Emergent Constraints on Carbon Budgets for the Paris Climate Targets

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Supplementary Material

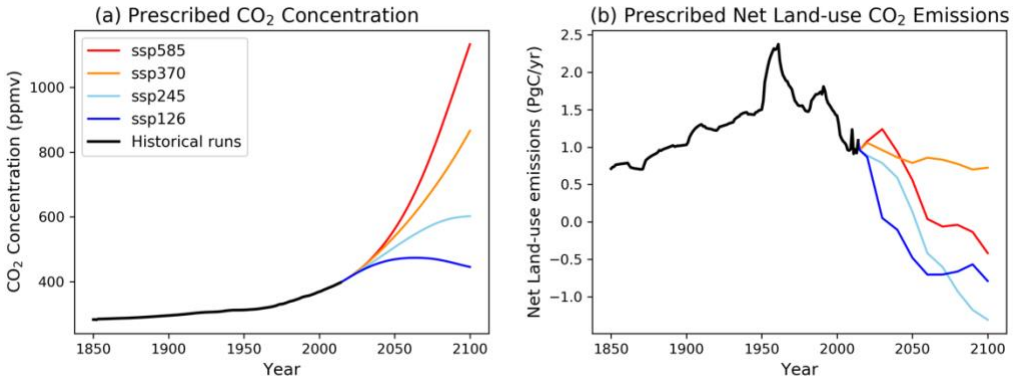

Figure S1: Prescribed inputs to the CMIP6 ESM runs: (a) global mean atmospheric CO_2 concentration; (b) net carbon emissions from land-use change. Black lines show the prescribed historical data (1850-2014) and coloured lines represent each of the four ssp scenarios (2015-2100).

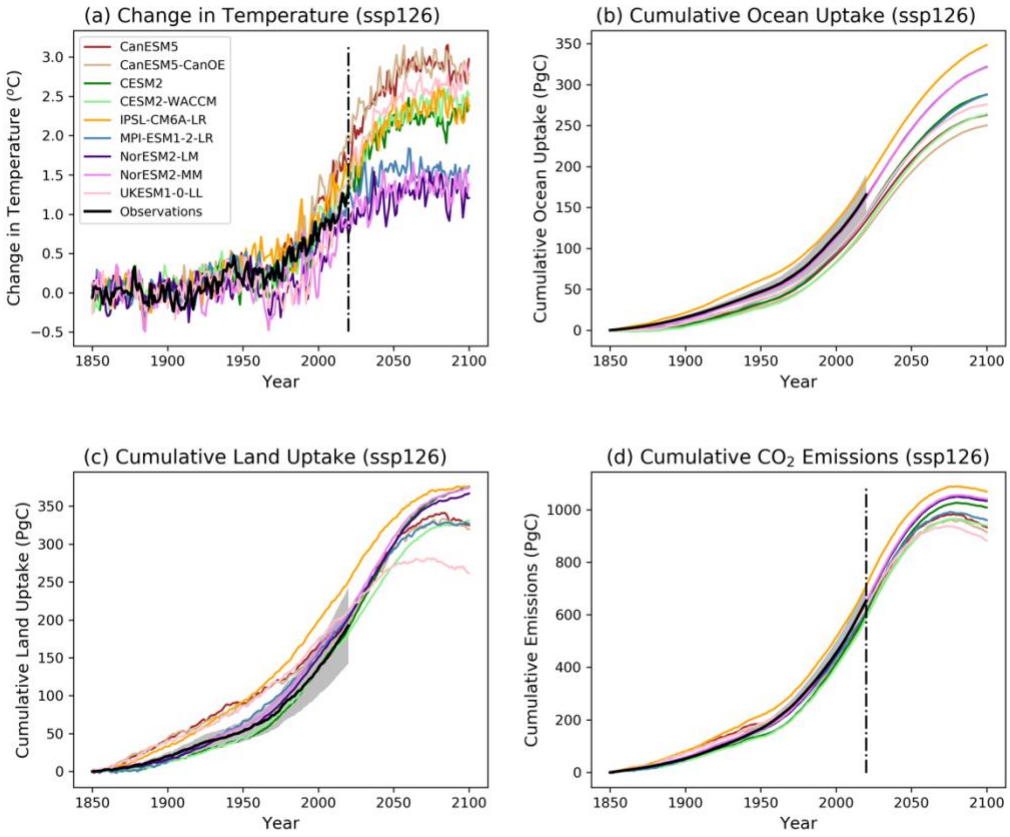

Figure S2: As figure 1 but for the SSP126 scenario, annual global mean anomalies relative to the 1850-1899 mean: (a) temperature change; (b) cumulative ocean carbon uptake; (c) cumulative land carbon uptake; (d) implied cumulative emissions (diagnosed using equation 1). Each coloured line represents a different CMIP6 Earth System Model (ESM) as identified in the key on panel (a). The thick black line in panel (a) is the observational estimate from IPCC AR6 WG1 Chapter 2[28]. The thick black lines in panels (b)-(d) represent observational estimates from the Global Carbon Project[11], with grey bands showing the estimated standard error in these values (see Methods for details).

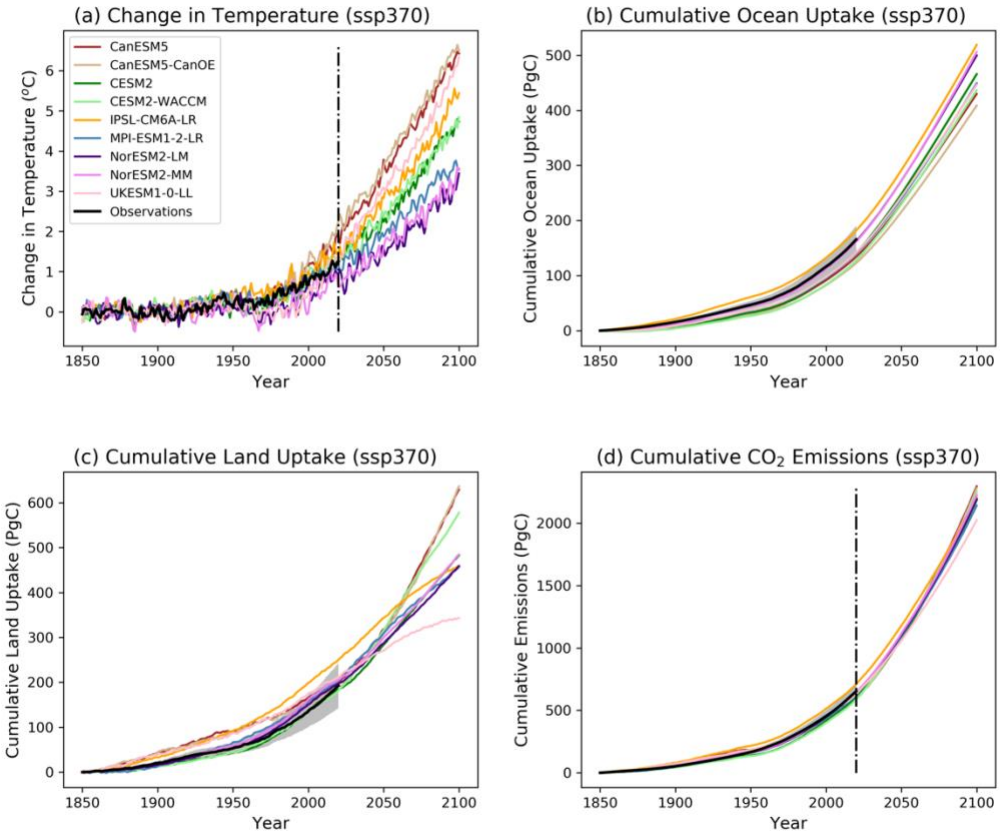

Figure S3: As figure 1 but for the SSP370 scenario, annual global mean anomalies relative to the 1850-1899 mean: (a) temperature change; (b) cumulative ocean carbon uptake; (c) cumulative land carbon uptake; (d) implied cumulative emissions (diagnosed using equation 1). Each coloured line represents a different CMIP6 Earth System Model (ESM) as identified in the key on panel (a). The thick black line in panel (a) is the observational estimate from IPCC AR6 WG1 Chapter 2[28]. The thick black lines in panels (b)-(d) represent observational estimates from the Global Carbon Project[11], with grey bands showing the estimated standard error in these values (see Methods for details).

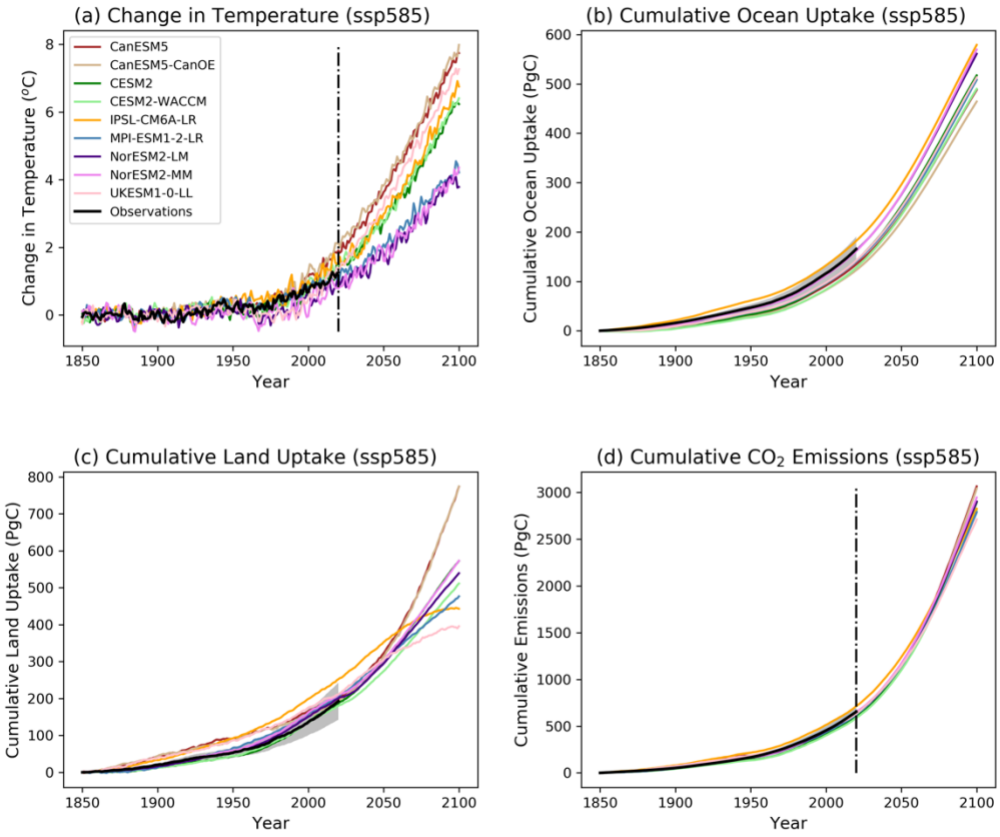

Figure S4: As figure 1 but for the SSP585 scenario, annual global mean anomalies relative to the 1850-1899 mean: (a) temperature change; (b) cumulative ocean carbon uptake; (c) cumulative land carbon uptake; (d) implied cumulative emissions (diagnosed using equation 1). Each coloured line represents a different CMIP6 Earth System Model (ESM) as identified in the key on panel (a). The thick black line in panel (a) is the observational estimate from IPCC AR6 WG1 Chapter 2[28]. The thick black lines in panels (b)-(d) represent observational estimates from the Global Carbon Project[11], with grey bands showing the estimated standard error in these values (see Methods for details).

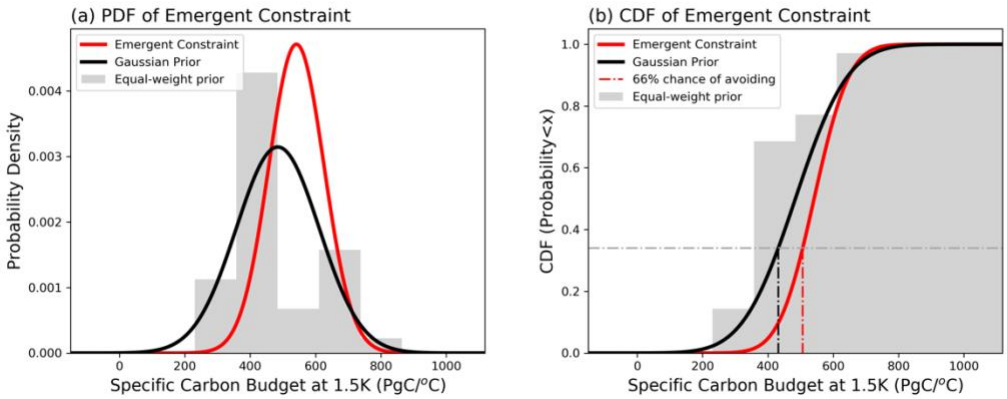

Figure S5: As figure 3 but for 1.5°C, emergent constraint on the specific carbon budget: (a) probability density function (PDF); (b) cumulative distribution function (CDF). The grey histograms show the distributions derived from the equal-weighted raw model output, and the black line is a Gaussian with the same mean and standard deviation. The thick red line shows the emergent constraint on the distribution.

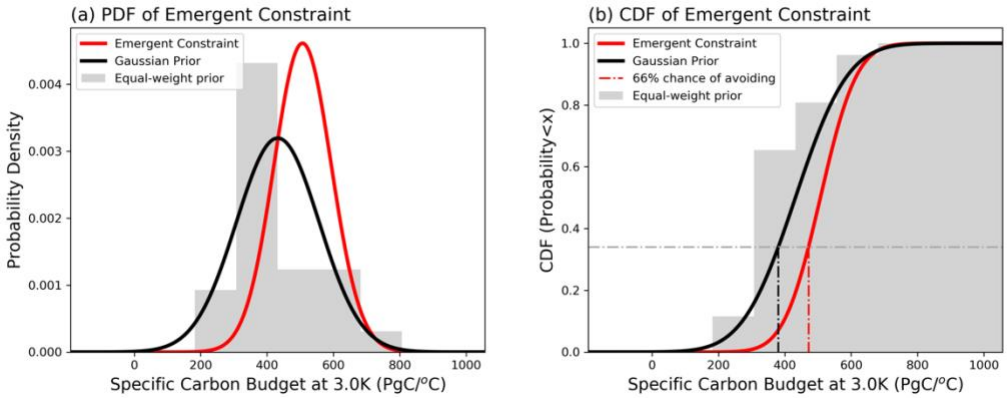

Figure S6: As figure 3 but for 3°C, emergent constraint on the specific carbon budget: (a) probability density function (PDF); (b) cumulative distribution function (CDF). The grey histograms show the distributions derived from the equal-weighted raw model output, and the black line is a Gaussian with the same mean and standard deviation. The thick red line shows the emergent constraint on the distribution.

Global Warming (K)	Carbon Budget (PgC)	
	Median	*Likely range*
1.0	588	[513, 664]
1.1	635	[555, 716]
1.2	674	[583, 766]
1.3	729	[621, 838]
1.4	772	[660, 884]
1.5	812	[691, 933]
1.6	848	[723, 974]
1.7	895	[761, 1030]
1.8	947	[797, 1097]
1.9	998	[841, 1157]
2.0	1048	[881, 1216]
2.1	1088	[914, 1263]
2.2	1143	[955, 1335]
2.3	1169	[979, 1361]
2.4	1220	[1024, 1419]
2.5	1272	[1065, 1480]
2.6	1321	[1107, 1537]
2.7	1357	[1137, 1581]
2.8	1406	[1173, 1642]
2.9	1468	[1231, 1711]
3.0	1520	[1274, 1771]
3.1	1576	[1315, 1836]
3.2	1594	[1335, 1858]
3.3	1642	[1374, 1915]
3.4	1693	[1415, 1983]
3.5	1750	[1457, 2053]
3.6	1802	[1495, 2119]
3.7	1853	[1538, 2180]
3.8	1893	[1574, 2227]
3.9	1952	[1616, 2305]
4.0	2023	[1663, 2400]

Table S1: as Table 1, but including intermediate levels of global warming and (weakly) asymmetric likely ranges.