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Discussions

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Interactive comment

Interactive comment on "Representativeness of single lidar stations for zonally averaged ozone profiles, their trends and attribution to proxies" *by* Christos Zerefos et al.

Anonymous Referee #1

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This paper compares SBUV and lidar ozone data from multiple stations to assess the representativeness of the lidar data of the global variability at different vertical regions. Additionally, it makes use of this data and a MLR analysis using various combinations of different proxies to assess the influence of these proxies on stratospheric ozone trends, which is important in the current context of ongoing work to determine the status of ozone recovery in the stratosphere. The analysis techniques seem thorough and comprehensive, although some additional explanation may be necessary for the purpose of clarification. Additionally, the results seem sound though the authors may overlook some more simple conclusions about the limitations of the methodology. I would recommend this paper for publication subject to some minor revisions detailed

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Discussion paper

below.

Major Comments

Pg. 07, Ln. 247: "Important aspects of Figure 7 are . . ."

I agree that the total amount of variability is similar between the lidars and SBUV over the lidar time period for most of the stratosphere but it may be worth noting and explaining the discrepancies at the highest altitudes (i.e., lidar data quality diminishes) and lowest altitudes (i.e., SBUV data quality and resolution diminishes). Additionally there appears to be poorer agreement for Lauder than for the other stations.

While, for many comparisons, the total variability is similar the individual attributions for different proxies can be very different. For example, Hohenpeissenberg shows systematically larger EESC responses than SBUV over the same time period at all altitudes. Another example is how the AOD responses can be very different across all figures (except at Hohenpeissenberg), making one question if the regressions have sufficient ability to separate the influence of volcanic aerosol from other proxies given different time periods.

Pg. 08, Ln. 281: "It was found that both in the upper and lower stratosphere the overall trends (1980-2015) were insignificant at the 99% confidence level."

It is important to remember the limitations of these regression analyses. It is generally highly unlikely that, after performing a MLR analysis to the data (i.e., a least-squares fitting technique), the residuals will have any trend-like behavior. However, that only means that on the whole the data is represented, not that the individual attributions to the different proxies are correct. For example, most MLR analyses to ozone cited by this manuscript (and apparently this manuscript's data as well) show negative monotonic trends in the lower stratosphere. These are expected to be primarily the result of the influence of greenhouse gases on increasing the strength of the Brewer Dobson circulation. What this means is that using the EESC as a proxy here, which forces a turnaround, is incorrect. Please see Kuttippurath et al., GRL, 2015 (DOI: 10.1002/2014GL062142) for more details. This is the main explanation for the nature of the residuals shown in Figure 9a at the bottom. It also means that the overall representation for the influence of the EESC on ozone in the lower stratosphere is incorrect in Figure 7. This is, of course, clearly evident in Figure 10b. In order to use incorporate the EESC in a way that allows for monotonic trends, you would need to use multiple EESC proxies such as those introduced in Damadeo et al., ACP, 2014 (DOI: 10.5194/acp-14-13455-2014).

Figure 10: It seems strange that the error bars in 10b and 10c in the left panel are comparable but are much smaller in 10c than 10b in the right panel. Do you have an explanation for how the uncertainties in these small recovery trends shrank so drastically?

Minor Comments

Pg. 03, Ln. 092: "Figure 1a shows the resulting correlation coefficients. All correlations are statistically significant at the 99.99% confidence level."

What kind of correlation coefficient is this (e.g., the Pearson product-moment correlation) and how was the statistical significance computed?

Can you elaborate more on what data is being correlated in figures 1 and 2? For example, figure 1a states it is plotting "correlation between monthly mean ozone anomalies from lidar and SBUV station overpasses on common days." Does this mean that you are computing SBUV overpasses over the lidar stations and then taking monthly means of those? If so, what are the coincident criteria? Or are you doing something different. It isn't clear how the data is being processed or binned for these different correlation comparisons.

Pg. 04, Ln. 140: "The fairly good "zonal representativeness" of the stations is obvious ..."

It is also worth noting the obvious patterns in the correlations. The data being used here are deseasonalized anomalies, so correlations are expected to be larger in the presence of larger geophysical variability that is represented in multiple zonal regions. For example, stations at midlatitudes show worse correlations with data in the tropics at lower altitudes where the QBO has a much larger amplitude. Similarly, stations at midlatitudes show better correlations at midlatitudes in the opposite hemisphere at the highest altitudes because the long-term trend is a significant source of variability here but has more similar trend values and turnaround times at midlatitudes than in the tropics. The nature of resulting patterns in solar cycle amplitude as they pertain to ozone variability in the middle to upper stratosphere also play a role.

Pg. 07, Ln. 264: "Notable synergistic negative anomalies can be seen . . ."

Why would you consider these anomalies if they are also represented in the data? This is perfectly acceptable as part of the regression analysis and these years should not be ignored. If the coincidental phasing of proxies was not represented by the data, then that would be considered an outlier or anomaly and would need to be considered.

Pg. 08, Ln. 292: "As a first step . . ."

Did you also test just using the PWLT to compare the influence of adding the AOD proxy?

Pg. 08, Ln. 301: "The proxy that has the largest influence on trends is the solar cycle."

It should be noted that the solar cycle can have a larger influence on these MLR analyses if the data record being utilized is smaller (i.e., less than 2 solar cycles).

Pg. 08, Ln. 304: "For the post-1998 period (right panels), results are not so close to each other, albeit both show clear positive ozone trends after 1998."

Both show positive ozone trends after 1998 above about 15 hPa. Of course, for reasons stated earlier, the EESC proxy are forced to show positive trends during this time period regardless of whether the trends are actually positive.

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Pg. 09, Ln. 323: "... we see that there is a region between 10 and 5 hPa over the tropics which shows positive ozone trends over the whole 1980 to 2015 period of record ..."

Although these are not statistically significant.

Pg. 09, Ln. 333: "It is obvious from the top and middle panels of Figure 11 that adding or removing the natural proxies has little effect on the observed trends."

Except for the AOD proxy?

Pg. 09, Ln. 339: "The reasons must be quite complex."

Not really. As mentioned earlier, they simply can't from a mathematical standpoint.

Figure 11: What sort of zonal binning scale was used here?

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