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Supplement of

Radiative sensitivity quantified by a new set of radiation flux kernels based on the ECMWF Reanalysis v5 (ERA5)

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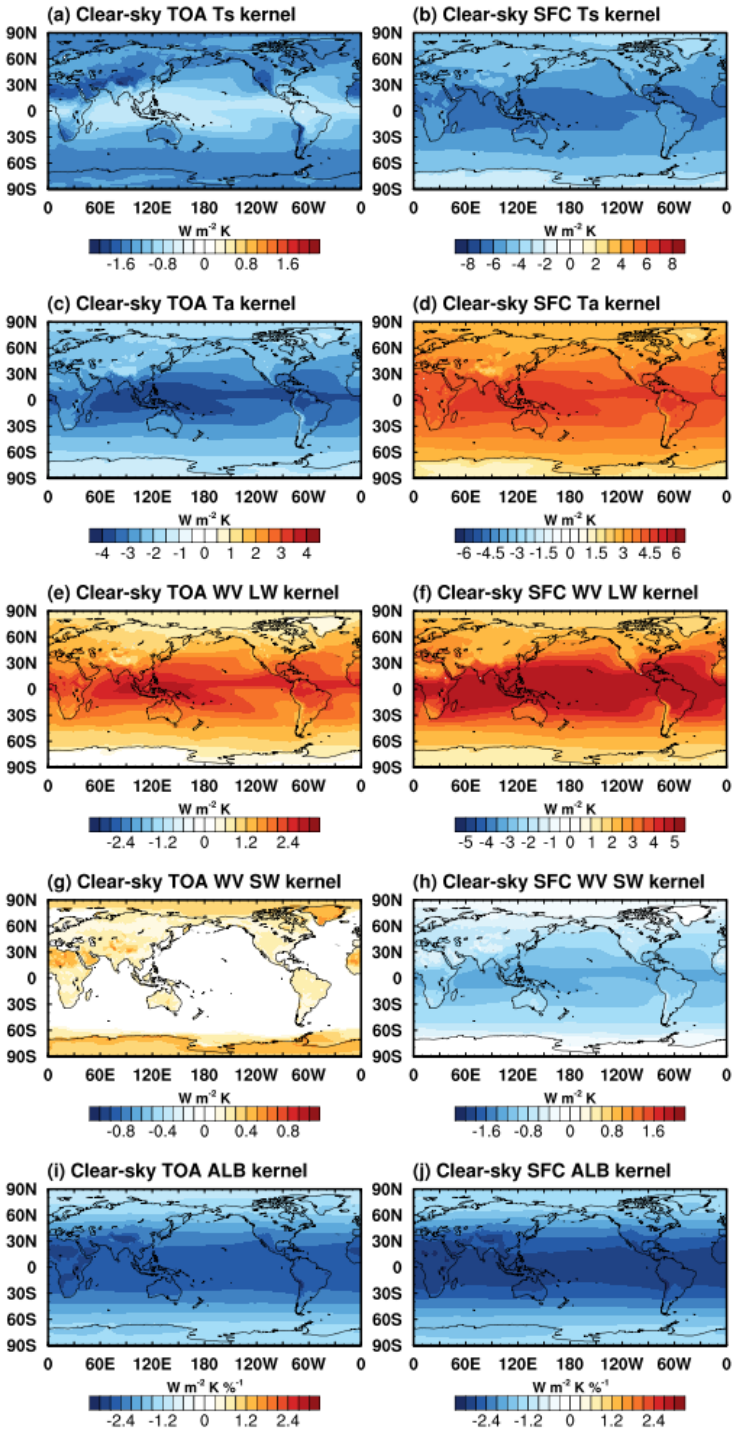

Figure S1. Similar to Figure 1, but for clear-sky vertically integrated ERA5 kernels.

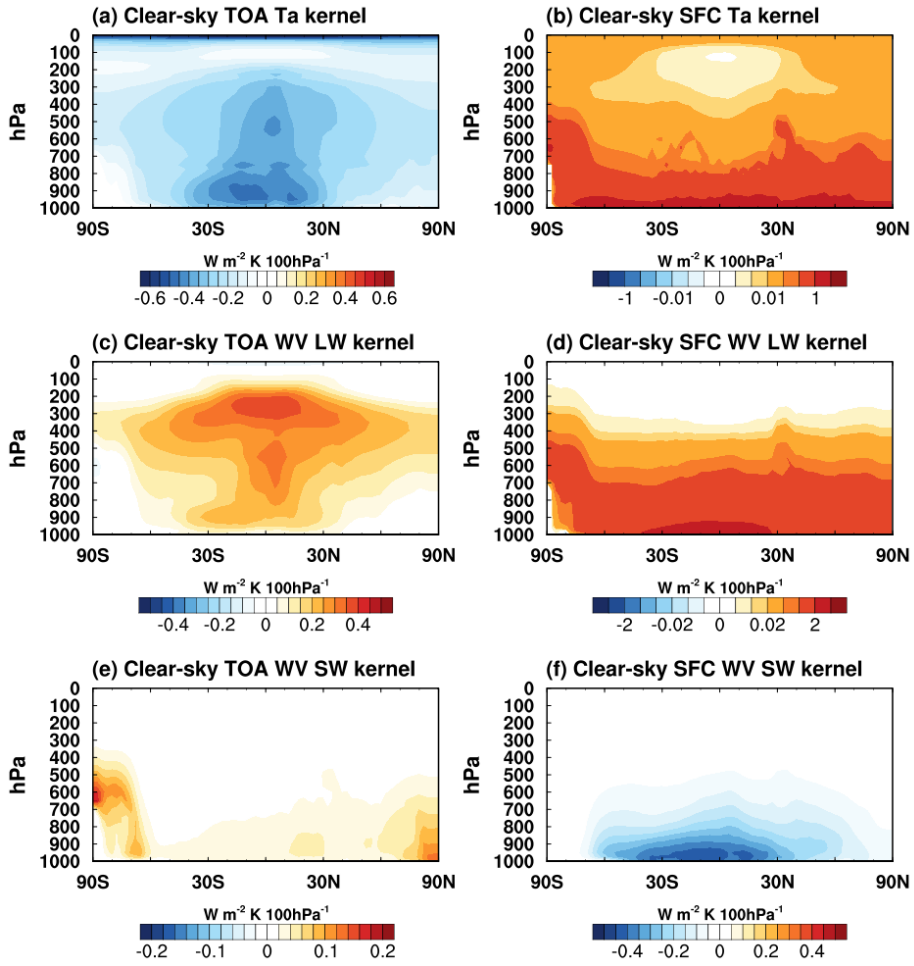

Figure S2. Similar to Figure 2, but for clear-sky vertically resolved ERA5 kernels.

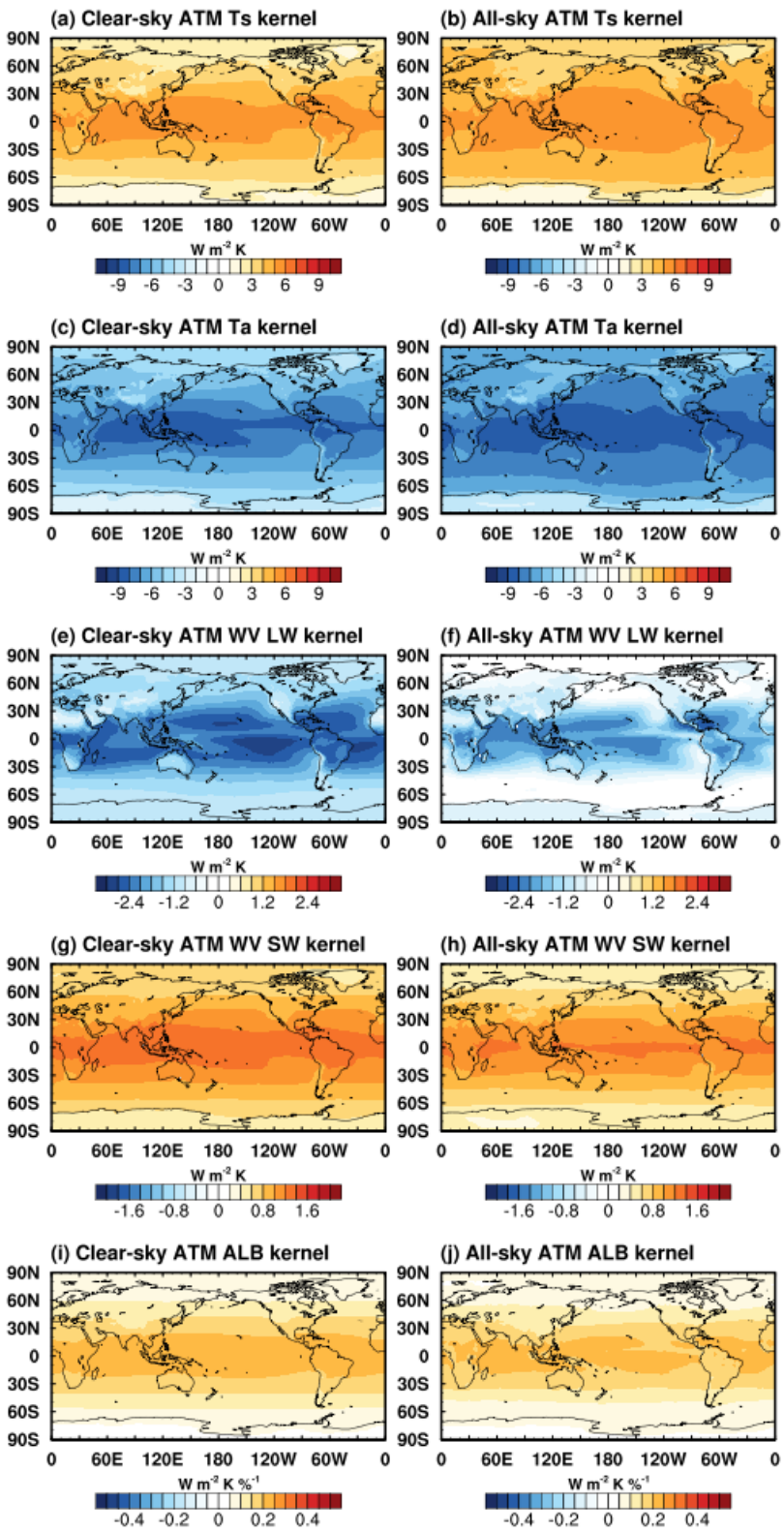

Figure S3. Similar to Figure 1 and S1, but for the atmospheric (ATM) ERA5 kernels in clear-sky and all-sky.

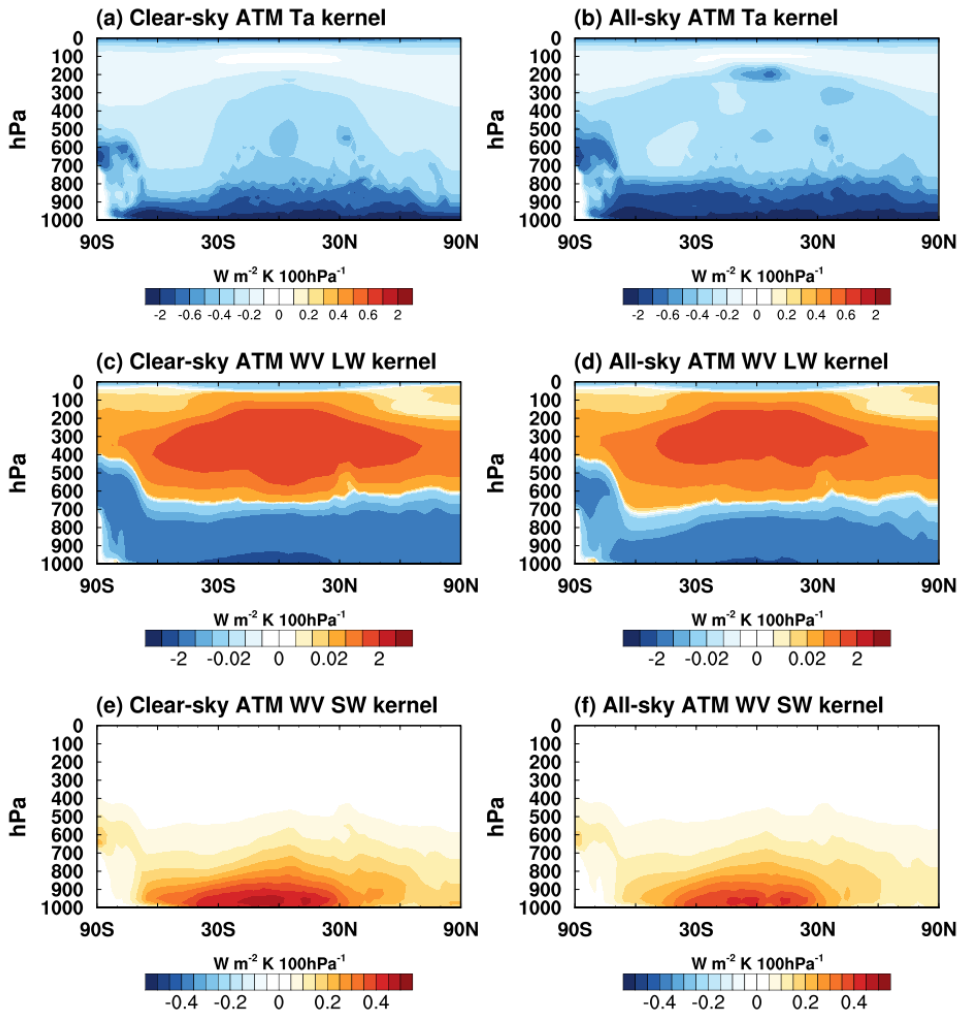

Figure S4. Similar to Figure 2 and S2, but for vertically resolved ATM EAR5 kernels in clear-sky and all-sky.

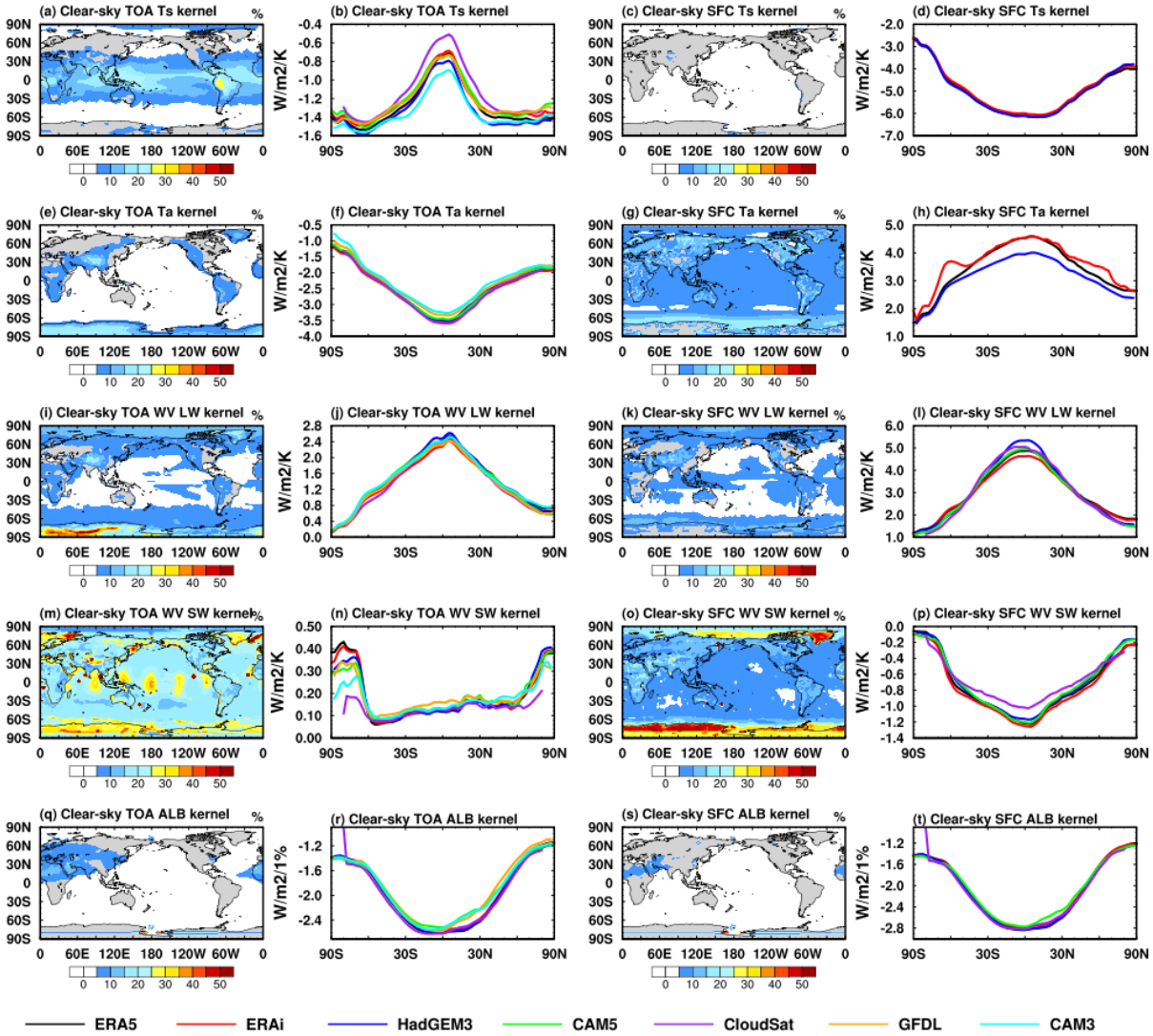

Figure S5. Similar to Figure 3, but for multi-kernel comparisons in clear-sky.

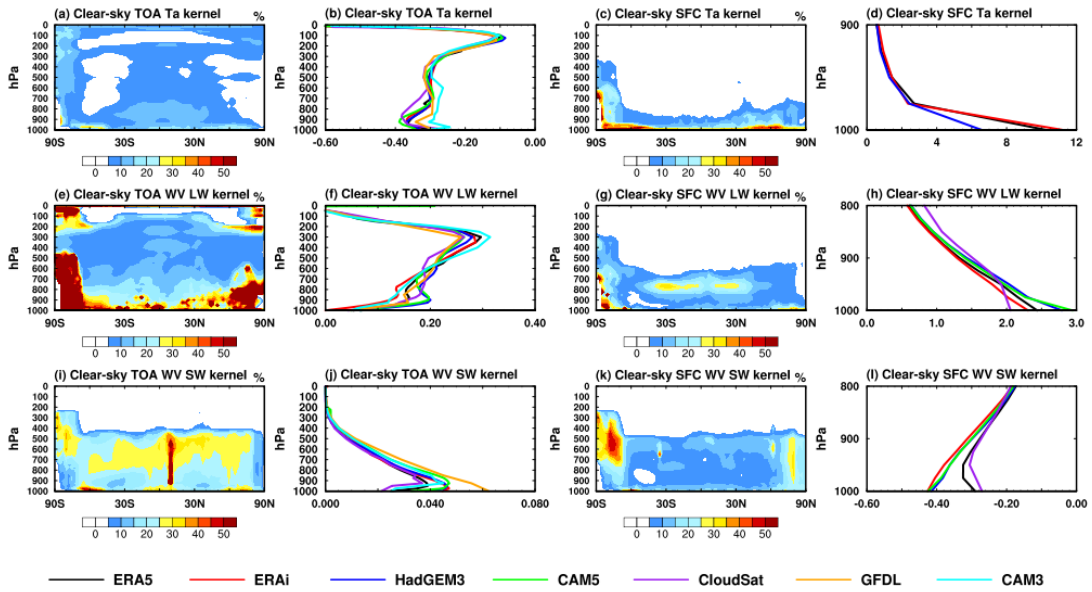

Figure S6. Similar to Figure 4, but for the inter-kernel discrepancies in clear-sky.

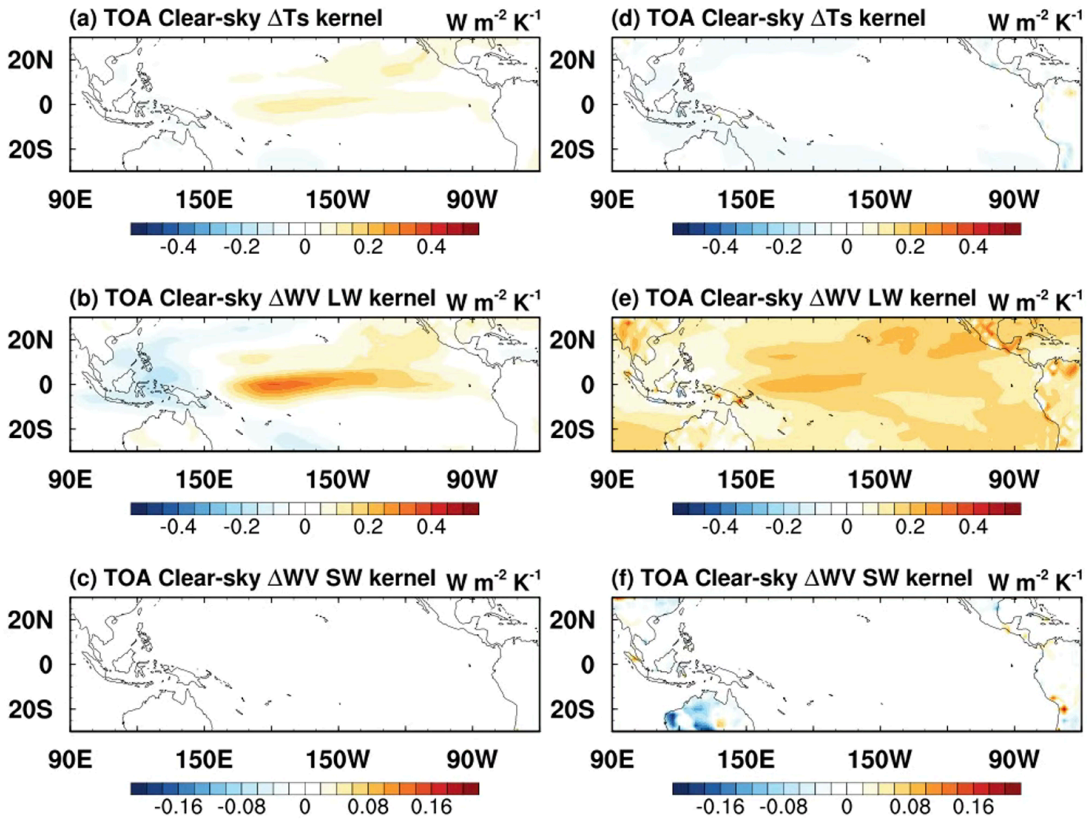

Figure S7. Similar to Figure 5, but for the clear-sky TOA kernel differences between (left) year 2015 and multi-year mean in ERA5, and (right) between the 5-year mean ERA5 and ERAi, in terms of (a, d) skin temperature, (b, e) water vapor LW and (c, f) water vapor SW kernels.

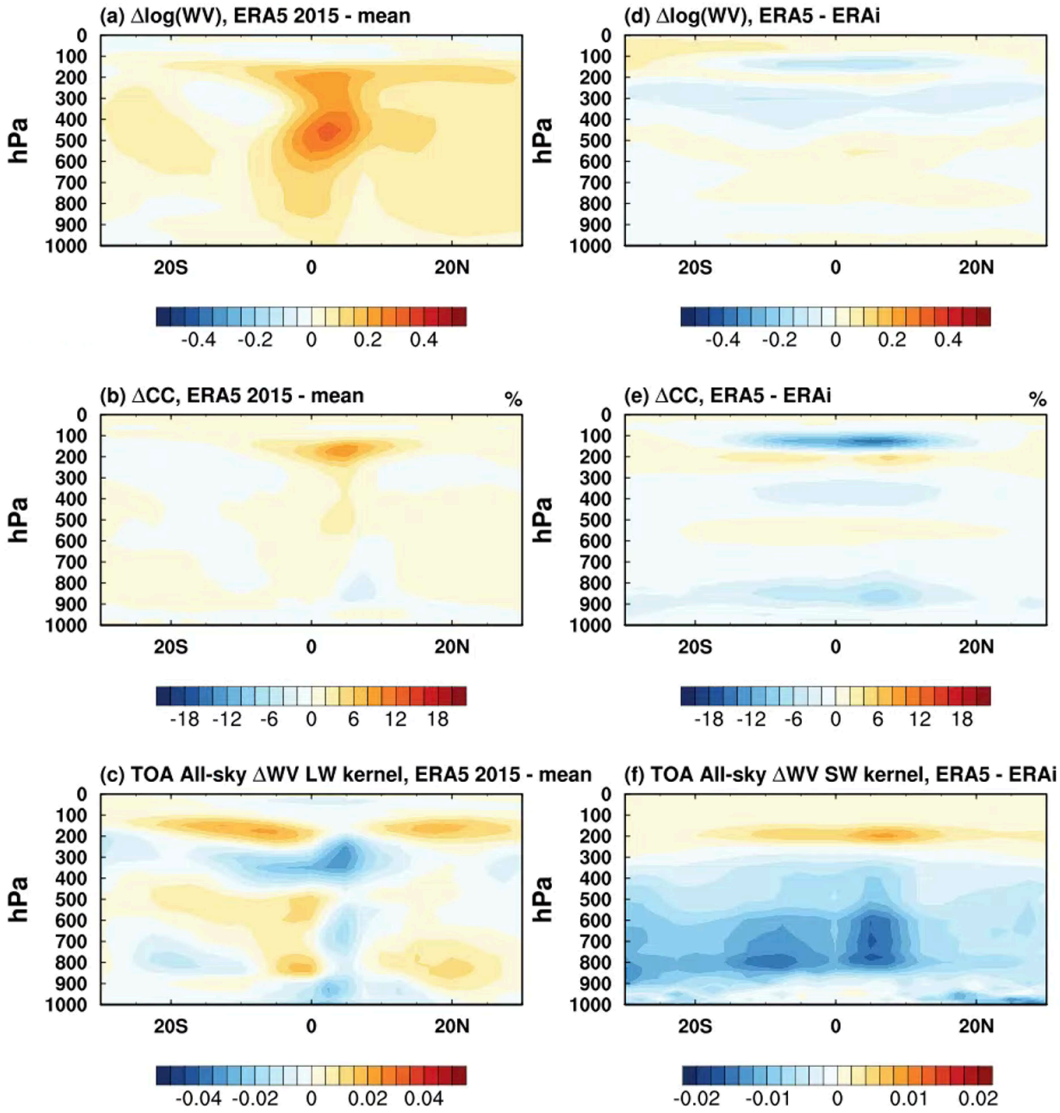

Figure S8. Vertically resolved differences of atmospheric variables and kernels (left) between year 2015 and multi-year mean in the EAR5, and (right) between the 5-year mean of ERA5 and ERAi datasets: (a, d) specific humidity, (b, e) cloud cover, (c) TOA water vapor LW kernel in all-sky, and (f) TOA water vapor SW kernel in all-sky, units: W m^{-2} K^{-2} $100hPa^{-1}$. Note that panels (a, b, c) are averaged from longitude 180E to 300E while panels (d, e, f) are zonally averaged.

Table S1. Kernel-diagnosed all-sky TOA overall feedback parameter of CMIP6 models, units: W m^{-2} K^{-1}. The numbers in the brackets of the ERAi kernel row are the results from Zelinka et al. (2020) for comparison. The bolded rows: the mean and standard deviation of the feedback parameter values diagnosed from different kernels for the same GCM; the last column: the mean and standard deviation of the feedback parameter values of different GCMs diagnosed from a same kernel, units: W m^{-2} K^{-1}.

	CESM2			CNRM-CM6-1			EC-Earth3			HadGEM3-GC3-LL			IPSL-CM6A-LR			MPI-ESM1-2-LR			**Multi-model mean**		
	LW	SW	Net	LW	SW	Net	LW	SW	Net	LW	SW	Net	LW	SW	Net	LW	SW	Net	**LW**	**SW**	**Net**
ERA5	-1.95	1.28	-0.67	-1.40	0.62	-0.78	-1.55	0.77	-0.78	-2.36	1.59	-0.78	-1.48	0.63	-0.85	-1.41	-0.02	-1.43	**-1.69±0.39**	**0.81±0.56**	**-0.88±0.28**
ERAi	-2.01	1.27	-0.74 (-0.64)	-1.46	0.61	-0.85 (-0.87)	-1.61	0.76	-0.85 (-0.89)	-2.42	1.57	-0.84 (-0.81)	-1.55	0.62	-0.93 (-0.97)	-1.48	-0.03	-1.51	**-1.75±0.38**	**0.80±0.56**	**-0.95±0.28**
HadGEM3	-1.92	1.26	-0.65	-1.39	0.61	-0.78	-1.55	0.77	-0.78	-2.35	1.58	-0.77	-1.47	0.62	-0.85	-1.40	-0.03	-1.43	**-1.68±0.38**	**0.80±0.56**	**-0.88±0.28**
CAM5	-1.97	1.30	-0.67	-1.42	0.64	-0.78	-1.58	0.79	-0.78	-2.38	1.61	-0.78	-1.51	0.64	-0.86	-1.44	0.00	-1.43	**-1.72±0.38**	**0.83±0.56**	**-0.88±0.28**
CloudSat	-2.05	1.27	-0.78	-1.51	0.61	-0.89	-1.64	0.75	-0.89	-2.47	1.58	-0.89	-1.58	0.61	-0.96	-1.53	-0.04	-1.57	**1.80±0.38**	**0.80±0.57**	**-1.00±0.29**
GFDL	-2.04	1.28	-0.76	-1.50	0.61	-0.90	-1.65	0.75	-0.90	-2.46	1.57	-0.89	-1.60	0.62	-0.98	-1.55	-0.02	-1.57	**-1.80±0.37**	**0.80±0.56**	**-1.00±0.29**
CAM3	-1.88	1.28	-0.60	-1.32	0.62	-0.70	-1.50	0.77	-0.72	-2.31	1.59	-0.72	-1.42	0.63	-0.79	-1.35	-0.01	-1.36	**-1.63±0.39**	**0.81±0.56**	**-0.81±0.27**
Multi-kernel mean	**-1.97±0.06**	**1.28±0.01**	**-0.70±0.06**	**-1.43±0.07**	**0.62±0.01**	**-0.81±0.07**	**-1.58±0.06**	**0.77±0.01**	**-0.82±0.06**	**-2.39±0.06**	**1.58±0.01**	**-0.81±0.06**	**-1.51±0.06**	**0.62±0.01**	**-0.89±0.07**	**-1.45±0.07**	**-0.02±0.01**	**-1.47±0.08**			
Multi-kernel λ_{res}	**0.06±0.06**	**-0.15±0.01**	**-0.09±0.06**	**-0.02±0.07**	**-0.04±0.01**	**-0.06±0.07**	**-0.06±0.06**	**-0.08±0.01**	**-0.14±0.06**	**0.07±0.06**	**-0.03±0.01**	**0.04±0.06**	**0.01±0.07**	**-0.03±0.01**	**-0.02±0.07**	**-0.07±0.07**	**-0.04±0.01**	**-0.11±0.07**			
dT_s (K)	11.16			6.59			7.18			7.61			8.24			4.70					

Table S2. Kernel-diagnosed all-sky TOA radiative feedback parameters, units: W m^{-2} K^{-1}. First six columns: the mean and standard deviation of the feedback parameter values diagnosed from different kernels for the same GCM; the last column: the mean and standard deviation of the feedback parameter values of different GCMs diagnosed from multi-kernel mean results, units: W m^{-2} K^{-1}.

	CESM2	CNRM-CM6-1	EC-Earth3	HadGEM3-GC3-LL	IPSL-CM6A-LR	MPI-ESM1-2-LR	**Multi-model**
λ_{Ts}	-0.66±0.06	-0.63±0.05	-0.62±0.05	-0.65±0.06	-0.61±0.05	-0.62±0.05	**-0.63±0.02**
λ_{Ta}	-3.02±0.06	-2.93±0.05	-2.78±0.05	-3.07±0.05	-2.84±0.05	-3.15±0.06	**-2.97±0.14**
λ_q LW	1.58±0.07	1.56±0.08	1.52±0.07	1.49±0.06	1.63±0.07	1.65±0.07	**1.57±0.06**
λ_c LW	0.13±0.04	0.58±0.04	0.30±0.04	-0.17±0.04	0.31±0.04	0.67±0.04	**0.30±0.30**
λ_q SW	0.25±0.03	0.24±0.03	0.25±0.03	0.24±0.03	0.25±0.03	0.25±0.03	**0.25±0.01**
λ_{alb}	0.28±0.04	0.40±0.06	0.44±0.07	0.37±0.06	0.33±0.05	0.31±0.05	**0.36±0.06**
λ_c SW	0.75±0.05	-0.02±0.07	0.07±0.07	0.97±0.06	0.05±0.06	-0.59±0.06	**0.21±0.57**

Table S3. Similar to Table S1, but for the surface feedback. The overall feedback parameter and residual term from HadGEM3 kernel are shown in last two rows for comparison.

	CESM2			CNRM-CM6-1			EC-Earth3			HadGEM3-GC3-LL			IPSL-CM6A-LR			MPI-ESM1-2-LR			**Multi-model mean**		
	LW	SW	Net	LW	SW	Net	LW	SW	Net	LW	SW	Net	LW	SW	Net	LW	SW	Net	**LW**	**SW**	**Net**
ERA5	0.64	0.55	1.19	0.85	-0.17	0.68	1.02	-0.01	1.00	0.67	0.80	1.48	0.85	-0.20	0.65	1.29	-0.87	0.43	**0.89±0.24**	**0.02±0.60**	**0.90±0.39**
ERAi	0.56	0.52	1.08	0.79	-0.20	0.59	0.95	-0.05	0.90	0.57	0.77	1.35	0.74	-0.23	0.51	1.11	-0.90	0.21	**0.79±0.22**	**-0.01±0.60**	**0.77±0.41**
CAM5	0.53	0.60	1.12	0.69	-0.12	0.57	0.99	0.03	1.02	0.58	0.85	1.43	0.76	-0.15	0.61	1.27	-0.83	0.44	**0.80±0.28**	**0.06±0.60**	**0.87±0.39**
CloudSat	0.72	0.67	1.39	0.92	-0.06	0.86	1.20	0.08	1.28	0.74	0.91	1.65	0.88	-0.09	0.79	1.37	-0.77	0.60	**0.97±0.26**	**0.12±0.60**	**1.09±0.41**
Multi-kernel mean	**0.61 ±0.09**	**0.58 ±0.07**	**1.19±0.14**	**0.81 ±0.10**	**-0.14 ±0.06**	**0.67± 0.13**	**1.04 ±0.11**	**-0.01 ±0.05**	**1.05± 0.16**	**0.64 ±0.08**	**0.84 ±0.06**	**1.48± 0.13**	**0.81 ±0.07**	**-0.17 ±0.06**	**0.64± 0.12**	**1.26 ±0.11**	**-0.84 ±0.05**	**0.42 ±0.16**			
Multi-kernel λ_{res}	**0.22 ±0.08**	**-0.25 ±0.07**	**-0.03±0.14**	**0.10 ±0.09**	**0.02 ±0.07**	**0.12± 0.13**	**-0.05 ±0.10**	**-0.11 ±0.06**	**-0.16± 0.16**	**0.08 ±0.08**	**-0.19 ±0.07**	**-0.11± 0.13**	**0.07 ±0.07**	**0.00 ±0.07**	**0.07± 0.12**	**-0.17 ±0.10**	**-0.07 ±0.06**	**-0.24 ±0.16**			
HadGEM3	-2.69	0.70	-1.99	-2.27	-0.02	-2.30	-2.08	0.14	-1.94	-2.58	0.96	-1.63	-2.25	-0.05	-2.30	-1.89	-0.72	-2.61			
HadGEM3 λ_{res}	3.52	-0.37	3.15	3.19	-0.09	3.10	3.06	-0.23	2.84	3.30	-0.31	2.99	3.14	-0.12	3.02	2.98	-0.18	2.79			

Table S4. Similar to Table S2, but for the surface feedbacks. The temperature feedback parameters from HadGEM3 kernel are shown in last three rows for comparison.

	CESM2	CNRM-CM6-1	EC-Earth3	HadGEM3-GC3-LL	IPSL-CM6A-LR	MPI-ESM1-2-LR	**Multi-model mean**
$\lambda_{Ta} + \lambda_{Ts}$	-1.10±0.10	-1.09±0.10	-1.04±0.09	-1.04±0.08	-1.02±0.06	-0.87±0.04	**-1.02±0.08**
λ_{Ts}	-3.67±1.06	-3.50±1.01	-3.48±1.01	-3.63±1.05	-3.41±0.98	-3.44±1.00	**-3.52±0.11**
λ_{Ta}	2.57±0.99	2.42±0.94	2.44±0.93	2.59±0.99	2.39±0.93	2.57±0.97	**2.50±0.09**
λ_q LW	1.97±0.13	1.83±0.13	1.99±0.12	1.90±0.12	1.91±0.13	2.00±0.12	**1.93±0.06**
λ_c LW	-0.26±0.07	0.07±0.07	0.09±0.09	-0.22±0.07	-0.09±0.08	0.13±0.09	**-0.05±0.17**
λ_q SW	-0.61±0.06	-0.57±0.06	-0.61±0.06	-0.57±0.05	-0.59±0.06	-0.62±0.06	**-0.59±0.02**
λ_{alb}	0.33±0.04	0.47±0.05	0.52±0.05	0.44±0.05	0.39±0.04	0.37±0.04	**0.42±0.07**
λ_c SW	0.86±0.06	-0.04±0.06	0.10±0.06	0.97±0.06	0.04±0.05	-0.59±0.06	**0.22±0.59**
HadGEM3 $\lambda_{Ta} + \lambda_{Ts}$	-3.86	-3.70	-3.66	-3.76	-3.60	-3.54	
HadGEM3 λ_{Ts}	-5.12	-4.89	-4.86	-5.06	-4.74	-4.79	
HadGEM3 λ_{Ta}	1.26	1.19	1.20	1.29	1.15	1.26	