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A global long-term (1981–2019) daily land surface radiation budget product from AVHRR satellite data using a residual convolutional neural network

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S5.1 Examination of spatial adjacent effect using the MLR model

To ensure that the RCNN model retrieves R_n measurements with the highest possible accuracy, it is crucial to determine the optimal spatial size of the input image block. If the size of the input image is too small, insufficient vicinity information is input into the RCNN, whereas if the spatial size of the tensor is too large, irrelevant redundant information is included that can negatively affect retrieval accuracy.

In this study, we utilized a simple method to investigate the effects that different spatial scales can have on the retrieval accuracy of surface R_n using AVHRR data. Specifically, spatial scale effects on R_n retrieval were quantified by observing the response of the built model's performance to changes in input image block sizes. In this study, a multivariate linear regression model (MLR) was adopted to account for spatial scale effects. When *m* response observations and *n* explanatory variables are given, the MLR model can be mathematically expressed as:

$$y_i = \alpha_0 + \alpha_1 x_{i1} + \alpha_2 x_{i2} + \cdots + \alpha_n x_{in} + \varepsilon_i, \quad i = 1, 2, 3, \ldots, m \qquad \text{Eq. (1)}$$

where *x* and *y* represent explanatory and response variables, respectively; α is the fitting coefficient, and ε is the notation for mode deviations. The best-fitting line can be obtained by minimizing the sum of squares of the vertical deviations using the ordinary least squares method. In this study, the explanatory variables (n = 25) are statistical parameters—including maximum, minimum, mean, median, and variance values—that describe the associated input image blocks in different channels; the corresponding response variable is surface R_n. To maintain the consistency of the MLR model structure at different spatial scales, statistical parameters, rather than pixel values,

were taken as MLR inputs. The performance of the built MLR model performance was observed under varying spatial scales because the statistical parameters of valid images are affected by the input size.

Table S1. The detailed information of collected 522 sites.

Station name	Latitude (°)	Longitude (°)	Elevation (m)	Land cover
Training sites				
ARM_E01	38.202	-99.316	632	CRO
ARM_E02	38.31	-97.3	447	GRA
ARM_E03	38.201	-95.597	338	CRO
ARM_E04	37.95	-98.33	513	GRA
ARM_E05	38.114	-97.513	440	CRO
ARM_E07	37.38	-96.18	283	GRA
ARM_E08	37.33	-99.31	664	GRA
ARM_E09	37.13	-97.27	386	GRA
ARM_E10	37.068	-95.788	248	CRO
ARM_E11	36.881	-98.285	360	GRA
ARM_E12	36.84	-96.43	331	GRA
ARM_E15	36.43	-98.28	418	GRA
ARM_E16	36.061	-99.134	602	GRA
ARM_E18	35.687	-95.86	217	GRA
ARM_E19	35.56	-98.02	421	GRA
ARM_E20	35.56	-96.99	309	GRA
ARM_E21	35.615	-96.065	240	DBF
ARM_E22	35.35	-98.98	465	GRA
ARM_E24	34.883	-98.205	409	CRO
ARM_E25	35.25	-96.74	277	GRA
ARM_E27	35.27	-96.74	300	GRA
ARM_E31	37.151	-98.362	412	GRA
ARM_E32	36.819	-97.82	328	GRA
ARM_E33	36.926	-97.082	357	GRA
ARM_E34	37.069	-96.761	417	GRA
ARM_E35	35.862	-97.069	294	GRA
ARM_E36	36.117	-97.511	337	GRA
ARM_E37	36.311	-97.928	379	CRO
ARM_E38	35.88	-98.173	371	CRO
ARM_E39	36.37354	-97.069	279	CRO
ARM_E40	36.3199	-96.7652	247	GRA
BSRN_BON	40.0667	-88.3667	213	CRO
BSRN_BOU	40.05	-105.007	1577	CRO
BSRN_DAR	-12.425	130.891	30	GRA
BSRN_E13	36.605	-97.485	318	GRA
BSRN_GOB	-23.5614	15.042	407	BSV
BSRN_IZA	28.3093	-16.4993	2373	BSV
BSRN_NYA	78.925	11.93	11	TUN
BSRN_PAY	46.815	6.944	491	CRO

BSRN_SOV	24.91	46.41	650	BSV
BSRN_SYO	-69.005	39.589	18	ICE
BSRN_TAT	36.05	140.1333	25	GRA
BSRN_TIK	71.5862	128.9188	48	TUN
BSRN_TOR	58.254	26.462	70	GRA
CD04_KM83	-3.01806	-54.96889	100	MF
CD32_RON_FNS	-10.76167	-62.35833	288	GRA
CD32_RON_RJA	-10.07833	-61.9331	200	MF
CD32_SP_PDG	-21.61917	-47.63278	659	SAV
CD32_STM_K34	-2.608333	-60.20833	67	MF
CD32_STM_K77	-3.012	-54.537	41	CRO
CD32_STR_K83	-3.05	-54.93333	95	MF
CD32_TOC_BAN	-9.821139	-50.14869	229	MF
CEOPInt_ANBrw	71.32	-156.61	8	WET
CEOPInt_ATDar	-12.425	130.892	29.9	OSH
CEOPInt_ATMan	-2.06	147.43	4	GRA
CEOPInt_ATNau	-0.521	166.916	7.1	DBF
CEOPInt_LinFK	52.17	14.12	73	GRA
CEOPInt_LinF	52.18	13.95	49.1	DBF
CEOPInt_SodOSA	67.36667	26.629056	193.3	ENF
CEOP_AR	38.043333	100.46467	3033	GRA
CEOP_DS	44.088889	113.57417	970	GRA
CEOP_DX	35.556367	104.59383	1896	CRO
CEOP_JZ	41.1841	121.20167	22	CRO
CEOP_MQ	33.8872	102.1407	3423	WET
CEOP_MY	40.630833	117.32333	350	CRO
CEOP_NM	42.928833	120.69783	361	GRA
CEOP_SPT	37.32	105.11	1227	BSV
CEOP_TYCRO	44.566667	122.88333	184	CRO
CEOP_TYGRA	44.566667	122.88333	184	GRA
CEOP_YK	38.86	100.41	1519	CRO
CEOP_YZ	35.95	104.13333	1965	GRA
CERN_FK	44.28	87.92	482	GRA
CF_DZ	19.5464	109.475	114	CRO
CF_PD	26.3675	105.7522	1158	EBF
EOL-CAMP_ANNI	31.25442	92.17241	4480	BSV
EOL-CAMP_BJ	31.36866	91.89871	4509.2	BSV
EOL-CAMP_D105	33.0643	91.9425	5038.6	BSV
EOL-CAMP_FOR	46.3989	10.5903	2669	BSV
EOL-CAMP_Gaize	32.3	84.05	4416	BSV
EOL-CAMP_LAM	18.4	99.47	241	EBF
EOL-CAMP_PYR	27.9591	86.8132	5035	BSV
EOL-CAMP_TYGRA	44.416	122.867	184	GRA
EOL-CRD_C2	64.89	-163.64	110	OSH

EOL-KRD_K2	65.43	-164.64	59	BSV
EOL-PAN	-19.5597	-57.5833	160	SAV
EOL-SAN	-3.02	-54.97	130	EBF
FGI_MET0002	67.361866	26.637728	179	ENF
FGI_MET0005	67.361866	26.637728	179	ENF
FR_Mau	43.0519	-1.1256	384	GRA
FxMt_BKS	-0.861389	117.04472	20	EBF
FxMt_BNS	21.95	101.02	20	EBF
FxMt_CLM	24.583333	121.4	1400	ENF
FxMt_GCK	37.748333	127.16222	132	DNF
FxMt_KBU	47.213972	108.73733	1235	GRA
FxMt_LSH	45.278611	127.57839	340	DNF
FxMt_MBF	44.384167	142.31861	585	DBF
FxMt_MKL	14.576278	98.843889	231	MF
FxMt_MMF	44.321944	142.26139	340	MF
FxMt_MSE	36.053972	140.02692	13	CRO
FxMt_PSO	2.96667	102.3	134	EBF
FxMt_QHB	37.6	101.33333	3250	GRA
FxMt_QYZ	26.7333	115.06667	100	WSA
FxMt_SKR	14.492361	101.91631	543	EBF
FxMt_SKT	48.351861	108.65433	1630	DNF
FxMt_SMF	35.25	137.06667	205	MF
FxMt_TKY	36.146167	137.42311	1420	DBF
FxMt_TMK	42.736972	141.51864	140	DNF
FxMt_TSE	45.05	142.1	70	MF
FxMt_YCS	36.5	116.34	28	CRO
FxMt_YPF	62.241389	129.65056	220	ENF
GCNET-01	69.564722	-49.33083	1176	ICE
GCNET-02	69.564722	-46.99667	2022	ICE
GCNET-03	73.841389	-49.50694	2334	ICE
GCNET-04	77.137778	-61.04	1869	ICE
GCNET-05	78.526667	-56.83056	1995	ICE
GCNET-06	72.579444	-38.50528	3199	ICE
GCNET-07	78.016389	-33.98333	2052	ICE
GCNET-08	66.480556	-46.28306	2099	ICE
GCNET-09	69.495	-49.70389	932	ICE
GCNET-10	65.999722	-44.50017	2467	ICE
GCNET-11	63.14889	-44.81717	2901	ICE
GCNET-12	75.000556	-29.99722	2614	ICE
GCNET-13	69.913333	-46.98962	1990	ICE
GCNET-15	66.475	-42.49861	2373	ICE
GCNET-16	69.699444	-33.00058	2579	ICE
GCNET-17	69.414722	-50.09278	507	ICE
GCNET-20	67.135833	-47.29222	1798	ICE

GCNET-21	80.683611	-60.29306	37	ICE
GM_Amdo	32.241133	91.625117	4700	GRA
GM_KogMa	18.8126	98.9002	1268	ENF
HAWS01	38.89322	100.35813	1552.75	CRO
HAWS02	38.88695	100.35406	1559.09	CRO
HAWS03	38.89053	100.37634	1543.05	CRO
HAWS04	38.87752	100.35753	1561.87	BSV
HAWS05	38.87574	100.35068	1567.65	CRO
HAWS06	38.87116	100.3597	1562.97	CRO
HAWS07	38.87676	100.36521	1556.39	CRO
HAWS08	38.87254	100.37649	1550.06	CRO
HAWS09	38.87239	100.38646	1543.34	CRO
HAWS10	38.87567	100.39572	1534.73	CRO
HAWS11	38.86991	100.34197	1575.65	CRO
HAWS12	38.86515	100.36631	1559.25	CRO
HAWS13	38.86074	100.37852	1550.73	CRO
HAWS14	38.85867	100.3531	1570.23	CRO
HAWS17	38.8451	100.36972	1559.63	MF
HAWS18	38.91496	100.3042	1562	BSV
HAWS19	38.78917	100.4933	1594	BSV
HAWS21	38.97514	100.4464	1460	WET
IMAU-S10	67.0005	-47.0167	1850	ICE
IMAU-S5	67.0833	50.1	500	ICE
IMAU-S6	67.06667	49.383333	1000	ICE
IMAU-S9	67.05	48.216667	1500	ICE
Lath_AT-Neu	47.11667	11.3175	970	GRA
Lath_AU-ASM	-22.283	133.249	608	ENF
Lath_AU-Cpr	-34.0021	140.5891	63	SAV
Lath_AU-Fog	-12.5425	131.307	4	WET
Lath_AU-Gin	-31.3764	115.7138	50	WSA
Lath_AU-How	-12.4943	131.152	40	WSA
Lath_AU-Rig	-36.6499	145.5759	151	GRA
Lath_AU-Wac	-37.429	145.187	545	MF
Lath_AU-Whr	-36.6732	145.0294	151	EBF
Lath_AU-Wom	-37.4222	144.0944	705	EBF
Lath_BE-Bra	51.3092	4.52056	16	MF
Lath_BE-Lon	50.5522	4.74494	167	CRO
Lath_BE-Vie	50.3055	5.99683	450	MF
Lath_BR-Cax	-1.71972	-51.459	50	EBF
Lath_BR-Ma2	-2.6091	-60.2093	120	EBF
Lath_BR-Sa3	-3.01803	-54.9714	100	EBF
Lath_BR-Sp1	-21.6195	-47.6499	690	WSA
Lath_BW-Ghg	-21.51	21.74	1162	SAV
Lath_BW-Ma1	-19.9155	23.5605	950	WSA

Lath_CA-ARB	52.694999	-83.94523	90	WET
Lath_CA-ARF	52.70078	-83.95505	88	WET
Lath_CA-Ca1	49.8672	-125.334	300	ENF
Lath_CA-Ca2	49.8705	-125.291	300	ENF
Lath_CA-Ca3	49.5346	-124.9	300	ENF
Lath_CA-Gro	48.2167	-82.1556	355	MF
Lath_CA-Let	49.7093	-112.94	960	GRA
Lath_CA-Man	55.8796	-98.4808	259	ENF
Lath_CA-Mer	45.4094	-75.5186	70	WET
Lath_CA-NS1	55.8792	-98.4839	260	ENF
Lath_CA-NS2	55.9058	-98.5247	260	ENF
Lath_CA-NS3	55.9117	-98.3822	260	ENF
Lath_CA-NS4	55.9117	-98.3822	260	ENF
Lath_CA-NS5	55.8631	-98.485	260	ENF
Lath_CA-NS6	55.9167	-98.9644	244	OSH
Lath_CA-NS7	56.6358	-99.9483	273	OSH
Lath_CA-Oas	53.6289	-106.198	530	DBF
Lath_CA-Obs	53.9872	-105.118	629	ENF
Lath_CA-Ojp	53.9163	-104.692	579	ENF
Lath_CA-Qcu	49.2671	-74.0365	392	ENF
Lath_CA-Qfo	49.6925	-74.3421	382	ENF
Lath_CA-SCB	61.3089	-121.2984	280	WET
Lath_CA-SF1	54.485	-105.818	536	ENF
Lath_CA-SF2	54.2539	-105.878	520	ENF
Lath_CA-SF3	54.0916	-106.005	540	OSH
Lath_CA-SJ1	53.908	-104.656	580	ENF
Lath_CA-SJ2	53.945	-104.649	580	ENF
Lath_CA-SJ3	53.8758	-104.645	580	ENF
Lath_CA-TP1	42.6609	-80.5595	265	ENF
Lath_CA-TP2	42.7744	-80.4588	212	ENF
Lath_CA-TP3	42.7068	-80.3483	184	ENF
Lath_CA-TP4	42.7098	-80.3574	184	ENF
Lath_CA-TPD	42.635328	-80.55773	260	DBF
Lath_CA-WP1	54.9538	-112.467	540	WET
Lath_CA-WP2	55.5375	-112.334	540	WET
Lath_CA-WP3	54.47	-113.32	540	WET
Lath_CG-Tch	-4.28917	11.6564	87	OSH
Lath_CH-Cha	47.21022	8.41044	393	GRA
Lath_CH-Dav	46.81533	9.85591	1639	ENF
Lath_CH-Oe1	47.2856	7.73214	450	GRA
Lath_CH-Oe2	47.2863	7.73433	452	CRO
Lath_CN-Anh	33	117	23	DBF
Lath_CN-Bed	39.5306	116.252	30	EBF
Lath_CN-Cha	42.4025	128.096	761	MF

Lath_CN-Cng	44.5934	123.5092	141	GRA
Lath_CN-Do1	31.5167	121.961	2	WET
Lath_CN-Do3	31.5169	121.972	2	WET
Lath_CN-Du1	42.0456	116.671	1350	CRO
Lath_CN-Du2	42.0467	116.284	1350	GRA
Lath_CN-HaM	37.37	101.18	3250	GRA
Lath_CN-Ku1	40.5383	108.694	1020	EBF
Lath_CN-Ku2	40.3808	108.549	1160	OSH
Lath_CN-Xfs	44.13417	116.3286	1121	GRA
Lath_CN-Xi1	43.54583	116.6778	1270	GRA
Lath_CN-Xi2	43.5544	116.671	1203	GRA
Lath_CZ-BK1	49.5026	18.5384	908	ENF
Lath_CZ-BK2	49.4953	18.5447	855	GRA
Lath_CZ-wet	49.025	14.772	420	WET
Lath_DE-Akm	53.86617	13.68342	-1	WET
Lath_DE-Geb	51.1001	10.9143	162	CRO
Lath_DE-Gri	50.9495	13.5125	385	GRA
Lath_DE-Hai	51.0793	10.452	430	DBF
Lath_DE-Har	47.9344	7.601	201	ENF
Lath_DE-Kli	50.8929	13.5225	480	CRO
Lath_DE-Lkb	49.09962	13.30467	1308	ENF
Lath_DE-Lnf	51.32822	10.3678	451	DBF
Lath_DE-Meh	51.2753	10.6555	286	GRA
Lath_DE-Spw	51.89225	14.03369	61	WET
Lath_DE-Tha	50.9636	13.5669	380	ENF
Lath_DE-Wet	50.4535	11.4575	785	ENF
Lath_DK-Fou	56.4842	9.58722	51	CRO
Lath_DK-Lva	55.6833	12.0833	15	GRA
Lath_DK-Nuf	64.13083	-51.38611	50	WET
Lath_DK-Ris	55.5303	12.0972	10	CRO
Lath_DK-Sor	55.4869	11.6458	40	DBF
Lath_ES-ES1	39.346	-0.31881	10	ENF
Lath_ES-ES2	39.2755	-0.31522	10	CRO
Lath_ES-LJu	36.9282	-2.75047	1600	OSH
Lath_ES-LMa	39.9415	-5.77336	260	SAV
Lath_ES-VDA	42.1522	1.4485	1770	GRA
Lath_FI-Hyy	61.8474	24.2948	181	ENF
Lath_FI-Kaa	69.1407	27.295	155	WET
Lath_FI-Sii	61.833	24.193	170	GRA
Lath_FI-Sod	67.3619	26.6378	180	ENF
Lath_FR-Aur	43.5494	1.10778	240	CRO
Lath_FR-Fon	48.4763	2.78015	90	DBF
Lath_FR-Gri	48.844	1.95243	125	CRO
Lath_FR-Hes	48.6742	7.06462	300	DBF

Lath_FR-LBr	44.7171	-0.7693	61	ENF
Lath_FR-Lam	43.4933	1.23722	180	CRO
Lath_FR-Lq1	45.6441	2.73703	1040	GRA
Lath_FR-Lq2	45.6392	2.73703	1040	GRA
Lath_FR-Pue	43.7414	3.59583	270	EBF
Lath_GF-Guy	5.2777	-52.9288	35	EBF
Lath_GH-Ank	5.26854	-2.69421	154	EBF
Lath_HU-Bug	46.6911	19.6013	140	GRA
Lath_HU-Mat	47.8469	19.726	350	GRA
Lath_ID-Pag	2.345	114.036	30	EBF
Lath_IE-Ca1	52.8588	-6.91814	50	CRO
Lath_IE-Dri	51.9867	-8.75181	187	GRA
Lath_IL-Yat	31.345	35.0515	650	ENF
Lath_IT-Amp	41.9041	13.6052	833	GRA
Lath_IT-BCi	40.5238	14.9574	20	CRO
Lath_IT-Be2	46.0031	13.0257	67	GRA
Lath_IT-Bon	39.4778	16.5347	1170	ENF
Lath_IT-Cas	45.06285	8.668539	90	CRO
Lath_IT-Col	41.8494	13.5881	1550	DBF
Lath_IT-Cpz	41.7052	12.3761	68	EBF
Lath_IT-LMa	45.5813	7.15463	350	GRA
Lath_IT-Lav	45.9553	11.2812	1353	ENF
Lath_IT-Lec	43.3046	11.2706	314	EBF
Lath_IT-MBo	46.0156	11.0467	1550	GRA
Lath_IT-Mal	46.1167	11.7028	1730	GRA
Lath_IT-Noe	40.606	8.151	28	CSH
Lath_IT-Non	44.6898	11.0887	25	DBF
Lath_IT-PT1	45.2009	9.06104	60	DBF
Lath_IT-Ren	46.5878	11.4347	11	ENF
Lath_IT-Ro1	42.4081	11.93	235	DBF
Lath_IT-Ro2	42.3903	11.9209	224	DBF
Lath_IT-SRo	43.72786	10.28444	4	ENF
Lath_IT-Tor	45.84444	7.57806	2160	GRA
Lath_IT-Vig	45.31667	8.85	106	DBF
Lath_KR-Hnm	34.55	126.57	7	CRO
Lath_NL-Ca1	52.0031	4.8055	0.7	GRA
Lath_NL-Haa	52.0031	4.8055	1	GRA
Lath_NL-Hor	52.0289	5.0675	1	GRA
Lath_NL-Lan	51.9536	4.9029	1	CRO
Lath_NL-Loo	52.16658	5.74396	25	ENF
Lath_NL-Lut	53.3989	6.356	1	CRO
Lath_NL-Mol	52.775	4.899	1	CRO
Lath_NO-Adv	78.186	15.923	17	WET
Lath_PL-wet	52.7622	16.3094	54	WET

Lath_PT-Esp	38.6394	-8.6018	95	EBF
Lath_PT-Mi1	38.5407	-8.0004	250	EBF
Lath_PT-Mi2	38.4765	-8.02455	190	GRA
Lath_RU-Che	68.6147	161.339	3	WET
Lath_RU-Cok	70.6167	147.883	15	OSH
Lath_RU-Fyo	56.46167	32.92389	260	ENF
Lath_RU-Zot	60.8008	89.3508	90	ENF
Lath_SE-Abi	68.36239	18.79475	345	DBF
Lath_SE-Deg	64.1833	19.55	270	WET
Lath_SE-Fla	64.1128	19.4569	226	ENF
Lath_SE-Nor	60.0865	17.4795	43	ENF
Lath_SE-Sk1	60.125	17.9181	42	ENF
Lath_SE-Sk2	60.12967	17.84006	55	ENF
Lath_SK-Tat	49.1208	20.1635	1050	ENF
Lath_UK-AMo	55.7917	-3.23889	270	WET
Lath_UK-EBu	55.866	-3.20578	190	GRA
Lath_UK-ESa	55.90694	-2.85861	97	CRO
Lath_UK-Gri	56.60722	-3.79806	340	ENF
Lath_UK-Ham	51.15353	-0.8583	80	DBF
Lath_UK-Her	51.7838	-0.47608	140	CRO
Lath_UK-PL3	51.45	-1.26667	115	DBF
Lath_UK-Tad	51.2071	-2.82864	3	GRA
Lath_US-AR1	36.4267	-99.42	611	GRA
Lath_US-ARM	36.6058	-97.4888	314	CRO
Lath_US-ARb	35.5497	-98.0402	424	GRA
Lath_US-ARc	35.54649	-98.04	424	GRA
Lath_US-An2	68.95	-150.21	600	OSH
Lath_US-An3	68.93	-150.27	600	OSH
Lath_US-Atq	70.4696	-157.409	15	WET
Lath_US-Aud	31.5907	-110.51	1469	GRA
Lath_US-Bar	44.0646	-71.28808	272	DBF
Lath_US-Bi1	38.1022	-121.5042	-3.92	CRO
Lath_US-Bkg	44.3453	-96.8362	510	GRA
Lath_US-Blk	44.158	-103.65	1718	ENF
Lath_US-Blo	38.8952	-120.6328	1315	ENF
Lath_US-Bn1	63.9198	-145.378	518	ENF
Lath_US-Bn2	63.9198	-145.378	410	DBF
Lath_US-Bn3	63.9227	-145.744	469	OSH
Lath_US-Bo1	40.0062	-88.2904	219	CRO
Lath_US-Br1	41.9749	-93.6906	313	CRO
Lath_US-Br3	41.97472	-93.69357	313	CRO
Lath_US-Brw	71.3225	-156.6259	1	WET
Lath_US-CPk	41.067963	-106.1187	2750	ENF
Lath_US-CaV	39.0633	-79.4208	994	GRA

Lath_US-ChR	35.93109	-84.33242	286	DBF
Lath_US-FPe	48.3077	-105.1019	634	GRA
Lath_US-FR2	29.9495	-97.9962	272	WSA
Lath_US-FR3	29.94	-97.99	232	CSH
Lath_US-Fmf	35.1426	-111.7273	2160	ENF
Lath_US-Fuf	35.089	-111.762	2180	ENF
Lath_US-Fwf	35.4454	-111.7718	2270	GRA
Lath_US-GBT	41.36579	-106.2397	3191	ENF
Lath_US-GLE	41.36653	-106.2399	3197	ENF
Lath_US-Goo	34.2547	-89.8735	87	GRA
Lath_US-Ha1	42.5378	-72.1715	340	DBF
Lath_US-Ho1	45.2041	-68.7402	60	ENF
Lath_US-Ho2	45.2091	-68.747	91	ENF
Lath_US-Ho3	45.2072	-68.725	61	ENF
Lath_US-IB1	41.8593	-88.2227	225	CRO
Lath_US-IB2	41.8406	-88.241	225	GRA
Lath_US-Ivo	68.4865	-155.75	579	WET
Lath_US-KFS	39.0561	-95.1907	310	GRA
Lath_US-KS2	28.6086	-80.6715	3	CSH
Lath_US-KUT	44.994989	-93.18628	301	GRA
Lath_US-Los	46.0827	-89.9792	480	CSH
Lath_US-MMS	39.3231	-86.4131	275	DBF
Lath_US-MOz	38.7441	-92.2	220	DBF
Lath_US-MRf	44.64649	-123.5515	263	ENF
Lath_US-Me2	44.4523	-121.5574	1253	ENF
Lath_US-Me3	44.3154	-121.6078	1005	ENF
Lath_US-Me6	44.323284	-121.6078	998	ENF
Lath_US-Mpj	34.4385	-106.2377	2196	WSA
Lath_US-NC1	35.8115	-76.7115	5	OSH
Lath_US-NC2	35.8031	-76.6679	12	ENF
Lath_US-NC3	35.799	-76.656	5	ENF
Lath_US-NC4	35.7879	-75.9038	1	WET
Lath_US-NGB	71.280044	-156.6092	5.273	ICE
Lath_US-NR1	40.0329	-105.546	3050	ENF
Lath_US-Ne1	41.1651	-96.4766	361	CRO
Lath_US-Ne2	41.1649	-96.4701	362	CRO
Lath_US-Ne3	41.1797	-96.4397	363	CRO
Lath_US-Oho	41.5545	-83.8438	230	DBF
Lath_US-PFa	45.9459	-90.2723	470	MF
Lath_US-Prr	65.12367	-147.4876	210	ENF
Lath_US-RO1	44.7143	-93.0898	290	CRO
Lath_US-RO4	44.6781	-93.0723	274	GRA
Lath_US-SO2	33.3739	-116.6229	1394	CSH
Lath_US-SO3	33.3772	-116.6227	1429	CSH

Lath_US-SO4	33.3844	-116.6403	1429	CSH
Lath_US-SP1	29.7381	-82.2188	50	ENF
Lath_US-SP2	29.7648	-82.2448	50	ENF
Lath_US-SP3	29.7548	-82.1633	50	ENF
Lath_US-SRC	31.9083	-110.8395	991	OSH
Lath_US-SRG	31.789379	-110.8277	1291	GRA
Lath_US-SRM	31.8214	-110.866	1120	WSA
Lath_US-Seg	34.3623	-106.702	1596	GRA
Lath_US-Ses	34.3349	-106.7442	1604	OSH
Lath_US-Skr	25.362933	-81.07758	0	EBF
Lath_US-Slt	39.9138	-74.596	30	DBF
Lath_US-Srr	38.200556	-122.0264	8	WET
Lath_US-Syv	46.242	-89.3477	540	MF
Lath_US-Ton	38.4316	-120.966	177	WSA
Lath_US-Tw1	38.1074	-121.6469	-9	WET
Lath_US-UMB	45.5598	-84.7138	234	DBF
Lath_US-UMd	45.5625	-84.6975	239	DBF
Lath_US-Uaf	64.86627	-147.8555	155	ENF
Lath_US-Var	38.4133	-120.9507	129	GRA
Lath_US-WBW	35.9588	-84.2874	387	DBF
Lath_US-WCr	45.8059	-90.0799	520	DBF
Lath_US-Whs	31.7438	-110.0522	1370	OSH
Lath_US-Wi7	46.6491	-91.0693	349	OSH
Lath_US-Wi9	46.6188	-91.0814	349	ENF
Lath_US-Wjs	34.425489	-105.8615	1931	SAV
Lath_US-Wkg	31.7365	-109.942	1531	GRA
Lath_US-Wrc	45.8205	-121.952	371	ENF
Lath_VU-Coc	-15.4427	167.192	80	EBF
Lath_ZA-Kru	-25.0197	31.4969	359	SAV
Lath_ZM-Mon	-15.43778	23.25278	1053	DBF
PM-KAN_L	67.0955	-49.9513	670	ICE
PM-KAN_M	67.067	-48.8355	1270	ICE
PM-KPC_L	79.9108	-24.0828	370	ICE
PM-KPC_U	79.8347	-25.1662	870	ICE
PM-MIT	65.6922	-37.828	440	ICE
PM-NUK_L	64.4822	-49.5358	530	ICE
PM-NUK_N	64.1623	-51.3587	710	ICE
PM-NUK_U	64.5108	-49.2692	1120	ICE
PM-QAS_L	61.0308	-46.8493	280	ICE
PM-QAS_U	61.1753	-46.8195	900	ICE
PM-SCO_L	72.223	-26.8182	460	ICE
PM-SCO_U	72.3933	-27.2333	970	ICE
PM-TAS_L	61.0308	-46.8493	280	ICE
PM-THU_L	76.3998	-68.2665	570	ICE

PM-THU_U	76.4197	-68.1463	760	ICE
PM-UPE_L	72.8932	-54.2955	220	ICE
PM-UPE_U	72.8878	-53.5783	940	ICE
SFR_Skukuza	-25.02	31.484444	346	SAV
SF_BND	40.05	-88.37	230	CRO
SF_DRA	36.63	-116.02	1007	BSV
SF_FPK	48.31	-105.1	634	GRA
SF_GCM	34.25	-89.87	98	GRA
SF_PSU	40.72	-77.93	376	CRO
SF_SXF	43.73	-96.62	473	CRO
SF_TBL	40.13	-105.24	1689	GRA
stKOB	64.116667	-51.35	968	TUN
stZAC	74.466667	-21	822	TUN
Independent validation sites				
ARM_E06	37.842	-97.02	409	CRO
ARM_E41	36.87956	-97.0865	340	CRO
BSRN_ALE	82.49	-62.42	127	ICE
BSRN_GVN	-70.65	-8.25	42	ICE
CEOPInt_OR	35.9583	-84.2916	326	DBF
CEOP_DYK	38.533667	100.25017	2853	GRA
CEOP_GT	36.515	115.12744	42	CRO
CEOP_QY	35.59	107.54	1095	GRA
CEOP_ZY	39.085542	100.27924	1483	GRA
CNAADC_ZS	-69.3735	76.3706	14.9	ICE
EOL-CRD_C1	64.84	-163.7	40	OSH
EOL-CRD_C3	64.75	-163.89	171	TUN
EOL-KRD_K1	65.44	-164.57	258	BSV
EOL-KRD_K3	65.45	-164.64	571	BSV
EOL-SIB	69	161	3	TUN
FGI_SAA0001	68.33019	27.55062	440	ENF
FGI_SUO0010	67.368617	26.654067	180	CRO
FGI_VUO0002	67.361883	26.643233	180	ENF
FxMt_GDK	37.75	127.15	340	MF
FxMt_IRI	14.2	121.3	21	CRO
FxMt_SMK	37.938886	126.9547	293	MF
FxMt_SWL	36.046561	138.10839	759	WAT
FxMt_TKC	36.139722	137.37083	800	ENF
FxMt_TUR	64.208889	100.46356	250	DNF
FxMt_TWH	24.076	121.126	2076	EBF
FxMt_YLF	62.255	129.24139	220	DNF
GM_Dunhuang	40.15	94.683333	1140	CRO
HAWS16	38.84931	100.36411	1564.31	CRO
Lath_AR-SLu	-33.4648	-66.4598	506	MF
Lath_AU-Cum	-33.61518	150.72362	27	EBF

Lath_AU-Emr	-23.8587	148.4746	176	GRA
Lath_AU-RDF	-14.5636	132.4776	188	WSA
Lath_AU-Rob	-17.1175	145.6301	712	EBF
Lath_BR-Ban	-9.82442	-50.1591	174	EBF
Lath_BR-Sa1	-2.85667	-54.9589	198	EBF
Lath_CA-Na1	46.4722	-67.1	341	ENF
Lath_CA-Qc2	49.7598	-74.5711	393	MF
Lath_CA-SCC	61.3079	-121.2992	285	ENF
Lath_DE-SfN	47.80639	11.3275	290	WET
Lath_IT-Cp2	41.70427	12.35729	19	EBF
Lath_RU-Vrk	67.05468	62.94047	100	CSH
Lath_SD-Dem	13.2829	30.4783	500	SAV
Lath_TW-Tar	24.0312	120.688	55	CRO
Lath_US-AR2	36.6358	-99.5975	646	GRA
Lath_US-An1	68.99	-150.28	600	OSH
Lath_US-Bi2	38.109	-121.535	-4.98	CRO
Lath_US-CRT	41.628495	-83.34709	180	CRO
Lath_US-Ctn	43.95	-101.8466	744	GRA
Lath_US-DK1	35.9712	-79.0934	161	GRA
Lath_US-DK2	35.9736	-79.1004	168	DBF
Lath_US-DK3	35.9782	-79.0942	163	ENF
Lath_US-KS1	28.4583	-80.6709	3	ENF
Lath_US-LPH	42.5419	-72.185	360	DBF
Lath_US-Me1	44.5794	-121.5	896	ENF
Lath_US-Ro2	44.7288	-93.0888	292	CRO
Lath_US-Ro5	44.691	-93.0576	283	CRO
Lath_US-Ro6	44.6946	-93.05776	282	CRO
Lath_US-SFP	43.2408	-96.902	386	CRO
Lath_US-Tw2	38.1047	-121.6433	-5	CRO
Lath_US-Tw3	38.1159	-121.6467	-9	CRO
Lath_US-Tw4	38.10298	-121.6414	-5	CRO
Lath_US-UM3	45.568589	-84.67072	234	WAT
Lath_US-WPT	41.464639	-82.99616	175	WET
Lath_US-Wi1	46.7305	-91.2329	349	DBF
Lath_US-Wi2	46.6869	-91.1528	349	ENF
Lath_US-Wi5	46.6531	-91.0858	349	ENF
Lath_US-Wi8	46.7223	-91.2524	349	DBF
PM-EGP	75.6247	-35.9748	2660	ICE
PM-KAN_U	67.0003	-47.0253	1840	ICE
PM-NUK_K	64.1623	-51.3587	710	ICE
PM-QAS_A	61.243	-46.7328	1000	ICE
PM-QAS_M	61.0998	-46.833	630	ICE
PM-TAS_A	65.779	-38.8995	890	ICE
PM-TAS_U	65.6978	-38.8668	570	ICE

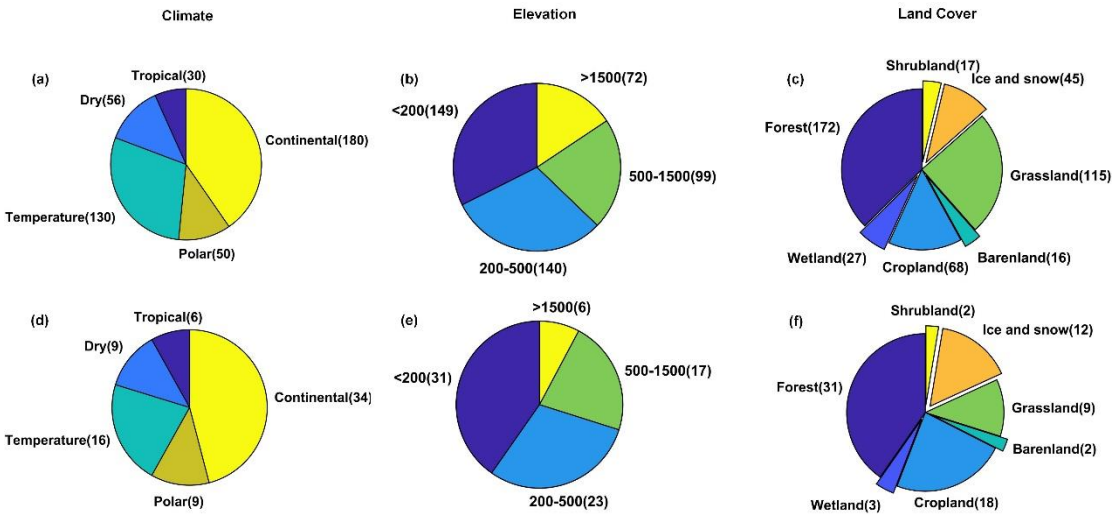

Fig. S1. Proportional distributions of (a-c) training sites and (d-f) validation sites under different climates, elevation ranges, and land covers, respectively. The value in the brackets is total number of sites under specific condition.

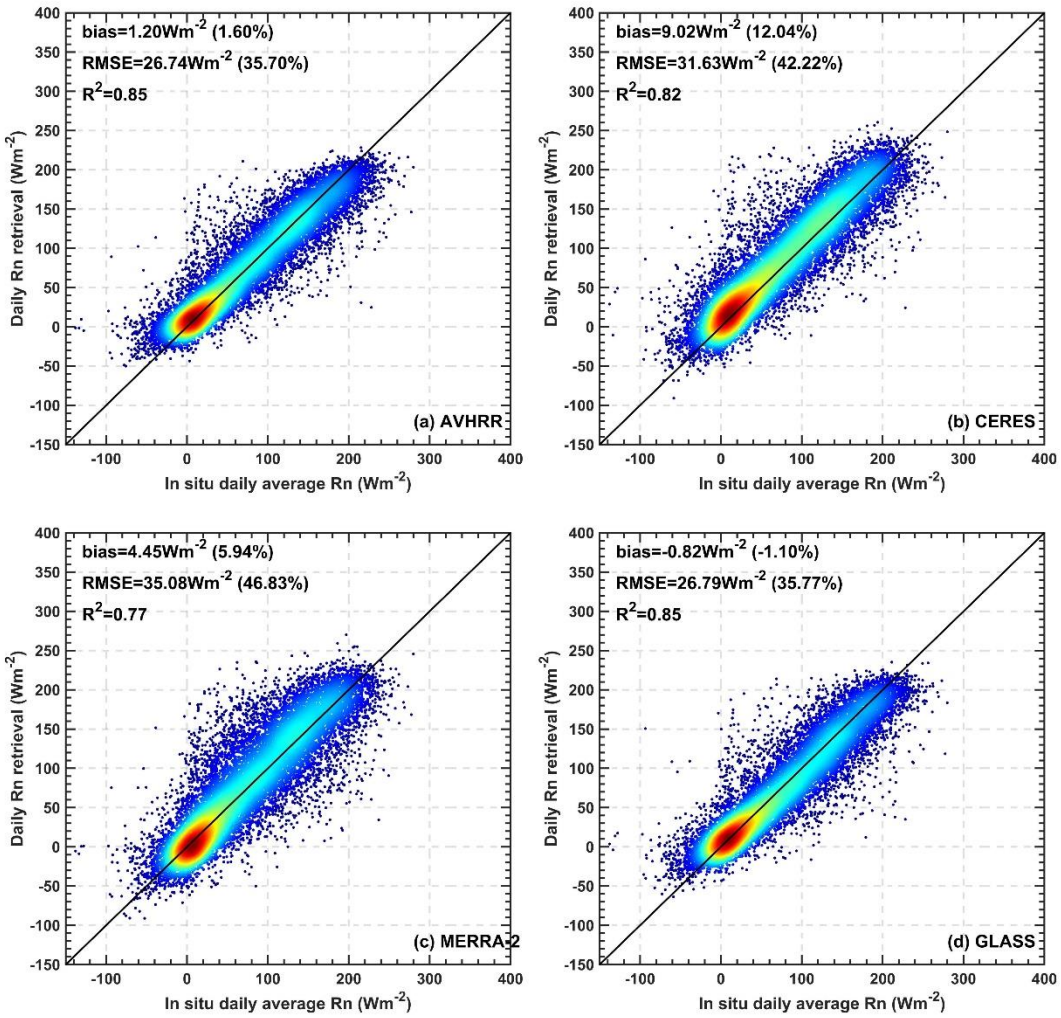

Fig. S2 Scatterplots of product validation for (a) AVHRR, (b) CERES-SYN, (c) MERRA2 and (d) GLASS at all sites.

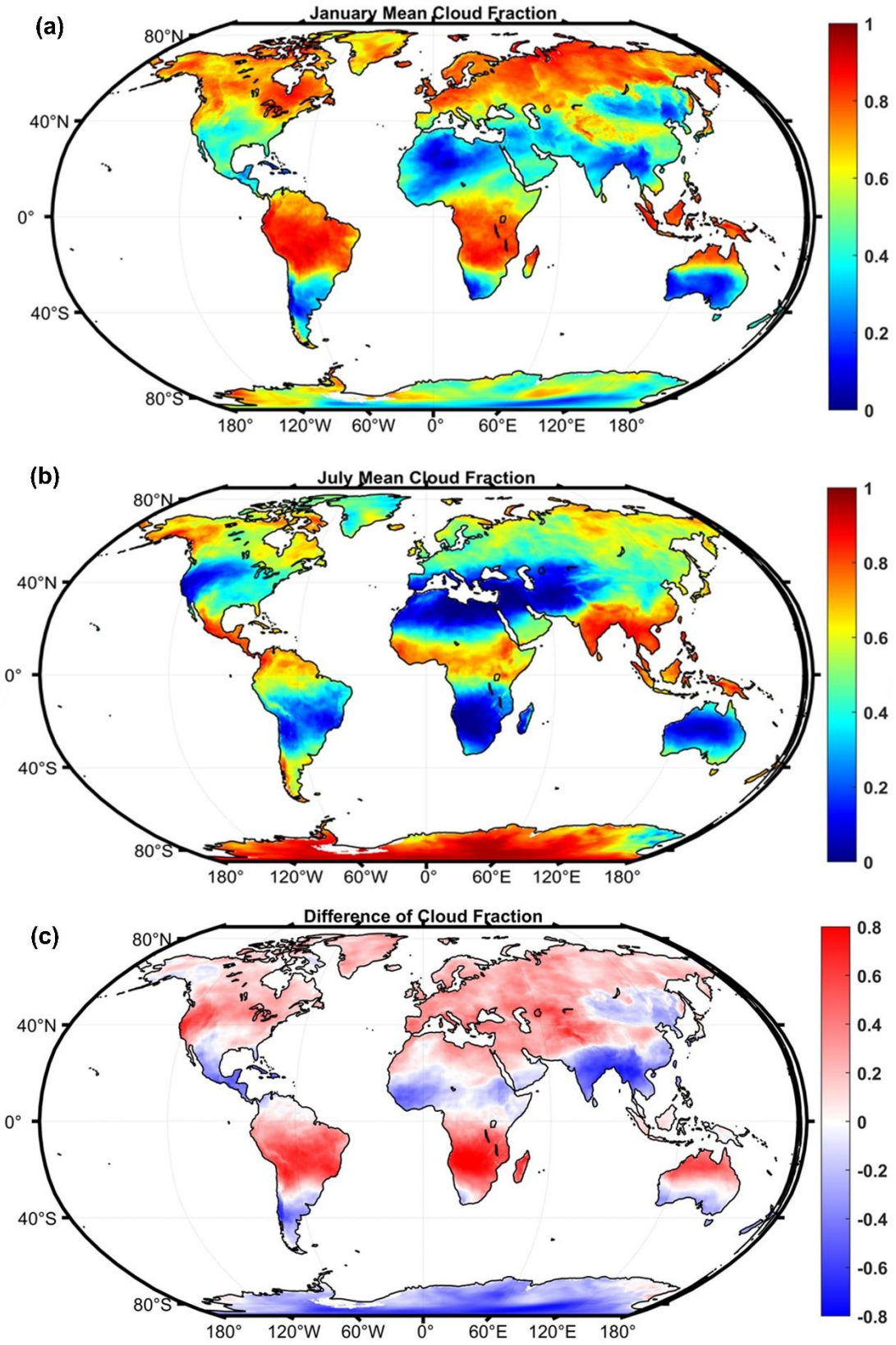

Fig. S3 Spatial distribution of monthly mean cloud cover fraction in (a) January and (b) July 2008, and (c) their differences of cloud fraction (Jan.-July).

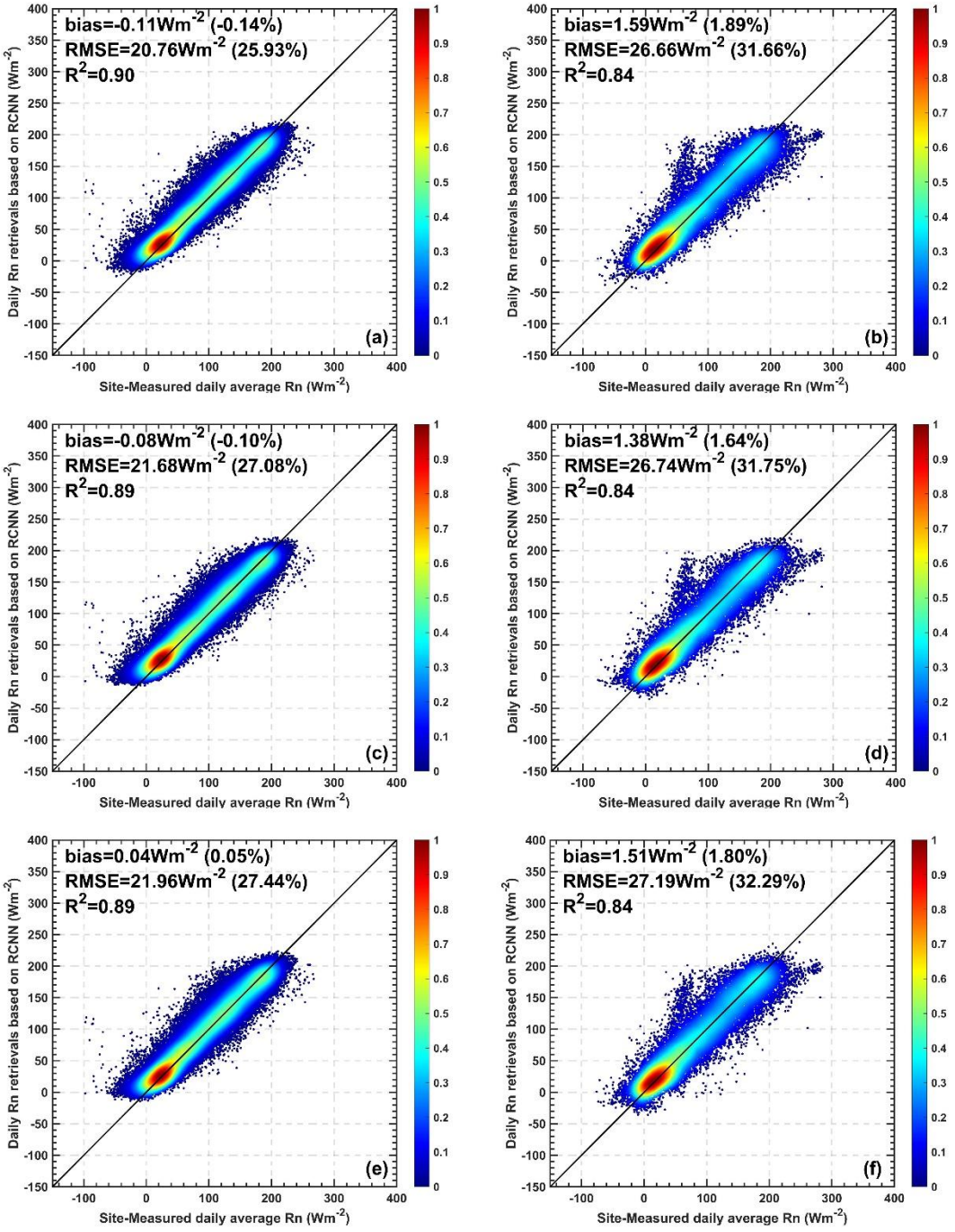

Fig. S4 Training accuracy and independent test accuracy of RCNN with MERRA2 R_n (a, b), MERAA2 DSR (c, d) and no MERRA2 radiation (e, f).