Comments by Owen R. Cooper (TOAR Scientific Coordinator of the Community Special Issue) on:

Improved CCD tropospheric ozone from S5P TROPOMI satellite data using local cloud fields

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This review is by Owen Cooper, TOAR Scientific Coordinator of the TOAR-II Community Special Issue. I, or a member of the TOAR-II Steering Committee, will post comments on all papers submitted to the TOAR-II Community Special Issue, which is an inter-journal special issue accommodating submissions to six Copernicus journals: ACP (lead journal), AMT, GMD, ESSD, ASCMO and BG. The primary purpose of these reviews is to identify any discrepancies across the TOAR-II submissions, and to allow the author teams time to address the discrepancies. Additional comments may be included with the reviews. While O. Cooper and members of the TOAR Steering Committee may post open comments on papers submitted to the TOAR-II Community Special Issue, they are not involved with the decision to accept or reject a paper for publication, which is entirely handled by the journal's editorial team.

General Comments:

TOAR-II has produced two guidance documents to help authors develop their manuscripts so that results can be consistently compared across the wide range of studies that will be written for the TOAR- II Community Special Issue. Both guidance documents can be found on the TOAR-II webpage: https://igacproject.org/activities/TOAR/TOAR-II

The TOAR-II Community Special Issue Guidelines: In the spirit of collaboration and to allow TOAR-II findings to be directly comparable across publications, the TOAR-II Steering Committee has issued this set of guidelines regarding style, units, plotting scales, regional and tropospheric column comparisons, tropopause definitions and best statistical practices.

Guidance note on best statistical for TOAR analyses: The aim of this guidance note is to provide recommendations on best statistical practices and to ensure consistent communication of statistical analysis and associated uncertainty across TOAR publications. The scope includes approaches for reporting trends, a discussion of strengths and weaknesses of commonly used techniques, and calibrated language for the communication of uncertainty. Table 3 of the TOAR-II statistical guidelines

provides calibrated language for describing trends and uncertainty, similar to the approach of IPCC, which allows trends to be discussed without having to use the problematic expression, “statistically significant”.

Major Comments:

This manuscript describes the new CHORA (Cloud Height Ozone Reference Algorithm) algorithm for retrieving tropospheric ozone columns from TROPOMI, which improves upon the standard CCD (Convective Cloud Differential) approach that uses cloud data from the Pacific region. The topic is relevant to TOAR-II and the product will be useful to the scientific community. I see no discrepancies between this paper and the other papers that have been submitted to the TOAR-II Community Special Issue so far. I have a few suggestions to improve the description of the method, and to cite relevant work from TOAR and other research groups, as follows:

The region of the subtropics does not have a clear definition. According to the AMS Glossary of Meteorology (https://glossary.ametsoc.org/wiki/Subtropics) the subtropics is vaguely defined as: “The indefinite belts in each hemisphere between the regions of tropical and temperate climates.” It would be helpful if the Methods section can define your interpretation of the latitude bounds of the tropics, subtropics and mid-latitudes. It seems that you are using 20 degrees as the boundary of the tropics and subtropics. It also seems that you are classifying Hilo as tropical even though it is very close to the latitude of Hanoi, and even though it is impacted by mid-latitude air masses (and stratospheric intrusions) like the other subtropical cites. Is there a compelling reason to treat Hilo separately from the subtropical sites?

Ans: The standard CCD method is formulated for the tropics, covering within 20 degrees north and south of the equator (20S–20N). While Hilo is near the subtropics and can indeed be influenced by mid-latitude air masses and stratospheric intrusions, it still falls within this tropical boundary. Therefore, we have classified Hilo within the tropical region in accordance with the methodology established for the CCD approach (Leventidou et al. 2018, Hubert et al. 2021).

In several places the paper discusses the potential impact of stratospheric intrusions in the tropics, but provides few citations that describe this process. Nice overviews of the location and frequency of stratospheric intrusions are provided by Škerlak et al. (2014) and Škerlak et al. (2015). In terms of intrusions directly impacting the Hilo ozonesonde station (located near Mauna Loa Observatory), the first study to show that stratospheric ozone can impact Mauna Loa was Hübler et al. (1992); other studies are Cooper et al. (2005) and Lin et al. (2014).

Revised: Updated the references. (**line 36, line 259**)

Introduction
When summarizing global tropospheric ozone trends, a concise summary can be found in Chapter 2 (Section 2.2.5.3) of IPCC AR6 (Gulev et al, 2021). The earliest known free tropospheric ozone observations (mid-20th century) are reviewed by Tarasick and Galbally et al. 2019 (a paper from the first phase of TOAR), which were lower than the present-day, although the data coverage was very limited.

Dr. Klaus-Peter Heue posted an open comment on this paper and pointed out that 15-20 ozone profiles per month are required to produce an accurate monthly mean. This number was established by earlier work published by Logan (1999) and Saunois et al. (2012), which focused on mid-latitudes. A new study submitted to the TOAR-II Community Special Issue shows similar results for the tropics by focusing on free-tropospheric ozone measured at Mauna Loa Observatory (Chang et al., 2024).

Ans: We appreciate your suggestion, but upon reviewing our data, particularly for subtropical stations, we noticed a lack of sufficient daily collocated data for validation (seasonal variation of Tropospheric Column Ozone (TCO) with daily collocated data is shown in the supplement for reference (Fig.S1). Therefore, we decided to rely on non-collocated data to ensure a more robust analysis. It's important to note that our daily TCO retrievals do not involve any smoothing.

Minor Comments:

line 32
smog is not a scientific term and should be replaced by something like air quality

Revised: Changed the sentence (**now line 30**) as;

"At the top of the troposphere, it acts as a greenhouse gas and contributes to global warming. When it appears closer to the earth's surface, it adversely affects the air quality and is hazardous to the health of humans, animals, and vegetation".

line 32
Regarding the potential impacts of ozone on animals, it seems likely that animals would be affected, but I don't know of any studies that have ever demonstrated this link. Can you find an authoritative reference?

Revised: Added new references (Crutzen, 2016; Iriti and Faoro, 2008; Fleming et al., 2018; Mills et al., 2018; Gaudel et al., 2018; Szopa et al., 2021) to the sentence (**line 32**).
line 32
While Paul Crutzen made key contributions to the field of ozone research, his description of the Anthropocene is not a good reference for the impact of ozone on

human health, vegetation, or climate. It would be more appropriate to cite IPCC and the TOAR-I papers (Fleming and Doherty et al., 2018; Mills et al., 2018; Gaudel et al., 2018; Szopa et al., 2021).

Revised: Added the above-mentioned references (**line 32**).

line 46
change lifespan to lifetime

Revised: Changed to lifetime (**now line 46**).

"However, due to its short lifetime and dependence on sunlight and precursor emissions from natural and anthropogenic sources, tropospheric ozone exhibits a high spatio-temporal variability on seasonal, interannual and decadal time scales (Cooper et al., 2014b; Putero et al., 2023; Seguel et al., 2024) which, in turn, poses a clear challenge to the satellite observing system"

line 46-49
The purpose of this sentence is to demonstrate that tropospheric ozone's high spatial and temporal variability poses a challenge to satellite monitoring. I don't understand how the paper by Kgabi and Sehlolo (2012) is relevant. This paper does not seem to be indexed with Web of Science, although I could find it through Google Scholar. It focuses on urban ozone in Johannesburg, and one nearby rural site, so it does not provide any kind of broad regional or global overview. Again, the TOAR-I papers would be very appropriate, and there are new papers submitted to the TOAR-II Community Special Issue that also provide large-scale regional and continental surveys, such as Putero et al., 2023, and Seguel et al., 2024.

Revised: Removed the reference Kgabi and Sehlolo (2012) and updated by adding the above-mentioned references. (**Now line 48**)

line 159
the word "before" is not necessary

Revised: That sentence doesn't exist anymore due to the updated text.

line 261
A paper that looks at ozone increases over Hanoi is Ogino et al., 2022. Another recent paper that looks at ozone increases about Southeast Asia is Li et al., 2023.

Revised: updated the reference for Hanoi (**now line 416**).

References:

Leventidou, E., Weber, M., Eichmann, K.-U., Burrows, J. P., Heue, K.-P., Thompson, A. M., and Johnson, B. J.: Harmonisation and trends of 20-year tropical tropospheric ozone data, Atmospheric Chemistry and Physics, 18, 9189–9205, 2018.

Hubert, D., Heue, K.-P., Lambert, J.-C., Verhoelst, T., Allaart, M., Compernolle, S., Cullis, P. D., Dehn, A., Félix, C., Johnson, B. J., et al.: TROPOMI tropospheric ozone column data: geophysical assessment and comparison to ozonesondes, GOME-2B and OMI, Atmospheric Measurement Techniques, 14, 7405–7433, 2021.