Supporting Information for

Weakening of the Antarctic Stratospheric Planetary Wave Activities in Austral Early Spring Since Early 2000s Due to Sea Surface Temperature Trends

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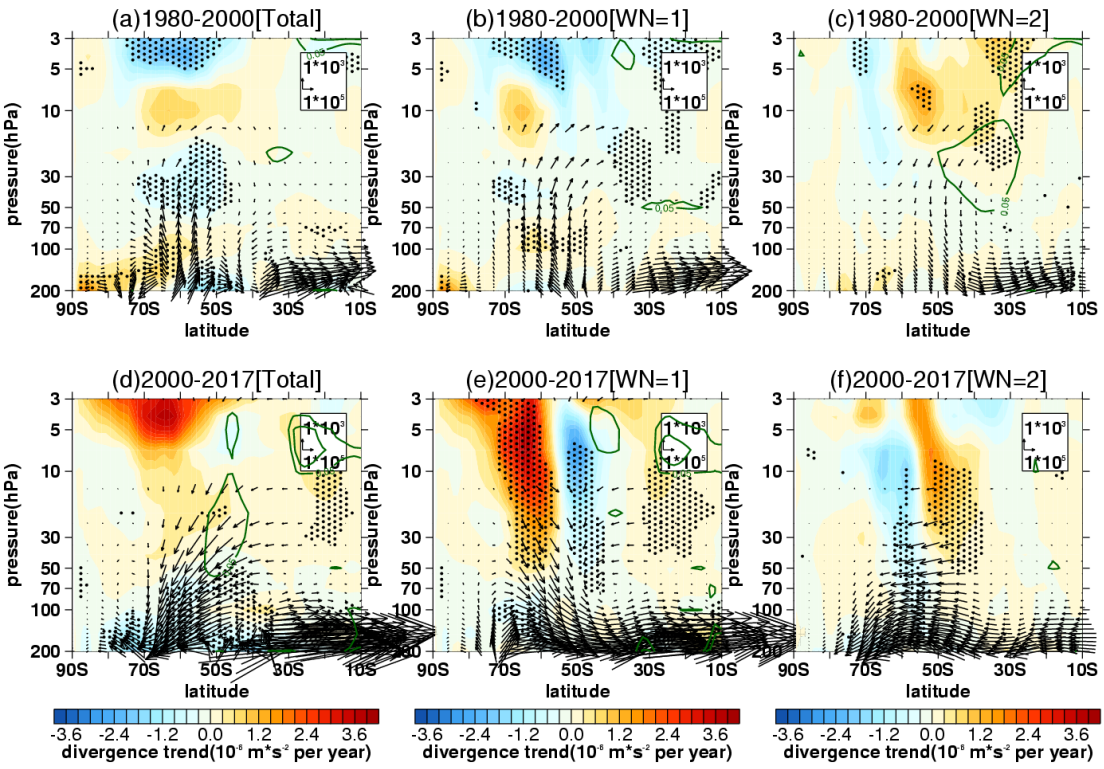
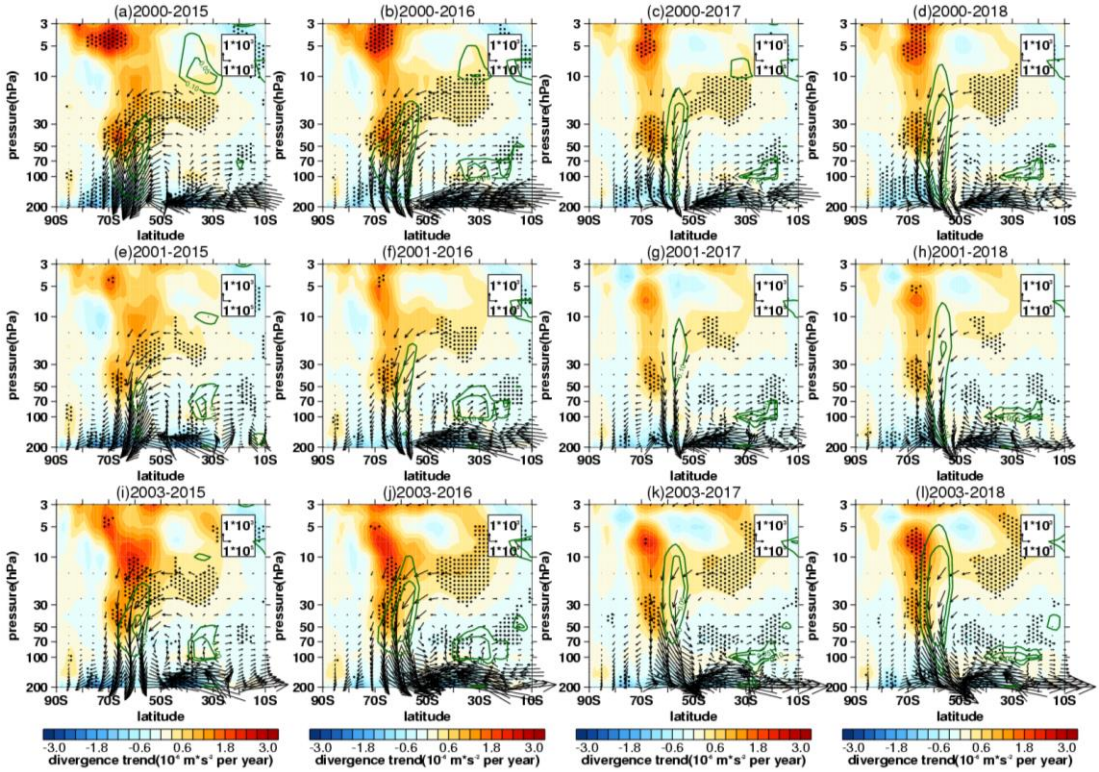


1

2 **FIG. S1.** Same as Fig. 1, except for the August.



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4 **FIG. S2.** Trends of Southern Hemispheric undecomposed stratospheric E-P flux

5 (arrows, units in horizontal and vertical components are 10^5 and 10^3 kg·s^{-2} per year,

respectively) and its divergence (shadings) in September over different periods (titles) derived from MERRA-2 dataset. Data in 2002 are removed when calculating trends with beginning year before it. The stippled regions and green contours are the same as Figure 1.

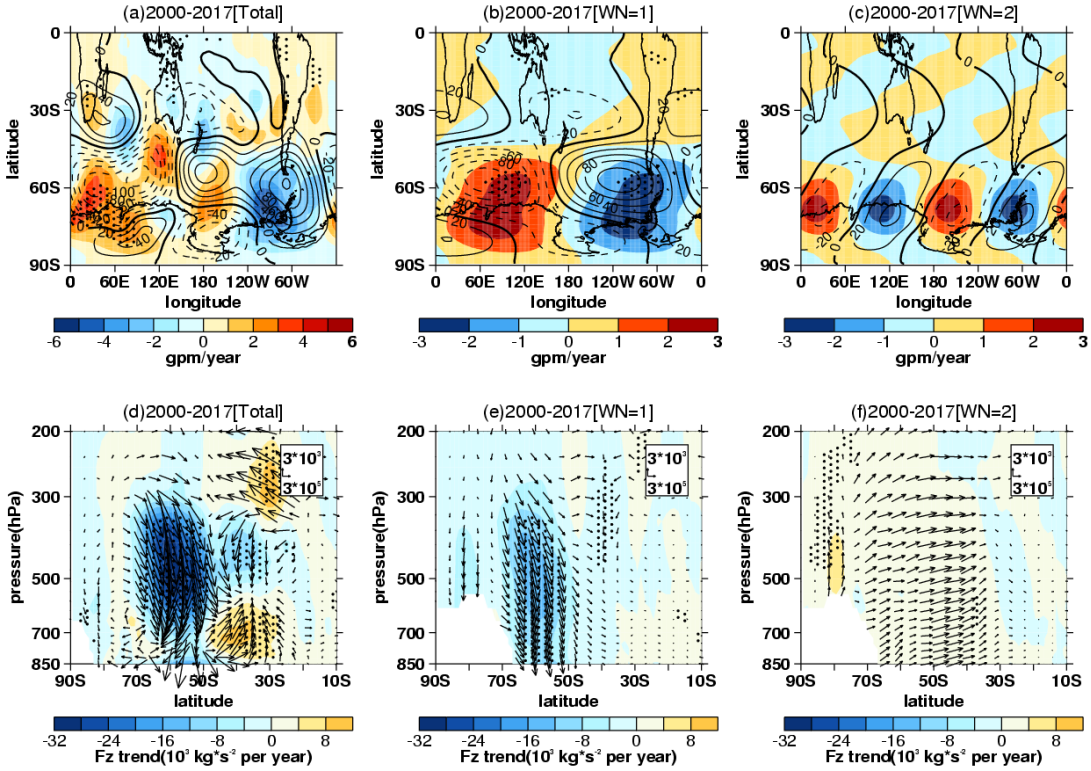

FIG. S3. Same as Fig. 3, except that the values in 2002 are removed.

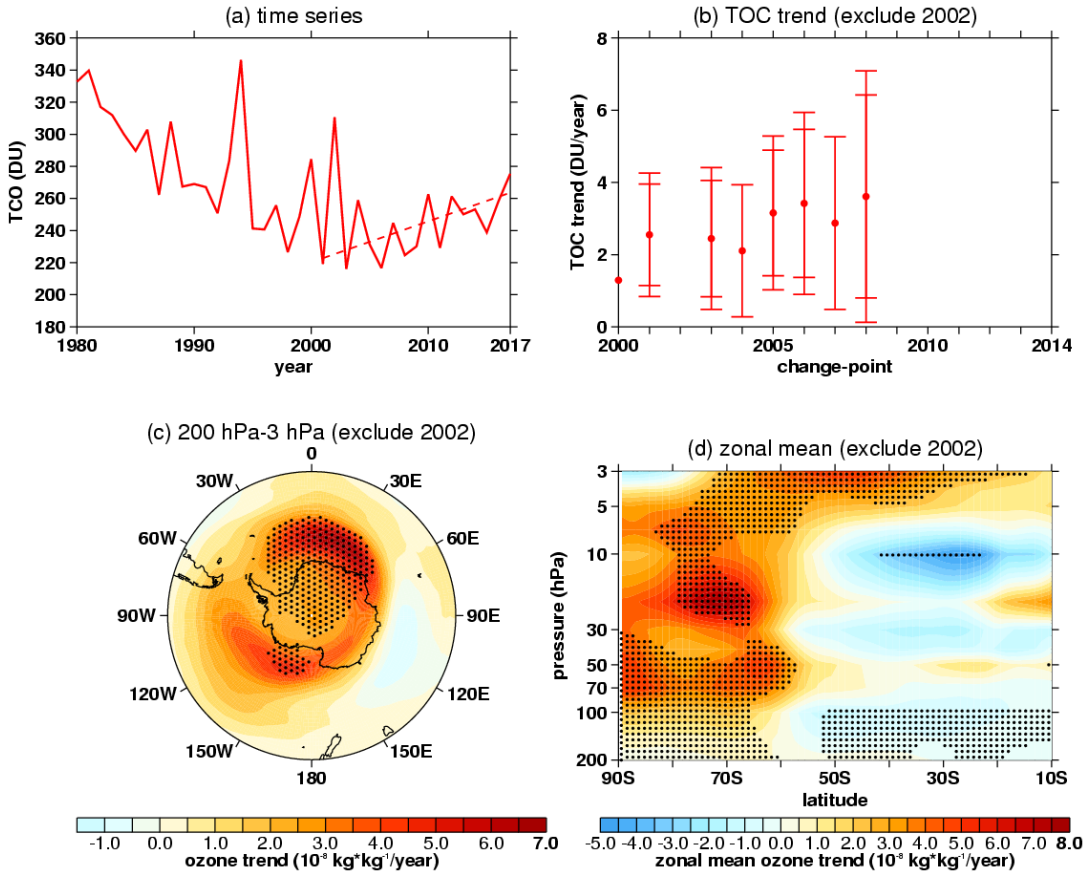

FIG. S4. (a) Time series (red solid line) of area-weighted total column ozone (TCO) over 60°S to 90°S. The red dash line represents linear regression of TCO during 2001-2017. (b) The trends (dots) and uncertainties (error bars) of September TCO time series from several beginning years after 2000 to 2017. The long and short error bars reflect the 95% and 90% confidence intervals calculated by two-tailed t test. The error bar is omitted when significance of trend is lower than corresponding confidence level. (c) The ozone trend on horizontal plane averaged from 200 hPa to 3 hPa from 2001 to 2017. (d) The zonal mean ozone trend on latitude-pressure profile in Southern Hemisphere from 2001 to 2017. The stippled regions in Fig. S4c and Fig. S4d represent the trends significant at/above the 90% confidence level. Data in 2002 are removed when trends, regression, significances or confidence intervals are calculated in Fig. S4. All data

involved in Fig. S4 are derived from MERRA-2 dataset.

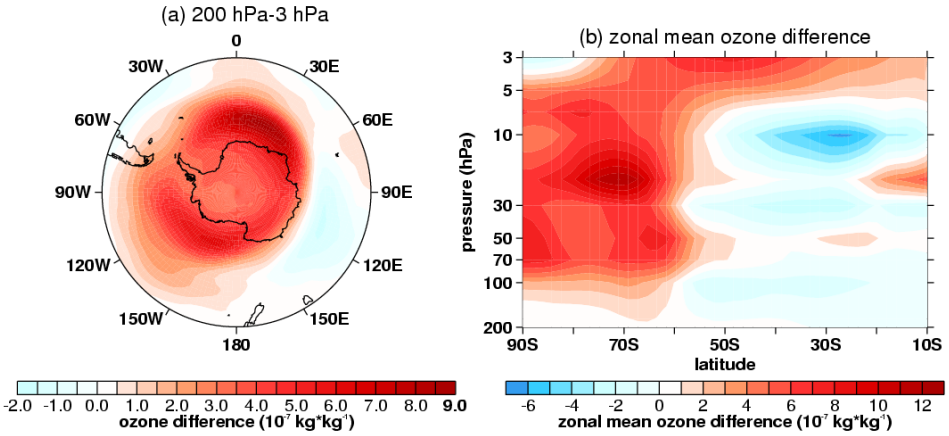

FIG. S5. (a) Difference of ozone forcing fields on horizontal plane averaged from 200 hPa to 3 hPa between O3sen and O3ctrl. The outermost latitude in Fig. S5a is 40°S. (b) Zonal mean difference of ozone forcing fields on latitude-pressure profile in Southern Hemisphere between O3sen and O3ctrl.

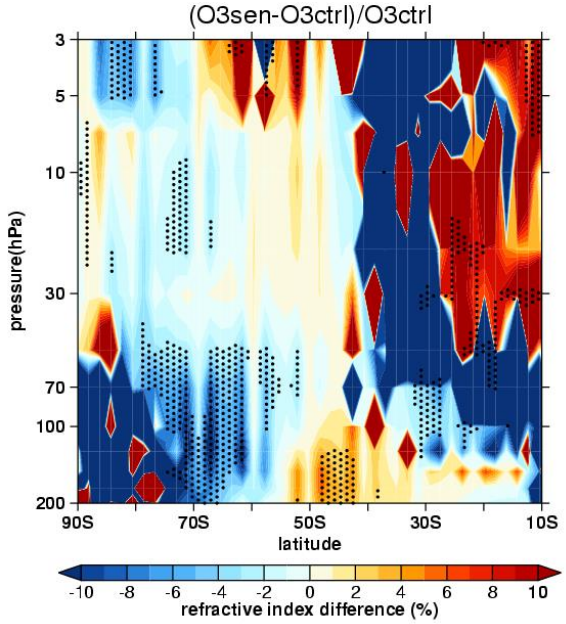

Fig. S6. Difference of refractive index between O3sen and O3ctrl. The stippled region represent the difference significant at/above the 90% confidence level. Although there is significant reduction of refractive index over 50°S-70°S, 200 hPa-70 hPa, the mean reduction induced by ozone recovery in this region is about only 3%.