily Fire Radiative Power Variability versus Prescribed Diurnal Cycles to Assess the Impact of African Fires on Tropospheric Ozone"

Comment [2-5]: Line 70-72: repeated statements.

Response [2-5]: We thank the reviewer for pointing this out. We have removed the repeated statements in the revised manuscript.

Comment [2-6]: Line 150: remove a "both".

Response [2-6]: Thank you for pointing it out. We have removed the "both" in the revised manuscript.

Comment [2-7]: Line 296: "We also show emissions in the lower part of the fire seasons" not sure what this means.

Response [2-7]: We thank the reviewer for noting the unclear wording. The intended meaning was to indicate months with relatively low fire activity during the fire season.

We have revised the sentence in Line 351-352 to: "For comparison, we also present emissions for April and October, which represent months of relatively low fire activity within the fire season."

Comment [2-8]: Line 82: "Most satellite instruments, operating in sun-synchronous orbits, sample at fixed local times, limiting the temporal resolution of inventories like GFED and GFAS to weekly or monthly scales, with sub-weekly estimates relying on empirical scaling factors" This statement is wrong. GFED has monthly temporal resolution because it is based on monthly MODIS burned area product, not because of the satellite overpass time. Also is GFAS really weekly product? GFAS is FRP based product and it's hard to imagine it's a weekly/monthly dataset. Even so, there are widely used global fire emission inventories that are daily such as QFED and FINN. The authors ignored that.

Response [2-8]: We thank the reviewer for this important clarification. We agree that our original wording was inaccurate. Specifically, GFED has monthly temporal resolution because it is based on the MODIS burned area product provided at monthly intervals, not because of satellite overpass times. GFAS, in turn, is an FRP-based product that provides daily emissions, rather than a weekly or monthly dataset as we originally implied. We have corrected these statements in Section 2.2. In addition, we have now acknowledged other widely used global fire emission inventories such as QFED (Darmenov and da Silva, 2013) and FINN (Wiedinmyer et al., 2011), which also provide daily emissions.

We have rephrased the text as: "Most widely used global fire emission inventories, such as Global Fire Emission Database (GFED), Global Fire Assimilation System (GFAS), Quick Fire Emissions Dataset (QFED), and Fire Inventory from NCAR (FINN), provide emissions at monthly or daily resolution. GFED is based on the MODIS burned area product available at monthly intervals, while GFAS, QFED, and FINN use active fire detections or FRP to provide daily emissions that can be further disaggregated to sub-daily scales using empirical or observation-based factors (WRAP, 2005; Akagi et al., 2011; Wooster et al., 2021)"

References

Darmenov, A., and da Silva, A.: The Quick Fire Emissions Dataset (QFED) – Documentation of versions 2.1, 2.2 and 2.4, NASA Technical Report Series on Global Modeling and Data Assimilation, NASA/TM-2013-104606, Vol. 32, 183 pp., 2013.

Wiedinmyer, C., Akagi, S. K., Yokelson, R. J., Emmons, L. K., Al-Saadi, J. A., Orlando, J. J., and Soja, A. J.: The Fire INventory from NCAR (FINN): a high resolution global model to estimate the emissions from open burning, Geosci. Model Dev., 4, 625–641, https://doi.org/10.5194/gmd-4-625-2011, 2011.

Comment [2-9]: The motivation to study diurnal variation of fire emissions on atmospheric chemistry is valid. However the study overlooked previous efforts on this topic. I suggest revise the introduction to reflect previous efforts in the area. The manuscript also misses important references. Below are a few examples.

Andela, N., Kaiser, J. W., van der Werf, G. R., & Wooster, M. J. (2015). New fire diurnal cycle characterizations to improve fire radiative energy assessments made from MODIS observations. Atmospheric Chemistry and Physics, 15, 8831–8846. https://doi.org/10.5194/acp-15-8831-2015

Li, F., Zhang, X., Roy, D. P., & Kondragunta, S. (2019). Estimation of biomass-burning emissions by fusing the fire radiative power retrievals from polar-orbiting and geostationary satellites across the conterminous United States. Atmospheric Environment, 211, 274–287. https://doi.org/10.1016/j.atmosenv.2019.05.017

Tang, W., Emmons, L. K., Buchholz, R. R., Wiedinmyer, C., Schwantes, R. H., He, C., Kumar, R., Pfister, G. G., Worden, H. M., Hornbrook, R. S., Apel, E. C., Tilmes, S., Gaubert, B., Martinez-Alonso, S.-E., Lacey, F., Holmes, C. D., Diskin, G. S., Bourgeois, I., Peischl, J., Ryerson, T. B., Hair, J. W., Weinheimer, A. J., Montzka, D. D., Tyndall, G. S., Campos, T. L., Effects of fire diurnal variation and plume rise on US air quality during FIREX‐AQ and WE‐CAN based on the Multi‐Scale Infrastructure for Chemistry and Aerosols (MUSICAv0). Journal of Geophysical Research: Atmospheres, p.e2022JD036650, 2022.

Freeborn, P. H., Wooster, M. J., Roberts, G., Malamud, B. D., & Xu, W. (2009). Development of a virtual active fire product for Africa through a synthesis of geostationary and polar orbiting satellite data. Remote Sensing of Environment, 113, 1700–1711. https://doi.org/10.1016/j.rse.2009.03.013

Mu, M., Randerson, J. T., van der Werf, G. R., Giglio, L., Kasibhatla, P., Morton, D., et al. (2011). Daily and 3-hourly variability in global fire emissions and consequences for atmospheric model of predictions of carbon monoxide. Journal of Geophysical Research, 116, D24303. https://doi.org/10.1029/2011JD016245.

Response [2-9]: We thank the reviewer for this valuable comment. We agree that the Introduction did not sufficiently acknowledge previous work on the diurnal variability of fire emissions. We have revised the Introduction accordingly and added the suggested references.

L100-102: "More recently, Tang et al. (2022) emphasized that fire diurnal cycles exert strong influences on regional air quality during major field campaigns in the United States, underscoring the need for improved representation of sub-daily variability in chemical transport models (Mu et al., 2011; Li et al., 2019)."

L117-120: "Previous efforts have sought to characterize fire diurnal cycles directly from satellite observations, for example by combining geostationary and polar-orbiting data for Africa (Freeborn et al., 2009) and by developing new MODIS-based diurnal parameterizations to improve FRP-derived fire energy estimates (Andela et al., 2015)."

Comment [2-10]: Line 115: remove "high spatial resolution".

Response [2-10]: Corrected.

Comment [2-11]: Line 454: Perhaps "meteorology" or "transport" is more appropriate here than "atmospheric circulation" as "atmospheric circulation" often refers to large scale motion.

Response [2-11]: We thank the reviewer for this suggestion. We have revised the wording accordingly.

Comment [2-12]: Figure 2: do panels b-e have the same legend as panels f-i?

Response [2-12]: We thank the reviewer for pointing this out. Panels b–e and f–i share the same legend. We have clarified this in the caption of Figure 2 to avoid confusion.

Comment [2-13]: Satellite retrievals of O3 are subject to relatively large uncertainties compared to satellite CO and NO2 products. That need to be considered when you explain model-satellite discrepancies.

Response [2-13]: We thank the reviewer for this valuable comment. We agree that satellite retrievals of O_3 are subject to larger uncertainties compared to CO and NO_2 products. We have revised the discussion to explicitly acknowledge this limitation. Some of the observed model–satellite differences for ozone may partly reflect retrieval uncertainties.

We have clarified in the text: “In addition, satellite retrievals of tropospheric ozone are subject to relatively large uncertainties compared to CO and NO_2 products, partly due to retrieval sensitivity to clouds and the vertical distribution of ozone (Gaudel et al., 2018). Therefore, part of the model–satellite discrepancies in ozone may also reflect retrieval uncertainties.”

References

Gaudel, A., Cooper, O. R., et al.: Tropospheric Ozone Assessment Report: Present-day distribution and trends of tropospheric ozone relevant to climate and global atmospheric chemistry model evaluation, Elem. Sci. Anth., 6, 39, https://doi.org/10.1525/elementa.291, 2018.

Comment [2-14]: Line 375: It’s surprising there is no AK for OMI tropospheric O3 column. Is this true?

Response [2-14]: We thank the reviewer for this question. In this study we used the OMI/MLS tropospheric ozone column product (Ziemke et al., 2006; Ziemke et al., 2019), which is constructed by subtracting the co-located MLS stratospheric ozone column from the OMI total ozone column. This product provides monthly mean fields but does not include averaging kernel information, since it is not a direct profile retrieval but a residual-based column estimate. We have clarified this point in the revised manuscript.

We have clarified in the text: “The OMI/MLS tropospheric column is constructed as a residual between OMI total ozone and MLS stratospheric ozone (Ziemke et al., 2006; Ziemke et al., 2019), and therefore does not include averaging kernel information. While OMI/Aura Level-2 datasets with averaging kernels are available, they are generally specific to the total ozone column that is less relevant to the focus of our study.”

References

Ziemke, J. R., Chandra, S., Duncan, B. N., Froidevaux, L., Bhartia, P. K., Levelt, P. F., and Waters, J. W.: Tropospheric ozone determined from Aura OMI and MLS: Evaluation of measurements and comparison with the Global Modeling Initiative’s Chemical Transport Model, J. Geophys. Res., 111, D19303, https://doi.org/10.1029/2006JD007089, 2006.

Ziemke, J. R., Chandra, S., Labow, G. J., Bhartia, P. K., Froidevaux, L., and Witte, J. C.: A global ozone climatology from OMI and MLS measurements for the decade 2004–2014, Atmos. Chem. Phys., 19, 3257–3269, https://doi.org/10.5194/acp-19-3257-2019, 2019.

Comment [2-15]: Line 558: Again it is not fair to say “conventional BB emission inventories like GFED and GFAS are typically available at daily-to-monthly temporal resolutions”. Most global fire emission inventories are daily. Some regional ones are hourly, just not over Africa.

Response [2-15]: We thank the reviewer for this helpful comment. GFED provides emissions at monthly resolution based on MODIS burned area, whereas GFAS, QFED, and FINN provide daily emissions, and some regional products even offer hourly resolution. In particular, we now state that while most global fire emission inventories provide daily emissions, and some regional products achieve hourly resolution, high-temporal-resolution inventories remain lacking for Africa, which motivates to make use of geostationary observations over Africa to examine how the diurnal variability of fire emissions influences ozone.

We have revised the text to clarify this point as follows: "However, most conventional BB emission inventories provide emissions at daily resolution. Although some regional inventories can reach hourly resolution, high-temporal-resolution estimates remain largely unavailable over Africa. As a result, sub-daily variability is generally represented only through empirical diurnal scaling factors."

Comment [2-16]: The authors need to discuss how uncertainties in plume injection height influence the results, especially for the "global impacts of the diurnal cycle of BB emissions over Africa" part.

Response [2-16]: We thank the reviewer for this valuable comment. The FREM high-temporal-resolution emissions inventory developed for Africa does not provide plume injection height information. Therefore, in this study we used the daily plume injection height fields from GFAS to drive the model. We acknowledge that uncertainties in plume rise remain an important limitation, as higher or lower injection heights can significantly alter the partitioning of emissions between the boundary layer and free troposphere, thereby affecting both regional ozone formation and the long-range transport of fire plumes. We have added a note in Section 3.4 to clarify this limitation when interpreting the global impacts of the diurnal cycle of BB emissions.

We have clarified in the text: "An additional source of uncertainty arises from the treatment of plume injection height. In this study, we used daily plume heights from GFAS, since the FREM inventory does not provide this information. The lack of sub-daily variability and uncertainties in the vertical distribution of emissions may influence the efficiency of lofting into the free troposphere, thereby modulating both the magnitude of local ozone impacts and the extent of long-range transport."