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

Investigation of spatial and temporal variability in lower tropospheric ozone from RAL Space UV-Vis satellite products

Richard J. Pope (corresponding author), Brian J. Kerridge, Richard Siddans, Barry G. Latter, Martyn P. Chipperfield, Wuhu Feng, Matilda A. Pimlott, Sandip S. Dhomse, Christian Retscher, and Richard Rigby

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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.

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.

The TOAR-II Recommendations for Statistical 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.

Discussion of trends:
The expression “statistically significant” is used throughout the submitted manuscript, however this expression is now recognized as being problematic and it should be abandoned and replaced by the more useful method of reporting all trends (with uncertainty, e.g. 95% confidence intervals) and all *p*-values, followed by a discussion of the trends and the author’s opinion regarding their confidence in the trend values. This advice comes from a highly influential paper by Wasserstein et al. (2019), published in the journal, The American Statistician, that has already been cited over 1400 times (according to Web of Science). This advice was adopted by the first phase of TOAR (Tarasick et al., 2019) and will also be used

by TOAR-II. Some other recent papers on ozone trends that have taken this advice are: Chang et al., 2020; Cooper et al., 2020; Gaudel et al., 2020; Chang et al., 2022; Wang et al., 2022. Because these papers report all trend values, uncertainties, and all p-values, and also discuss the trend results, there is no confusion regarding the findings, and one does not even notice that the term “statistically significant” is not used at all. Table 3 of the TOAR-II statistical guidelines provides calibrated language for describing trends and uncertainty, similar to the approach of IPCC.

Below is a figure from Chapter 2 of IPCC AR6 WG-I (Gulev et al., 2021) summarizing observed global ozone trends. TOAR-II will produce a similar figure from all recent ozone trend studies published in the TOAR-II Community Special Issue (as well as from studies not in the special issue). Trends from all new satellite studies can be added to the right-hand panel, but the trends must be reported in units of ppbv/decade, with p-values and 95% confidence intervals. Your study currently reports ozone changes in Dobson units from one 5-year period to the next. Could you report these values as trends in units of ppbv/decade? You can choose whichever latitude bands you like when reporting the zonal trends, but useful intervals would be 10 or 15 degrees.

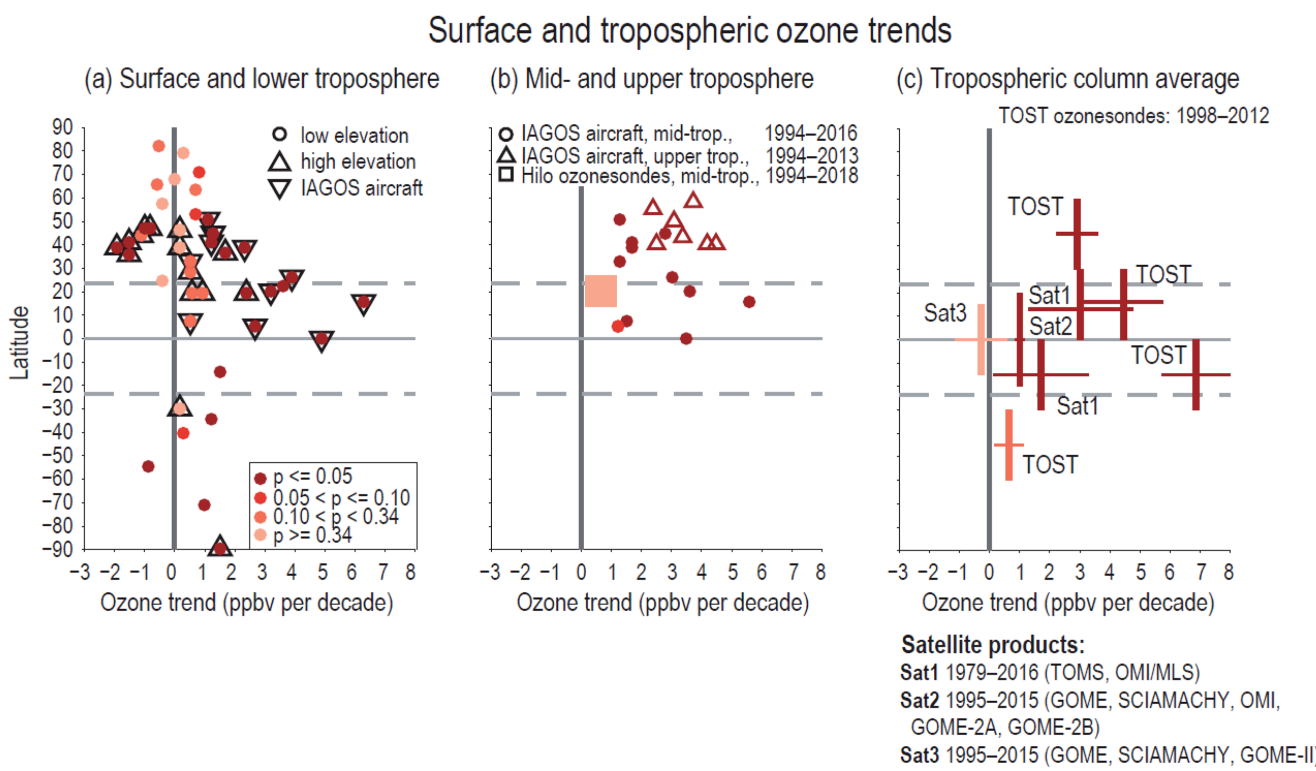

Figure 2.8 | Surface and tropospheric ozone trends. (a) Decadal ozone trends by latitude at 28 remote surface sites and in the lower free troposphere (650 hPa, about 3.5 km) as measured by IAGOS aircraft above 11 regions. All trends are estimated for the time series up to the most recently available year, but begin in 1995 or 1994. Colours indicate significance (p-value) as denoted in the in-line key. See Figure 6.5 for a depiction of these trends globally. **(b)** Trends of ozone since 1994 as measured by IAGOS aircraft in 11 regions in the mid-troposphere (700–300 hPa; about 3–9 km) and upper troposphere (about 10–12 km), as measured by IAGOS aircraft and ozonesondes. **(c)** Trends of average tropospheric column ozone mixing ratios from the TOST composite ozonesonde product and three composite satellite products based on TOMS, OMI/MLS (Sat1), GOME, SCIAMACHY, OMI, GOME-2A, GOME-2B (Sat2), and GOME, SCIAMACHY, GOME-II (Sat3). Vertical bars indicate the latitude range of each product, while horizontal lines indicate the *very likely* uncertainty range. Further details on data sources and processing are available in the chapter data table (Table 2.SM.1).

This paper reports satellite ozone retrievals for the lower troposphere, which is defined as the surface to 450 hPa. Typically, when one thinks of the lower troposphere, the layer from the surface to about 700 or 600 hPa comes to mind, for example the IASI-GOME2 product focuses on the lower troposphere and spans the layer from the surface to 3 km. The layer from the surface to 450 hPa also includes the region of the atmosphere that is typically thought of as the mid-troposphere (600-400 hPa). In cold months at high latitudes the tropopause is often as low as 300 hPa, in which case the surface-450 hPa layer spans most of the troposphere. To avoid confusion with other products/definitions, and to highlight that the new RAL product also spans the mid-troposphere, can the product be referred to as lower-mid tropospheric?

Line 321
The paper sates that IR satellite instruments tend to report negative ozone trends globally, but I don't think that such a generalization can be made. Gaudel et al (2018) compared two IASI ozone products and the trends don't always agree. As shown in Figure 23, In the northern tropics IASI-FORLI shows a weak positive trend (IASI-SOFRID is negative), while at northern mid-latitudes IASI-SOFRID shows no trend but IASI-FORLI is strongly negative. After the publication of Gaudel at al. (2018), Boynard et al. (2018) reported a negative drift in the IASI-A instrument. If this drift is taken into account in updated IASI trends then the negative trends may not be so strong.

Ziemke et al. (2019) found a positive drift in the OMI/MLS product and added a correction to their final product to account for the drift. The submitted paper reports drift values for all products but only found the GOME-II drift to be of concern and rejected that particular dataset. The drift for OMI was reported as 0.22 DU/yr in the tropics, but deemed insignificant. But still, after 15 years the drift would add up to 3.3 DU, which is more than 10-20% of the tropical tropospheric ozone column. Was a correction applied to account for drift?

Minor Comments:

Abstract, Line 35
"While GOME-2…" would sound better as "However, GOME-2…"

Line 44
Here and throughout, references to IPCC AR5 should be updated with References to IPCC AR6. For this work, the relevant chapters of IPCC AR6 WG-I are Chapters 2 (Gulev et al., 2021), 6 (Szopa et al., 2021) and 7 (Forster et al., 2021). For example, the latest IPCC estimate of ozone's effective radiative forcing (ERF) is +0.47 [0.24 to 0.70] W m^{-2} (1750-2019, tropospheric + stratospheric ozone) (Forster et al., 2021).

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