This paper presents analysis of 13 years of temperature data from homogenized IASI measurements, based on a neural network retrieval. Results include comparisons with several other temperature data sets (ERA5, radiosondes and independent EUMETSAT retrievals), and calculation of temperature trends over 2008-2020. The new IASI retrievals show reasonable agreement with the other data sets, and trends from the short data record show the expected structure of tropospheric warming and stratospheric cooling, although with interesting detailed structure. Overall the IASI neural network retrieval seems reasonable and can provide accurate information on tropospheric and stratospheric temperatures. The paper is a useful contribution regarding the details of the data and retrieval, and it is appropriate for AMT. I have a number of comments for the authors to consider in revision.

We thank the reviewer for their useful comments. We answer each of the questions raised in blue hereafter.

The comparisons with ERA5 in Fig. 3 show systematic patterns in the tropics over levels 100-7 hPa that are suggestive of the quasi-biennial oscillation (QBO), and not tropospheric cloud cover as suggested near line 188. I would guess that IASI data have relatively low vertical resolution and underestimate some of the QBO temperature signal in ERA5. A simple comparison of IASI vs. ERA5 in height-time cross sections at the equator would clarify this behavior (showing deseasonalized temperature anomalies in both data sets, along with their differences). This may also explain the large equatorial rms differences seen in Fig. 4.

Thank you for pointing this out, you are indeed right. A figure showing the monthly differences averaged over 10°S-10°N and the corresponding zonal wind from ERA5 was added. It shows, as you suggested, that the differences between 100 and 7 hPa are correlated to the QBO, and that the neural network overestimates temperatures during the easterly phase of the QBO.

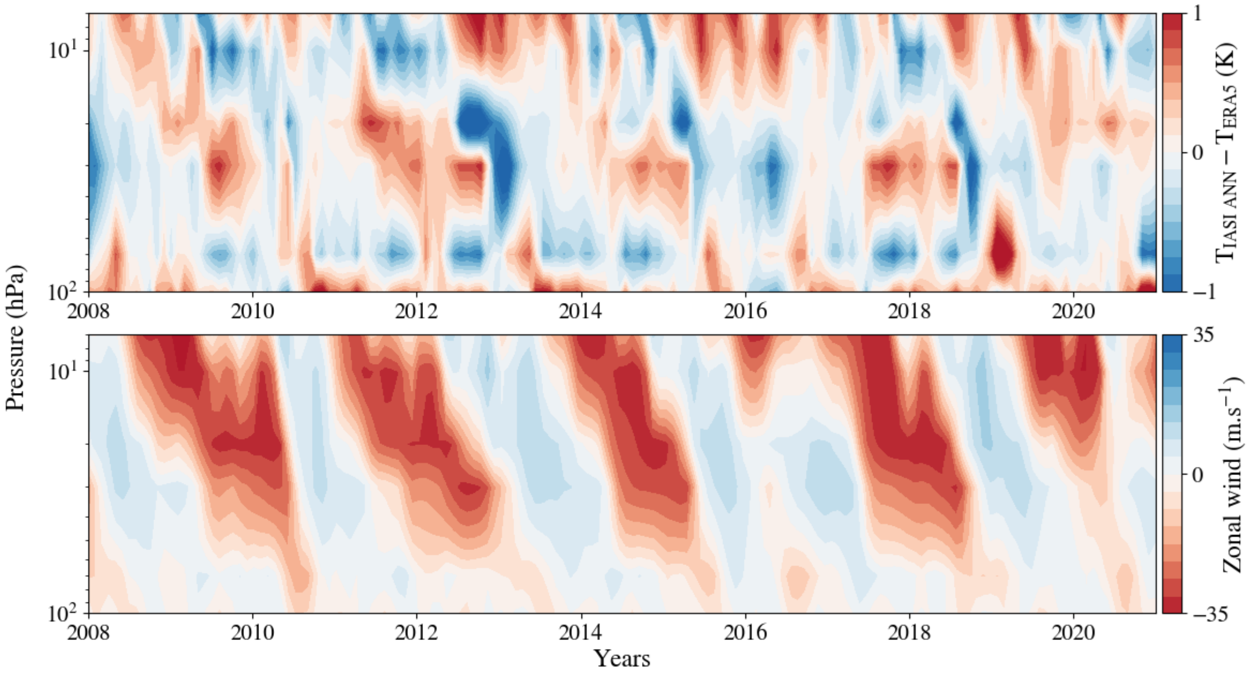

Figure 4: Monthly mean of the temperature differences between IASI-ANN and ERA5 (top) and monthly zonal wind from ERA5 (bottom) between 10°S and 10°N.

The following sentences were then added in Section 4.1:

"Figure 4 shows the monthly mean of the differences between 10°S and 10°N from 100 to 7 hPa, as well as the monthly zonal wind from ERA5 in the same latitude range. Positive differences (ANN temperatures larger than ERA5) are correlated to negative zonal wind and negative differences are correlated to positive zonal wind.

This suggests that the neural network overestimates temperatures during the easterly phase of the Quasi-Biennal Oscillation (QBO).”

I think the comparisons with radiosondes (ARSA data) should be limited to pressures 750-30 hPa, where the radiosonde measurements occur. Higher levels are simply other data sets. I don’t find the complicated/noisy differences in Fig. 6 to be quantitatively very useful. Additional or complementary calculations could show the mean and rms differences for each region as a function of pressure (750-30 hPa), and perhaps include correlations to quantify the agreement between IASI and radiosondes.

This is a good remak, thank you. Figure 7 (Figure 6 in the first version) was modified and is now only showing the differences from 750 to 30 hPa, as well as the time averaged differences (as suggested by the second reviewer), and the paragraphs describing this figure were modified as follows :

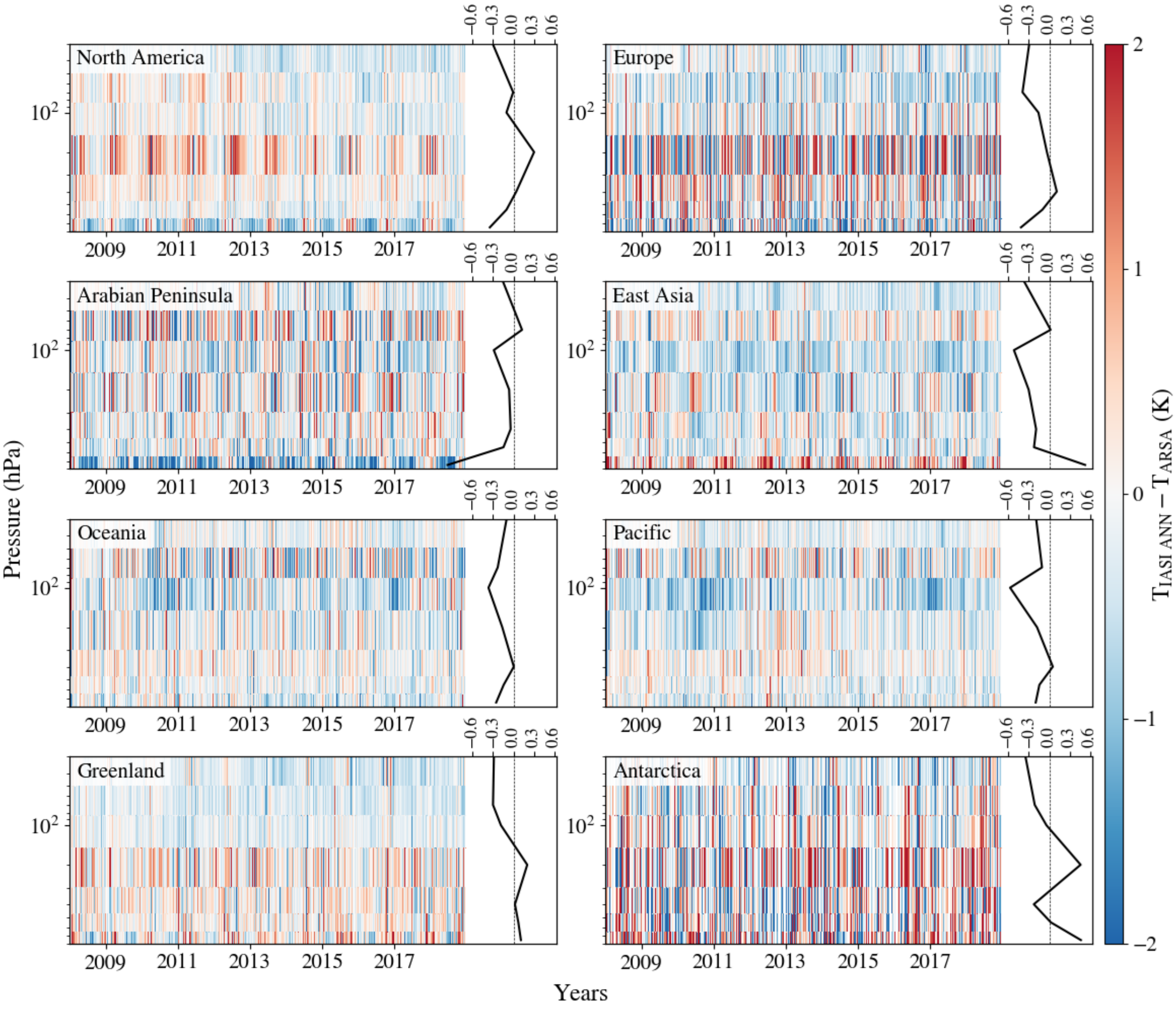

Figure 7: Daily differences between IASI and ARSA temperatures between 2008 and 2018 in North America, Europe, the Arabian Peninsula, East Asia, Oceania, the Pacific, Greenland and Antarctica, with the time average differences profiles on the right of each subplot.

“Figure 7 shows the daily differences between IASI retrievals and ARSA mean regional temperature in the 8 selected regions between 2008 and 2018, and the time averaged difference profiles. We only show differences between 750 and 30 hPa as ARSA data above 30 hPa does not always come from radiosounding measurement but from the extrapolation datasets. Between 7 and 100 hPa, the differences are small and mostly negative (about 0.5 K). At 200 hPa and below, the differences remain small and negative in the Pacific, Oceania and

East Asia. In Greenland, North America and Europe, the differences at these pressure levels are slightly larger and more often positive (about 0.5 K, up to 1 K in North America and Europe) than in the other regions.

In Antarctica and, to a lesser extent, the Arabian Peninsula, there are more daily variations of positive and negative differences, and they are a little larger (about 0.7 K in the Arabian Peninsula and 1 K in Antarctica) than in the other regions. This can be because of the low space (few stations) and time coverage (only for Antarctica) in these regions. However, we see the same pattern than in the other regions: large differences at 2 hPa, small differences at 7 hPa and lower, more positive differences in the troposphere.

In all the regions, the time averaged differences range from -0.6 K to 0.6 K except in the Arabian Peninsula at 750 hPa where they reach 0.9 K."

A new figure (Figure 8) showing the standard deviation of the differences and the correlation between the two datasets was added. The following discussion was added to the text:

"Figure 8 show the standard deviation of the daily differences between IASI-ANN and ARSA temperatures and the correlation between the two datasets in the 8 regions. In most regions, the standard deviation ranges from 0.5 to 1 K, except in the Arabian Peninsula and East Asia where they reach 1.3 K at 750 hPa, and in Antarctica and Europe where they range from 1 to 2 K. The correlations between IASI-ANN and ARSA temperatures show that there is no significant bias between the two datasets."

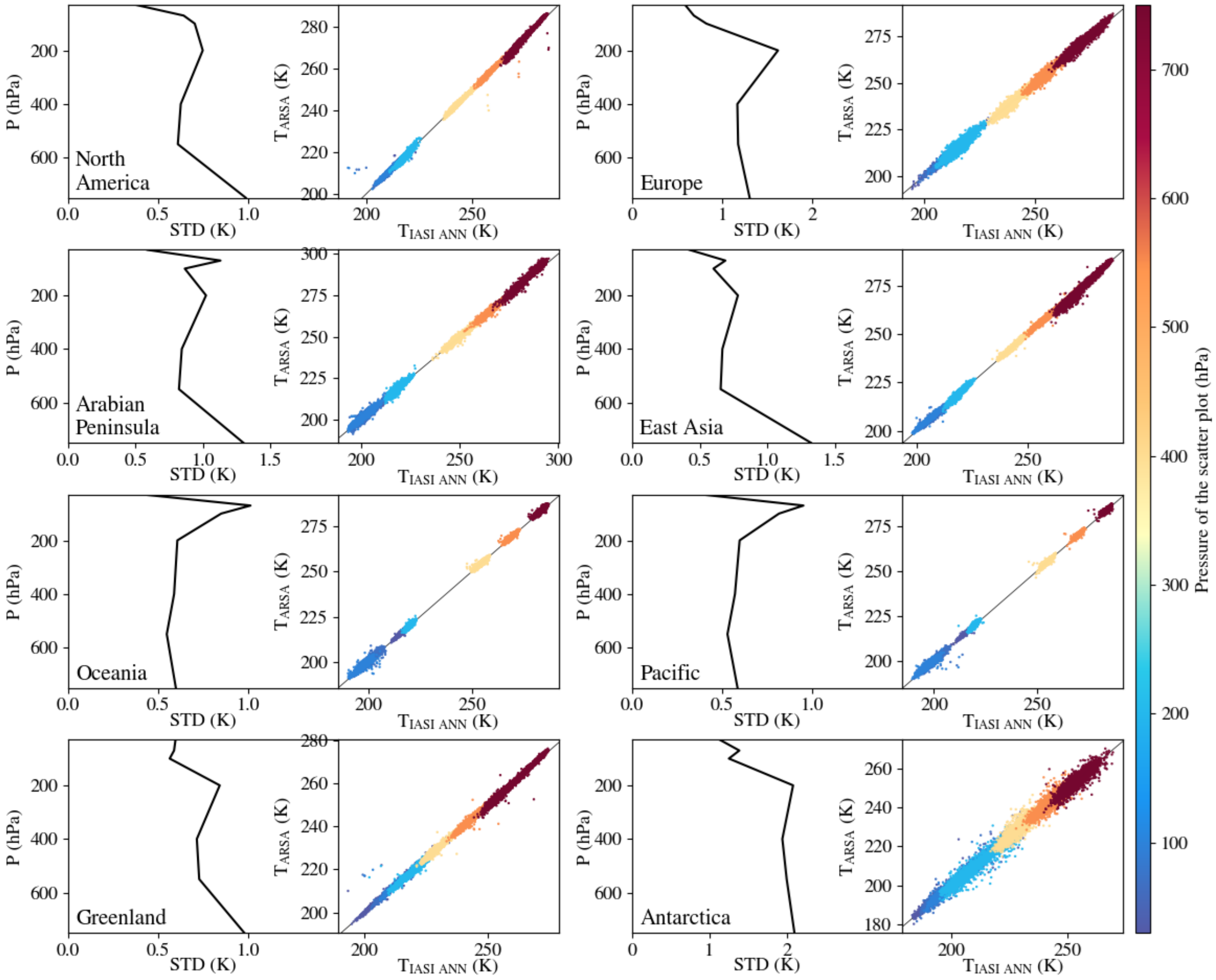

Figure 8: Standard deviation profiles of the differences between IASI-ANN and ARSA temperatures (left of each subplot) and correlation between the two dataset (right of each subplot).

Several comments on the trend results in Fig. 8:

1- Results are shown for simple linear trends, but it would be good to test the sensitivity to including additional terms in the regression that explain known variations in tropospheric and stratospheric temperatures, including the QBO and ENSO. This is standard practice in calculation of long-term trends, e.g. Steiner et al 2020 (DOI:10.1175/JCLI-D-19-0998.1). The tropical stratospheric trends look to me to have structure possibly aliased from the QBO in this short record.

Figure 10 (Figure 8 in the previous version of the manuscript) shows trends computed without the contribution of ENSO and QBO, that were removed with a multiple linear regression. The main change is the reduction of the warming trend in the equatorial troposphere, that was mostly due to the El-Nino event of 2015-2016. However, stratospheric trends do not seem to be significantly impacted by the QBO.

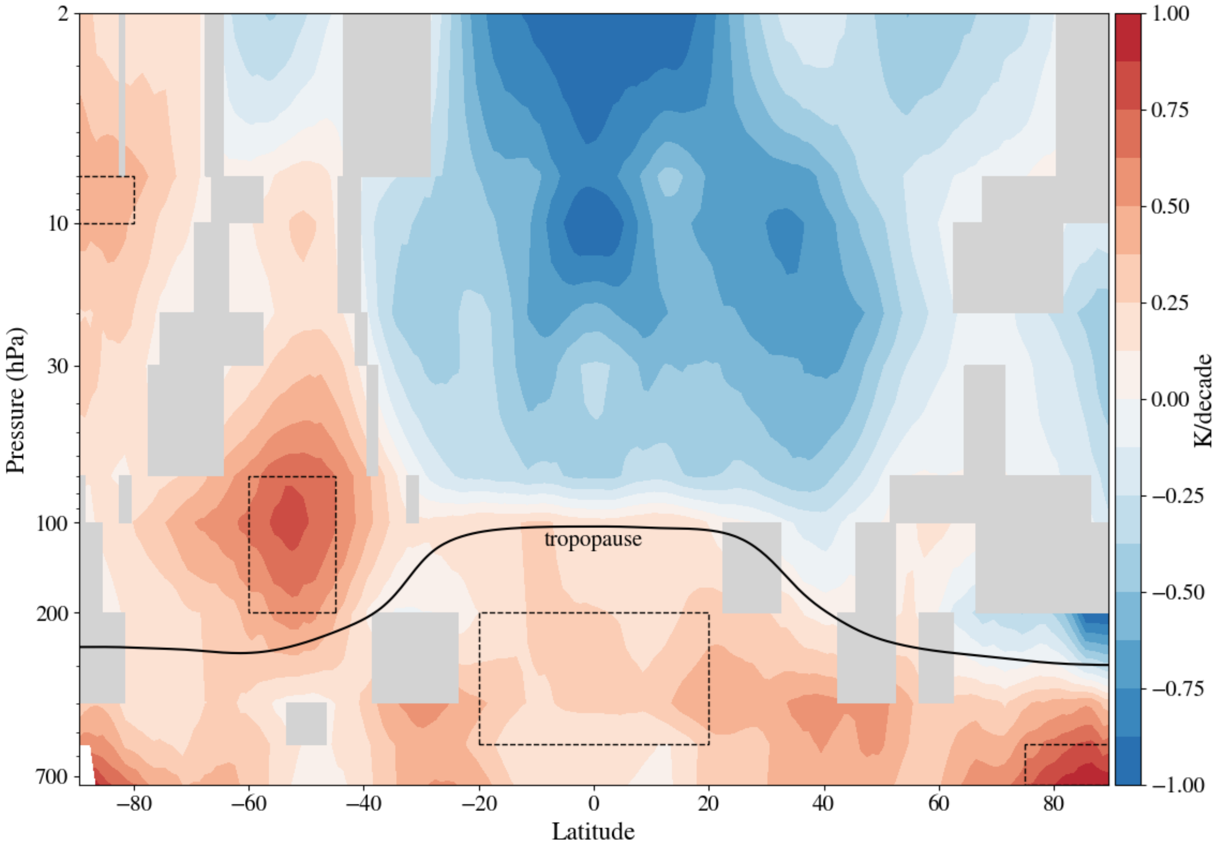

Figure 10: Zonal temperature trends for the period 2008-2020 computed with the outputs of the ANN. Grey areas correspond to trends that are not statistically significant. The dotted rectangles represent the regions for which the time series are shown in Figure 11.

The main change from the figure in the previous version is a weaker warming in the equatorial troposphere. The text was modified accordingly:

"We use IASI daily zonal mean temperature (latitude bands of 1°) and we compute the Theil-Sen estimator for each latitude and each pressure level. The Theil-Sen estimator is a robust method for computing linear trends, where the trend is determined by the median of all the possible slopes between pairs of points (Theil, 1950; Sen, 1968). We also computed the associated p-values, with a 0.05 threshold for significance being considered. Before the Theil-Sen estimator was applied, we removed the contributions of El Niño-Southern Oscillation (ENSO) and the QBO to temperatures. Their contribution was computed using a multiple linear regression based on the Multivariate ENSO Index (MEI, https://psl.noaa.gov/enso/mei/) and the QBO30 and QBO50

indices (equatorial zonal winds at 30 and 50 hPa, https://www.cpc.ncep.noaa.gov/data/indices/). Figure 10 shows the significant temperature trends for the 2008-2020 period. Non-significant trends are shown in grey in Figure 10.

We clearly see a warming in the troposphere. In the tropics, we see a warming of 0.2-0.3 K/decade. At mid latitude, the warming is stronger (0.5-0.6 K/decade). As highlighted by previous studies (Masson-Delmotte et al., 2021), the poles are where tropospheric temperatures are warming the quickest, especially the Arctic, where temperatures increase by 1 K/decade (arctic amplification). The values of the trends we found between 45°S and 45°N are similar to those found by Shangguan et al. (2019).”

2- The calculated tropospheric temperature trends are reasonably close to results shown in Steiner et al 2020 based on radiosonde and GPS RO data sets for the period 2007-2018 (their Fig. 11). However, these trends are much larger than corresponding results for longer time series, and are certainly influenced by the short data record and large warm ENSO event occurring in 2016, near the end of the time series. This detail should be clarified, as trends in excess of 0.7 K/decade are not representative of long-term tropospheric trends. In addition to Fig. 8, it could be helpful to include time series at several specific locations (tropical upper troposphere, Arctic troposphere, SH lower stratosphere – see below) to show the actual behavior and provide perspective to the trends calculated from this short record.

Figure 11 shows the time series in the 4 rectangles of Figure 10. The strong warming observed in the equatorial troposphere was indeed driven by the 2015 El-Nino, and the warming is significantly reduced when ENSO contribution is removed. In the other regions, ENSO and QBO do not seem to have a significant impact on the evolution of temperatures.

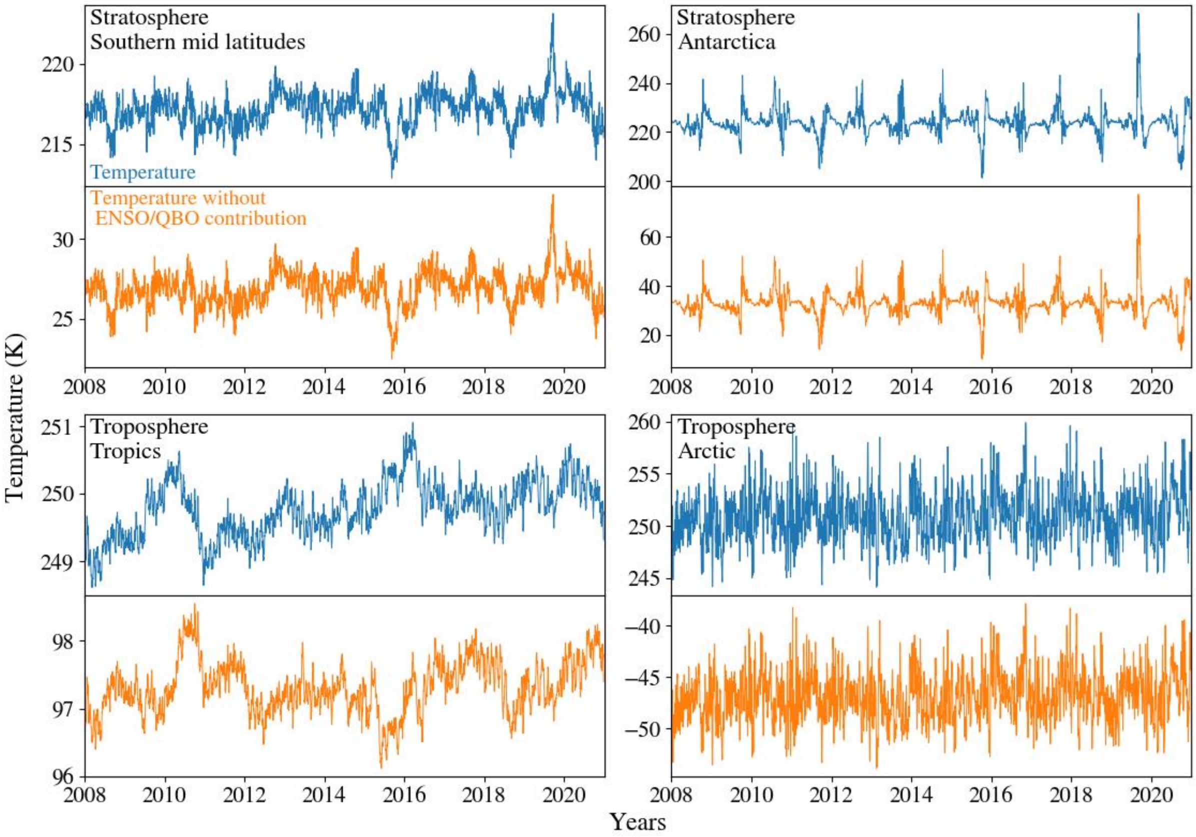

Figure 11: Times series of temperatures in the four rectangles of Figure 10 (blue) and time series without ENSO and QBO conttibutions (orange). The exact locations of the four regions are 45°S-60°S and 100-70 hPa for Stratosphere Southern mid latitudes, 80°S-90°S and 10-7 hPa for Antarctic stratosphere, 20°S-20°N and 550-200 hPa for Tropical troposphere, and 75°N-90°N and 750-550 hPa for Arctic troposphere.

The following paragraph was added in Section 5:

"Figure 11 shows the temperature time series in the regions delimited by dashed rectangles in Figure 10. The time series are shown with and without the contributions of ENSO and QBO. In the equatorial troposphere, we see that temperature are increasing. However, removing the contribution of ENSO significantly reduces the warming trend, as most of it was driven by the strong El Niño event of 2015-2016. In the Arctic troposphere, there is no significant differences in the time series with and without the contribution of ENSO/QBO, suggesting that these phenomena does not have a large impact on Arctic temperature, and the warming observed in this region is due to the increase of greenhouse gases and Arctic amplification. In the Southern stratosphere, the trend in both warming regions seem to be driven by the 2019 SSW. However, we see a continuous increase of temperatures before 2019 (with and without ENSO/QBO contribution) that cannot be attributed to the SSW and is most likely due to ozone hole recovery."

3- The large warming trend in the SH lower stratosphere (50 S, 100 hPa) is probably a result of transient warming in early 2000 (2020?) tied to the Australian New Year fires (Yu et al, 2021, doi: 10.1029/2021GL092609). This could easily be confirmed by examining the associated time series.

Figure 11 shows that the warming observed at 50°S/10hPa happened before 2020. Some of the warming happens continuously from 2008 to 2019 and is due to ozone hole recovery, and the 2019 SSW also had an impact on the observed warming trend. There could be an increase of temperatures observed in early 2020 (before a decrease in the second half of 2020) but it is complicated to distinguish the contribution of the Australian fires from the general warming trend.

4- I suggest adding a line in Fig. 8 indicating the time average tropopause.

A line indicating the time average tropopause height between 2008-2020 (from MERRA2 reanalysis) was added on Figure 10:

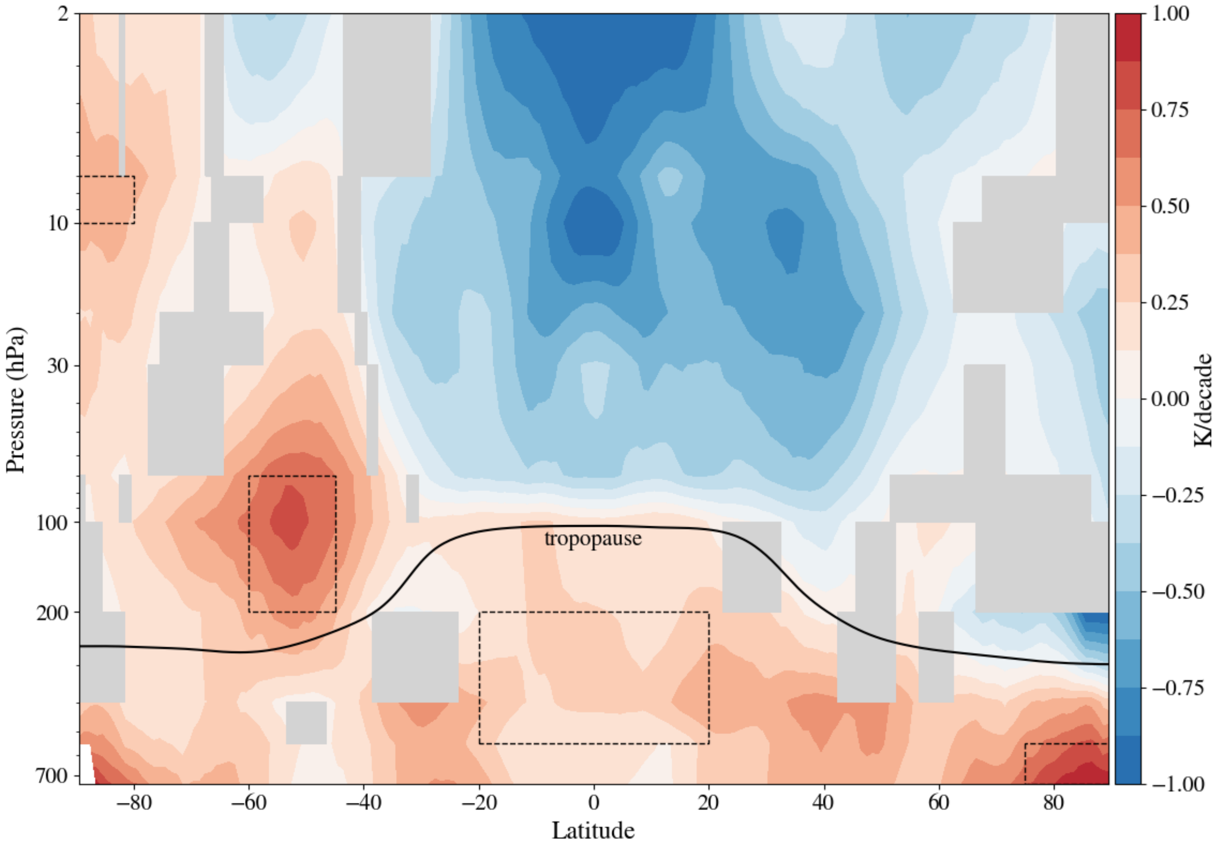

Figure 10: Zonal temperature trends for the period 2008-2020 computed with the outputs of the ANN. Grey areas correspond to trends that are not statistically significant. The dotted rectangles represent the regions for which the time series are shown in Figure 11.