

Reply to the reviewer's comments on the manuscript "Increase in Carbon Monoxide (CO) and Aerosol Optical Depth (AOD) observed by satellite in the northern hemisphere over the summers of 2008-2023, linked to an increase in wildfires" Ehret et al

The authors would like to thank the reviewers for their careful reading of the paper and for their comments that improved the quality of the manuscript. All comments have been addressed and a point-by-point answer is provided in the following (in blue after the corresponding comment). The line numbers given in response to comments correspond to the latest version submitted. Finally, modifications made in the new manuscript version are highlighted in the track changes file provided by the authors.

## **Reviewer #1**

In general, the manuscript discussed the change in wildfire and wildfire emissions in a wide range of the northern hemisphere using widely used variables to represent fire (fire activity, burned area, fire radiative power), land conditions (fire weather index), and emissions (CO and AOD). These selected variables permit a good comparison with the literature, and those variables and the distinct techniques used to analyse changes provide robust results in the manuscript. The regional base analysis for the northern region made it possible to discuss the change and trend of fire emission plume transport between them. This manuscript is suitable for publication in ACP but requires some improvements, mainly in consistency and structure.

### **General comments:**

**GC1:** I noticed that the main objective of the study shifts throughout the manuscript. The objectives highlighted below were announced in order in the abstract, introduction, and methodology, but they are all different. I identified that they were actually addressed in the manuscript, so the suggestion is to coherently announce that the investigation has multiple objectives or announce them as part of a more general objective.

Abstract L3: "This study aims to examine the correlation between fire variability and the mean and extreme values of CO and aerosol optical depth (AOD) observed by satellite (IASI/Metop for total column CO and MODIS/Terra and Aqua for AOD), focusing on the extratropical Northern Hemisphere (NH) from 2008 to 2023."

Introduction L73: "This study aims to quantify the impact of fires on the long-range transport of pollution in the Northern Hemisphere during the period 2008-2023, and how it has changed in recent years."

L51: "The purpose of this article is to present an analysis of the extreme values of burned area, fire weather index, CO concentrations and AOD between 2008 and 2023 in the Northern Hemisphere."

We thank the reviewer for this comment. As suggested, the identified discrepancies have been modified and a more general objective has been proposed for this study. Please see Ln. 3: "This study aims to examine the variability of fires and their impact on the mean and extreme values of CO and aerosol optical depth (AOD) observed by satellite (IASI/Metop

for total column CO and MODIS/Terra and Aqua for AOD), focusing on the extratropical Northern Hemisphere (NH) from 2008 to 2023.”

Please see Ln. 86: “This study aims to examine the variability of fires and their impact on the atmospheric composition in the northern hemisphere between June and October for the 2008-2023 period.”

Please see Ln. 163: “To study the impact of fires on the atmospheric composition, this study focuses on the average and extreme values of total CO and AOD between June and October for the 2008-2023 period. In addition, the average and extreme values of the FWI are used in the analysis of fire variability.”

**GC2:** I would suggest rewording the start of Section 3 to “Results” or “Results: Variability and Trends in Fire Activity” or something along these lines. At present, it is unclear that Section 3 is actually the start of the results and Section 2 is the end of the Methods & Data section. The same is true for Section 2, currently “Observations and Indicators”. I would suggest “Data & Methods” or something similar.

Repetitive titles “3.2 Trends during 2008–2023”, “3.2 Trends during 2008–2023”

Titles of Section 2, 3 and 4 and of Subsections 3.2, 3.3, 3.4, 4.2 and 4.3 have been changed as suggested. Please see Ln. 92: “Data & Methods”, Ln. 211: “Results on variability and trends in fire activity”, Ln. 242: “Trends in fire activity during 2008-2023”, Ln. 264: “Anomalies in fire activity during recent years”, Ln. 312: “Fire weather index evolution”, Ln. 346: “Results on variability and trends in total CO and AOD”, Ln. 401: “Trends in CO and AOD during 2008-2023” and Ln. 456: “Anomalies in CO and AOD during recent years”

**GC3:** I've noticed that the authors often refer to the entire figure even when only a specific sub-panel is relevant to what is being described in the text. For example, in L279, the author refers to Fig. 5 but only describes Fig. 5a and Fig. 5b. Furthermore, since the figure has already been mentioned, the author didn't mention when a specific subfigure should be highlighted. On L286, for instance, the reference to Figure 5c would enhance the understanding of the message.

We thank the reviewer for this comment. Mentions of specific sub-figures have been added all along the article. Please see Ln. 316, 318, 325, 339, 368, 407, 410, 434, 437, 443, 444, 468, 493 and 496.

#### Specific comments:

L83. In this paragraph, “Section 3.3” and “Section 4.4.” are summarised, but what happened with sections 3.1, 3.2, 4.1, 4.2, ...? I appreciate the authors want to highlight some key sections; however, it would be nice to bring the general picture of the content of sections 3, 4 and 5 as well.

The paragraph has been rewritten to provide the general picture of the content of sections 3, 4 and 5 as suggested. Please see Ln. 85 : “The data and methods used for this study are described in section 2. After a presentation of the general characteristics of fire activity in the Northern Hemisphere (section 3.1), the trends (section 3.2) and recent anomalies (section 3.3) in fire activity are analyzed. A more specific focus on the evolution of the Fire

Weather Index is presented in section 3.4. The variability of the means and extremes of total CO and AOD is investigated in section 4.1. In a similar approach to that adopted for fire activity, the trends (section 4.2) and recent anomalies (section 4.3) in total CO and AOD are examined. Finally, the evolution of the impact of wildfires is characterized in terms of the number of days with plumes of extreme values of CO and AOD over different regions of the Northern Hemisphere (sections 4.4)."

1. "TCO"? I believe this is the total column CO, but it was never referenced like that before in the manuscript.

We thank the reviewer for their careful reading. "TCO" has been replaced by "CO" (Ln. 155) to be consistent with the answer to comment 7 of reviewer #2.

L151, L166, L323. Here, and throughout the manuscript, the authors make reference to "CO concentration(s)". The retrieved quantity from the satellite is a total column and NOT a concentration. Please update the manuscript accordingly.

"CO concentration(s)" has been changed to "CO" on Ln. 163 and Ln. 181. As "CO concentrations" on Ln. 399 doesn't refer to a retrieved quantity from IASI, we have decided that this should be maintained.

L93. Reference?

As suggested, a reference has been added. Please see Ln. 99: "Wooster and Zhang, 2004"

L155. I suggest making X even clearer, with something such as "For each variable X (i.e., total CO, AOD, burned area or fire weather index)".

As suggested, "(i.e., total CO, AOD, burned area or fire weather index)" has been added on Ln. 167.

L155. I imagine that the 97th percentile is calculated over the fire seasons during the study period, right? All seasons from 2008 to 2023 were put together, and then the percentage 97th was calculated, and the values below were excluded. Am I right? If so please add "during the study period".

You are absolutely right. Thus, "during the study period (2008–2023)" has been added on Ln. 169.

L157. The definitions of extreme events and plumes are a bit mixed in the paragraph. The paragraph should be rewritten to make it clearer to the reader.

What I understood is the following:

For AOD and total CO, the defined extreme events track extreme fire plumes. Besides the high CO and AOD load, the accounted plumes should be surrounded by pixels with extreme events. For that, in a box in size of  $20^{\circ} \times 24^{\circ}$  (i.e., ), the plumes are required to contain at least 5% of pixels categorised as extreme events for at least two days.

If correct, are the boxes already defined before the extreme event definition, or are they created based on the identified plumes?, And if so, how is this determined?

This paragraph has been rewritten on Ln. 170 to make it clear that the 20°×24° boxes are arbitrarily defined before-hand : “Using this definition of extreme values of CO and AOD, intense plumes transported from major wildfires can be identified based on a percentile limit anomaly. The spatial extent of plumes is assessed using boxes of size 20°x24°, with each box containing an identical number of 0.5° grid cells. These boxes are arbitrarily defined beforehand, with the northern hemisphere subdivided into 60 boxes. Consequently, if  $X$  represents the variable under consideration (e.g. total CO or AOD) in grid cell  $i$ , a percentile limit anomaly is calculated as  $PLA_{97,x}(i)=X(i)-Q_{97,x}(i)$ . A plume is identified if  $PLA_{97,x}(i) > 0$  on more than 5 % of the grid cells in the box and for at least two days. Therefore, values of total CO or/and AOD within a given region are considered to be indicative of intense plumes transported from major wildfires when these values are extreme, i.e. well above the background level, for two consecutive days and when they are close to a set of extreme values. This definition enables the number of false detections to be minimized by not considering extreme values with limited spatial and temporal extents as plumes from intense fires.”

L185. I suggest being as specific as Eastern Central Asia (ECEAS), saying that Western boreal Asia (WBOAS) (i.e., not BOAS in general) has a large, burned area in spring. Additionally, more than “large BA are also observed during spring.” To be more transparent, I would say something like “large BA, frequently higher than in summer, are observed during spring.”

We have modified the sentence as suggested on Ln. 215 : “However, in several regions (eastern temperate North America ETENA, western boreal Asia WBOAS, and eastern central Asia ECEAS), large burned area, frequently higher than in summer, are observed during spring.”

L192. The classified zone can be improved in consistency. For instance, for the type 1 region, fire radiative power wasn't mentioned, and for type 1 and 2, the duration of the fires wasn't mentioned. For types 1 and 2, the frequency is described, but the type 3 doesn't have a description.

Mentions of fire radiative power, and average burned area per fire have been added. Please see Ln. 223 - 233.

L202. I don't completely understand the selection of the regions of primary interest, especially the exclusion of Western Central Asia.

We have clarified the reasons for the selection of the regions of primary interest. Please see Ln. 234: “In order to facilitate the reading of the manuscript, the decision was taken to concentrate on the regions where fires are most intense and where extreme smoke plumes are most likely to originate. The Eastern Central Asia region was retained due to its significant contribution to the levels of pollutants in the Pacific. To simplify the analysis, regions identified as “human-initiated fire regions” where fires do not appear to cause extreme smoke plumes as defined by our method, have been excluded.”

Table A2. (As in Fig. 9) I find it beneficial to add the significance of the difference between  $X_{recent}$  and  $X_{full}$  to support the positive or negative value in this table. For instance, is extreme FWI significantly higher in  $X_{full}$  for Europe than in  $X_{recent}$ ? With that calculated, stronger results can be presented, for instance, in L293: “The

seasonal average FWI is lower during recent years across all periods.” Maybe significantly (?).

An unequal variances t-test was performed on each calculation of the difference between  $X_{recent}$  and  $X_{full}$ . This analysis yielded minimal significant differences. Significant differences in tables 1, 2, 3 and A2 and figure 9 ( $p\text{-value} < 0.1$ ) have been highlighted. Two factors may explain this low significance. Firstly, the time series is only 16 years long. Secondly, the method of calculation employed, which considers differences between recent years (2017-2023) and the entire time series (2008-2023), reduces the significance of the differences since the two periods are not disjoint. We have added a paragraph to explain the low significance in Ln. 206.

However, we believe that this approach provides additional information into trend calculation. We have shown the importance of the impact of recent years on the variables studied. It will be important to observe future years to ascertain if any significant trends emerge and if the differences between recent years and the full period become more pronounced.

L316. I don't see the high values mentioned there, but perhaps it is because of the colour bar. It might be worth using a more quantitative description, perhaps.

There was a mistake in Figure 6. Figure 6(c) exhibited identical values to Figure 6(a), while Figure 6(d) displayed the same values as Figure 6(b), but with different range values. However, the text was based on the correct figure. Consequently, Figure 6 has been updated to its correct version.

L387. I suggest keeping the labels for the regions selected at the beginning (i.e., use Eastern Boreal Asia and Eastern Central Asia, not only Central Asia). For example, in “Negative trends are observed in Eastern Asia and the Pacific Ocean for both the average and the extreme AOD,” I think the author refers to Eastern Central Asia only because I don't see the negative trend described for Eastern Boreal Asia (it seems slightly positive).

We thank the reviewer for this comment. Please see Ln. 427: “Negative trends are observed in Eastern Central Asia and the Pacific Ocean for both the average and the extreme AOD, in agreement with the results obtained for CO.”

L230 and L417. This particular way of calculating anomalies should be described in the methods. This would be beneficial after the dates for the recent and full periods were introduced.

We have added a description of why the reference period for comparison was chosen to be 2008-2023 instead of another period. Please see Ln. 193 : “The decision to use values averaged over the entire 2008-2023 period as reference, as opposed to the 2008-2016 period, is motivated by the objective of employing the most extensive time series possible. Additionally, the selection of the recent period (2017-2023) is visually determined from the temporal variation of fires in the middle and high latitudes of the Northern Hemisphere. The selection of the 2008-2016 period for the calculation of anomalies would result in an increase in the bias associated with the choice of recent period. Finally, the anomalies are expected to be higher when calculated using values averaged over the 2008-2016 period as opposed to the 2008-2023 period. For instance, the recent anomaly of the IASI total CO in Europe is 1.6 % when calculated using  $(\bar{X}_{2017-2023} - \bar{X}_{2008-2023}) / \bar{X}_{2008-2023}$  and is 2.9 % when



calculated using  $(\bar{X}_{2017-2023} - \bar{X}_{2008-2016}) / \bar{X}_{2008-2016}$ . Consequently, our choice is a conservative one."

Figure 11. I am confused by this figure, which is excellent at showing different features. Just one clarification: the burn area plot in x-axes excluded the Western Central and Boreal Asia regions, but the fractions presented by the pie charts include them as also include a category named "other". Is that right? If so, what do others include? Are others considered in the x-axis burned area? As the different circle diameters diagram at the bottom left of the figure clarifies that the diameter is the total CO (it says 'concentrations'), can you provide a legend which explains what the pie chart is describing? Maybe something like a segment of the circle and a small label would be enough.

We have specified the method used to calculate the total burned area distribution and what "other" category includes. We have corrected the legend of the circle diameters from "CO concentrations" to "total CO". We have added a legend to describe the pie chart. Please see in the caption of Figure 11 : "This distribution is computed using the total burned area in the Northern Hemisphere mid and high latitudes ( $\geq 30^\circ\text{N}$ ). The category 'Other' is employed to denote all lands situated within the mid and high latitudes of the Northern Hemisphere ( $\geq 30^\circ\text{N}$ ) that do not fall within the regions of Western and Eastern Boreal North America, Western Temperate North America, the Atlantic, Europe, Eastern Boreal Asia and Eastern Central Asia."

L496. It was only until I read the complete label of Figure 11 that I was sure the number of plumes was added for all the regions. It might also be good to write that explicitly in the paragraph. Perhaps something like: "Figure 11 illustrates the cumulative number of days with total CO plumes (i.e., the sum of days with a detected plume in each region) and the total burned area for June-October of every year in the study period. Both cumulative days with plume and total burned area were calculated for the latitude range above  $30^\circ\text{N}$ , excluding the Western Central and Boreal Asia regions." It is unclear if the second sentence is true; I don't see it as explicit. Are both variables calculated with those conditions?

The cumulative number of days with total CO plumes is calculated as the sum of days with a detected plume in each of the following region: Western and Eastern Boreal North America, Western Temperate North America, the Atlantic, Europe, Eastern Boreal and Eastern Central Asia. The total burned area is calculated for the latitude range above  $30^\circ\text{N}$ , excluding the Western Central and Western Boreal Asia regions. The paragraph has been re-formulated as suggested. Please see Ln. 535: "Figure 11 illustrates the cumulative number of days with total CO plumes (i.e., the sum of days with a detected plume in each of the following region: Western and Eastern Boreal North America, Western Temperate North America, the Atlantic, Europe, Eastern Boreal and Eastern Central Asia) and the total burned area for June--October of every year in the study period (2008--2023). The total burned area is calculated for the latitude range above  $30^\circ\text{N}$ , excluding the Western Central and Western Boreal Asia regions."

L510. The repetitive fragment "excluding the Western Central and Boreal Asia regions" is unclear. I am unsure if you are excluding Western Central Asia and Boreal Asia (as a whole) or Western Central Asia and Western Boreal Asia. This would not be the first time that Boreal Asia is named as a whole (e.g. L418), so it is still possible. I suggest consistently using the whole name introduced from the beginning (e.g. Western Central Asia and Western Boreal Asia).

As suggested, we have changed “excluding the Western Central and Boreal Asia regions” to “excluding the Western Central Asia and Western Boreal Asia regions” to avoid any ambiguity.

L593. It is worth mentioning again the examples of agricultural regions.

We have mentioned the names of the regions considered as Human-managed fire regions (please see comment 5 of Reviewer #2). Please see Ln. 635: “Human-managed fire regions (Western Boreal and Western Central Asia, Eastern Temperate North America)”

L605. It might be worth discussing the role of land cover change in CO emissions and how this may change relations discussed here as AOD/CO or CO/ Burned area.

We have added a discussion on the role of land cover change in CO emissions in regions designated as 'human-managed fire regions' in this study (Western Boreal and Western Central Asia and Eastern Temperate North America). Please see Ln. 641 : “Land cover changes have the potential to modify the CO emissions intensity from fires and the ratios of CO emissions to the burned area. Wang et al. (2020) estimate that, in the case of the RCP4.5 scenario, forest areas could increase by up to 20 % in Western Boreal and Western Central Asia and Eastern Temperate North America in 2050 compared with 2000. These regions, which are designated as 'human-managed fire regions' in this study, characterised by less intense fires compared to other study regions, are susceptible to the emergence of extreme forest fires”

#### Technical corrections :

L27 “The variation,” which variations? The sentence was written as a variation introduced before, but it was talking about stability. Maybe it would be better just to say, “The emissions.” This sentence needs a reference; I think it is the same source as the previous sentence (van Marle et al ., 2017), but this is not always true.

We thank the reviewer for this comment. As suggested, we have changed “The variations” to “The emissions”. Please see Ln. 27.

L33. I would suggest: “The extent of a wildfire after ignition depends on the availability of fuel and weather conditions (e.g., hot and dry conditions being favourable to propagation)”.

As suggested, we have modified the sentence on Ln. 33: “The extent of a wildfire after ignition depends on the availability of fuel and weather conditions (e.g., hot and dry conditions being favourable to propagation)”

L35. I would suggest the verb phrasal verb “derived from” instead of “driven by” since the index is calculated based on those variables.

As suggested, we have modified the sentence on Ln. 36: “In these regions, fire weather indexes derived from surface temperature...”

L58. The sentence “The plumes having CO concentrations well above background values, CO is considered a good proxy for biomass fire smoke plumes” needs to be rewritten. Maybe remove the second “CO”.

As suggested, we have modified the sentence on Ln. 60: “The plumes exhibit CO concentrations that are well above background values. It is therefore considered a reliable proxy of biomass fire smoke plumes.”

L183. It seems that the abbreviation BA was mentioned here for the first time without being introduced before. This is introduced for the first time in L210.

We thank the reviewer for their careful reading. “BA” has been replaced by “burned area” on Ln. 213.

Caption on Fig. A1., Fig. 3 Please warn the reader about the different y-axis in the subplots.

As suggested, we have added the following warning in the caption on Fig. A1 and Fig. 3: “Note the different y-axis limits between panels.”

Figure 6. In the colour bar of Total CO, the abbreviation TCO hasn’t been explained before.

The abbreviation TCO has been removed in Figure 6 and replaced by “total column CO”.

## **Reviewer #2**

The authors investigate mean and extreme carbon monoxide (CO) and aerosol optical depth (AOD) measured from space between 2008 and 2023. They focus on regions of the Northern Hemisphere (NH) and evaluate trends and variability for the fire season June to October. They find larger values for both mean and extreme values of CO and AOD for summer and autumn in recent years since 2017 for most regions, than for the full record. The study uses satellite measured burned area to link composition trends over extratropical NH with biomass burning signatures. The authors postulate through investigating fire weather index, where changing weather has impacted BB and where influences are from potential direct human activity.

Long term measurements, like the ones presented in this manuscript, are extremely important in understanding atmospheric chemistry changes. Evaluation of atmospheric chemistry long-term behavior, as is achieved in this manuscript, is imperative for understanding how pollution sources such as biomass burning might be changing over time. The manuscript is very well written and the methodology is rigorous. I have some minor comments below.

### **Comments:**

1. The manuscript would benefit from a description of why the reference period for comparison was chosen to be the whole record (2008–2023) instead of an earlier period (such as 2008 – 2016). I suggest to add this justification in around Line 178.



We thank the reviewer for this comment. We have added a description of why the reference period for comparison was chosen to be 2008-2023 instead of another period. Please see Ln. 193 : “The decision to use values averaged over the entire 2008-2023 period as reference, as opposed to the 2008-2016 period, is motivated by the objective of employing the most extensive time series possible. Additionally, the selection of the recent period (2017-2023) is visually determined from the temporal variation of fires in the middle and high latitudes of the Northern Hemisphere. The selection of the 2008-2016 period for the calculation of anomalies would result in an increase in the bias associated with the choice of recent period. Finally, the anomalies are expected to be higher when calculated using values averaged over the 2008-2016 period as opposed to the 2008-2023 period. For instance, the recent anomaly of the IASI total CO in Europe is 1.6 % when calculated using  $(\bar{X}_{2017-2023} - \bar{X}_{2008-2023}) / \bar{X}_{2008-2023}$  and is 2.9 % when calculated using  $(\bar{X}_{2017-2023} - \bar{X}_{2008-2016}) / \bar{X}_{2008-2016}$ . Consequently, our choice is a conservative one.”

2. Line 161: I am a little confused about the definition of spatial anomalies and the usage of the larger boxes. How was the box size 20 degrees × 24 degrees chosen as the spatial extent for plume analysis, and how exactly is it used on plumes? For example, is it centered on each anomaly point in turn?

The box size 20°×24° has been chosen arbitrarily and before-hand, with the northern hemisphere subdivided into 60 boxes. Since this study focuses on large and extreme plumes, these boxes are used to be sure that we don't consider isolated extreme grid cells as plumes. This simple definition of these boxes contribute to have a simple and fast detection method. The sentence “The spatial extent of plumes is defined using boxes of size 20°x24°” is not clear. Thus, we have rewritten this sentence and we have precised that the 20°×24° boxes are arbitrarily defined before-hand. Please see Ln. 171: “The spatial extent of plumes is assessed using boxes of size 20°x24°, with each box containing an identical number of 0.5° grid cells. These boxes are arbitrarily defined beforehand, with the northern hemisphere subdivided into 60 boxes. ”

3. Figure 1: I suggest adding a box to highlight the region “above the Atlantic”.

As suggested, a box to highlight the region “above the Atlantic” has been added in Figure 1.

4. On line 246 to 247, the definitions are slightly different to the definitions on line 179. It would be wise to be consistent with the definitions. I suggest using the latter definitions, which are a little more general: full season (June–October), the early season (June–July), the middle season (July–August) or the late season (September– October).

The first definitions have been changed to be consistent with the more general definition. Please see Ln. 204: “June-October (full season), June-July (early season), July-August (middle season) and September-October (late season).”

5. On page 7, it might be valuable to give the three main regimes heading names. For example, 1: Human-managed fire 2: Wildfire, 3. Remote fire

As suggested, heading names have been given to the three main regimes. To be consistent, “Agricultural regions” on Ln. 635 has been replaced by “Human-managed fire regions”.

6. In the caption of Figure 4, consider mentioning the blue diamonds are the difference values presented in Table 1.

We thank the reviewer for this comment. Please see in the caption of Figure 4 : “The June-October average relative differences, represented here as the blue diamonds, are the difference values presented in Table 1”

7. Line 310, 312, and elsewhere. My opinion is “total CO” would be better described as “total column CO”. Because this work only evaluates total column CO, I would suggest to define/clarify that in section 2.2 as well as at the beginning of section 4.1, and then continue to talk about “CO” (without the “total” classifier).

As suggested, we have defined that “total column CO” is referred as “CO” in section 2.2 as well as at the beginning of section 4.1 and the 'total' classifier has also been removed from all other occurrences.

8. Line 316: Approximately what values are considered “particularly high values of CO”. It is difficult for me to determine the high values from the color scale in Fig 2 c).

There was a mistake in Figure 6. Figure 6(c) exhibited identical values to Figure 6(a), while Figure 6(d) displayed the same values as Figure 6(b), but with different range values. However, the text was based on the correct figure. Consequently, Figure 6 has been updated to its correct version.

9. In central Asia, I am wondering if the authors have considered clouds or high aerosols affecting retrievals being a contributing factor to low CO measured there?

Only IASI CO observations containing less than 25% cloud cover are taken into account in the CO inversion for IASI CO CDR data. Coarse aerosols such as dust could influence the spectra in the thermal infrared. However, we only use data of the highest quality and clear-sky retrievals. We therefore believe that clouds and aerosols do not have a significant impact on CO inversion in this region.

Moreover, the June-October mean number of IASI CO observations per grid cell in Western Central Asia and Eastern Central Asia between the 2008-2023 period (687 and 374 IASI CO observations per grid cell, respectively) is comparable to that of other regions (394 IASI CO observations per grid cell in the extra-tropical Northern Hemisphere (>30°N)).

10. Line 344: Add more details about how the correlation coefficient is calculated between CO and AOD, e.g. how is it aggregated over time and space?

As suggested, more details have been added about how the correlation coefficient is calculated between CO and AOD. Please see Ln. 383: “The correlation coefficient between the June-October and the July-August annual regional average CO and AOD is calculated (Table A3).”

### Technical Corrections:

Line 42 to 44: This sentence is a little convoluted and difficult to understand. Consider re-wording.

This sentence has been re-formulated. Please see Ln. 44: "The anthropogenic origin of most wildfires in temperate regions offers potential for mitigating their effect. Indeed, human-initiated fires account for more than 80 % of population exposure to fire PM<sub>2.5</sub> in the US (Carter et al., 2023) and over 96 % of the fires in the European Union are caused by humans (San-Miguel-Ayanz et al., 2024)."