

## Constraining human contributions to observed warming since preindustrial: Supplementary Information

Dataset	GMST warming	GSAT warming
HadCRUT4	0.94 (0.90–0.99)	1.10 (1.01–1.20)
GISTEMP	1.05	1.18
NOAA	0.96	1.12

**Supplementary Table 1: Observed warming in 2010–2019 relative to 1850–1900 in three observational datasets in °C.** GISTEMP and NOAA GlobalTemp datasets were concatenated with HadCRUT4 anomalies for the period 1850–1879, since these datasets start in 1880. The GMST column shows the mean warming in these datasets. The GSAT column shows the corresponding warming in globally-complete GSAT, estimated by multiplying the GMST warming by the multi-model mean ratio of globally-complete GSAT to masked GMST warming in the historical-ssp245 simulations of the thirteen models used here, using the masking pattern for the corresponding observational dataset. The bracketed range for HadCRUT4 GMST is the 5–95% ranges across ensemble members. The bracketed 5–95% range for HadCRUT4 GSAT was derived by bootstrapping, sampling from the HadCRUT4 ensemble and the ratio of GSAT to GMST warming in individual CMIP6 simulations, with equal weight given to each model.

Model name	historical -ssp245	hist-nat	hist-GHG	hist-aer	hist- stratO3	hist-sol	hist-volc	hist-CO2
ACCESS-ESM1-5	3	3	2	3				
BCC-CSM2-MR	1	3	3	3				
CanESM5	50	50	50	30	10	50	50	10
CESM2	3	2	1	2				
CNRM-CM6-1	6	10	10	10				
FGOALS-g3	4	3	3	3				
GFDL-ESM4	3	3	1	1				
GISS-E2-1-G	10	5	5	5				
HadGEM3-GC31	4	4	4	4				
IPSL-CM6A-LR	11	10	10	10	10			
MIROC6	3	3	3	3	3	3	3	3
MRI-ESM2-0	5	5	5	5	3	5		
NorESM2-LM	2	3	3	3				

**Supplementary Table 2: CMIP6 historical<sup>12</sup>, SSP2-4.5<sup>13</sup> and DAMIP<sup>18</sup> simulations used and associated ensemble sizes.** In each case, the ensemble size used is determined by the number of simulations for which monthly mean tas, tos and siconc are available for the period 1850–2020. Historical simulations over the period 1850–2014 were merged with corresponding ssp245 simulations for the period 2015–2019 (historical-ssp245). Note that historical-ssp245 simulations from both p1 and p2 versions of CanESM5 were used together. These model versions employ different methods of interpolation of wind stress at the ocean surface, but exhibit indistinguishable global mean temperature responses to CO<sub>2</sub> increases<sup>21</sup>. Based on data availability, f2 simulations were used from CNRM-CM6-1, f2 simulations were used from GISS-E2-1-G, and f3 simulations were used from HadGEM3-GC31-LL, and in all other cases p1 model version and f1 forcing version simulations were used. Since the hist-nat, hist-aer and hist-GHG simulations of CESM2 and GISS-E2-1-G finished in 2014, they were concatenated with the corresponding ssp245-nat, ssp245-aer and ssp245-GHG simulations respectively.