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Future volcanic eruptions may delay the recovery of lower stratospheric ozone over Antarctica and Southern Hemisphere mid-latitudes

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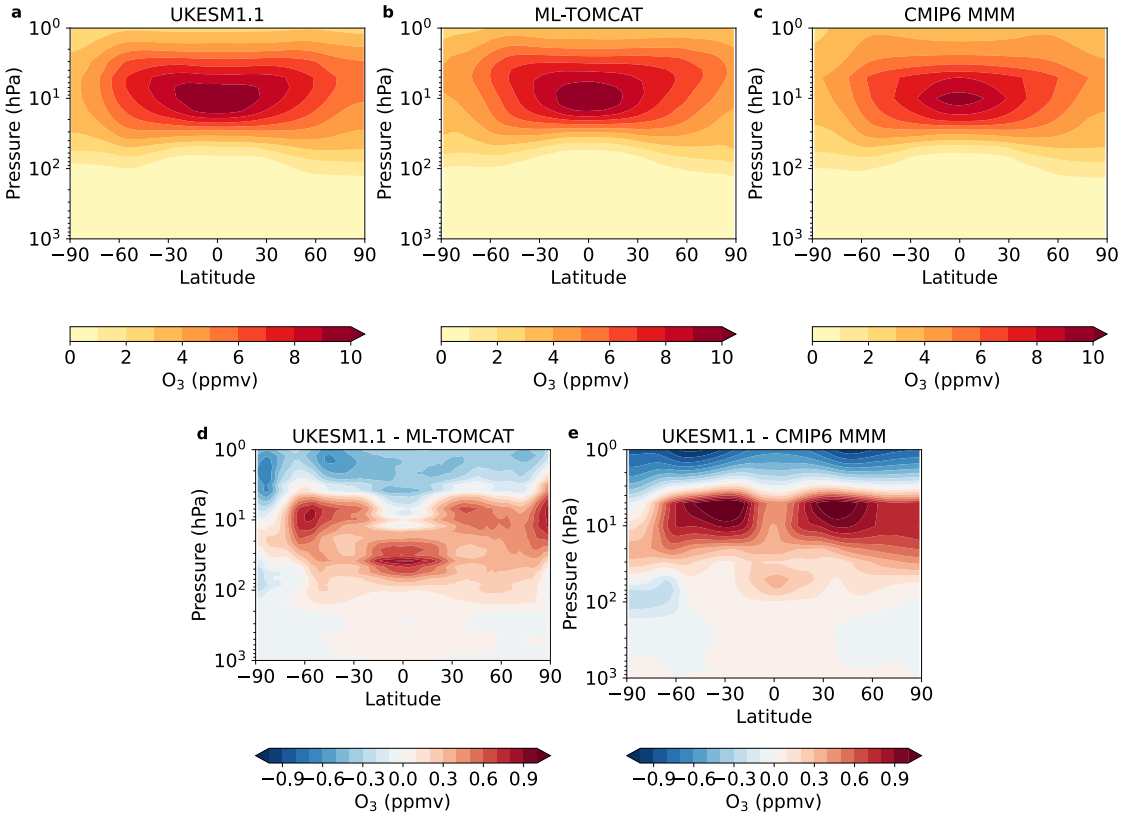
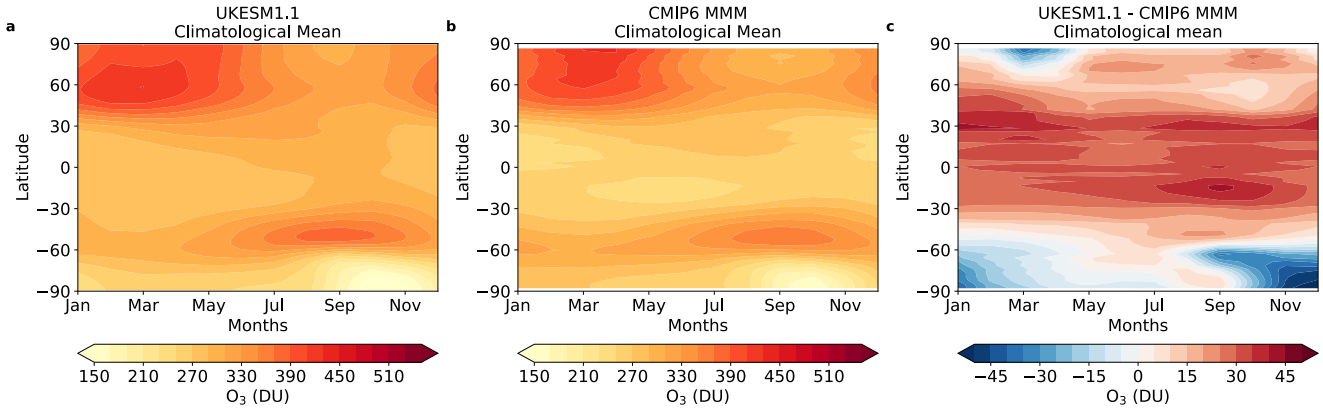


Figure S1. Zonal mean ozone mass mixing ratio (ppmv), averaged from 2000-2014, for (a) UKESM1.1, (b) ML-TOMCAT, and (c) CMIP6 multi-model mean (MMM), (d) the difference between UKESM1.1 and ML-TOMCAT, and (e) the difference between UKESM1.1 and CMIP6 MMM.



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23 **Figure S2. Climatological total column ozone (DU) averaged from 2000 to 2014 for (a) UKESM1.1, (b) CMIP6 multi-model mean,**
24 **and (c) the difference between UKESM1.1 and CMIP6 multi-model mean.**

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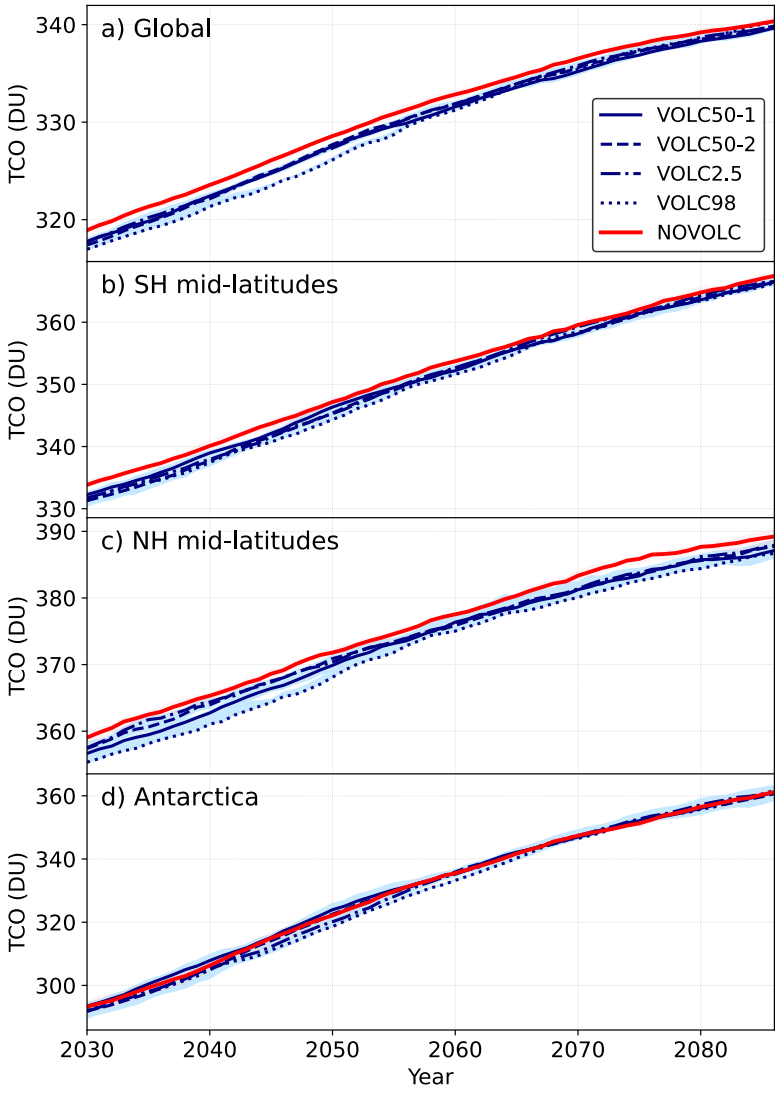

Figure S3. Total column ozone (in DU) averaged over (a) global, (b) SH mid-latitudes, (c) NH mid-latitudes, and (d) Antarctica for VOLC and NOVOLC runs, applied with a 30-year moving mean.

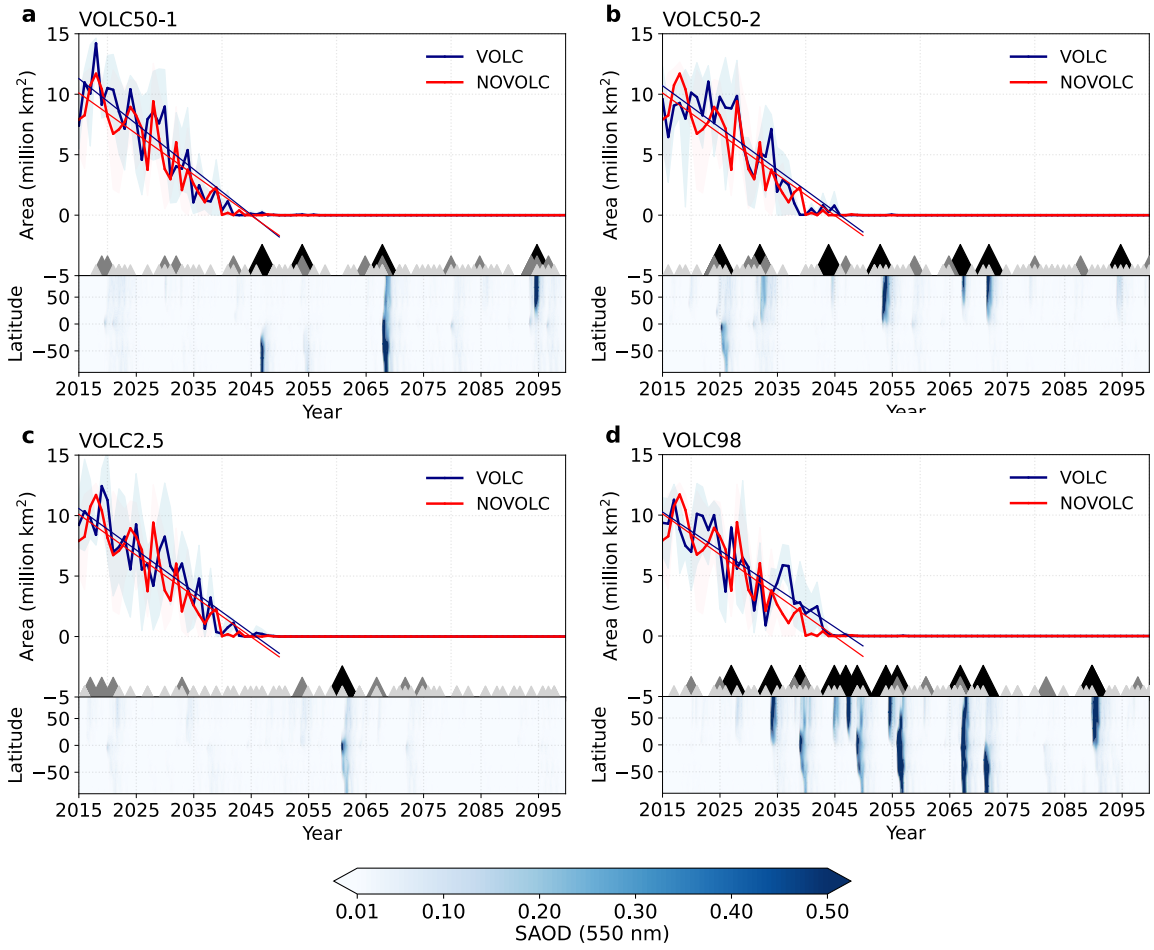

Figure S4. October-mean ozone hole area (in million km^2), for a 175DU threshold, averaged over Antarctica for (a) VOLC50-1, (b) VOLC50-2, (c) VOLC2.5, and (d) VOLC98. The solid lines show the ensemble mean values and the shading shows the values of the maximum and minimum values across the ensemble members. The triangles refer to the occurrence of eruptions in each stochastic scenario: the black triangles refer to eruptions with > 3 Tg of SO_2 injection, the grey triangles refer to eruptions with 1 to 3 Tg of SO_2 injection, and the light grey triangles refer to eruptions with 0.1 to 1 Tg of SO_2 injection. The lower panel shows the zonal mean stratospheric aerosol optical depth at 550 nm for the four VOLC runs.

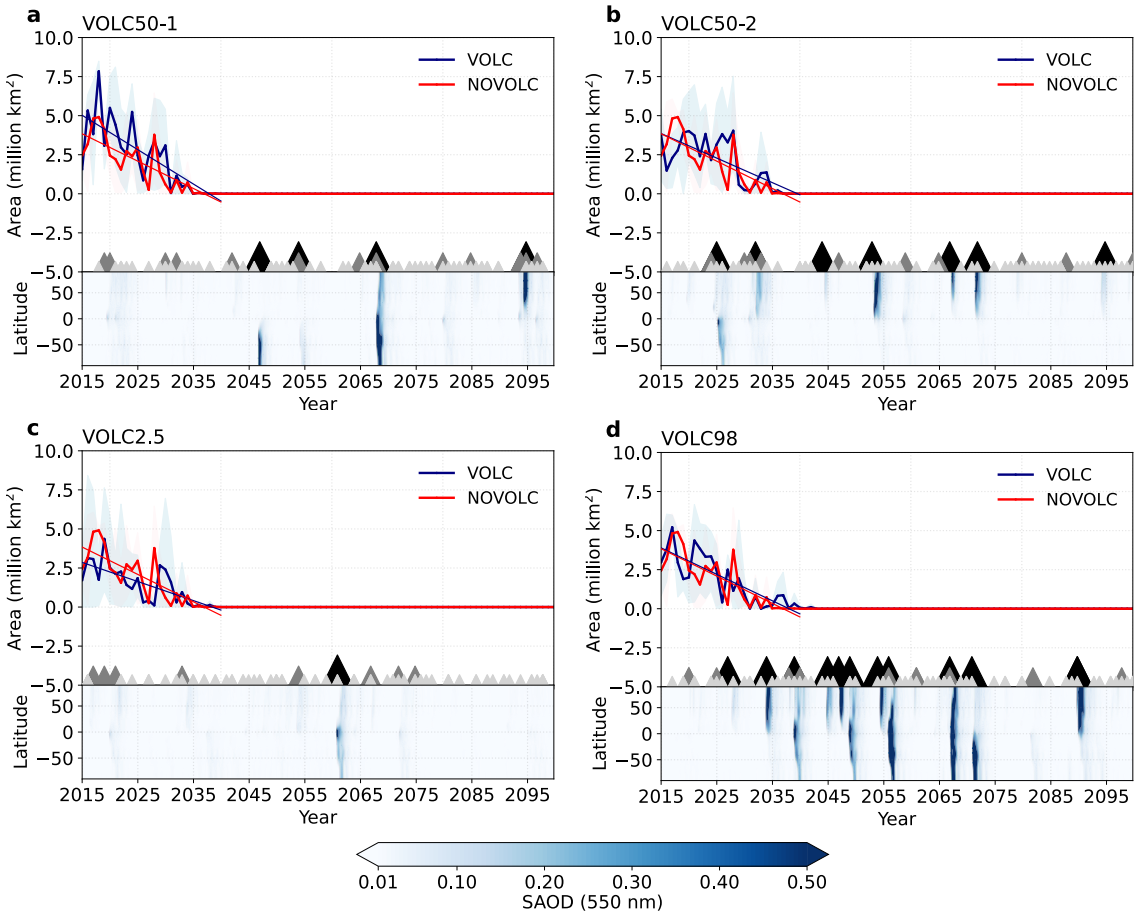

Figure S5. October-mean ozone hole area (in million km^2), for a 150DU threshold, averaged over Antarctica for (a) VOLC50-1, (b) VOLC50-2, (c) VOLC2.5, and (d) VOLC98. The solid lines show the ensemble mean values and the shading shows the values of the maximum and minimum values across the ensemble members. The triangles refer to the occurrence of eruptions in each stochastic scenario: the black triangles refer to eruptions with > 3 Tg of SO_2 injection, the grey triangles refer to eruptions with 1 to 3 Tg of SO_2 injection, and the light grey triangles refer to eruptions with 0.1 to 1 Tg of SO_2 injection. The lower panel shows the zonal mean stratospheric aerosol optical depth at 550 nm for the four VOLC runs.

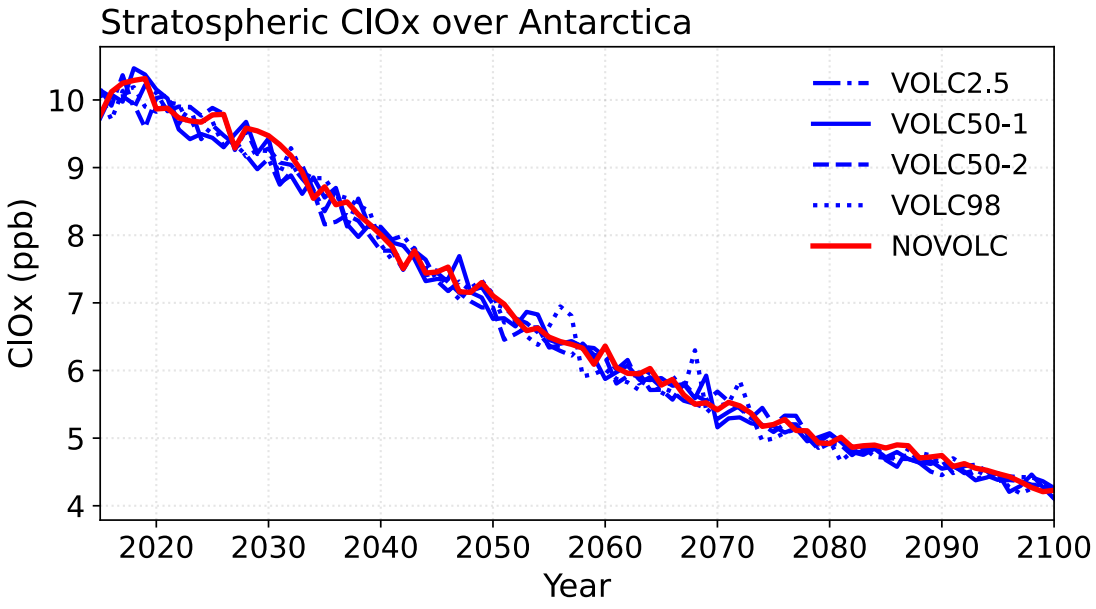

Figure S6. Annual-mean stratospheric ClOx over Antarctica (in ppb) for VOLC and NOVOLC runs, averaged over the stratosphere above the model-simulated thermal tropopause.

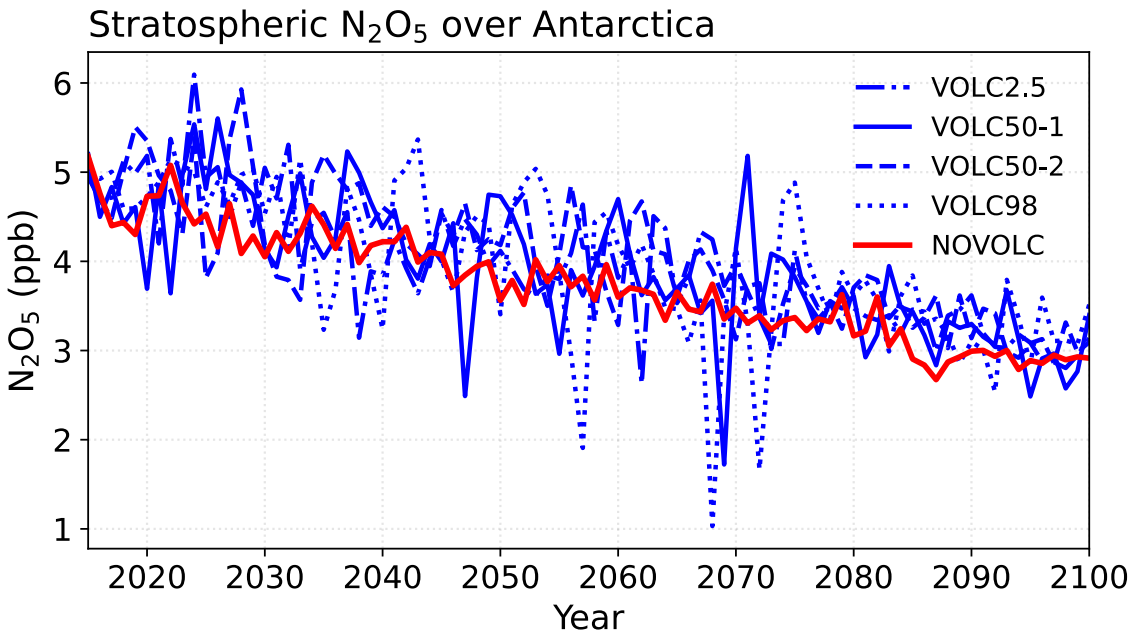

Figure S7. Annual-mean stratospheric N_2O_5 over Antarctica (in ppb) for VOLC and NOVOLC runs, averaged over the stratosphere above the model-simulated thermal tropopause.

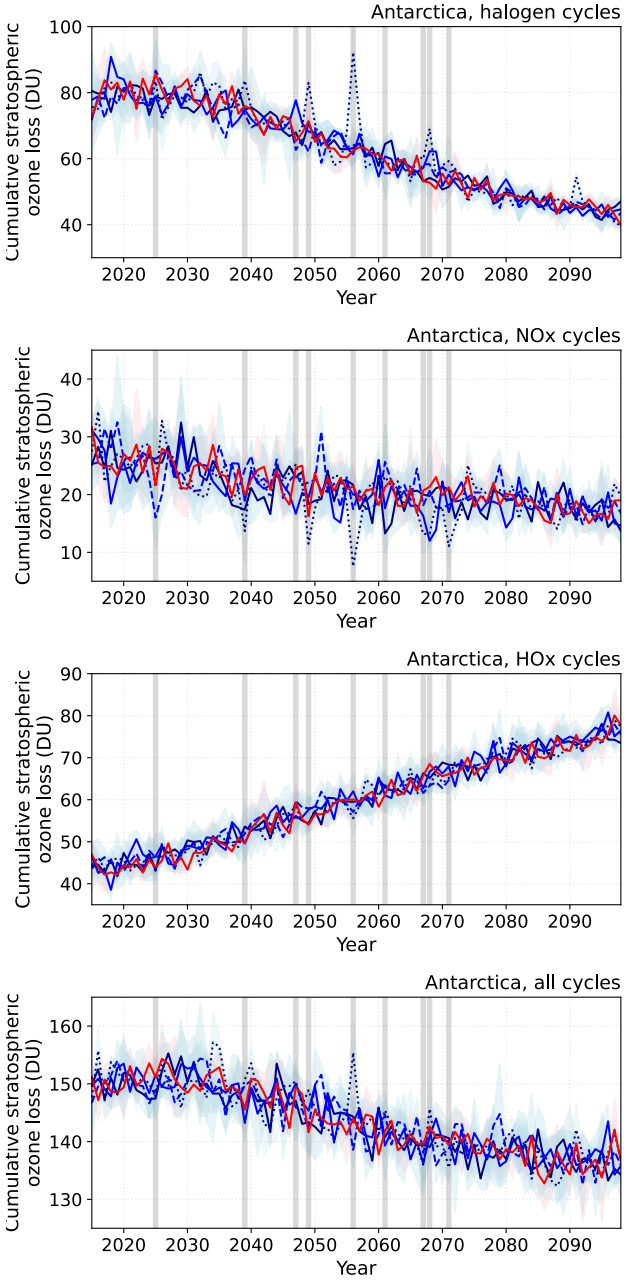

Figure S8. Cumulative stratospheric ozone loss (in DU) over Antarctica for (a) halogen cycles, (b) NOx cycle, (c) HOx cycle, and (d) the sum of all cycles (halogen + NOx + HOx). The grey vertical lines show the eruption years of the 9 selected eruptions (with stratospheric S burden > 0.2 Tg of S over Antarctica).

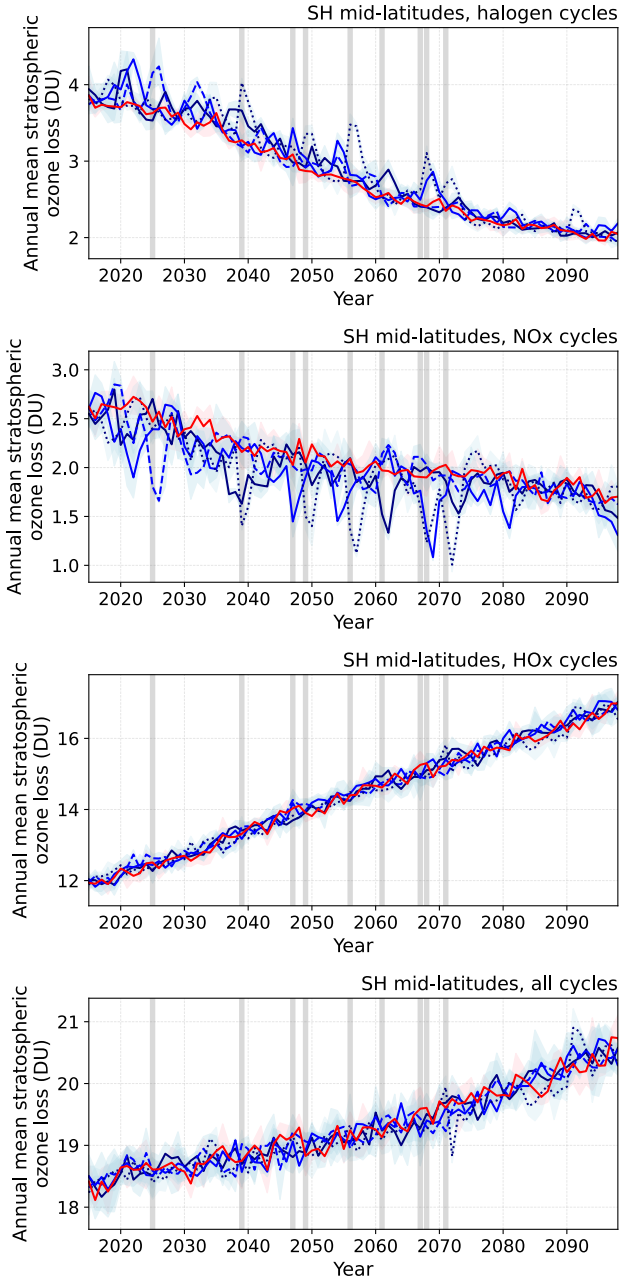

Figure S9. Annual-mean stratospheric ozone loss (in DU) over the SH mid-latitudes for (a) halogen cycles, (b) NOx cycle, (c) HOx cycle, and (d) the sum of all cycles (halogen + NOx + HOx). The grey vertical lines show the eruption years of the 9 selected eruptions (with stratospheric S burden > 0.2 Tg of S over Antarctica).

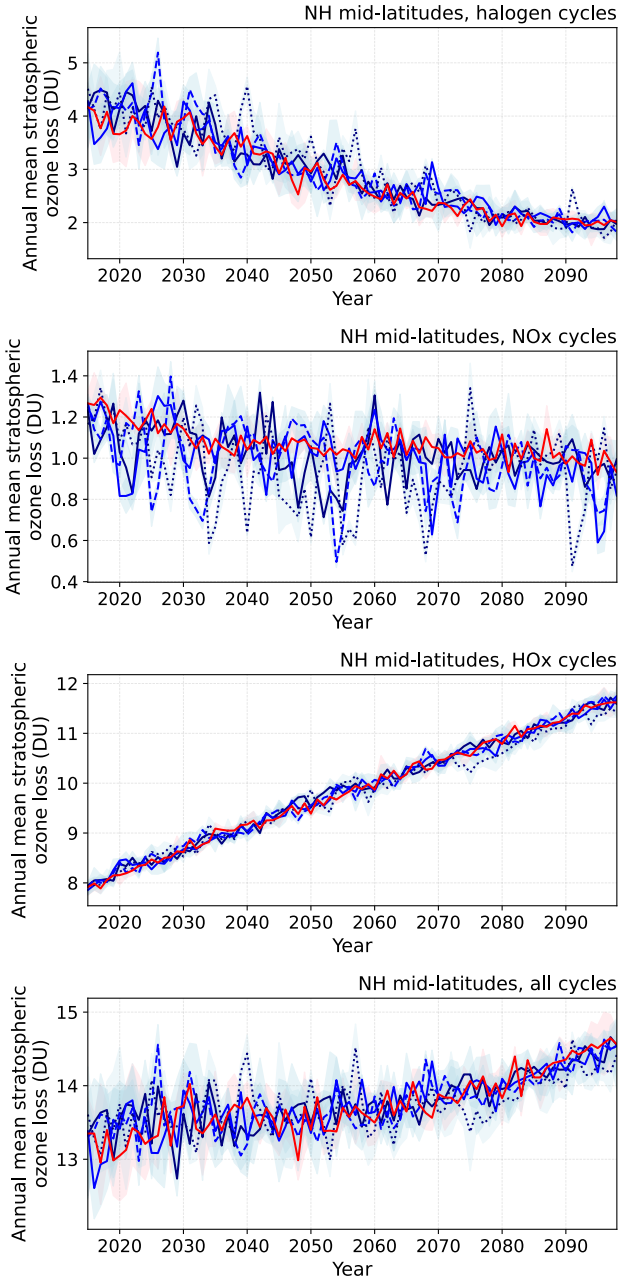

Figure S10. Annual-mean stratospheric ozone loss (in DU) over the NH mid-latitudes for (a) halogen cycles, (b) NOx cycle, (c) HOx cycle, and (d) the sum of all cycles (halogen + NOx + HOx).

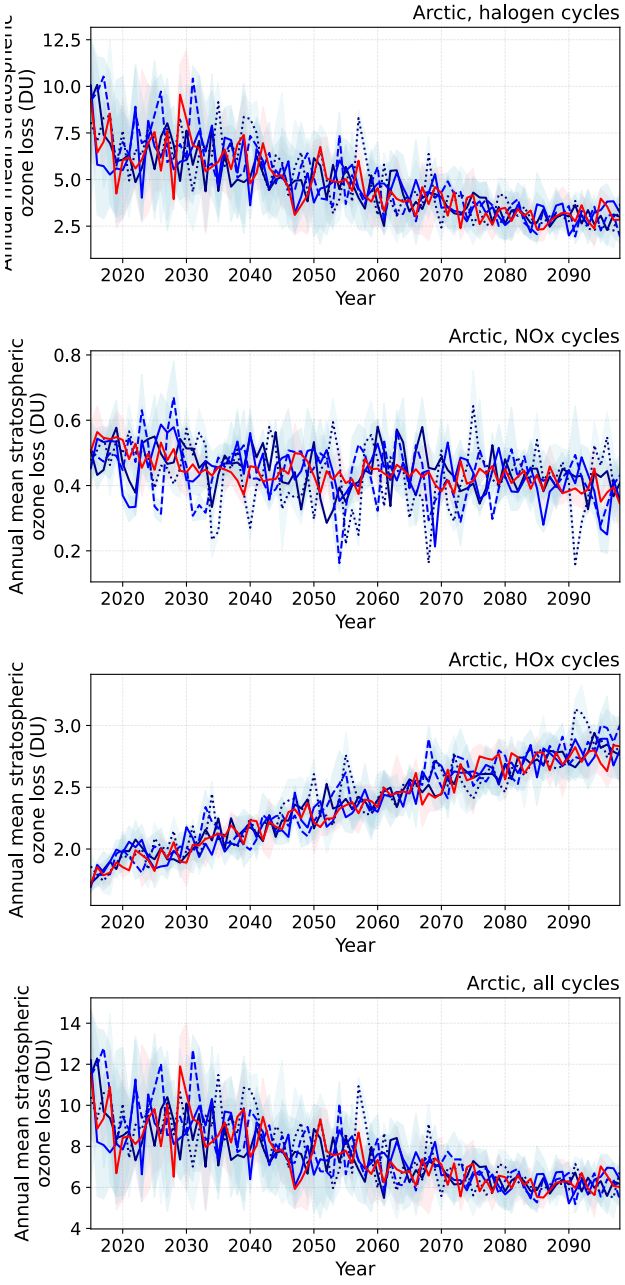

Figure S11. Annual-mean stratospheric ozone loss (in DU) over the Arctic for (a) halogen cycles, (b) NOx cycle, (c) HOx cycle, and (d) the sum of all cycles (halogen + NOx + HOx).

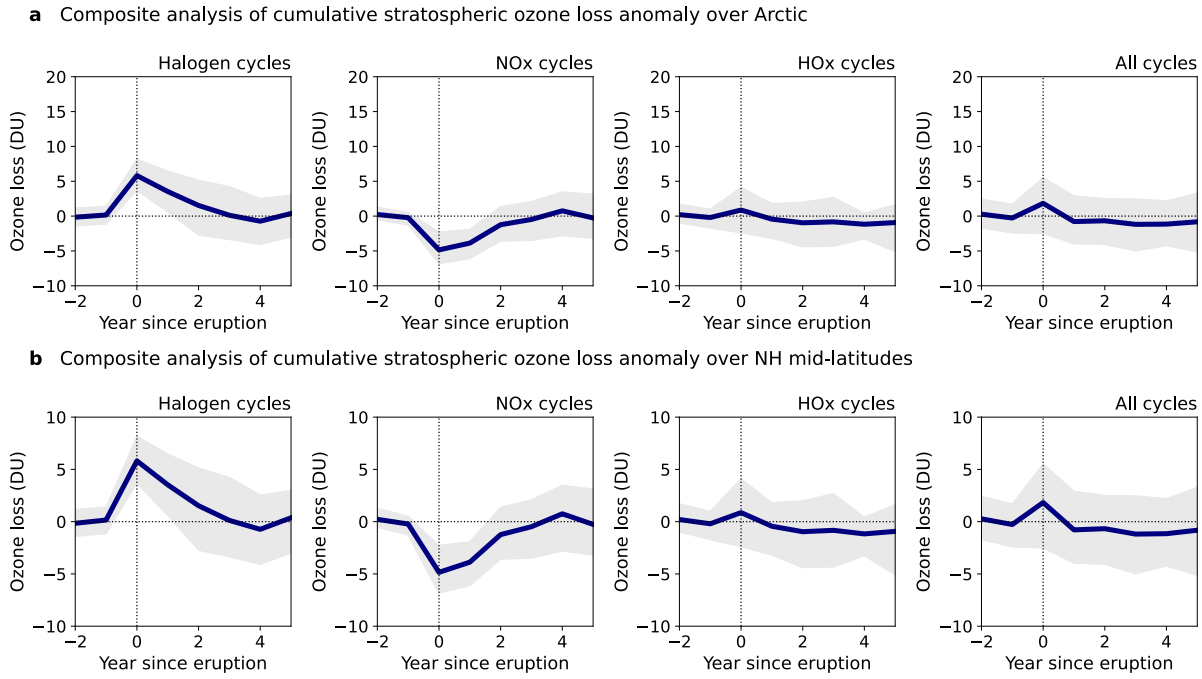

Figure S12. Composite analysis of cumulative stratospheric ozone loss anomaly relative to NOVOLC for catalytic cycles over (a) the Arctic and (b) NH mid-latitudes. The analysis includes 15 selected eruptions with stratospheric S burden > 0.5 Tg of S over the NH mid-latitudes for at least 5 months and eruption year before 2095.