

1 The climate effects of increasing ocean albedo: An idealized representation of solar  
2 geoengineering  
3 (Supplemental Online Material)  
4

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39 **Table S1.** Change in top-of-atmosphere net radiative flux (calculated as a difference  
40 from piControl), averaged over years 11-50. Units are in  $W m^{-2}$ . In each box, the top  
41 value is the global mean, the middle value is the land mean, and the bottom value is  
42 the ocean mean.  
43

	abrupt4xCO2	G1	G1ocean-Albedo
BNU-ESM	2.7034	0.0225	0.3902
	3.0115	1.1062	8.6776
	2.5737	-0.4334	-3.0965
CanESM2	2.6143	0.0157	-0.2090
	0.9064	0.2731	7.8560
	3.3572	-0.0964	-3.7167
CESM-CAM5.1-FV	2.6255	-0.1285	-1.4300
	3.4981	2.0866	7.6058
	2.2672	-1.0379	-5.1396
CSIRO-Mk3L-1.2	2.6297	0.1231	0.0185
	0.4771	0.6013	6.4003
	3.5258	-0.0758	-2.6378
EC-Earth	2.2190	-0.2027	-0.1969
	0.3640	0.0434	5.7491
	2.1971	-0.2245	-2.5721
GISS-E2-R	2.4457	-0.1763	-0.0461
	-0.7055	-1.1029	5.0568
	3.7458	0.2059	-2.1515
HadGEM2-ES	2.4941	0.1978	-0.0694
	2.9576	2.5157	10.1434
	2.3075	-0.7363	-4.1839
IPSL-CM5A-LR	2.8225	0.0842	-0.0730
	-0.0944	0.1188	6.6513
	4.0603	0.0695	-2.9265
MIROC-ESM	3.6240	0.2318	0.1329
	2.7807	-0.4711	9.4762
	3.6263	0.2337	0.1060
MPI-ESM-LR	2.7332	0.1576	0.0220
	1.2825	1.8587	8.9188
	3.3211	-0.5319	-3.5837
NorESM1-M	2.4198	-0.0120	-0.0986
	3.6437	1.4902	8.2321
	1.9218	-0.6234	-3.4879
Model mean	2.6665	0.0285	-0.1417
	1.6474	0.7745	7.7061
	2.9913	-0.2955	-3.0355

44

45 **Table S2.** Temperature trend for each model over years 11-50, as calculated by  
 46 ordinary linear regression. Units are in K per decade. In each box, the top value is  
 47 the global mean, the middle value is the land mean, and the bottom value is the  
 48 ocean mean.  
 49

	abrupt4xCO2	G1	G1ocean-Albedo
BNU-ESM	0.2702	0.0450	0.0441
	0.2830	0.0877	0.0630
	0.2649	0.0270	0.0361
CanESM2	0.2881	-0.0359	-0.0124
	0.3193	-0.0353	0.0086
	0.2745	-0.0362	-0.0215
CESM-CAM5.1-FV	0.2230	-0.0221	-0.0088
	0.2195	-0.0431	-0.0169
	0.2244	-0.0135	-0.0056
CSIRO-Mk3L-1.2	0.2395	0.0152	-0.0169
	0.2631	0.0185	-0.0184
	0.2297	0.0138	-0.0162
EC-Earth	0.2600	-0.0383	0.0369
	0.2890	-0.0400	0.0457
	0.2484	-0.0376	0.0334
GISS-E2-R	0.1029	0.0091	-0.0373
	0.0922	0.0097	-0.0408
	0.1073	0.0088	-0.0359
HadGEM2-ES	0.2976	0.0397	0.1075
	0.3593	0.0551	0.1384
	0.2727	0.0335	0.0950
IPSL-CM5A-LR	0.3782	0.0238	-0.0486
	0.4404	0.0278	-0.0792
	0.3518	0.0220	-0.0355
MIROC-ESM	0.3391	0.0161	-0.0251
	0.4033	0.0253	-0.0216
	0.3390	0.0161	-0.0251
MPI-ESM-LR	0.2214	0.0300	0.0196
	0.2698	0.0497	0.0385
	0.2019	0.0220	0.0119
NorESM1-M	0.1852	-0.0243	-0.0592
	0.2180	-0.0352	-0.0546
	0.1718	-0.0199	-0.0611
Model mean	0.2550	0.0053	-0.0000
	0.2870	0.0109	0.0057
	0.2442	0.0033	-0.0022

50

51 **Table S3.** Change (from piControl) in albedo as measured at the top of the  
 52 atmosphere, averaged over years 11-50 of simulation. Calculations are differences  
 53 in ratios of upward to downward shortwave radiative flux at TOA. Values in each  
 54 box are (in order) ensemble minimum, ensemble mean, and ensemble maximum.  
 55 All values are rounded to four decimal places.  
 56

	Global	Land	Ocean
abrupt4xCO2	-0.0243	-0.0293	-0.0239
	-0.0130	-0.0192	-0.0104
	0.0017	0.0031	0.0011
G1	-0.0096	-0.0130	-0.0110
	-0.0067	-0.0074	-0.0065
	-0.0036	0.0003	-0.0036
G1ocean-Albedo	-0.0036	-0.0271	0.0061
	0.0145	-0.0068	0.0233
	0.0232	0.0033	0.0334

57

58 **Table S4.** Change (from piControl) in surface albedo, averaged over years 11-50 of  
 59 simulation. Calculations are differences in ratios of upward to downward  
 60 shortwave radiative flux at the surface. Values in each box are (in order) ensemble  
 61 minimum, ensemble mean, and ensemble maximum. All values are rounded to four  
 62 decimal places.  
 63

	Global	Land	Ocean
abrupt4xCO2	-0.0358	-0.0414	-0.0336
	-0.0193	-0.0216	-0.0184
	-0.0063	-0.0112	-0.0043
G1	-0.0104	-0.0154	-0.0083
	-0.0020	-0.0034	-0.0015
	0.0006	0.0006	0.0010
G1ocean-Albedo	0.0340	-0.0214	0.0568
	0.0599	-0.0020	0.0854
	0.0927	0.0041	0.1317

64

65 **Table S5.** Change in surface air temperature (K) from piControl, averaged over  
 66 years 11-50 of simulation. Values in each box are (in order) ensemble minimum,  
 67 ensemble mean, and ensemble maximum. All values are rounded to four decimal  
 68 places.  
 69

	Global	Land	Ocean
abrupt4xCO2	2.7921	4.0407	2.2780
	4.4207	5.9323	3.7983
	5.2867	7.3039	4.6467
G1	-0.3121	-0.2428	-0.3835
	0.0219	0.2405	-0.0681
	0.6433	0.8094	0.5749
G1ocean-Albedo	-0.1150	0.4061	-0.3296
	0.3595	1.1366	0.0395
	1.2025	1.8263	0.9456

70

71 **Table S6.** Change in TOA net radiative flux ( $W m^{-2}$ ) from piControl, averaged over  
 72 years 11-50 of simulation. Values in each box are (in order) ensemble minimum,  
 73 ensemble mean, and ensemble maximum. All values are rounded to four decimal  
 74 places.  
 75

	Global	Land	Ocean
abrupt4xCO2	2.2171	-0.6630	1.9168
	2.6543	1.7063	3.0447
	3.6238	3.6351	4.0082
G1	-0.2030	-1.0747	-1.0347
	0.0296	0.7384	-0.2623
	0.2328	2.4538	0.5433
G1ocean-Albedo	-1.4455	4.8524	-5.1055
	-0.1444	7.2214	-3.1774
	0.3850	9.7284	-2.0628

76

77 **Table S7.** Change in Horizontal Energy Transport (Section 3.4;  $W m^{-2}$ ) from  
 78 piControl, averaged over years 11-50 of simulation.  
 79

	abrupt4xCO2	G1	G1ocean-Albedo
BNU-ESM	0.8841	0.1272	1.4590
CanESM2	0.2692	0.7860	2.4572
CESM-CAM5.1-FV	1.0178	0.8764	2.3648
CSIRO-Mk3L-1.2	0.1369	0.2559	1.8933
EC-Earth	0.0922	0.4281	2.0179
GISS-E2-R	-0.2096	0.7228	1.3489
HadGEM2-ES	0.8401	1.0271	2.5350
IPSL-CM5A-LR	-0.0402	0.8239	1.8023
MIROC-ESM	0.8100	0.2917	2.6708
MPI-ESM-LR	0.3462	0.9928	2.4516
NorESM1-M	1.0670	0.9204	3.2067
Model mean	0.4740	0.6593	2.2007

80



81 **Table S8.** Change in net shortwave radiative flux at the surface ( $W m^{-2}$ ) from  
 82 piControl, averaged over years 11-50 of simulation. Values in each box are (in  
 83 order) ensemble minimum, ensemble mean, and ensemble maximum. All values are  
 84 rounded to four decimal places.

85

	Global	Land	Ocean
abrupt4xCO2	-2.1671	-3.5186	-3.0579
	-0.2830	1.5559	-1.0401
	1.8646	4.1210	2.0111
G1	-6.4131	-6.5193	-6.6912
	-5.0029	-4.0800	-5.3829
	-4.0065	-1.6973	-3.6521
G1ocean-Albedo	-9.8711	-3.5994	-13.0138
	-7.8274	-0.2060	-10.9657
	-6.0680	2.7900	-8.5389

86

87 **Table S9.** Change in net longwave radiative flux at the surface ( $W m^{-2}$ ) from  
 88 piControl, averaged over years 11-50 of simulation. Values in each box are (in  
 89 order) ensemble minimum, ensemble mean, and ensemble maximum. All values are  
 90 rounded to four decimal places.

91

	Global	Land	Ocean
abrupt4xCO2	4.2188	1.8003	4.5272
	6.6073	3.7548	7.7818
	8.6313	6.3119	9.8035
G1	0.7702	0.3031	0.4394
	1.2745	1.5366	1.1666
	2.5119	3.6859	2.2724
G1ocean-Albedo	1.0227	-0.1474	0.9634
	2.5708	2.0528	2.7840
	6.2470	4.7390	7.2199

92

93 **Table S10.** Change in sensible heat flux from the surface to the atmosphere  
 94 (positive upward;  $W m^{-2}$ ) from piControl, averaged over years 11-50 of simulation.  
 95 Values in each box are (in order) ensemble minimum, ensemble mean, and  
 96 ensemble maximum. All values are rounded to four decimal places.  
 97

	Global	Land	Ocean
abrupt4xCO2	-2.3625	0.7265	-4.4561
	-1.1389	3.8471	-3.1920
	0.1424	6.6390	-2.2544
G1	-1.1581	-1.7343	-1.0483
	-0.2061	1.1302	-0.7563
	0.8142	3.8898	-0.2803
G1ocean-Albedo	-1.8505	-0.9924	-2.2039
	-0.2028	2.8650	-1.4660
	1.0485	6.0004	-0.3389

98

99 **Table S11.** Change in latent heat flux from the surface to the atmosphere (positive  
 100 upward;  $W m^{-2}$ ) from piControl, averaged over years 11-50 of simulation. Values in  
 101 each box are (in order) ensemble minimum, ensemble mean, and ensemble  
 102 maximum. All values are rounded to four decimal places.  
 103

	Global	Land	Ocean
abrupt4xCO2	1.3994	-4.7517	3.9322
	4.9044	1.0980	6.4717
	7.2406	6.5022	8.3796
G1	-5.9854	-8.6432	-4.8910
	-3.5747	-3.6358	-3.5496
	-1.2305	1.1154	-2.1965
G1ocean-Albedo	-7.2742	-6.4748	-7.8862
	-5.0481	-1.0120	-6.7101
	-2.1549	4.6424	-4.9538

104

105 **Table S12.** Change in  $\Delta S$  (Equation 4;  $W m^{-2}$ ) from piControl, averaged over years  
 106 11-50 of simulation. Values in each box are (in order) ensemble minimum,  
 107 ensemble mean, and ensemble maximum. All values are rounded to four decimal  
 108 places.  
 109

	Global	Land	Ocean
abrupt4xCO2	2.1704	-0.1485	2.9713
	2.5683	0.2046	3.4356
	3.2566	0.4413	3.9824
G1	-0.2053	-0.1232	-0.2756
	0.0512	-0.0380	0.0834
	0.2856	0.0354	0.3908
G1ocean-Albedo	-0.2915	-0.1350	-0.3695
	0.0147	-0.0084	0.0229
	0.5674	0.1352	0.7491

110

111 **Table S13.** Change in precipitation (mm day<sup>-1</sup>) from piControl, averaged over years  
 112 11-50 of simulation. Values in each box are (in order) ensemble minimum,  
 113 ensemble mean, and ensemble maximum. All values are rounded to four decimal  
 114 places.  
 115

	Global	Land	Ocean
abrupt4xCO2	0.0483	-0.0833	0.0850
	0.1705	0.1333	0.1858
	0.2769	0.2393	0.3303
G1	-0.2069	-0.2757	-0.1907
	-0.1245	-0.1052	-0.1325
	-0.0563	-0.0137	-0.0739
G1ocean-Albedo	-0.2621	-0.1415	-0.3603
	-0.1917	0.0515	-0.2919
	-0.1112	0.1963	-0.2178

116

117 **Table S14.** Change in evaporation (mm day<sup>-1</sup>) from piControl, averaged over years  
 118 11-50 of simulation. Values in each box are (in order) ensemble minimum,  
 119 ensemble mean, and ensemble maximum. All values are rounded to four decimal  
 120 places.  
 121

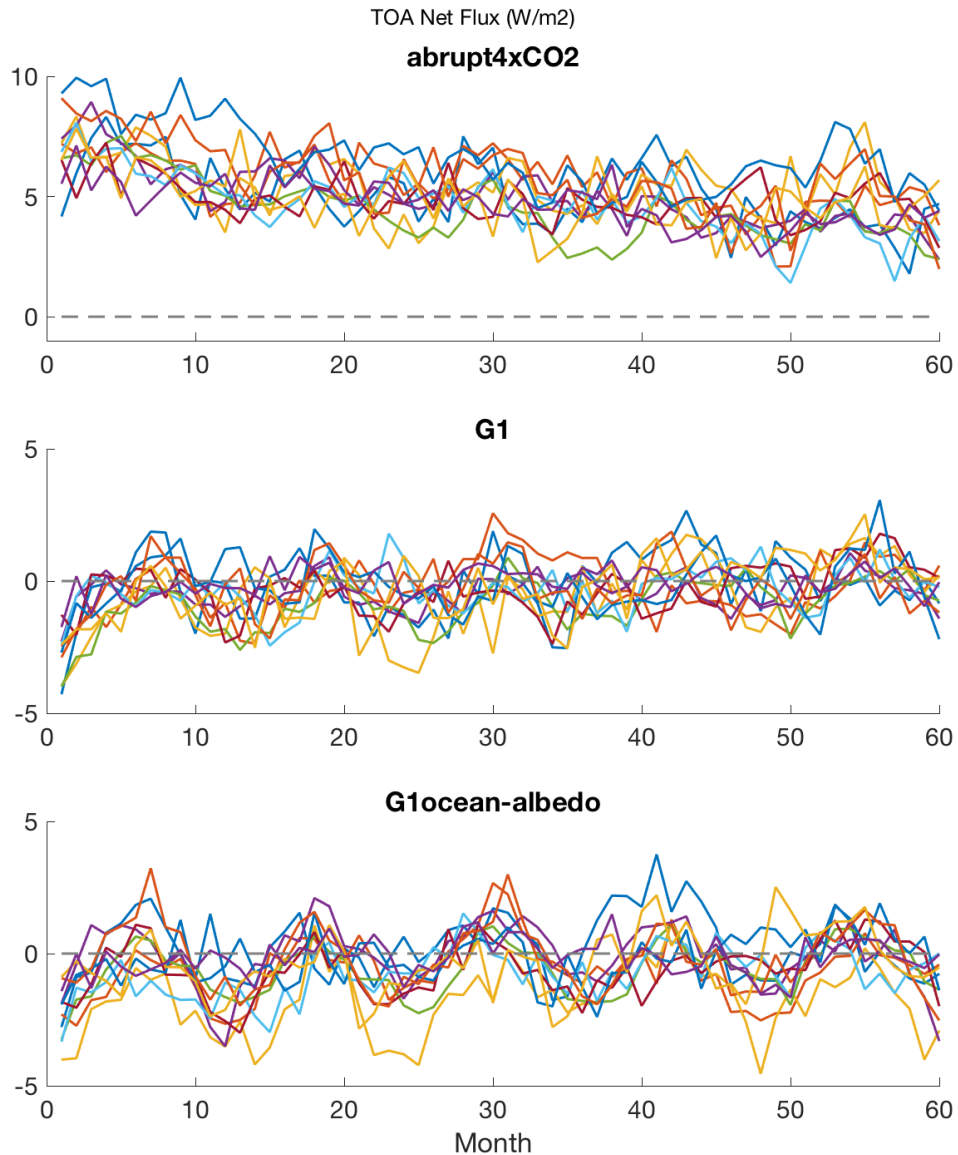
	Global	Land	Ocean
abrupt4xCO2	0.0484	-0.1642	0.1359
	0.1765	0.0403	0.2326
	0.2770	0.2261	0.3860
G1	-0.2069	-0.2987	-0.1690
	-0.1234	-0.1256	-0.1225
	-0.0424	0.0387	-0.0758
G1ocean-Albedo	-0.2514	-0.2238	-0.2714
	-0.1752	-0.0356	-0.2326
	-0.0744	0.1602	-0.1710

122

123 **Table S15.** Change in precipitation minus evaporation (mm day<sup>-1</sup>) from piControl,  
 124 averaged over years 11-50 of simulation. Values in each box are (in order)  
 125 ensemble minimum, ensemble mean, and ensemble maximum. All values are  
 126 rounded to four decimal places.  
 127

	Global	Land	Ocean
abrupt4xCO2	-0.0634	-0.0076	-0.0863
	-0.0061	0.0930	-0.0468
	0.0016	0.1994	-0.0081
G1	-0.0140	-0.0524	-0.0435
	-0.0011	0.0204	-0.0100
	0.0012	0.1059	0.0099
G1ocean-Albedo	-0.1877	-0.1837	-0.1893
	-0.0166	0.0871	-0.0593
	0.0021	0.1801	-0.0069

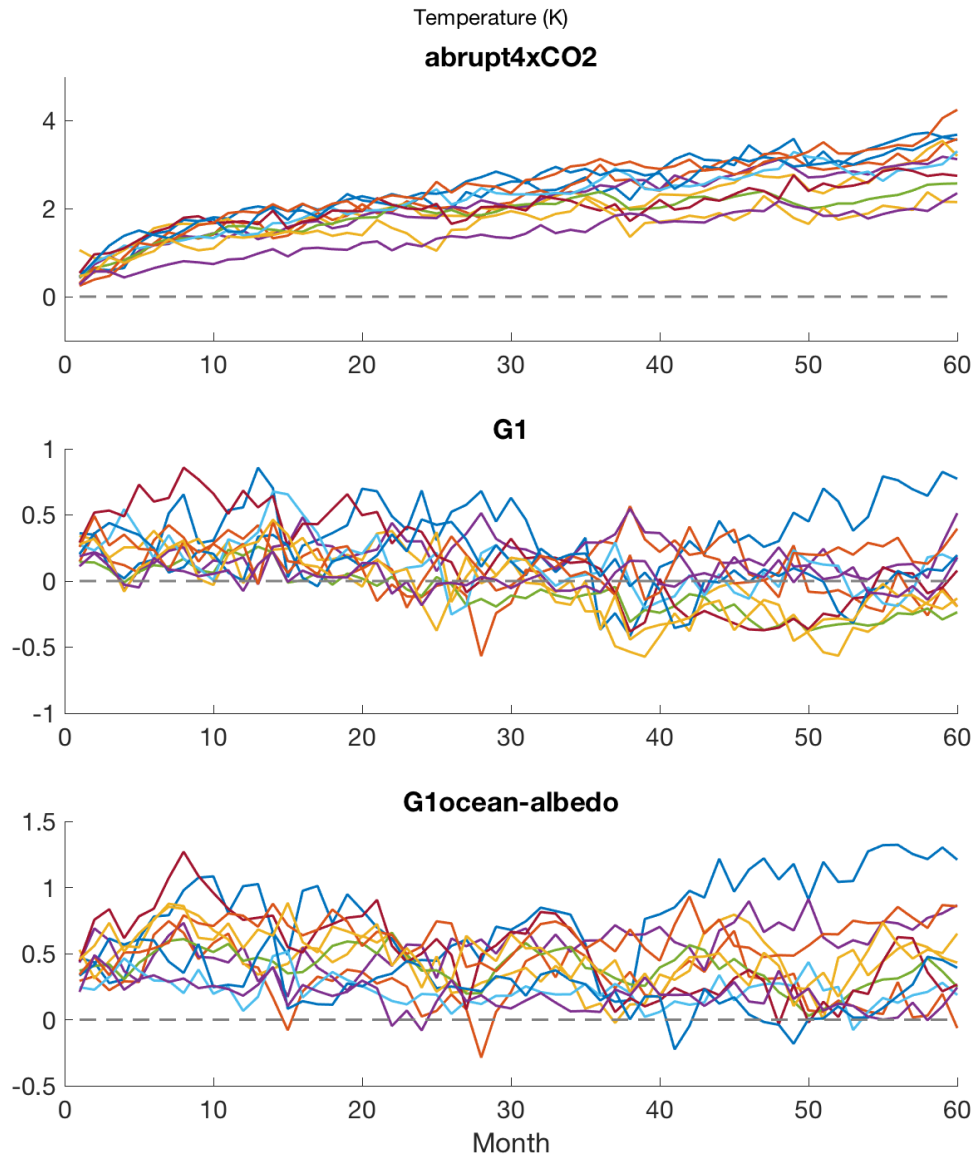




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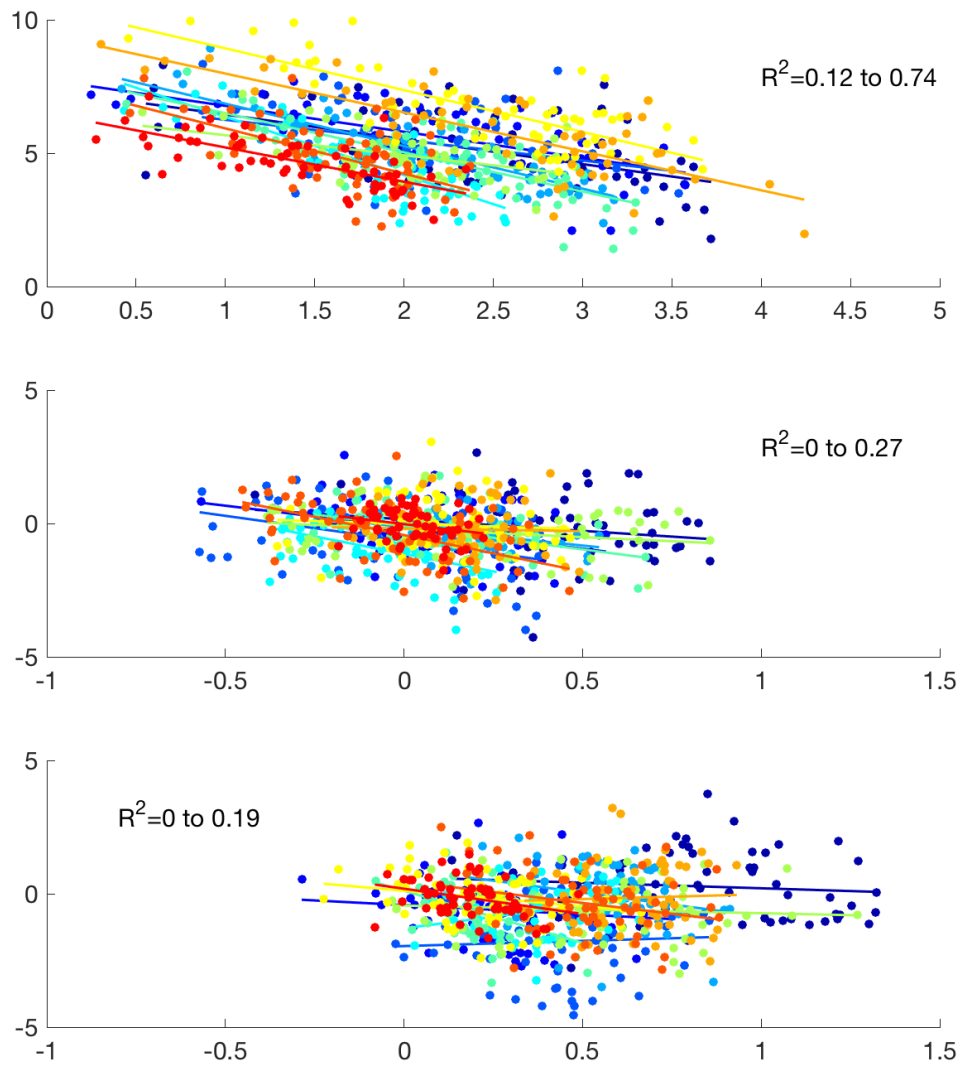
129

130 **Figure S1.** Top-of-atmosphere net radiative flux change ( $W\ m^{-2}$ ) in the  
 131 abrupt4xCO<sub>2</sub> (top), G1 (middle), and G1ocean-albedo (bottom) experiments. Each  
 132 color represents a different model. All values are subtracted month-by-month from  
 133 the corresponding months of the preindustrial control simulation for the first 60  
 134 months (5 years) of simulation.



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**Figure S2.** As in Figure S1 but for global mean temperature change (K).



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139

140 **Figure S3.** Gregory plots (Gregory et al., 2004), as described in Section 3.2 of the  
141 main text. All values are monthly averages over the first five years of simulation,  
142 essentially scatter plots of the values in Figures S1 and S2. Each color represents a  
143 different model. Lines are obtained through ordinary least squares regression  
144 through the points of the same color.  $R^2$  ranges indicate the minimum and  
145 maximum  $R^2$  value among the model ensemble in each panel.