

# Supporting Information for Extratropical shortwave cloud feedbacks in the context of the global circulation and hydrological cycle

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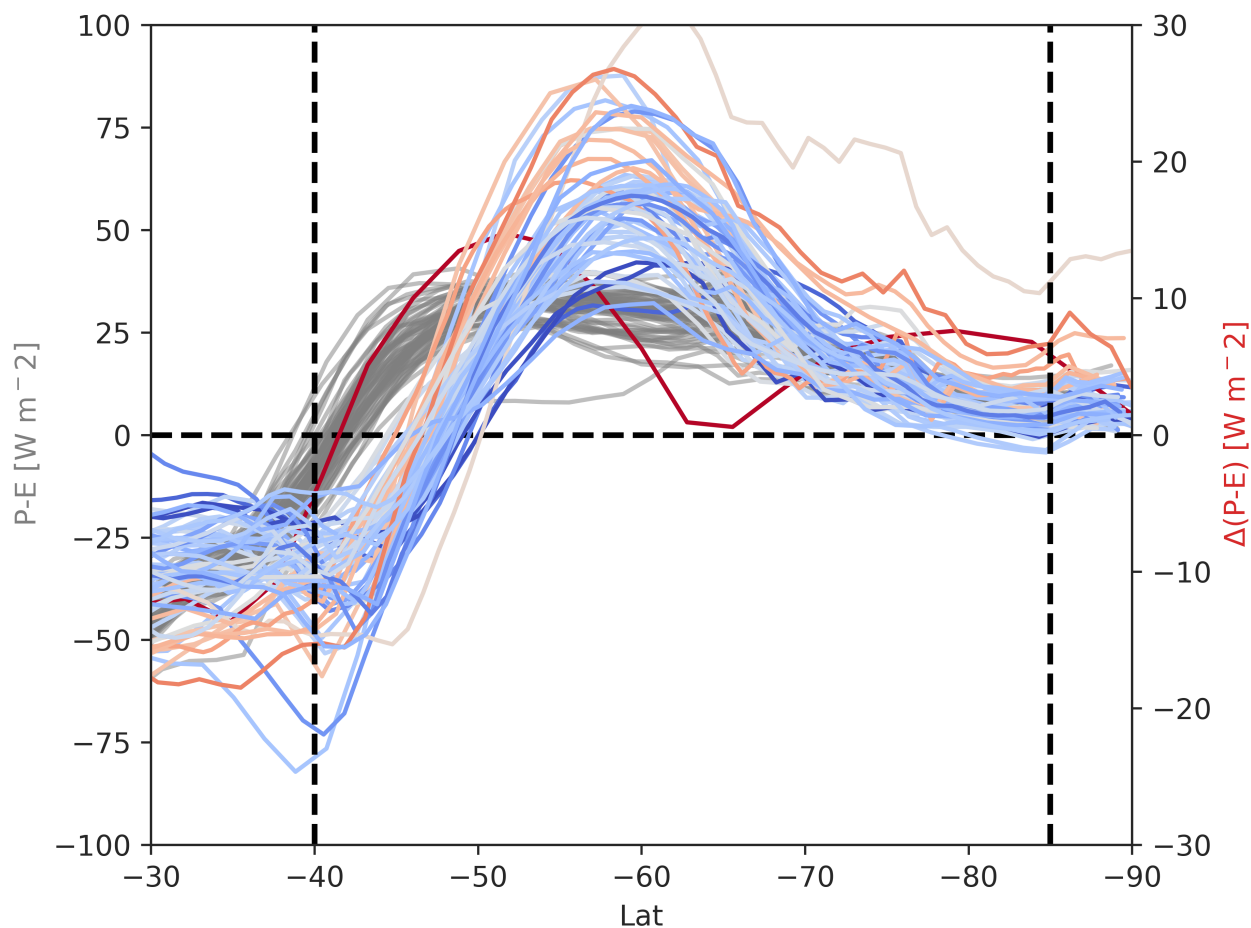
## Contents of this file

1. Figures S1 to S6

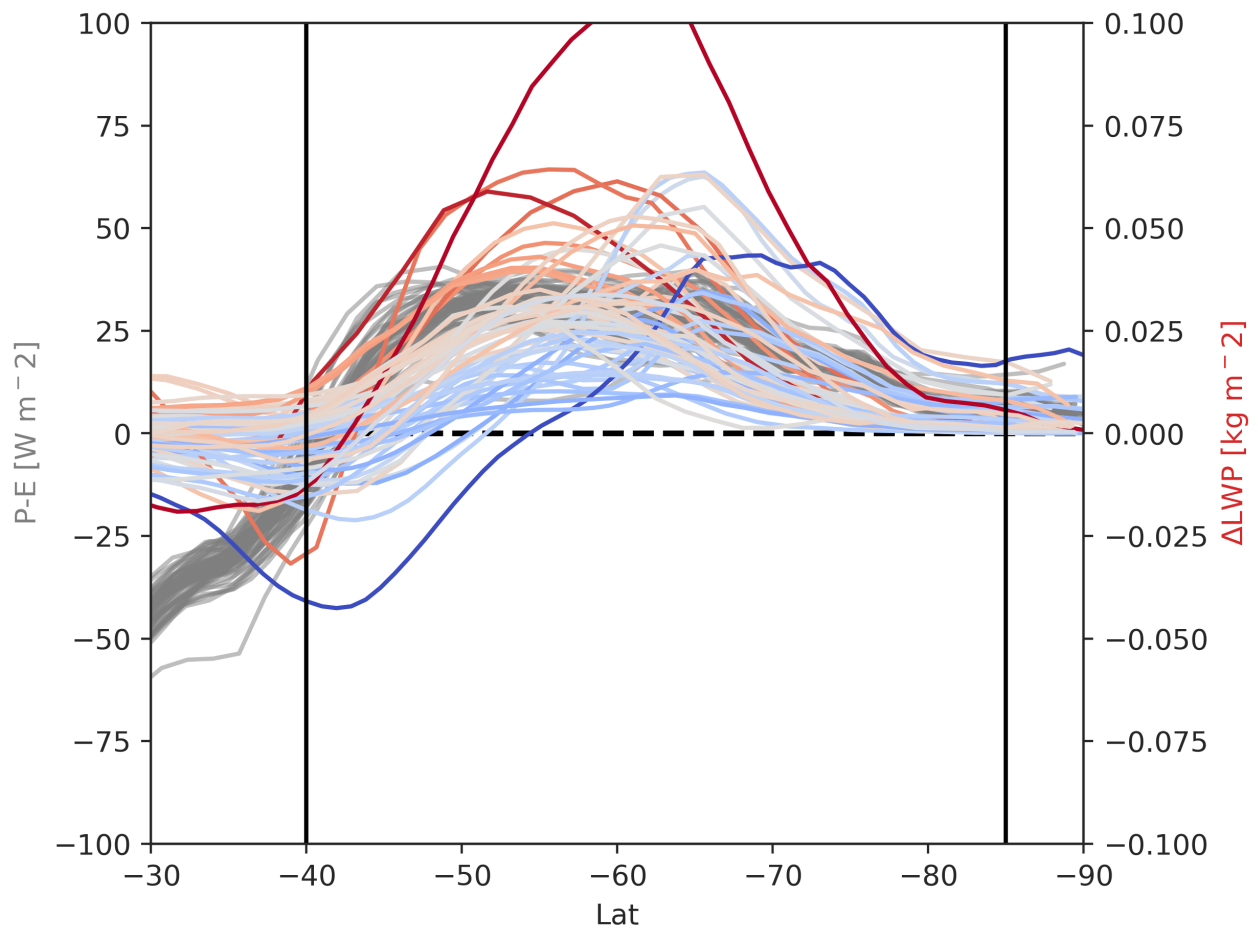
## 2. Table S1

**Introduction** This supporting information gives the list of global climate models (GCMs) analyzed in Fig. 2 and 3 of the main text. Supporting figures described in the main text are also provided.

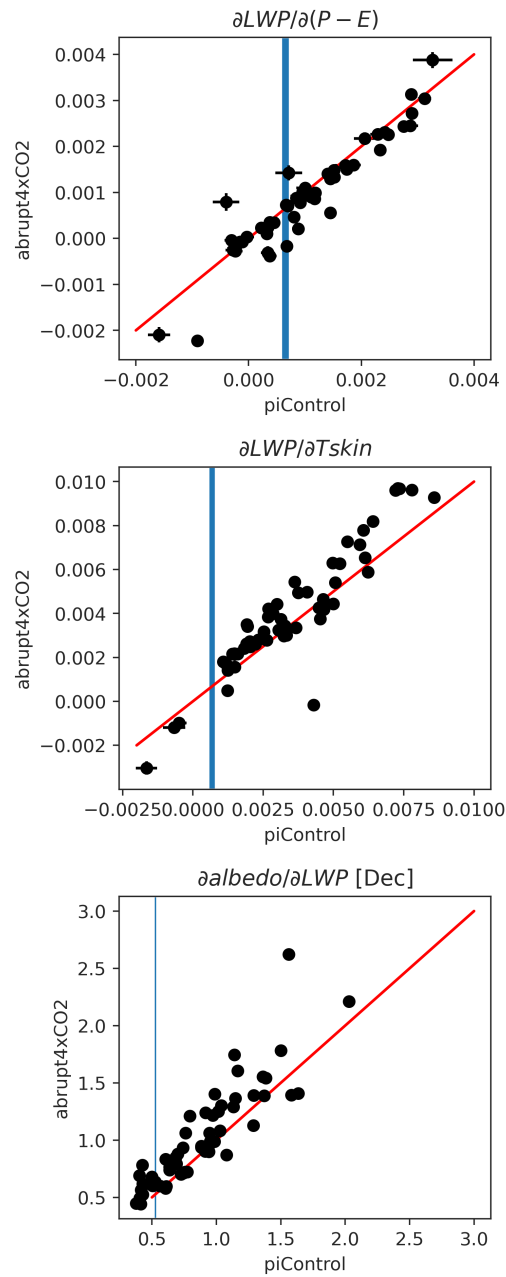
## References



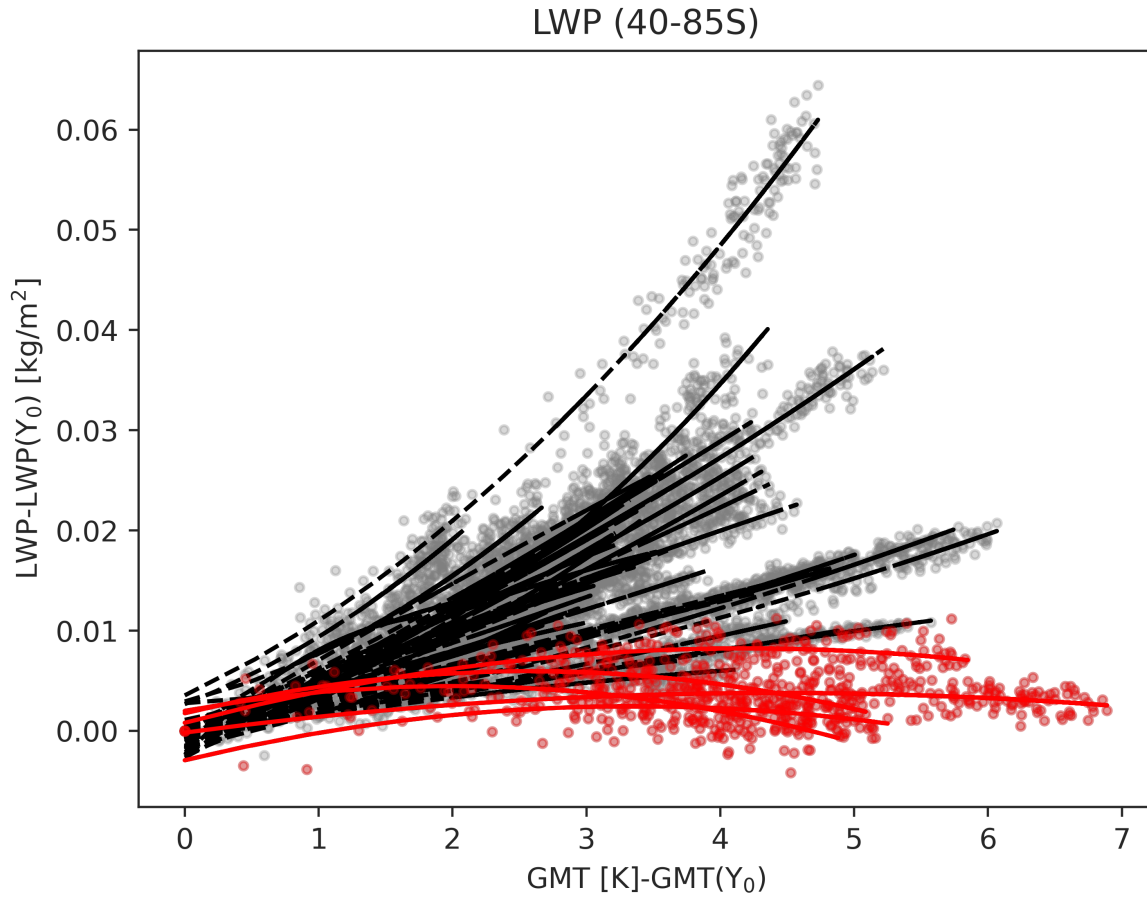
**Figure S1.** Precipitation minus evaporation ( $P - E$ ) in piControl simulations (grey lines) and difference in  $P - E$  between piControl and abrupt4xCO2 simulations (red-blue lines). Dashed vertical lines show the region being examined and red-blue coloring denotes the average  $\Delta(P - E)$  in the study region.



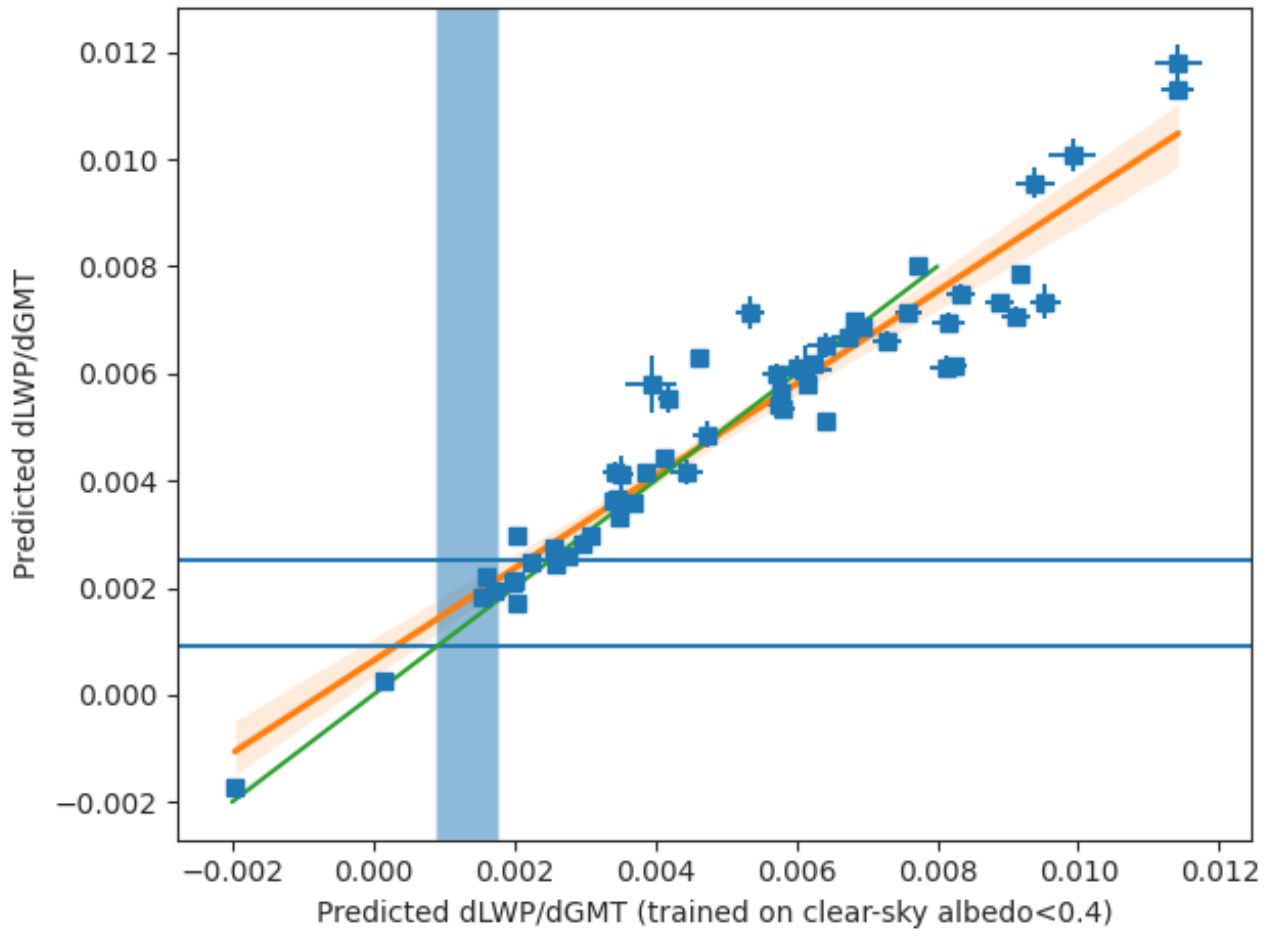
**Figure S2.** As in Fig. S1, but showing LWP in color. Grey lines show piControl  $P - E$



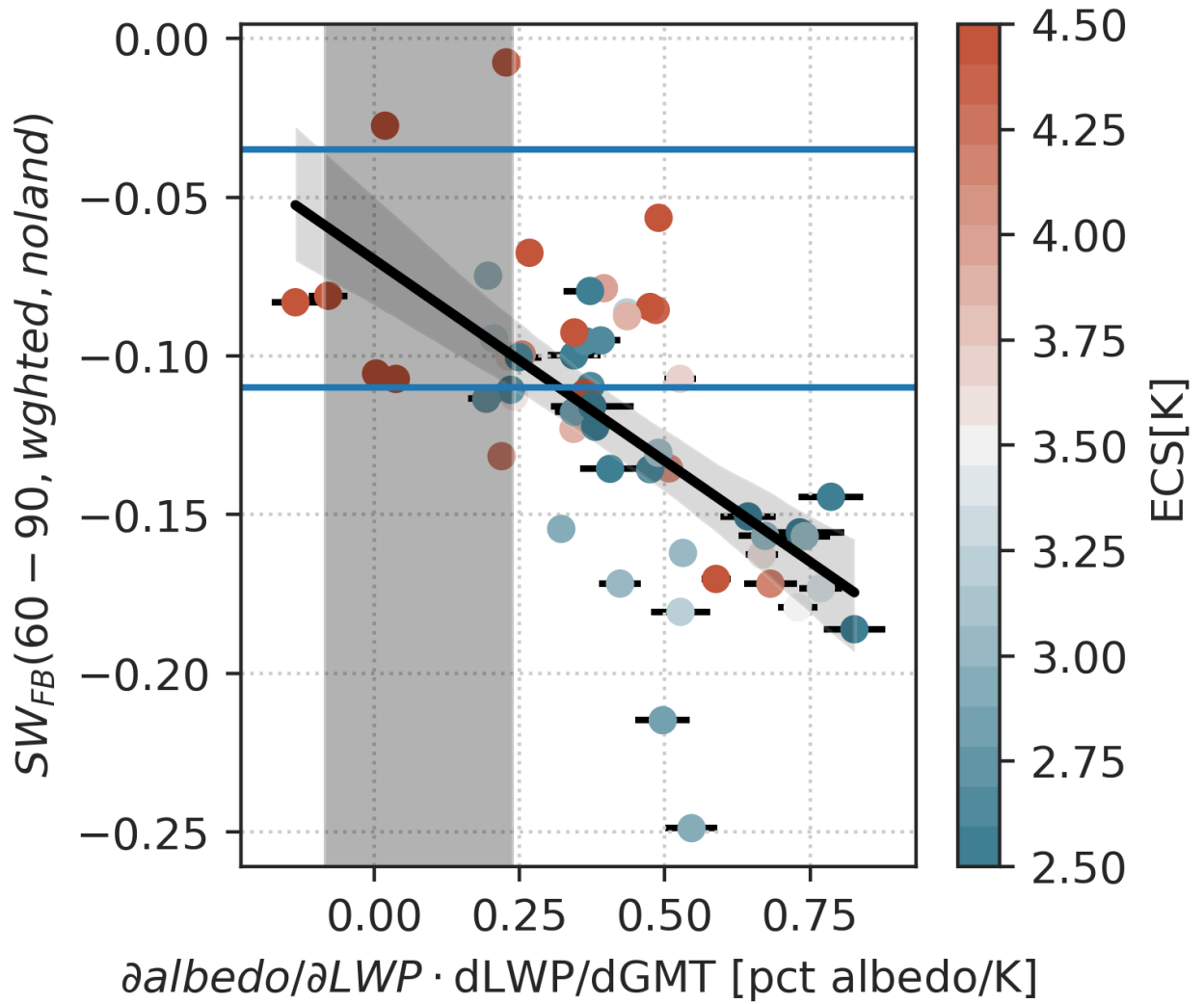
**Figure S3.** The coefficients derived from the multiple linear regression models as described in the main text. The value of the regression coefficient calculated from the piControl and abrupt4xCO2 simulations is shown along with a 1-1 line. Observational 95% confidence ranges for each coefficient are shown in blue along the x-axis.



**Figure S4.** Extratropical LWP in GCMs as a function of GMT. The LWP in the first year of simulation for each GCM is subtracted to make the plot clearer. Each dot is an annual mean in the abrupt4xCO2 simulation expressed as an anomaly relative to the first year of the simulation. A second order polynomial is fit to each model for visual clarity (not used in the analysis). CESM2 variants (CESM2, CESM2-FV, CESM2-WACCM, WACCM-FV) and E3SM-1-0 are colored red and exhibit an unusual downward trend with warming later in the simulation.



**Figure S5.** Microwave radiometers do not retrieve LWP over sea ice and land. To support the development of an observational constraint we contrast the predicted  $d\overline{LWP}/dGMT$  trained on all GCM data using  $P - E$  and  $T_{skin}$ , and trained on only GCM data where surface albedo is less than 0.4 (which corresponds to open ocean). The range of  $d\overline{LWP}/dGMT$  when the sensitivity of LWP to  $P - E$  and SST derived from observations is shown as a shaded box. The 1-1 and best fit line are shown as well as the resulting observational constraint (intersection of the orange best range with the observations) on  $d\overline{LWP}/dGMT$ .



**Figure S6.** As in Fig. 4 of the main text, but showing SW cloud feedback over oceans in the 60-90° latitude band. Points are colored by ECS.



**Table S1.** List of GCMs

Number	Model	CMIP	Number	Model	CMIP
1	ACCESS1-0	cmip5	46	GISS-E2-1-H	cmip6
2	ACCESS1-3	cmip5	47	GISS-E2-2-G	cmip6
3	CCSM4	cmip5	48	INM-CM4-8	cmip6
4	CNRM-CM5	cmip5	49	IPSL-CM6A-LR	cmip6
5	CSIRO-Mk3-6-0	cmip5	50	MIROC-ES2L	cmip6
6	CanESM2	cmip5	51	MIROC6	cmip6
7	FGOALS-g2	cmip5	52	MPI-ESM-1-2-HAM	cmip6
8	FGOALS-s2	cmip5	53	MPI-ESM1-2-HR	cmip6
9	GFDL-CM3	cmip5	54	MPI-ESM1-2-LR	cmip6
10	GFDL-ESM2G	cmip5	55	MRI-ESM2-0	cmip6
11	GFDL-ESM2M	cmip5	56	NorESM2-MM	cmip6
12	GISS-E2-H	cmip5	57	UKESM1-0-LL	cmip6
13	GISS-E2-R	cmip5			
14	IPSL-CM5A-LR	cmip5			
15	IPSL-CM5A-MR	cmip5			
16	IPSL-CM5B-LR	cmip5			
17	MIROC-ESM	cmip5			
18	MIROC5	cmip5			
19	MPI-ESM-LR	cmip5			
20	MPI-ESM-MR	cmip5			
21	MPI-ESM-P	cmip5			
22	MRI-CGCM3	cmip5			
23	NorESM1-M	cmip5			
24	bcc-csm1-1-m	cmip5			
25	bcc-csm1-1	cmip5			
26	inmcm4	cmip5			
27	BCC-CSM2-MR	cmip6			
28	BCC-ESM1	cmip6			
29	CAMS-CSM1-0	cmip6			
30	CESM2-FV2	cmip6			
31	CESM2-WACCM-FV2	cmip6			
32	CESM2-WACCM	cmip6			
33	CESM2	cmip6			
34	CMCC-CM2-SR5	cmip6			
35	CNRM-CM6-1-HR	cmip6			
36	CNRM-CM6-1	cmip6			
37	CNRM-ESM2-1	cmip6			
38	CanESM5	cmip6			
39	E3SM-1-0	cmip6			
40	EC-Earth3-AerChem	cmip6			
41	EC-Earth3-Veg	cmip6			
42	FGOALS-f3-L	cmip6			
43	FGOALS-g3	cmip6			
44	GFDL-CM4	cmip6			
45	GFDL-ESM4	cmip6			

The number reflects the number listed in main-text figures.

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