Reviewer #1 comment on "Variability of temperature and ozone in the upper troposphere and lower stratosphere from multi-satellite observations and reanalysis data" by Shangguan et. al.

Reviewer #1 (Comments to Author):
Review of: Variability of temperature and ozone in the upper troposphere and lower stratosphere from multi-satellite observations and reanalysis data. Thank you for the pleasure of reviewing this paper. It is well written (with only a couple of English corrections), well laid out and has very good graphics. I very much like the usage of various satellite data, reanalysis data and comparisons with models to show if how/where/when reanalysis data could be problematic for trend detection. The usage of a model with and without real time SST shows the role of dynamics and radiation upon the temperature and ozone variations over this albeit short period of 2002-2017. The great thing about GNSS-RO data is that it is unbiased and has been shown by several authors how its assimilation harmonizes the temperatures of the various reanalyses from ~2004 forward. Unfortunately, as the reanalyses migrate their temperatures toward the GNSS-RO values, any previous bias impacts the temperature trends from before to after the usage of GNSS-RO data. This word of caution is presented by the authors and can't be over emphasized.
I thought the authors do a great job presenting how the ozone and temperatures are interdependent and the roles of dynamics and radiation upon them. The ozone data sets used have both pros and cons. The conversion of number density to ozone mixing ratio is dependent upon the temperatures used. An erroneous trend in temperatures could impart an unwanted trend in ozone mixing ratio values. But that is a separate issue unrelated to the purpose of this paper.
Thank you very much for your very helpful comments. We have revised our manuscript accordingly and hope the manuscript have been considerably improved. Please see our point-to-point response as follows.
Reviewer comments are in black, following by our respective replies in blue.

King regards,

Ming Shangguan (on behalf of all co-authors)
Here are my line-by-line comments:

It is my understanding that GPS-RO is a particular type of radio occultation and that the more general Global Navigation Satellite System (GNSS-RO) should be used to cover all types of RO satellite systems.
Thank you very much for your remark. We have modified all the GPS-RO to GNSS-RO in the text.
Page 3, Line 7: Replace 'get' with 'be'.
It has been corrected.
Page 3, Line 14: Replace 'continues' with 'continuous'
Corrected.

Page 3, Line 21: Remove the ‘a’ in the phrase ‘found decreasing ozone’
Updated.
Page 3, Line 25: Is ‘LS’ defined earlier in the paper, otherwise use ‘lower stratosphere’
Thank you for your remark. We have replaced LS with the lower stratosphere.
Page 3, Line 26: Use ‘increasing or declining’
Done.
Page 3, Line 30: Replace ‘Although might be still problematic’ with ‘Although it might still be problematic’
Corrected.
Page 4, Line 6: Replace ‘recorded’ with ‘record’
Done.
Page 4, Line 12: ‘In Sect. 3 we compare’
Updated.
Page 4, Line 17: Replace ‘Around one decade CHAMP’ with ‘Nearly one decade of CHAMP’
Thanks. We have updated this sentence as suggested.
Page 4, Line 19: Replace ‘provides more than 10 times of’ with ‘providing more than 10 times the number of’
Yes, it has been done.
Page 4, Line 27: Replace ‘can be already captured by single satellite’ with ‘has already been captured by a single satellite’
Thanks. We have revised this sentence as suggested.
Page 6, Line 12: ‘qulaity’ is misspelled ‘quality’
Corrected.
Page 6, Line 15: Replace ‘since’ with ‘beginning in’
We have done the correction according to your comment.
Page 7, Line 3: Replace ‘has been proved for a better representation to the detailed’with ‘has been proved to better represent the detailed’.
Done.
Page 7, Line 19: ‘QBO coefficients’
Corrected.
Page 7, Line 20: ‘a4’ is the QBO30 coefficient, is there a missing solar term in equation1 with a coefficient a5?
We apologize for this mistake. Yes, ‘a4’ is the QBO30 coefficient. We have corrected this sentence in the revised manuscript.
Page 7, Line 30: ‘between reanalyses and from the GPS-RO data.’
Corrected.
Page 9, Paragraph beginning at line 3: Does the transition and use of MLS temps affect the MERRA2 trends? How does MERRA2 perform after vs before the use of CHAMP in 2004?
According to previous studies (e.g., McCarty et al., 2016; Fujiwara et al., 2017), the MERRA2 only assimilated MLS temperature observations at and above 5 hPa. For this study, since we are focusing on the region below 10 hPa, the MERRA2 trends

shown in this study should not be affected by the MLS temperatures. However, this effect should be considered while investigating temperature trends above 5 hPa. The effect of the CHAMP to MERRA2, as introduced in MERRA2 on 15 July 2004 (McCarty et al., 2016), is not significant since the single CHAMP satellite has very limited number of observations.

Page 9, Line 31: 'MERRA2', Do you have a reason why ERA-I trends are 'flat'?

As shown in Figure 6(a) the ERA-I temperature anomalies from 2002 to mid-2006 are highest compared to other data sets. According to Simmons et al. (2014), local degradation occurs near the sub-tropical tropopause whereas substantial amounts of warm-biased aircraft data are assimilated since 1999. After 2006, while large number of COSMIC data is assimilated, this warm bias disappeared. This led to less warming at 150 hPa in the tropical region represented by ERA-I.

Page 10, Line 29: 'estimated'

Corrected.

Page 10, Line 31: 'MERRA2'

Corrected.

Page 11, Line 1: 'At 10 hPa all the data sets'

Updated.

Page 11, Line 11: 'confirmed by Table 1'

Done.

Page 11, Line 28: 'it does not assimilate as many ozone'

Corrected.

Page 12, Line 20: 'which is the reason of the positive'

Done.

Page 12, Line 32: 'SST's (Figures 15b-c).'

Corrected.

Page 13, Line 3: 'less ozone in the tropical lower'

Done.

Page 13, Line 7: 'SST increases are asymmetric in the two'

We have done this update.

Page 13, Line 22: 'shows obvious improvements in reference to ERA-I'

Corrected.

Page 13, Line 23:'well known that are related to'

Done.

Page 13, Line 31: 'In contrast to the troposphere'

Done.

Page 14, Line 6: 'can be found for the two hemispheres'

Done.

Page 14, Line 13: 'supports'

Corrected.

Page 14, Line 17: Remove 'neither'

Done.

Figure 1: Label every other year on the X-axis; in the caption: 'between three reanalyses'

Thanks. We have updated the figure as well as the caption as suggested.

Figure 2+: Referring to previous figures should be capitalized: 'Same as Figure 1'

Thanks, it has been corrected.

Figure 4: 'The two missions obtained'

Done.

Figures 1,2,3,13. It is hard to distinguish the black lines from the blue lines. Could another color or a lighter shade of blue be use.

Thank you very much for your advices. We have changed the color in Figures 1, 2, 3,13.

References

McCarty, W., Coy, L., Gelaro, R., Huang, A., Merkova, D., Smith, E. B., Sienkiewicz, M., and K., W.: NASA Tech. Rep. NASA/TM{2016{104606, https://gmao.gsfc.nasa.gov/pubs/docs/McCarty885.pdf, 2016.

Fujiwara, M., Wright, J. S., Manney, G. L., Gray, L. J., Anstey, J., Birner, T., Davis, S., Gerber, E. P., Harvey, V. L., Hegglin, M. I., Homeyer, C. R., Knox, J. A., Kruger, K., Lambert, A., Long, C. S., Martineau, P., Molod, A., Monge-Sanz, B. ¨M., San- tee, M. L., Tegtmeier, S., Chabrillat, S., Tan, D. G. H., Jack- son, D. R., Polavarapu, S., Compo, G. P., Dragani, R., Ebisuzaki, W., Harada, Y., Kobayashi, C., McCarty, W., Onogi, K., Paw- son, S., Simmons, A., Wargan, K., Whitaker, J. S., and Zou, C.-Z.: Introduction to the SPARC Reanalysis Intercomparison Project (S-RIP) and overview of the reanalysis systems, At- mos. Chem. Phys., 17, 1417{1452, https://doi.org/10.5194/acp- 17-1417-2017, 2017.

Simmons, A. J., Poli, P., Dee, D. P., Berrisford, P., Hersbach, H., Kobayashi, S., and Peubey, C.: Estimating low-frequency variability and trends in atmospheric temperature using ERA-Interim, Quarterly Journal of the Royal Meteorological Society, 140,329-353, 2014.