

Response to Editor

We thank the editor for their comments on the manuscript. We have addressed this comment as described below. The editor's comment is presented in italic font while the author responses are displayed in standard font. Specific text that was added to the updated manuscript is provided in blue text.

The findings in the manuscript are based on the older version of OMI HCHO (v3), which has been replaced by v4 after significant development in recent years (Ayazpour et al., (2023): <https://agu.confex.com/agu/fm23/meetingapp.cgi/Paper/1407690> ; Nowlan et al., (2023) using OMPS radiance). How do the deficiencies in V3, particularly the presence of artificial positive trends, adversely affect the accurate determination of FNRs worldwide?

We thank the editor for this comment. We have been in communication with the SAO HCHO algorithm team about this issue during the development of the manuscript. Given the new NASA OMI HCHO version 3 collection 4 product is not fully peer-reviewed or available to the public we decided it is best to not to use this product in the current manuscript. However, we attempt to investigate the potential impact of the positive drift in HCHO in the collection 3 data as described in the revised manuscript:

In the original manuscript we discuss the potential positive drift in OMI HCHO version 3 collection 3 in the discussion section (Sect. 4). However, we realize this issue needs to be discussed earlier in the manuscript and is introduced in Sect. 3.3 of the revised manuscript with the following text: “It should be noted that the NASA-released operational OMI HCHO version 3 collection 3 data product used in this study has been shown to have a positive drift due to instrument aging (e.g., Marais et al., 2012; Zhu et al., 2014, 2017b). This positive trend in OMI HCHO data displayed in Fig. 3 is likely largely impacted by the artificial positive drift in the collection 3 OMI data. A new NASA OMI HCHO version 3 collection 4 product is in development using the SAO algorithm which has removed this positive drift in HCHO (Ayazpour et al., 2024; personal communication with the SAO HCHO algorithm team). This new HCHO retrieval product shows that HCHO has a near-neutral trend across most of the populated cities in the Northern Hemisphere. This new collection 4 retrieval data is not yet peer-reviewed or available to the public therefore is not used here and the remaining results in this study use OMI HCHO version 3 collection 3 data. However, to test the potential impact on the results of this study using an OMI VCD product with this average positive drift eliminated, we removed the mean annual Northern Hemispheric HCHO trend (~ 0.004 DU yr⁻¹) from the collection 3 data and evaluate the resulting FNR trends over 18 selected large cities in the Northern Hemisphere which is discussed in Sect. 3.4.”.

We further discuss this issue in Sect. 3.4 of the revised manuscript with the following text: “To test whether the positive drift in the NASA OMI HCHO collection 3 data significantly impacted the results of the FNR trends over the 18 selected large cities in the Northern Hemisphere we present these same results in Fig. S5 with the OMI data which has the annual average Northern Hemispheric HCHO trend remove (more representative of OMI HCHO version 3 collection 4 data)

and Fig. S6 shows the spatial trends of HCHO, NO₂, and FNRs over the Northern Hemisphere using this detrended HCHO data. Comparing Figs. S5 and 4, it is seen that while some of the FNR values are slightly lower in magnitude the positive trends are very similar using collection 3 HCHO retrievals and a data product with the positive drift removed. Throughout the Northern Hemisphere HCHO trends now display both positive and negative values (see Fig S6) instead of the constant positive trends from the OMI HCHO collection 3 product. Using the detrended OMI HCHO data does result in more negative FNR trends in remote regions outside of large urban regions; however, over urban areas, and rural regions surrounding large cities, the FNR trends are still positive as displayed in Fig. S5 and S6. Overall, using the OMI HCHO version 3 collection 3 data product does not significantly impact the FNR results in large cities in the Northern Hemisphere focused on in this study. Future studies investigating FNRs conducted when the NASA OMI HCHO version 3 collection 4 data is available to the public should however use this new product to present more accurate results compared to those shown here using the NASA OMI HCHO version 3 collection 3 product.”.