Table S1. Details of the data products used in this comparison

Data Source	Data Period	Temporal Resolution	Spatial Resolution	Reference
GEWEX SRB	1983-2007	3 hourly/monthly	1 degree	(Pinker and Laszlo, 1992)
CERES EBAF	2000-present	monthly	1 degree	(Kato et al. 2018)
CMSAF CLAR A2	1982-2015	daily/monthly	0.25 degree	(Karlsson et al., 2017)
ISCCP-HXG derived Rs	1983-2017	3 hourly/monthly	~10 km	(Tang et al., 2019)

Table S2. Statistical summary of GWR parameter optimization. NPP is the number of nearest neighbor points. MAB is the mean absolute bias (W/m^2). Std is the standard deviation. RMSE is the root mean square error (W/m^2).

NNP	R2	Bias	MAB	Std	RMSE
29	0.91	0.12	7.27	9.87	9.87
30	0.91	0.12	7.27	9.87	9.87
31	0.91	0.12	7.27	9.87	9.87
32	0.91	0.12	7.27	9.87	9.87
33	0.91	0.12	7.28	9.87	9.88
34	0.91	0.12	7.28	9.88	9.88
35	0.91	0.13	7.28	9.88	9.88
36	0.91	0.13	7.28	9.88	9.88
37	0.91	0.13	7.29	9.88	9.89
38	0.91	0.13	7.29	9.89	9.89
39	0.91	0.13	7.29	9.89	9.90
40	0.90	0.13	7.30	9.90	9.90
41	0.90	0.13	7.30	9.90	9.91
42	0.90	0.13	7.31	9.91	9.91
43	0.90	0.14	7.31	9.91	9.92
44	0.90	0.14	7.31	9.92	9.92
45	0.90	0.14	7.32	9.93	9.93
46	0.90	0.14	7.32	9.93	9.94
47	0.90	0.14	7.33	9.94	9.94
48	0.90	0.14	7.33	9.94	9.95
49	0.90	0.14	7.34	9.95	9.95
50	0.90	0.15	7.34	9.96	9.96
100	0.90	0.20	7.59	10.28	10.28
200	0.89	0.20	7.97	10.77	10.78
300	0.88	0.16	8.23	11.09	11.10
400	0.88	0.11	8.43	11.35	11.35
500	0.87	0.07	8.60	11.57	11.57
600	0.87	0.05	8.75	11.76	11.77
700	0.86	0.05	8.89	11.94	11.94
800	0.86	0.04	9.01	12.09	12.10
900	0.86	0.04	9.11	12.23	12.23
1000	0.85	0.04	9.21	12.35	12.35

Table S3. Statistical comparison of surface solar radiation R_s from the CMSAF CLARA A2 (CMSAF), GEWEX-SRB (GEWEX), ISCCP-HXG based Rs data (HXG) and ISCCP-HXG merged SunDu derived Rs data (HGWR) from 2000 to 2007. Ref represent reference data of 121 validations sites including direct Rs observation (Obs), SunDu derived Rs (SunDu) and CERES EBAF (CERES) The statistics include the mean absolute bias (MAB), standard deviation (Std) and root mean square error (RMSE).

	Ref	Time scale	R2	Bias	MAB	Std	RMSE
CMSAF	Obs	monthly	0.89	11.89	18.96	20.94	24.08
CMSAF	SunDu	monthly	0.94	4.16	13.06	16.54	17.06
CMSAF	CERES	monthly	0.94	4.99	11.85	14.67	15.50
GEWEX	Obs	monthly	0.89	0.75	16.54	21.49	21.51
GEWEX	SunDu	monthly	0.92	-6.17	17.46	21.29	22.17
GEWEX	CERES	monthly	0.96	-5.98	11.00	13.33	14.61
HXG	Obs	monthly	0.93	8.43	14.23	17.56	19.48
HXG	SunDu	monthly	0.95	0.28	11.49	14.95	14.96
HXG	CERES	monthly	0.96	0.34	10.67	14.02	14.03
HGWR	Obs	monthly	0.93	7.87	13.86	17.47	19.16
HGWR	SunDu	monthly	0.97	0.34	7.69	10.79	10.80
HGWR	CERES	monthly	0.96	0.31	11.12	14.04	14.05
CMSAF	Obs	annual mean	0.80	14.77	17.78	13.73	20.12
CMSAF	SunDu	annual mean	0.83	7.43	11.06	11.08	13.31
CMSAF	CERES	annual mean	0.91	7.83	9.93	8.15	11.27
GEWEX	Obs	annual mean	0.84	0.60	9.81	12.40	12.35
GEWEX	SunDu	annual mean	0.86	-6.33	9.58	10.11	11.90
GEWEX	CERES	annual mean	0.93	-5.98	7.13	7.11	9.27
HXG	Obs	annual mean	0.89	8.06	10.13	9.51	12.43
HXG	SunDu	annual mean	0.91	0.03	6.86	8.23	8.20
HXG	CERES	annual mean	0.95	0.34	4.78	6.57	6.56
HGWR	Obs	annual mean	0.89	7.71	9.83	9.79	12.42
HGWR	SunDu	annual mean	0.95	0.11	4.97	6.16	6.13
HGWR	CERES	annual mean	0.91	0.31	6.11	7.60	7.57

Figure S1. The regional validations of monthly surface solar radiation (R_s). Nine subregions (I to IX) over China are shown in Figure 1. Driect Rs observed data (Obs), SunDu-derived R_s (SunDu) and CERES EBAF (CERES) are used as reference data, respectively. The R_s variation derived from the CMSAF CLARA A2 (CMSAF), GEWEX-SRB (GEWEX) and ISCCP-HXG derived R_s (HXG). The ISCCP-HXG derived Rs merged with SunDu derived R_s is shown as light green lines

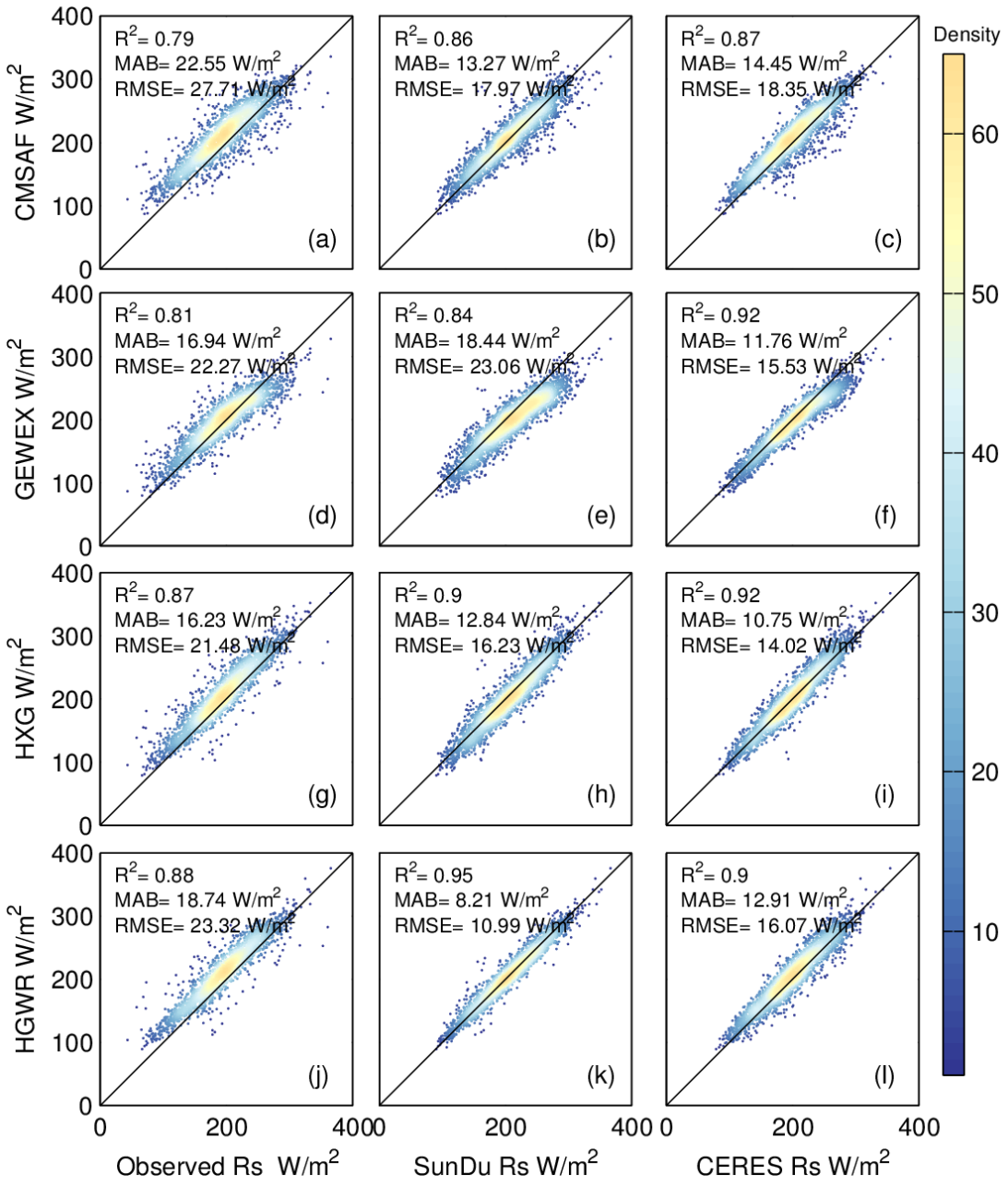

Figure S2. Comparison of monthly surface solar radiation (Rs) from the CMSAF CLARA-A2 (CMSAF), GEWEX-SRB (GEWEX), ISCCP-HXG-based Rs data (HXG) and the merged product (HGWR) by using different validation data from 2000 to 2007 for Spring Season (March, April, and May). Subplots (a, d, g, j) represent validation results using direct observations, while (b, e, h, k) represent SunDu-derived Rs data (SunDu Rs) and subplots (c, f, i, l) represent CERES EBAF data (CERES).

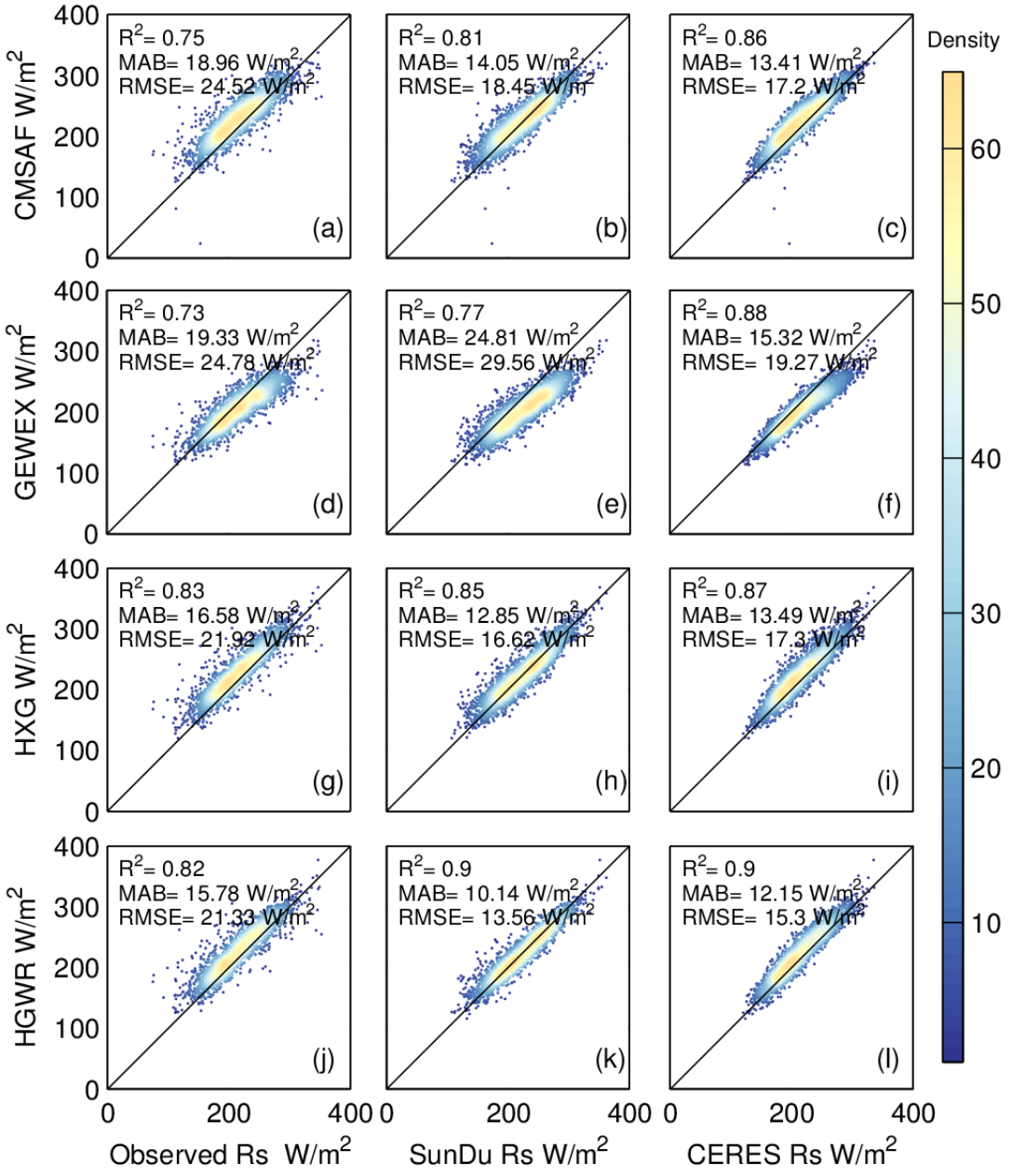

Figure S3. Comparison of monthly surface solar radiation (R_s) from the CMSAF CLARA-A2 (CMSAF), GEWEX-SRB (GEWEX), ISCCP-HXG-based R_s data (HXG) and the merged product (HGWR) by using different validation data from 2000 to 2007 for Summer Season (June, July, and August). Subplots (a, d, g, j) represent validation results using direct observations, while (b, e, h, k) represent SunDu-derived R_s data (SunDu R_s) and subplots (c, f, i, l) represent CERES EBAF data (CERES).

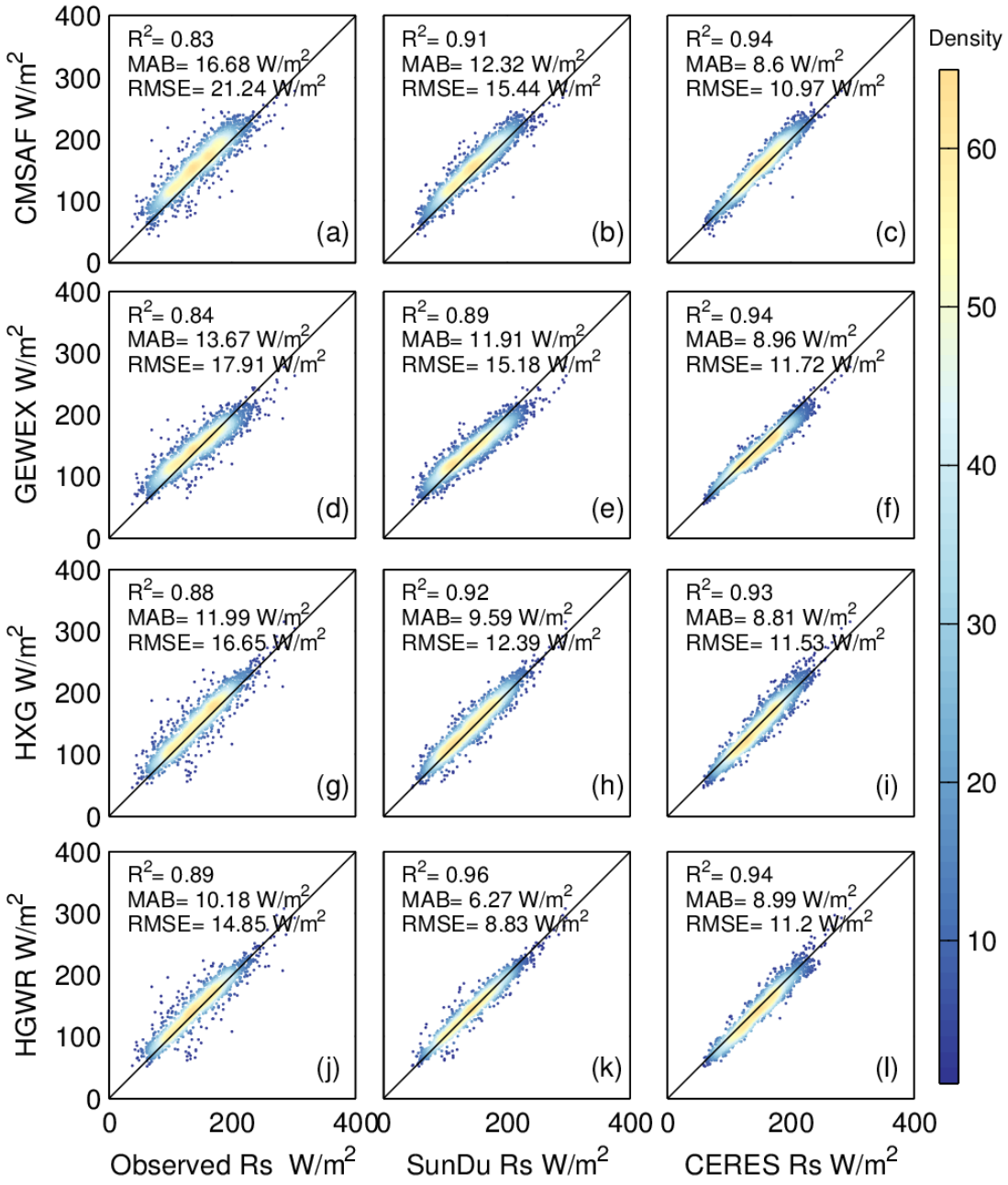

Figure S4. Comparison of monthly surface solar radiation (R_s) from the CMSAF CLARA-A2 (CMSAF), GEWEX-SRB (GEWEX), ISCCP-HXG-based R_s data (HXG) and the merged product (HGWR) by using different validation data from 2000 to 2007 for Autumn Season (September, October, and November). Subplots (a, d, g, j) represent validation results using direct observations, while (b, e, h, k) represent SunDu-derived R_s data (SunDu R_s) and subplots (c, f, i, l) represent CERES EBAF data (CERES).

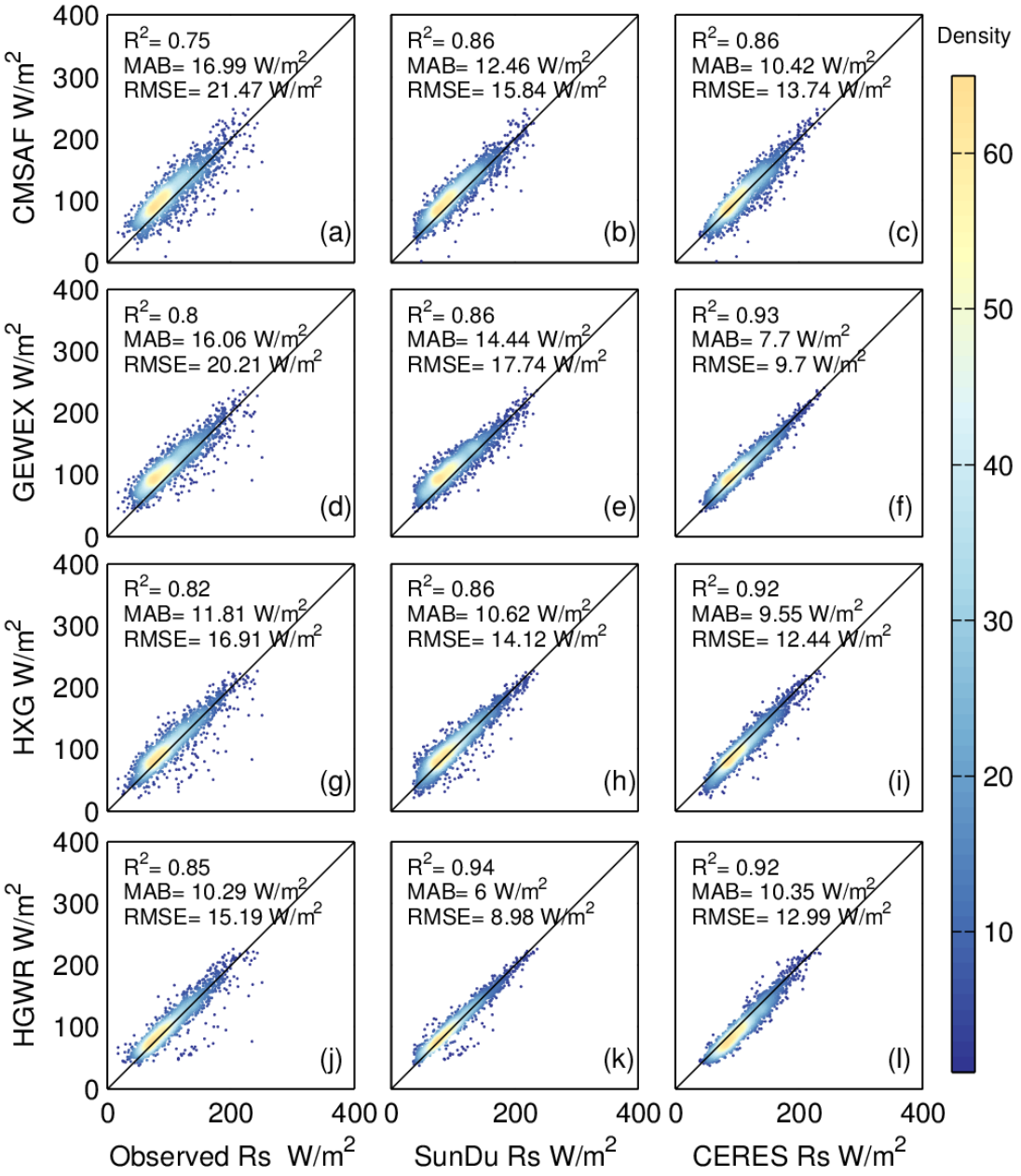

Figure S5. Comparison of monthly surface solar radiation (R_s) from the CMSAF CLARA-A2 (CMSAF), GEWEX-SRB (GEWEX), ISCCP-HXG-based R_s data (HXG) and the merged product (HGWR) by using different validation data from 2000 to 2007 for Winter Season (December, January, and February). Subplots (a, d, g, j) represent validation results using direct observations, while (b, e, h, k) represent SunDu-derived R_s data (SunDu R_s) and subplots (c, f, i, l) represent CERES EBAF data (CERES).

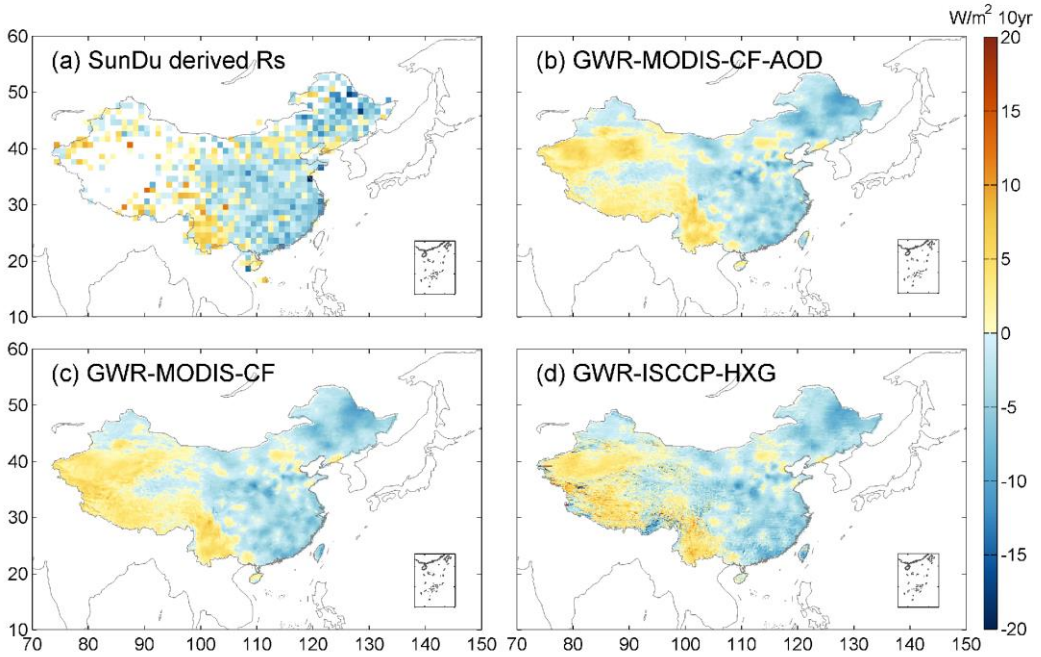

Figure S6. Spatial distributions of trends for Rs from 2000 to 2016. The first line (a, b) shows the SunDu-derived Rs and GWR-MODIS-CF-AOD; the GWR-MODIS-CF and GWR-ISCCP-HXG are shown in the second line (c, d). The GWR-MODIS-CF-AOD and GWR-MODIS-CF are the datasets from another manuscript. GWR-MODIS-CF-AOD is the datasets that merged MODIS cloud and AOD with SunDu derived R_s, while GWR-MODIS-CF is the dataset that merged with only MODIS cloud with SunDu derived R_s. The GWR-ISCCP-HXG is the merged dataset from this study.