**Review of "Bias characterization of OMI HCHO columns based on FTIR and aircraft measurements and impact on top-down emission estimates" by Muller et al., ACP, 2023**

**Description:**
The authors bias correct global OMI HCHO observations for 2005 to 2016 using ground-based total column density observations of HCHO from a global network of FTIR instruments and continuous in situ aircraft observations of HCHO from aircraft campaigns over the US. The bias corrected columns are used to derive biomass burning, biogenic and anthropogenic NMVOCs emissions and the results are compared to widely used bottom-up emissions inventories and to past estimates obtained with HCHO column densities and with satellite observations of isoprene concentrations. The authors also quantify trends in NMVOCs emissions and HCHO column densities. The manuscript is mostly clearly written (exceptions detailed below) and is suitable for publication in ACP after responding to concerns listed below.

**General Comments:**
The manuscript title is misleading, as "bias characterization" suggests that individual causes for biases in the OMI HCHO product will be diagnosed and quantified, but it is really a "bias correction" informed by independent observations. The manuscript and Sections 4.1 and 4.2 should be renamed to reflect this.

Section 2 should include details of the CrIS isoprene and Bauwens et al. (2016) datasets that the authors compare to in Section 5.3.

Is there any dependence of the sampling coincidence (50 km) on the regression statistics, as was found by Pinardi et al. (2020) for $NO_2$?

The updated / optimized model is evaluated against the same observations that are used to bias correct the OMI HCHO product used to derive emissions. The limitations of this evaluation should be acknowledged, given that it isn't truly independent.

The description of the OMI HCHO product in Section 2.1 is challenging to follow without prior detailed knowledge of the product. Non-European readers won't necessarily know what "EU-FP7" is. It's not apparent what the "cloud correction" is and what implication this has on the data. Defining what this is might help clarify what is meant by "in lieu of the cloud-corrected AMFs". Is the cloud fraction geometric or effective or something else? It's not clear what's being compensated for with model data over the Equatorial Pacific. Is the background removed in the background correction and the model data used to add back a background? Is the Equatorial Pacific the "reference region"?

It's not stated what fit is used to quantify trends in Section 5.4 and which of the reported trend values in Figures 12 and 14 are statistically significant.

The discussion of emissions trends in Section 5.4 has quite limited discussion of trends in biomass burning and the influence this has on trends in HCHO. For Africa, for example, Andela and van der Werf (2014) reported significant trends in biomass burning activity in

Africa and Hickman et al. (2021) reported decline in $NO_2$ abundances in North Equatorial Africa.

The Conclusion reads like a mix of concluding statements and as a discussion, as indicated by inclusion of citations.

**Specific Comments:**

L. 13: Consider a more informative summary of the comparison to CrIS isoprene than "striking similarities and differences".

L. 50: Should "higher-quality" be "higher spatial resolution"? If not, then perhaps indicate what it is about OMI that makes it higher quality.

L. 180-181: Justification for not using INTEX-B seems to contradict mention in Section 2.1 of the importance of the Pacific Ocean where OMI HCHO data are used to perform a background correction.

Figure 2: Intercept value and error estimate should be written to account for the scale of the axis ($10^{16}$).

Figure 12 caption: Unnecessary to include units in caption, as these are given in the figure.

L. 537-538: Clarify why a change in the version of the model would cause a change in data for 2017 and 2018? Is the updated TM5 model only applied to those years, rather than the full record being reprocessed to use the updated TM5 model?

L. 543-544: The statement starting "comparatively slower..." is confusing, as isoprene emissions have an exponential dependence on temperature, so should have a large response to warming. Is this statement meant to convey something else?

L. 550: Isn't 2012 too early for emissions to level off in India as a result of policies? Emissions controls were only implemented in earnest relatively recently, starting with power plants in 2015 and vehicles in 2018 (see for example Vohra et al., 2021)?

L. 564: Replace "is believed to be" with "one of"

L. 599: "poor" correlation would be R < 0.4.

L. 620-621: What's the utility of the sentence starting "This result demonstrates ...". It's an obvious statement. Is this stated because the product used by Bauwens et al. (2016) didn't undergo any validation?

**References:**

Andela and van der Werf, 2014, http://www.nature.com/doifinder/10.1038/nclimate2313
Hickman et al., 2021, https://doi.org/10.1073/pnas.2002579118
Pinardi et al., 2020, https://doi.org/10.5194/amt-13-6141-2020
Vohra et al., 2021, https://doi.org/10.5194/acp-21-6275-2021