The authors wish to thank two anonymous reviewers for their helpful comments on the manuscript. These reviews helped us to improve the manuscript.

Comment to Report 1:

1. **Line 97: Should this say "aseasonal" or "seasonal"?**

   Thank you for noticing the typo. We fixed it.

2. **Lines 226-229: This sentence is difficult to follow and might be clearer if it was split into separate sentences for Antarctic versus the NH tropical class widening. Then the discussion of causes of the tropical widening could be expanded a little.**

   Thank you for the suggestion. This sentence now reads as two different sentences. We also extended the tropical broadening paragraph:

The widening trends based on seasonality imply that the tropical broadening in SH is mainly due to the Antarctic ozone hole, which causes the largest radiative cooling effect in the lower stratosphere during DJF (Palmeiro et al., 2014). Increasing black carbon and tropospheric ozone are considered as major forcing for NH tropical class widening on a longer time scale during JJA (Allen et al., 2012). However, these two forcings together have the largest warming effect in the NH extratropics (Hu et al., 2018). Studies showed that the shallow branch (located in the lowermost stratosphere with upwelling in the tropics and downwelling in the subtropics) of tropical upwelling is much stronger toward the summer hemisphere during DJF than JJA (Palmeiro et al., 2014). The deep branch with upwelling in the upper stratosphere in the tropics and downwelling in the middle and high latitudes also show a similar seasonal cycle with downwelling extended to the polar latitudes in the stratosphere (Seviour et al., 2012; Palmeiro et al., 2014). The differentiation between twp branches are based on different forcing, planetary-scale wave forcing act on the shallow branch, and in the deep branch, the upwelling is associated with GHG increase (Palmeiro et al., 2014). However, the investigation of seasonal change of tropical upwelling in shallow and deep branches is beyond the scope of this study.

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3. **Line 246: missing apostrophe on continents and ranges.**

   We fixed the error.

4. **Line 290: Wouldn't changes in BVOC emissions be included in changes to ozone precursor emissions? Maybe clarify if "changes to ozone precursor emissions" means specifically anthropogenic or biomass burning emissions.**

We changed the statement. Since the BVOC term was introduced in this line, we modified the line as below:

However, changes to ozone precursor emissions (including biogenic volatile organic compounds (BVOC) emissions caused by increasing tropospheric temperature) alone do not drive tropospheric ozone changes, the availability of tropospheric water vapor, and stratosphere-to-troposphere transport of ozone, which taken together drive increases to tropospheric ozone concentrations.

Comment to Report 2:

1. **Line 174-176: As I explained in my previous review, the statement that ozone concentrations increase towards the surface is not correct. Figure 2 shows ozone as a partial pressure, which is not a concentration (concentration has units of mass per volume). If you convert the ozone to units of concentration, or ppbv, you will see that the ozone concentrations (or mixing ratios) decrease towards the surface, as shown in Figure 4 of Logan, 1999 (this is a very well-known phenomenon). Also see Figures 5, 6, 16 and 17 of Gaudel et al. (2018). The ozone climatology by Logan (1999) mainly focuses on observed ozone profiles in remote or rural locations, as does your analysis. If one carefully selects ozone profiles from an urban area with very high concentrations in the boundary layer, then one would see an increase of ozone concentrations towards the surface, but this applies to just a very small portion of the Earth's area (see Figure 18 of Gaudel et al. 2018).**

   Thank you for the suggestion. We got rid of the part.

2. **Line 199: Surface ozone is discussed, but the figures only show ozone down to the 850 hPa level, which in most regions of the world, is not the surface. To be accurate please use the expression "lower troposphere" instead of surface. The authors claim that classes 5 and 6 have more ozone in the lower troposphere than classes 3 and 4, but according to Table 1, classes 5 and 6 have less ozone than class 4.**

We reworded the line and changed the word “surface” to “lower troposphere”. The line now reads:

Class 4 features higher lower tropospheric ozone and higher variability than class 3. Finally, classes 5 and 6 are northern hemispheric classes with high lower tropospheric ozone concentrations and large variability from the tropopause to the stratosphere. The higher lower tropospheric values result from greater surface pollutants in classes 4, 5, and 6, including the associated ozone precursor emissions, which tend to be concentrated in the Northern Hemisphere due to anthropogenic emissions (Monks et al., 2009, 2015).

3. **Figure 6: September is misspelled under panel (d).**

   Thank you for noticing that. We fixed it.

4. **Line 239: Here the authors cite Allen et al. 2012, who discuss the impact of long-term climate change (i.e. many decades) on the widening of the tropical belt, and the authors seem to imply that this process is causing class 3 and 4 to be more prominent in JJA, but this is not the case. The seasonal cycle of ozone during the very brief period of 2009-2014 has nothing to do with long-term climate change, and it is simply driven by Earth’s normal seasonal dynamics.**

   Thank you for the suggestion. We changed the line as below:

   Increasing black carbon and tropospheric ozone are considered as major forcing for NH tropical class widening on a longer time scale during JJA (Allen et al., 2012).

5. **Line 243: Here the discussion of the northern hemisphere ozone hole seems to imply that this phenomenon does not occur in spring. But as shown in the Stratospheric Ozone section of Dunn et al., (2022), the northern ozone hole happens in spring (but it does not form every year).**

   Thank you for the suggestion. We modified the statement as below:

This indicates that in our study, the northern hemisphere ozone hole is not especially predominant during these months in seasonal mean. However, Dunn et al. (2022) showed that there are some particular years when the polar ozone hole can happen in NH spring.