

Supporting Information for "Large contribution of ozone-depleting substances to global and Arctic warming in the late 20th century"

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1. Model and simulations

1.1. CanESM5

All simulations analyzed here were performed with the “p2” variant of CanESM5.0, which includes minor bug fixes compared to the “p1” version (Swart et al., 2019). The radiation scheme of CanESM5 uses a correlated k -distribution approach to model absorption by gases and is almost identical to that described in von Salzen et al. (2013).

1.2. Forcings

Stratospheric ozone is prescribed and follows the CMIP6 protocol for models that lack interactive chemistry. Following Polvani et al. (2020), ODSs are defined as organic chlorine and bromine compounds including CFCs, hydrochlorofluorocarbons (HCFCs), halons, carbon tetrachloride, methyl chloride and methyl chloroform. In CanESM5 these are prescribed uniformly in the atmosphere by time-dependent CFC-11* and CFC-12 concentrations, where CFC-11* is a linear combination of CFC-11 and 25 other halocarbons (CF_4 , C_2F_6 , C_6F_{14} , HFC-23, HFC-32, HFC-43-10, HFC-125, HFC-134a, HFC-143a, HFC-227ea, HFC-245fa, SF_6 , CFC-113, CFC-114, CFC-115, CCl_4 , CH_3CCl_3 , HCFC-22, HCFC-141B, HCFC-142B, Halon-1211, Halon-1301, Halon-2402, CH_3Br and CH_3Cl), weighted by their radiative efficiency relative to CFC-11. We note that while HFCs are not always included in ODSs (because they do not deplete ozone), their change in ERF over the 1955 to 2005 period is very small ($\sim 0.01 \text{ W/m}^2$).

1.3. AR6 Effective Radiative Forcing

ERFs reported in AR6, the IPCC Sixth Assessment Report, were calculated from modeled and observational data. For many components of the total forcing (well-mixed GHGs,

land-use change, solar variability, volcanic stratospheric aerosol and minor anthropogenic forcings), a best estimate time series is derived, and uncertainty is introduced using a 100,000 member Monte Carlo ensemble that scales the best estimate time series by a factor that is governed by the uncertainty in each forcing as assessed in P. Forster et al. (2021). For aerosol and ozone forcing, the influence of how individual precursors combine is also varied using a 100,000 member Monte Carlo ensemble while preserving the total forcing uncertainty from preindustrial to present-day (which affects the historical trajectory of these more uncertain short-lived forcings alongside the present-day magnitude). The total forcing in each ensemble member sums up the contributions assuming they are independent. The 5th and 95th percentiles of the 100,000 ensemble members provide the AR6 uncertainties. For the uncertainty in the ODS ERF we use the AR6 assessed value of 19% for long-lived halogenated gases, as the majority of the halogenated species are long-lived.

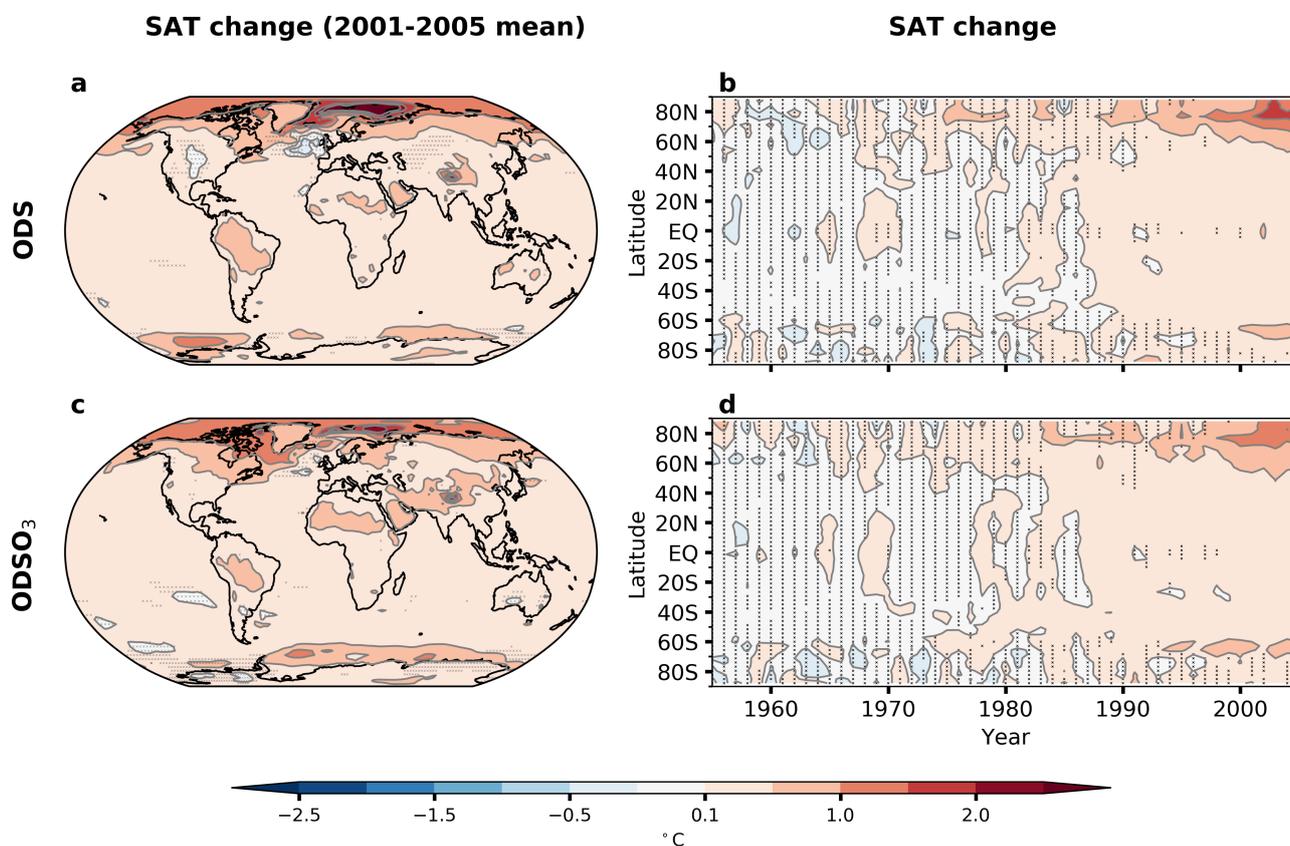


Figure S1. The (left) surface air temperature (SAT) and (right) zonal mean SAT response to (a,b) ODSs and (c,d) ODSs and stratospheric ozone. Crosses indicate gridpoints with changes that are not statistical significant at the 95% level.