Top-of-atmosphere, surface and atmospheric cloud radiative kernels

based on ISCCP-H datasets: Method and Evaluation

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Table S1.

Table S1. Summary of the statistics from comparison of monthly, global and 49- (or 42- for CERES associated) bins TOA for cloud radiative kernel (CRK) in Wm^{-2} %$^{-1}$

X vs. Y CRKs	X mean	Y mean	Mean difference of (X − Y)	Stdv of (X − Y)	Correlation coefficient	Total equal-area grid cell number
LW Cloud Radiative Kernel						
FH vs MZ	0.514	0.556	-0.043	0.097	0.982	399612
FH vs CS	0.490	0.510	-0.021	0.176	0.922	260867
MZ vs CS	0.539	0.507	0.032	0.169	0.930	262546
mean	0.514	0.525	-0.011	0.147	0.945	307675
modulus mean			0.032			
SW Cloud Radiative Kernel						
FH vs MZ	-0.957	-0.998	0.042	0.107	0.993	390251
FH vs CS	-0.966	-0.856	-0.110	0.172	0.978	260896
MZ vs CS	-1.043	-0.853	-0.190	0.180	0.983	262576
mean	-0.988	-0.902	-0.086	0.153	0.985	304574
modulus mean			0.114			
Net (total) Cloud Radiative Kernel						
FH vs MZ	-0.437	-0.436	-0.001	0.118	0.989	390251
FH vs CS	-0.476	-0.346	-0.130	0.212	0.954	260863
MZ vs CS	-0.504	-0.345	-0.159	0.233	0.954	262542
mean	-0.472	-0.376	-0.097	0.188	0.966	304552
modulus mean			0.097			

[†] Each pair's statistics are averaged from their 12-monthly comparison for all bins and 250-km equal-area grid cells (8252 cells for a full map). X and Y are for the 3 possible combinations of the 3 sets of CRKs. 'Stdv' is for standard deviation. The modulus (absolute) mean difference (Stdv) for 3 pairs are 0.032 (0.147), 0.114 (0.153) and 0.097 (0.188) Wm^{-2} %$^{-1}$ for LW, SW and Net, respectively, translated to (bias-included) RMS 0.150, 0.191 and 0.212 Wm^{-2} %$^{-1}$ for LW, SW and Net, respectively. The RMS estimates is about 20% larger than those in Table 2 in main text (based on 6 pairs, all the possible combinations for 4 CRK sets), and should be more objective (cf. Table 2 in Main text).

Table S2.

Table S2. **Summary of the statistics from comparison of monthly, global and 49- (or 42- for CERES associated) bins for cloud fraction change (CFC) in %/K from 1 x CO2 to 2 x CO2 model runs, normalized by individual model's surface air temperature changes†**

X vs. Y CFC	X mean	Y mean	Mean difference of (X – Y)	Stdv	Correlation coefficient	Total equal-area box number
n3 vs u3	-0.0004	-0.0088	0.008	0.335	0.103	397639
n3 vs gf	-0.0004	-0.0096	0.009	0.345	0.120	398015
n3 vs ip	-0.0004	-0.0158	0.015	0.357	0.173	397794
n3 vs bm	-0.0004	-0.0065	0.006	0.307	0.034	398015
n3 vs mh	-0.0004	-0.0185	0.018	0.326	0.151	397770
n3 vs ml	-0.0004	-0.0139	0.014	0.404	0.051	397770
n3 vs ui	-0.0004	-0.0112	0.011	0.435	0.061	397819
n3 vs u1	-0.0004	-0.0087	0.008	0.306	0.068	398015
n3 vs u4	-0.0004	-0.0064	0.006	0.295	0.100	397639
u3 vs gf	-0.0087	-0.0096	0.001	0.307	0.222	397680
u3 vs ip	-0.0087	-0.0158	0.007	0.351	0.122	397664
u3 vs bm	-0.0087	-0.0065	-0.002	0.282	0.047	397884
u3 vs mh	-0.0088	-0.0186	0.010	0.301	0.179	397459
u3 vs ml	-0.0088	-0.0140	0.005	0.365	0.158	397459
u3 vs ui	-0.0087	-0.0112	0.002	0.401	0.152	397680
u3 vs u1	-0.0087	-0.0087	-0.000	0.274	0.130	397884
u3 vs u4	-0.0087	-0.0063	-0.002	0.251	0.241	397884
gf vs ip	-0.0096	-0.0158	0.006	0.360	0.139	397835
gf vs bm	-0.0096	-0.0065	-0.003	0.308	0.046	398174
gf vs mh	-0.0097	-0.0185	0.009	0.293	0.247	397823
gf vs ml	-0.0097	-0.0139	0.004	0.360	0.199	397823
gf vs ui	-0.0096	-0.0112	0.002	0.423	0.103	397941
gf vs u1	-0.0096	-0.0087	-0.001	0.290	0.186	398174
gf vs u4	-0.0096	-0.0064	-0.003	0.272	0.199	397680
ip vs bm	-0.0158	-0.0065	-0.009	0.330	0.037	397860
ip vs mh	-0.0158	-0.0186	0.003	0.356	0.098	397562
ip vs ml	-0.0158	-0.0139	-0.002	0.398	0.154	397562
ip vs ui	-0.0158	-0.0112	-0.005	0.454	0.045	397696
ip vs u1	-0.0158	-0.0087	-0.007	0.305	0.212	397835
ip vs u4	-0.0158	-0.0064	-0.009	0.304	0.194	397664
bm vs mh	-0.0065	-0.0185	0.012	0.281	0.056	398015
bm vs ml	-0.0065	-0.0139	0.007	0.355	0.044	398015
bm vs ui	-0.0065	-0.0112	0.005	0.395	0.019	399158
bm vs u1	-0.0065	-0.0087	0.002	0.235	0.053	398627
bm vs u4	-0.0065	-0.0063	-0.000	0.221	0.089	397884
mh vs ml	-0.0185	-0.0139	-0.005	0.323	0.359	398015
mh vs ui	-0.0185	-0.0112	-0.007	0.391	0.195	397843
mh vs u1	-0.0185	-0.0087	-0.010	0.279	0.098	398015
mh vs u4	-0.0186	-0.0064	-0.012	0.262	0.162	397459
ml vs ui	-0.0139	-0.0112	-0.003	0.457	0.104	397843
ml vs u1	-0.0139	-0.0087	-0.005	0.331	0.208	398015
ml vs u4	-0.0140	-0.0064	-0.008	0.328	0.194	397459
ui vs u1	-0.0112	-0.0087	-0.002	0.398	0.020	398301
ui vs u4	-0.0112	-0.0064	-0.005	0.391	0.036	397680
u1 vs u4	-0.0087	-0.0063	-0.002	0.184	0.396	397884
mean	-0.0092	-0.0107	0.002	0.332	0.133	397865
modulus mean			0.004			

†Each pair's statistics are averaged from their 12-monthly comparison for all bins and 250-km equal-area grid cells (8252 cells for a full global map). The modulus mean of 45 pairs' mean difference (Stdv) is 0.004 (0.332), % K^{-1} translated to (bias-included) RMS of 0.332.The versions of the 45 pairs are referred to Table S3.

Table S3.

Table S3.Ten global CFMIP1 models used for 2 x CO_2 cloud fraction change experiment†

No.	GCM Climate Models	Abbrev.
1	CCSM3.0* National Center for Atmospheric Research, USA	'n3'
2	HadSM3 Hadley Centre for Climate Prediction and Research/Met Office, UK	'u3'
3	GFDL MLM2.1* NOAA/Geophysical Fluid Dynamics Laboratory, USA	'gf'
4	IPSL CM4* Institute Pierre Simon Laplace, France	'ip'
5	BMRC1* Bureau of Meteorology Research Centre, Australia	'bm'
6	MIROC(hires)* Center for Climate System Research, The University of Tokyo	'mh'
7	MIROC(lowres) Center for Climate System Research, The University of Tokyo	'ml'
8	UIUC University of Illinois at Urbana–Champaign, USA	'ui'
9	HadGSM1 Hadley Centre for Climate Prediction and Research/Met Office, United Kingdom	'ul'
10	HadSM4 Hadley Centre for Climate Prediction and Research/Met Office, United Kingdom	'u4'

†Z2012's Table 1 lists 12 CFMIP1 models, of which only 11 models (excluding MPI ECHAM5) were actually used in Z2012. Of the 11 models, one (AGCM4) has a quality issue so we do not use it (personal communication with Dr. Zelinka). Asterisks denote the 5 models whose atmospheric temperature and specific humidity profiles were unavailable and not used for Z2012's CRKs' calculation. The last column is the abbreviations of the ten models, used in Table S2.