We thank the reviewer for the comments and suggestion, and apologize for the misprints.

GENERAL

The paper is dedicated to tropospheric ozone column retrieval using a combination of TROPOMI total ozone measurements with stratospheric ozone from the BASCOE assimilated data. The paper describes the retrieval algorithm, intercomparisons with other tropospheric ozone datasets, and the illustrations of geographical distributions.

The paper introduces an important work, and it contains important information. However, the presentation need significant improvements. Please find my comments below.

MAIN COMMENTS

1) The language must be improved: too many misprints and unclear formulations. Several of them (but not the full list) are in the "Detailed comment" and "Technical corrections".

2) The structure of the paper is not optimal, from my point of view. It would be easier for reading, if comparison results would be placed immediately after a short description of other tropospheric datasets used for validation. I suggest: name Sect. 3: "Comparisons with other tropospheric datasets" with subsections like:

3.1. Comparison with TROPOMI_CCD

3.1.1 TROPOMI_CCD dataset

3.1.2 Comparison results

3.2 Comparisons with OMPS-MERRA-2

and so on for other datasets.

The suggested structure is reasonable as well.
Both these structures have their pros and cons and both can be found in the literature. The one suggested by the reviewer is sorted by the datasets but jumps between description and comparison. The one we used combines the comparisons, but the reader may have to go back to find some details on the dataset used for the current comparison.
After careful evaluation, we prefer to stick to selected structure: first explain the different datasets and then compare with S5P_BASCOE in a second step. But partially following the suggestion from the reviewer, we combine both sections in one .

3 Comparisons to other tropospheric ozone columns
3.1.other Observations
3.1.1 TROPOMI_CCD
3.1.2 OMPS-MERRA-2
3.1.3 Soundings

3.2 Comparison results
3.2.1 comparison to TROPOMI_CCD

..

3) There is no information about S5P-BASCOE data availability.
The data is not yet available to the user. This is planned in a next step that hopefully will be ready before the final version of the paper is published.
"Data availability. Currently the S5P-BASCOE data are available on request, we plan setting up a mapping and dissemination infrastructure."

4) All acronyms should be explained at first appearance (note that the abstract is considered separately).
corrected

5) It would be advantageous showing more details of global tropospheric ozone morphology, in particular, global maps in different seasons. This would also support subsequent illustrations of tropospheric ozone in specific regions.
added

DETAILED COMMENTS

In Abstract, instead noting that the "algorithm is similar to the well established OMI-MLS or OMPS-MERRA-2 retrieval" (Lines 3-4), please say about the main principle of the retrieval (residual method). Information about temporal resolution and vertical coverage should be present in the abstract.
corrected, added
"The BASCOE stratospheric data is interpolated to the S5P observations and subtracted from the TROPOMI total ozone column. Thereby a tropospheric residual ozone column from the surface up to the tropopause is gained. The tropospheric ozone columns are retrieved at the full spatial resolution of the TROPOMI sensor (5.5 x 3.5 km²) with a daily global coverage."

Lines 31-32: A better formulation of the sentence is needed. MLS measures sometimes below the tropopause.
The referee is certainly right MLS also observes the upper tropopshere. But we only use the stratospheric part of the profile here. We replaced "tropopause" by "upper troposphere". Thereby it is clear that also the upper troposphere is observed and in the following sentence it is stated that only the stratospheric part is used.

Lines 33-35: For OMI-MLS, both original and with assimilation datasets are available, this is worth to state more clearly.
clarified

Lines 37-39: Is SCIAMACHY retrieval approach similar or different compared to OMI-MLS? A short note would be useful.
yes the algorithm is similar, the limb observations are analysed and yield an ozone profile which is integrated later on, for the altitude range above the tropopause. added

Lines 53-54: Please be consistent: for other datasets, the validation results are not mentioned.
Validation results are removed

Lines 58-62: A link to CAMS tropospheric ozone data would be useful.

added: The CAMS ozone profiles can be downloaded at https://ads.atmosphere.copernicus.eu/cdsapp#!/search?type=dataset (last access March 2022).

Lines 117-119: Is the bias stationary?
No the bias varies within the yearly cycle and the latitude as obvious from figure 2 clarified

Line 128: "the correction is in the order of 2 DU" Is this the same as in Figure 2?
Yes, the correction added to the stratospheric column is illustrated in figure 2 (reference changed)

Line 131: "TROPOMI/S5P has a daily global coverage with a spatial resolution of 5.5 x 3.5 km2". This information is given above in the text and its repetition is not needed here.
I think it is useful to repeat this information here, because we have to combine the high resolution from total ozone columns and moderate resolution from BASCOE stratospheric columns. Hence we prefer to keep the repetition in this case.

Lines 157-159. I believe that even within tropics this approximation (uniformity in longitude) has an uncertainty. If known, it would be good to specify it.

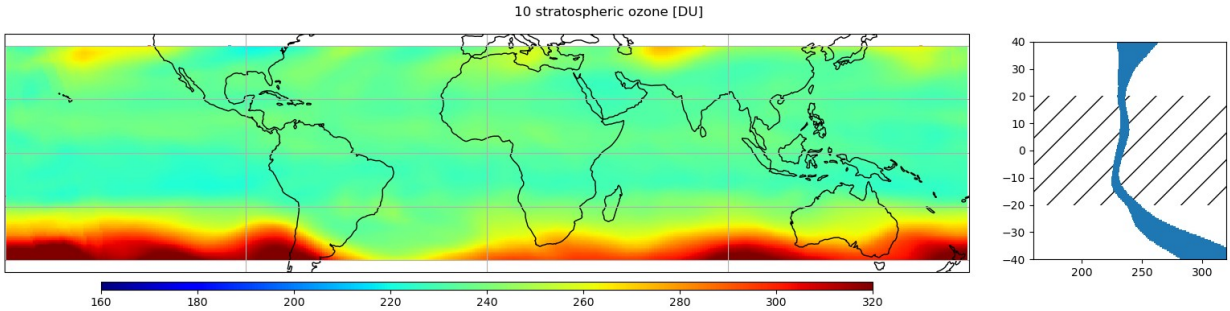

Figure 1: BASCOE stratospheric ozone column for 2019-10-01 until 2019-10-06. Temporal mean 40°S to 40°N (right), longitudinal and temporal mean and standard deviation (left), the hashed area indicates the tropical band as used in the CCD.
The figure is not included in the manuscript.

This is the basic assumption of the CCD algorithm and the application of the CCD shows it's justification and limitations. The S5P_CCD algorithm uses the mean stratospheric ozone column for 6 days. InFigure 1 the mean BASCOE stratospheric column for 6 days is shown. For the range between 40°S and 40°N within the tropical band (20°S to 20°N) the longitudinal variation is small, also the error bars (indicating the standard deviation within 0.5 degree latitude and 6 days) are small compared to the higher latitudes.
added to the manuscript:
"It is assumed that for each latitude band the stratospheric ozone column is constant along the longitude and varies only slowly in time and latitude. This assumption is in general used for the CCD algorithm and is only justified within the tropics, therefore the algorithm is limited to the latitude range between 20° S and 20° N. For several examples of BASCOE stratospheric column varied by less than 5 DU standard deviation within 6 days, along the longitude for 0.5° latitude. The temporal and spatial resolution is comparable to the S5P_CDD settings."

Line 196: OMPS-MLS -> OMPS-MERRA-2 ?
corrected

Lines 200-205: Do I understand correctly that not all available ozonesonde data are used? A map showing location of sounding stations, preferably with colouring according to number of observations, would be useful.
No, we used all soundings station available to us. Owen Cooper's comment included a link to two additional station in the United States i.e. Huntsville (Alabama) and Trinidad Head (California) a map (Figure 2) is included

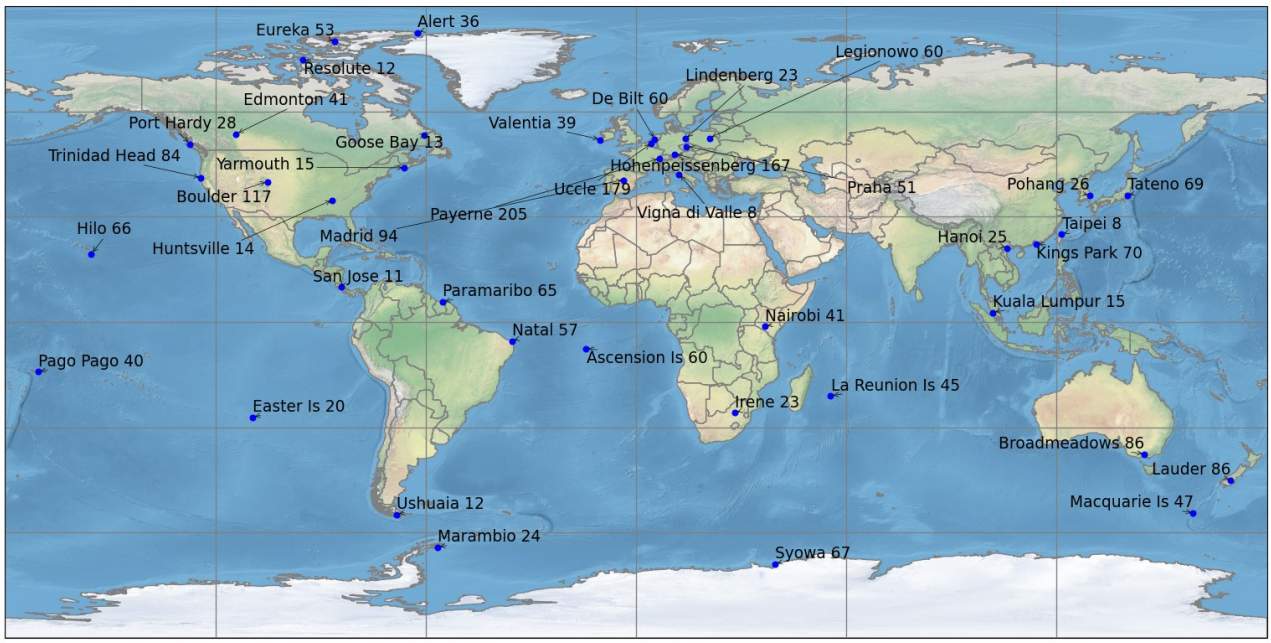

Figure 2: Global distribution of ozone sounding station used in this study. The number behind the names indicate the number of sounding between April 2018 and June 2020, where S5P-BASCOE data were available within 25 km around the station.

Lines 220-221: "The stripe in the south is caused by a well known and documented retrieval problem in the CCD data." A reference or an explanation would be useful.
The stripe was removed by applying a better QA filter(0.7 instead of 0.5) in the comparison, a reference to the TROPOMI CCD PUM was added

Figure 6 and discussion: Note also different spatial pattern, with large values over oceans in NH in S5P-BASCOE. Is this due to different tropopause height definition? To evaluate this, difference in tropospheric ozone column in Figure 7 should be for the same period as in Figure 6, and presented with the same color scaling.
corrected

Line 246: "For BASCOE data after August 1 " which year?
2019 included

Lines 251-252 : "The influence of the different tropopause definitions on the tropospheric ozone is about 1-2 DU" According to Fig.7, it can be up to 10-15 DU.
Yes, it can reach up to 15 DU but in the mean it is around 2 DU, clarified

Lines 262-263: "This allows ... and the potential deviations might be separated" Rephrasing is needed
changed to
"Sometimes Brewer or Dobson instruments are situated next to the sounding station and the respective total column data are provided together with the sonde profile. This allows us to compare both total and tropospheric ozone column. Thereby a potential deviation of the total column that might affect the tropospheric column can be detected."

Lines 264-266: "In version 2 of UPAS a new albedo retrieval scheme was implemented (Loyola et al., 2020) and respective comparison improved significantly." Are these improvements with respect to UPAS v 1? If this is not show, there is no need to mention.
changed. The improvements are indeed with respect to UPAS version 1, but this v1 was used in the validation paper by Garane et al. 2019, therefore it might be worth being mentioned here.
clarified:
"For the sonde validation at Hohenpeißenberg shown in Figure 10 an overestimation in the winter / spring season is observed. A deviation in the version 1 of the TROPOMI total ozone due to the enhanced albedo in winter was documented by Inness et al. (2019) and Garane et al. (2019). Version 2 of the TROPOMI total ozone includes a surface albedo retrieval (Loyola et al., 2020) that improved the total columns significantly. However, a small positive bias is still observed between the TROPOMI total column and the sondes. This deviation propagates into the tropospheric column."

Line 268: "This deviation propagates into the tropospheric column" I do not see strong correlation between deviations of full and tropospheric ozone columns (Figure 9 bottom).
The referee is right the correlation is not strong but the difference is systematically positive in the winter period, indicating an overestimation of satellite data or underestimation of the sondes in these periods.

Line 270: Any reference on presentation by W. Steinbrecht?
Unfortunately not, it was a chat comment by W. Steinbrecht to my presentation.

Lines 271-272: "The ozone effective temperature is not considered in the Dobson spectrometer observations and the sonde data are scaled to the Dobson total ozone column." What is the consequence for data quality?
The sonde data are scaled by the data providers. (see also comment to reviewer #1)
The aim of the scaling is that the consistency between integrated sonde column and Dobson spectrometer is improved. It also reduces the day to day variability of the sonde measurements. However, if the effective temperature is not considered in the data analysis of the spectrometer, the total ozone column might be underestimated in winter. Because the same scaling factor is applied to the tropospheric sub-column, this might also be underestimated by sonde.
clarified:
"At some sonde stations the data providers integrate the data up to the top of atmosphere, assuming a climatology above the burst altitude, and compare it with nearby total column observations. The measured mixing ratios are scaled according to the ratio of the total columns. This scaling is quite common though not used in general [Logan et al., 12]. It helps harmonizing the data for long term time series it also corrects for short term variations and artificial drifts. The scaling factors vary between 0.8 and 1.2.
However, if the ozone effective temperature is not considered in the Dobson spectrometer data retrieval, the scaling might result in slightly smaller total ozone column, especially in the winter month. If the sondes underestimate the total column also the tropospheric column can be underestimated."

Figure 10: The latitudes with zero collocations should be removed. Please add zero line and use better scaling. The caption says: "The stars indicate the mean of the tropospheric observations closest to the stations". Why some values indicated by stars are negative (for example, for 25N)? Is this correct? Deviations and absolute values should be shown either on different vertical axes with distinct colors, or stars should be removed.
The stars do not indicate absolute values but the difference between the sondes and those satellite observations being closest to the station. Clarified and a zero line is added. The 10° latitudes bands with zero collocation however will remain, to avoid jumps in the x-axes and hence increase readability.

Line 286: "In the tropics the typical wave one-pattern is found" Since this pattern is not related to wave activity, I believe, it should not be called "wave-one pattern".
It is correct that this pattern is not caused by any wave activity, however the name is commonly used to describe the distribution of tropospheric ozone maximum and minimum in the tropics e.g. Ziemke 1998: "We also note that TCO amounts given in Table 1 corroborate the existence of the persistent tropical zonal wave 1 distribution [e.g., Fishman and Larsen, 1987;Ziemke et al., 1996; Hudson and Thompson, 1998] with high values in the Atlantic and low values in the Pacific." Therefore the fixed term will be kept.

Sect 5.1. It would be advantageous to show also the seasonal dependence of total global maps. This would be useful in the discussions below. Figure 11 can have subplots corresponding to different seasons.
added

Sect. 5.2 Please explain the shift to the ocean and not observing strong ozone enhancement over Africa. *Following the reviewers suggestion we added four seasonal maps for the tropospheric ozone. These maps show that enhancement over the tropical Atlantic reaches the maximum in Sep-Nov. Because of that we replaced the tropospheric ozone and the fire maps by maps form the first week of September 2019 (Figure 3) instead of the last week of June 2019.*
Also here the maximum in the tropospheric ozone column is situated over the Atlantic ocean and not above fire emissions. "The interaction of transport and chemistry" [Moxim and Levy, 2000] shifts the maximum ozone column out to the Atlantic.
Clarified: "Tropospheric ozone over the tropical Atlantic is caused by combination of lighting NOx emissions and biomass burning emission in both Africa and South America combined with uplift and long range transport. According to Moxim and Levy [2000], the polluted air masses rise over the continents and they are transported over the ocean where they subside. During the transport NOx from lightning and biomass burning react with VOCs to ozone."

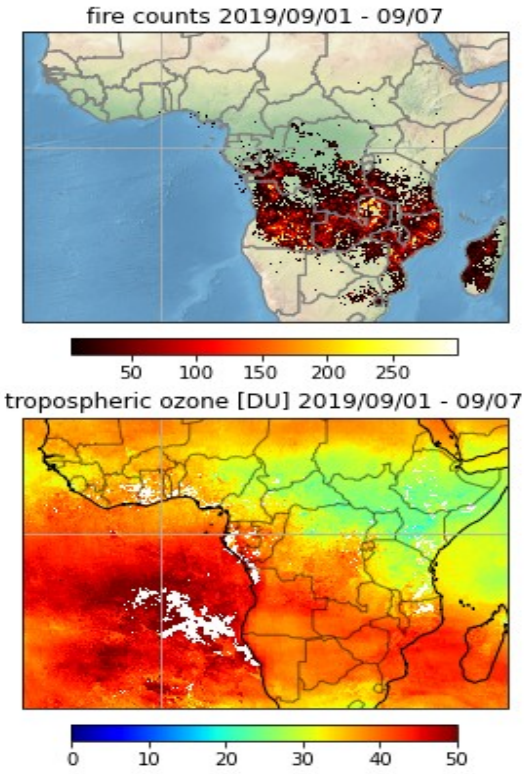

Figure 3: Top: first week of September 2019, VIIRS fire data (https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms/active-fire-data, May 2022) tropospheric ozone columns for the same period, bottom.

Section 5.3: For Europe and Mediterranean, I suggest using the cities, for which also ground-based observations are available. Adding the curves from ground-based observations to Figure 13 would confirm the validity of S5P-BASCOE time series

I checked the referee's suggestion to include ground based ozone measurements for Berlin and Athens (https://discomap.eea.europa.eu/map/fme/AirQualityExport.htm, April 2022). However, we have to be aware that ground based data in a city may differ from columnar observations due to the different altitude range and local chemical processes.

The data are illustrated in Figure 4 below. I averaged the available data for the respective city and for the noon time (12-14 local time). While the summer time maxima for Berlin and Athens are almost the same the winter time minima are higher in Athens. A similar effect is not seen in the satellite data. But both the ground based and satellite data show a stronger variability during the summer months for Berlin compared to Athens. The low ozone concentrations in Athens in summer 2020 will not be discussed here.

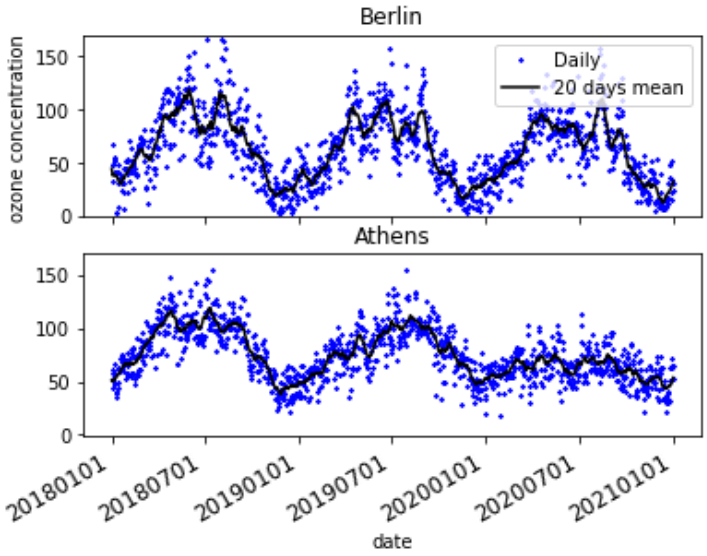

Figure 4: Ozone concentrations [µg/m³] in Berlin (top) and Athens (bottom) for the years 2018, 2019, 2020.The figure will not be included in the manuscript

Lines 322-324: "When the different . data product is reasonable" This needs rephrasing. You probably mean "the data agreement is reasonable".
Corrected:
The agreement between the data products is reasonable

Lines 330-333. This paragraph on future plans looks strange in the middle on conclusions. The second sentence is not clear, in particular, why long-term dataset is needed for evaluation of COVID-19 lock down measures.
From an atmospheric point of view the COVID lock down measures in 2020 can be seen as "large scale emission reduction experiment" especially the tropospheric ozone precursor NO_x was reduced. This might cause changes in the tropospheric ozone as well. However, also the meteorology affects the tropospheric ozone burden. So the normal non lock down ozone column varies depending not only on the NO_x emissions. Because of that the ozone column can not be directly compared from 2018/2019 to the 2020 data. A longer time series helps to estimate the typical variability, which might be in the order of the reduction caused by the COVID lock down. added,
the conclusion is reorganised

TECHNICAL CORRECTIONS

Line 1 Misprint in TROPOMI
corrected

Line 3. Microwave Limb Sounder (capitalize first letters)
corrected

Line 7 "S5P_O3_TCL" is not needed in the abstract

deleted, not needed at all.

Line 83: TROPOMI acronym should be explained above in the text.
TROPOspheric Monitoring Instrument added in line 26

Line 88: Remove "Clouds as Layers" before "Loyola et al., 2018".
removed

Line 94 UPAS version 1.x ? (Should be a number instead of "x")
The climatology was used for all subversion of UPAS 1 the ".x" was removed

Line 95: misprint in "latest"
removed, updated to version 2.1.3 meanwhile updates are available

Line 123: alternate -> alternative
corrected

Line 184: (0, 3, 6, ?, 21 UTC) -> (0, 3, 6, ..., 21 UTC)
corrected

Line 248 Figure7
corrected

Line 256: date -> data
corrected

Line 258:100km -> 100 km
corrected for all units

Line 275 found, which ...
corrected

Figure 14 caption, misprint in "tropospheric"
I can't find this misprint in: "Figure 14. Formaldehyde (top) and tropospheric ozone (bottom) over the United States observed in July 2018. Formaldehyde is a tropospheric ozone precursors."

Moxim, W., Levy II, H., 2000. A model analysis of the tropical South Atlantic ocean tropospheric ozone maximum: the interaction of transport and chemistry. Journal of Geophysical Research 105 (D13), 17,393e17,415. doi:10.1029/2000JD900175.