Extended data for

“Summer precipitation and wildfire changes in Siberia induced by stratospheric ozone”

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The extended data include:

Extended Data Tables 1–3

Extended Data Figs. 1–7

Extended Data Table 1: CESM-WACCM sensitivity experiments with various specified ozone forcings.

Experiment	Specified ozone forcings
SE1	Sensitivity run using the standard case ‘F_2000_WACCM_SC’ in CESM, which is a global climate model that incorporates an interactive atmosphere (WACCM) component, data ocean and sea ice, land (CLM); this case is always used to reproduce the 2000 climatic state. All natural and anthropogenic external forcings for SE1 are based on the original CESM input data. The specified ozone forcing is named ‘waccm_ozone_c121126.nc’ with 12-month seasonal cycle. The integration time is 43 years, with the first 3 years for spin-up and 40 years for the sensitivity analysis.
SE2	All forcings and experiment design are as in SE1, except that the ozone in the region 0°–90°N, 0–360°, 1000–0.1 hPa was increased by 20% in summer. Ozone outside of this region is the same as in SE1.

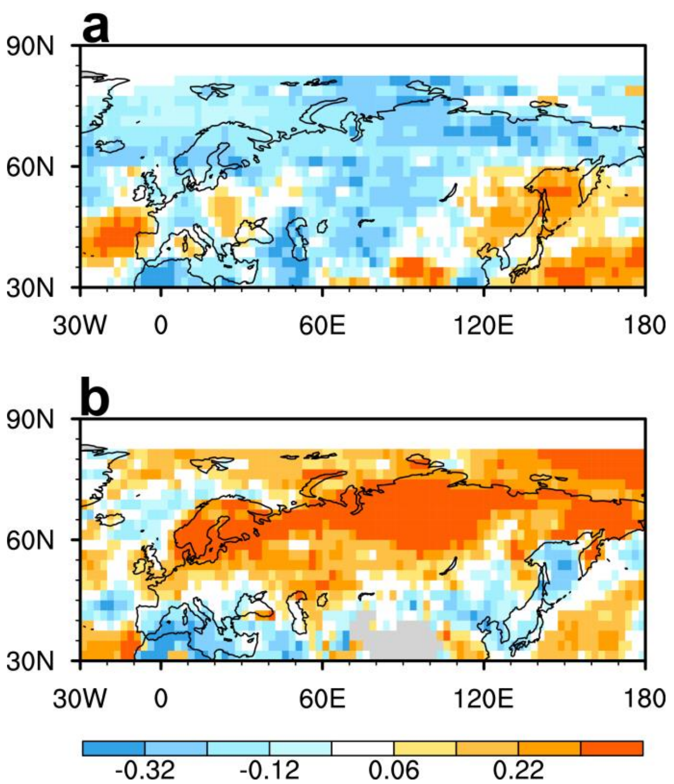
Extended Data Table 2: Selected models and ensemble experiments for the CMIP6 projected experiments.

Model	Scenario	Atmos-Chem	Top level	Variant label
CESM-WACCM	SSP245	MAM4	4.5e–06 hPa	r1i1p1f1, r2i1p1f1, r3i1p1f1
CNRM-CM6-1	SSP245	OZL_v2	78.4 km	r1i1p1f2, r2i1p1f2, r3i1p1f2, r4i1p1f2, r5i1p1f2
CNRM-ESM2-1	SSP245	REPROBUS-C_v2	78.4 km	r1i1p1f2, r2i1p1f2, r3i1p1f2, r4i1p1f2, r5i1p1f2
EC-Earth3-AerChem	SSP370 (no SSP245)	TM5	0.01 hPa	r1i1p1f1, r3i1p1f1,
GISS-E2-2-G	SSP245	GPUCCINI	0.002 hPa	r1i1p3f1, r2i1p3f1, r3i1p3f1, r4i1p3f1, r5i1p3f1
IPSL-CM5A2-INCA	SSP370 (no SSP245)	INCA v6 NMHC-AER-S	80 km	r1i1p1f1
MPI-ESM-1-2-HAM	SSP370 (no SSP245)	Sulfur Chemistry	0.01 hPa	r1i1p1f1, r2i1p1f1
MRI-ESM2-0	SSP245	MRI-CCM2.1	0.01 hPa	r1i1p1f1, r2i1p1f1, r3i1p1f1, r4i1p1f1
UKESM1-0-LL	SSP245	UKCA-StratTrop	85 km	r1i1p1f2, r2i1p1f2, r3i1p1f2, r4i1p1f2, r8i1p1f2

Extended Data Table 3: CESM-WACCM transient experiment with various specified ozone forcings.

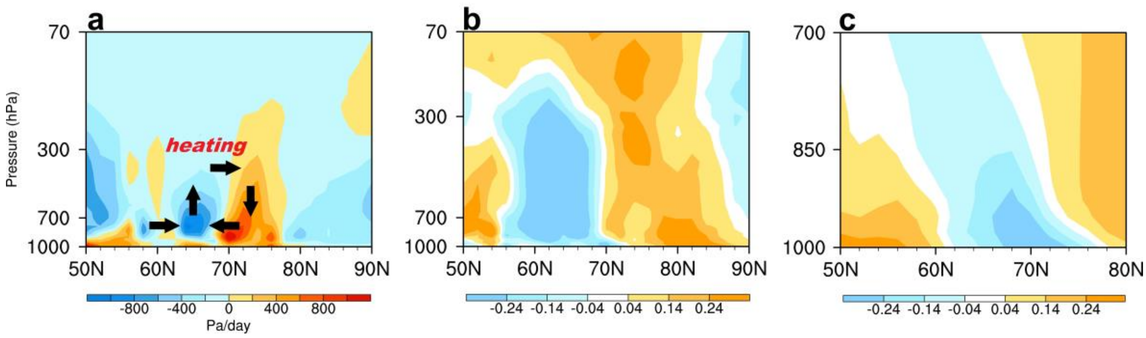
Experiment	Specified ozone forcings
TE1	Transient run using the standard case ‘B_RCP45_WACCM_SC_CN’ in CESM, which is a fully coupled global climate model that incorporates an interactive atmosphere (WACCM) component, ocean (POP), land (CLM), and sea ice (CICE). All natural and anthropogenic external forcings for TE1 are based on the original CESM input data. The specified ozone forcing is named ‘ghg_forcing_RCP45_2005-2099_CMIP5_EnsMean.c140411.nc’. The ozone concentration in the region 0°–90°N, 0–360°, 1000–0.1 hPa from 2005–2055 recycles 2005 values, and ozone outside of this region isn’t modified. The experiment ran from 2005 to 2055 (51 years).

Extended Data Fig. 1: Relationships between the UTLS temperature and high and low–medium clouds in summer.



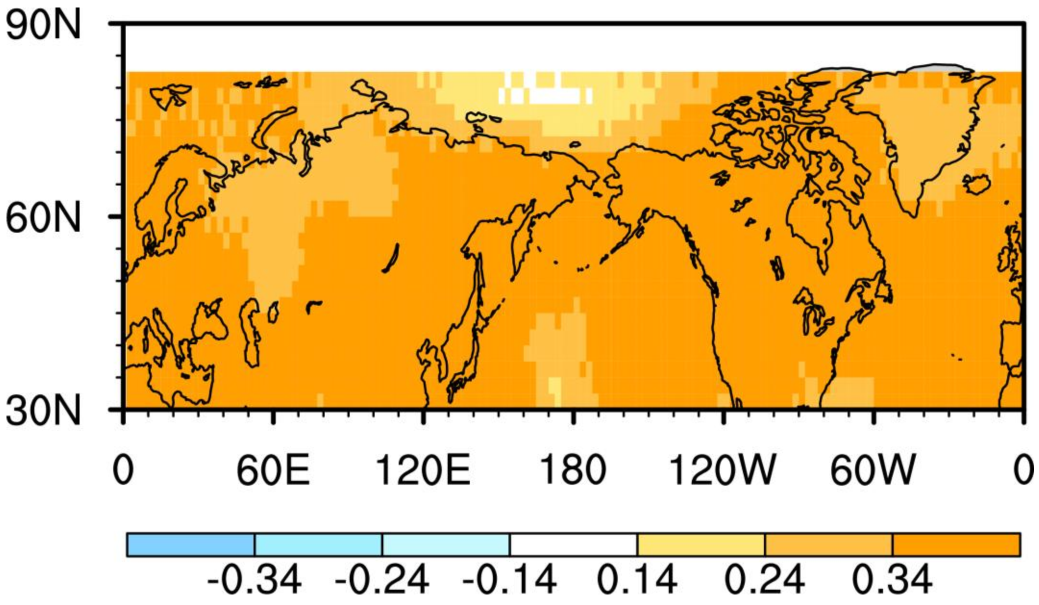
a. Distribution of correlation coefficients between each grid point of CERES high cloud cover and the corresponding grid point of MSU/AMSU RSS UTLS temperature (~200 hPa) variations from 2000 to 2020 in summer. b. Same as a, but between CERES low–medium cloud cover and the MSU/AMSU RSS UTLS temperature variations. Correlation coefficients of >0.32 are significant at the 99% confidence level.

Extended Data Fig. 2: Polar circulation variations related to the UTLS temperature.



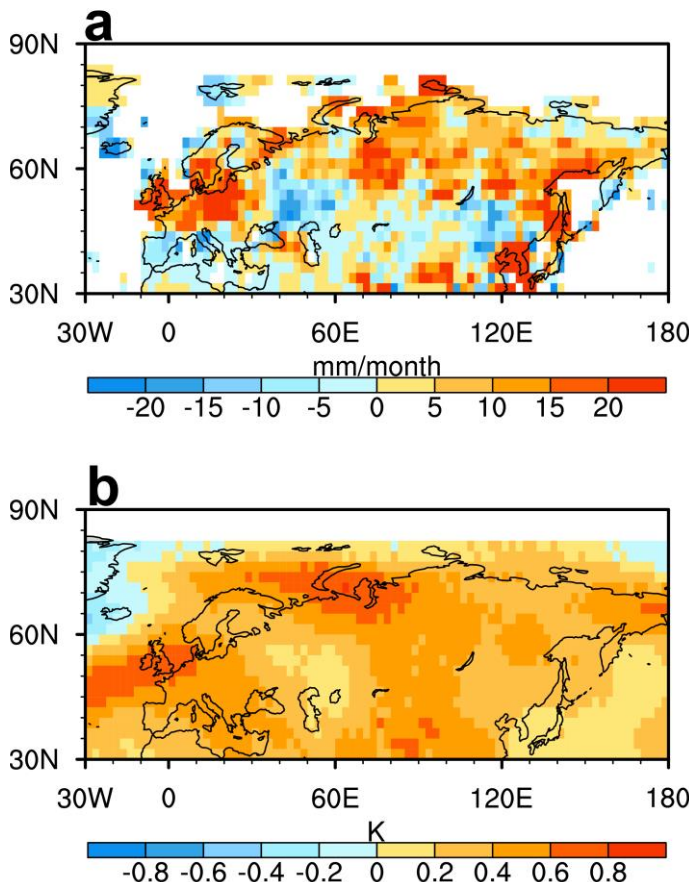
a. Climatology of ERA5 zonal mean omega (60°E–180° average) from 1985 to 2020 in summer; the black arrows represent the polar circulation. b. Distribution of correlation coefficients between the ERA5 zonal mean omega and UTLS temperature (200 hPa, 60°E–180° and 55°–70°N average) from 1985 to 2020 in summer. c Same as b, but between the ERA5 zonal mean meridional wind (60°E–180° average) and UTLS temperature. Correlation coefficients of >0.24 are significant at the 99% confidence level using Student's *t*-test.

Extended Data Fig. 3: Relationship between the lowermost stratospheric ozone and UTLS temperature in summer.



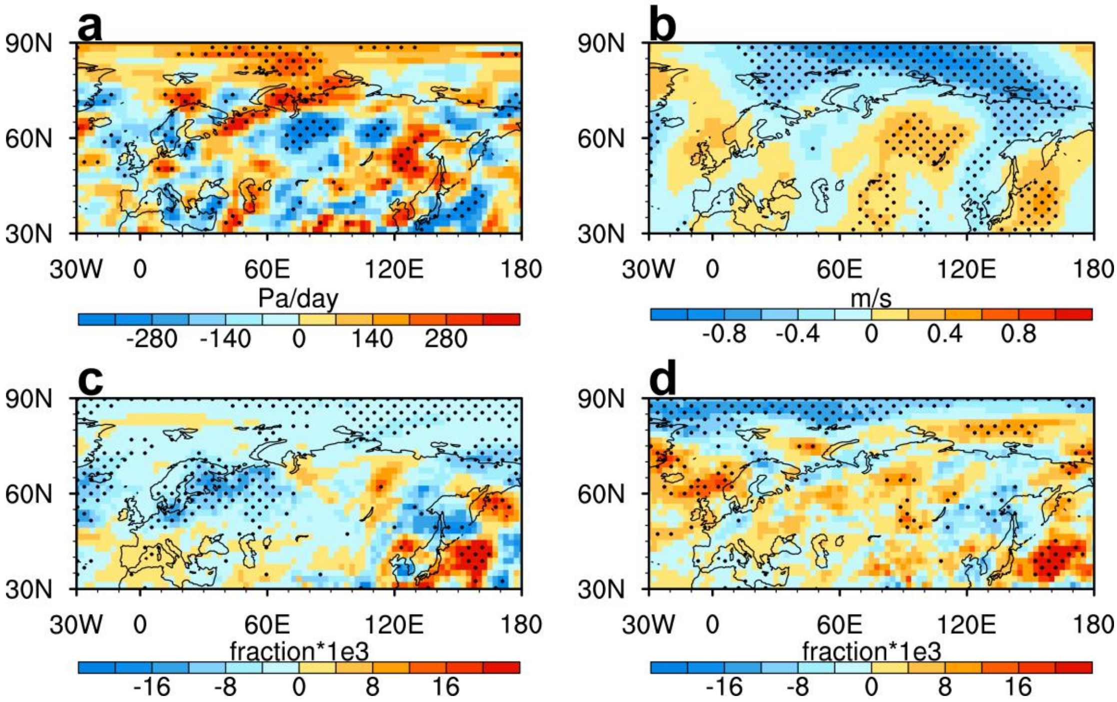
Distribution of correlation coefficients between SWOOSH lowermost stratospheric ozone (averaged over the region 100–300 hPa, 0°–360° and 55°–90°N) and the MSU/AMSU RSS UTLS temperature (~200 hPa) variations from 1985 to 2020 in summer. Correlation coefficients of >0.24 are significant at the 99% confidence level.

Extended Data Fig. 4: Changes of observed precipitation and UTLS temperature from 1990 to 2010.



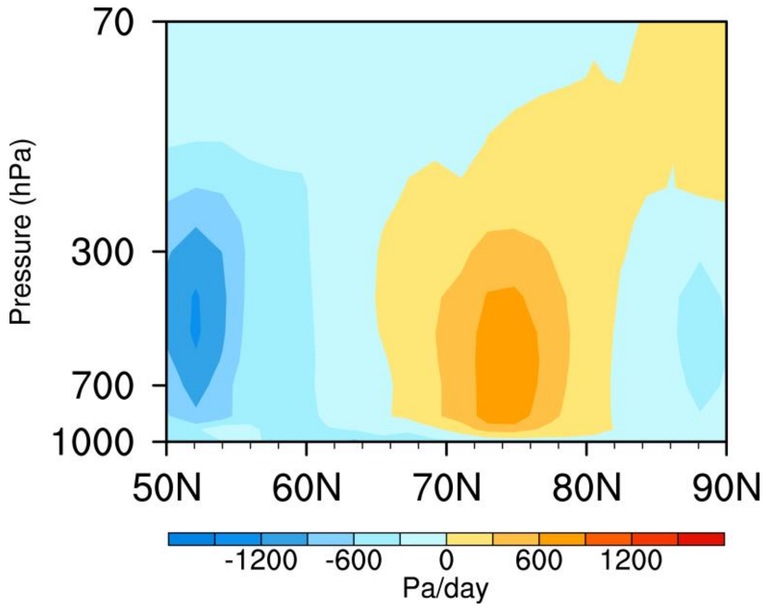
a. GPCC precipitation changes. b. The MSU/AMSU RSS UTLS temperature (~200 hPa) changes. The changes were obtained from (2009–2012) minus (1988–1991).

Extended Data Fig. 5: Simulated responses of omega, meridional wind, and cloud to the Northern Hemisphere stratospheric ozone increase in summer.



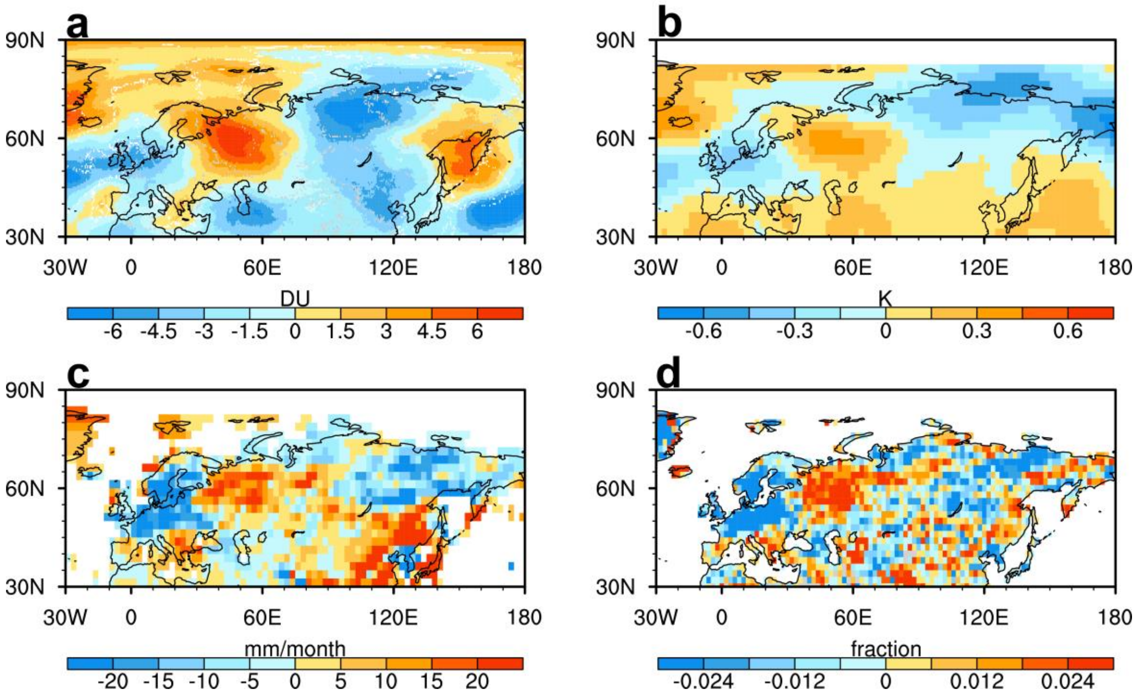
Simulated anomalies of (a) 500 hPa omega, (b) 700 hPa meridional wind, (c) 200 hPa cloud, and (d) 500 hPa cloud over northern Eurasia caused by the summer ozone increase. The anomalies were obtained by subtracting the CESM-WACCM simulation SE1 from SE2 (see Extended Data Table 1 for details). Dotted regions represent anomalies that are significant at the 95% confidence level (Student's *t*-test).

Extended Data Fig. 6: Simulated climatology of zonal mean omega in summer based on CESM-WACCM.



Climatology of zonal mean omega (60°E–180° average) based on CESM-WACCM. Data are from experiment SE1 (see the Extended Data Table 1).

Extended Data Fig. 7: Changes of observed total ozone column, UTLS temperature, precipitation, and soil moisture from 2010 to 2020.



a. The MSR-2 total ozone column changes. b. The MSU/AMSU RSS UTLS temperature (~200 hPa) changes. c. GPCC precipitation changes. d. ERA5 soil moisture (0–28cm) changes. The changes were obtained from (2017–2020) minus (2009–2012).