Review of “Multidecadal increases in global tropospheric ozone derived from ozonesonde and surface site observations: Can models reproduce ozone trends?” by A. Christiansen, et al.
-Review by Ryan Stauffer, NASA/GSFC, as a follow-up to public comment https://doi.org/10.5194/acp-2022-330-CC1

General Comments:
I sincerely thank the authors for addressing all of our public comments, as well as the two formal reviews provided to ACPD. The authors invested significant effort to ensure that the most up to date and accurate versions of available (i.e., homogenized) ozonesonde data were used. For example, the Canadian station trends in Figure S4 show changes that I expected based on experience working with both non-homogenized and homogenized versions of those data. The additional discussion, analyses, and arguments certainly satisfy all of my comments and concerns. I only have a few remaining minor/technical comments, and I think this paper is well-suited for publication in ACP.

Minor Comments:
Table 1: Wallops Island ozonesonde data have only been homogenized back to 1995 (https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018JD030098), so please double check these date ranges and/or specify when stations have not completely homogenized their records.

Thanks for finding this typo. We have fixed the date ranges in Table 1 (reproduced below).

Table 1. Summary of all ozonesonde launch locations, dates, sensor types, data source, and region. Also included is whether each site has been homogenized.

Sonde Launch Location	Dates	Sensor Type	Homogenized?	Data Source	Region
Alert	1990-2016	ECC	Y	HEGIFTOM	NH Polar
Boulder	1980-2016	ECC	Y	NOAA	North America
Broadmeadows	1999-2016	ECC	N	WOUDC	Southern Hemisphere
De Bilt	1993-2015	ECC	Y	HEGIFTOM	Europe
Edmonton	1980-2016	ECC	Y	HEGIFTOM	North America
Eureka	1993-2016	ECC	Y	HEGIFTOM	NH Polar
Goose Bay	1980-2016	ECC	Y	HEGIFTOM	North America
Hilo	1985-2015	ECC	Y	SHADOZ	Hawaii
Hohenpeissenberg	1980-2017	BM	Y	HEGIFTOM	Europe
Lauder	1986-2016	ECC	Y	HEGIFTOM	Southern Hemisphere
Legionowo	1980-2015	BM, ECC since 1993	N	WOUDC	Europe
Lerwick	1994-2016	ECC	N	WOUDC	Europe
Lindenberg	1980-2013	BM, ECC since 1992	N	WOUDC	Europe

Macquarie Island	1994-2017	ECC	N	WOUDC	Southern Hemisphere
Naha	1991-2016	CI, ECC since 2008	N	WOUDC	Japan
Nairobi	1998-2016	ECC	Y	SHADOZ	Southern Hemisphere
Neumayer	1992-2014	ECC	N	WOUDC	Southern Hemisphere
Ny Aalesund	1990-2012	ECC	N	WOUDC	NH Polar
Payerne	1980-2016	BM, ECC after 2002	Y*	HEGIFTOM	Europe
Sapporo	1993-2016	CI, ECC since 2009	N	WOUDC	Japan
Sodankyla	1989-2006	ECC	N	WOUDC	NH Polar
Syowa	1982-2017	CI, ECC since 2010	N	WOUDC	Southern Hemisphere
Tateno	1980-2016	CI, ECC since 2009	N	WOUDC	Japan
Uccle	1980-2015	BM, ECC since 1997	Y	HEGIFTOM	Europe
Wallops Island	1995-2016	ECC	Y	HEGIFTOM	North America

*Note that Payerne has been homogenized only since 2002, a timeframe too short for this analysis, so we use the original data that spans the full timeframe.

Line 204 and Figure S1: The Japanese stations certainly appear to have a notable step-change and increase associated with the move from CI to ECC ozonesondes around 2010. Is there also a step-change in stratospheric ozone at these stations at the same time, indicating a large overall change in sensor response? If so, then indeed caution should be used in interpreting these large positive trends in the troposphere.

Here, we remake Figure S1 to show annual median tropospheric ozone concentrations at the non-homogenized sites, with annual median stratospheric ozone shown for the Japanese sites. The stratospheric data for the Japanese sites are shown in the bottom 3 panels of Figure S1. In the stratosphere, the Japanese sites do not appear to have the type of step change around 2010 that is apparent in the troposphere. Here, we see that stratospheric ozone medians, while increasing, do not exhibit the drastic nature of the step changes in the troposphere. Since none of the Japanese stations have been homogenized, it is currently difficult to assess the extent to which a potential step change influences our results, but the fact that we see the step change occurring just in the troposphere implies that our derived ozone trend is not solely due to a large overall change in sensor response. We add a statement in our Results cautioning against over-interpreting the tropospheric trends:

"The strongest increasing trends from 1990-2017 occur in Japan, averaging 3.8 ± 0.8 ppb decade^{-1} (7.1% ± 1.5% decade^{-1}) across all pressure levels and ranging from 2.4 to 5.3 ppb decade^{-1} (4.4% to 9.9% decade^{-1}). Caution should be taken to not over-interpret the Japanese trends, as a potential step change occurs at these sites around 2010 in the troposphere (Fig. S1). While this may be partially due to a

change in sensor response, these step changes are not visible in the stratosphere (Fig. S1), suggesting that these trends mostly reflect the rapid increase in emissions over Asia in the past 4 decades."

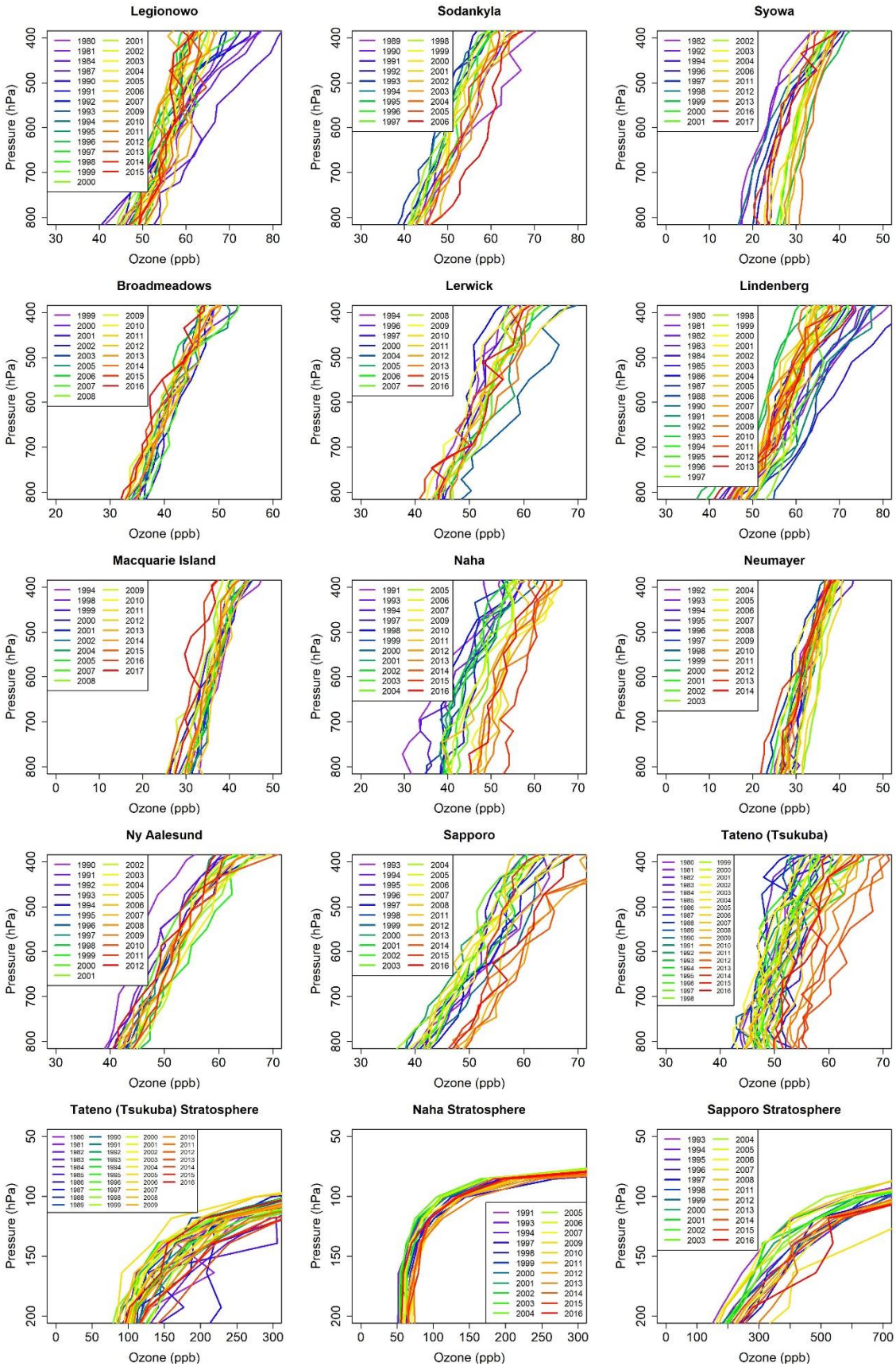
Legionowo
Sodankyla
Syowa
Broadmeadows
Lerwick
Lindenberg
Macquarie Island
Naha
Neumayer
Ny Aalesund
Sapporo
Tateno (Tsukuba)
Tateno (Tsukuba) Stratosphere
Naha Stratosphere
Sapporo Stratosphere
Pressure (hPa)
Ozone (ppb)

Figure S1. Annual median ozone profiles for ozonesonde data from the 12 non-homogenized sites from 1990-2017. No step changes are apparent in the data, with the exception of the Japanese sites (Naha, Sapporo, Tateno (Tsukuba)). These step changes are not apparent in the stratosphere.

Line 351: "I other simulation..." looks like a typo

We have corrected this to read "The other simulation…"

Line 847: "negligible" rather than "negligent"

We have corrected this to be "negligible."

A note on the Stauffer et al., (2020) study on the ozonesonde "dropoff": An updated analysis is now in press with Earth and Space Science. However, no additional stations are considered "affected" by the dropoff, so this is purely for your information:
Stauffer, R. M., Thompson, A. M., Kollonige, D. E., Tarasick, D. W., Van Malderen, R., Smit, H. G. J., et al. (2022). An Examination of the Recent Stability of Ozonesonde Global Network Data. Earth and Space Science, 9, e2022EA002459. https://doi.org/10.1029/2022EA002459

Thank you for passing this along! We have added this reference to our Methods section, where we discuss the dropoff: "A recent study showed a drop in total column and stratospheric ozone measured by ECC instruments compared to satellite observations in the latter parts of their records for reasons still under investigation (Stauffer et al., 2020, 2022). We find that 5 of our 25 sites were impacted by these ozone measurement drops, although these drop-offs were typically limited to pressures above ~50 hPa, so our results should not be affected. Out of an abundance of caution, at these impacted sites, we used only data from before the unexplained sharp drop-off in ozone concentrations, as data before these drops is still considered highly reliable (Stauffer et al., 2020, 2022), and this resulted in the removal of up to one year of data at each affected site."