

Supplement of

Direct radiative forcing of light-absorbing carbonaceous aerosol and the influencing factors over China

Shuangqin Yang et al.

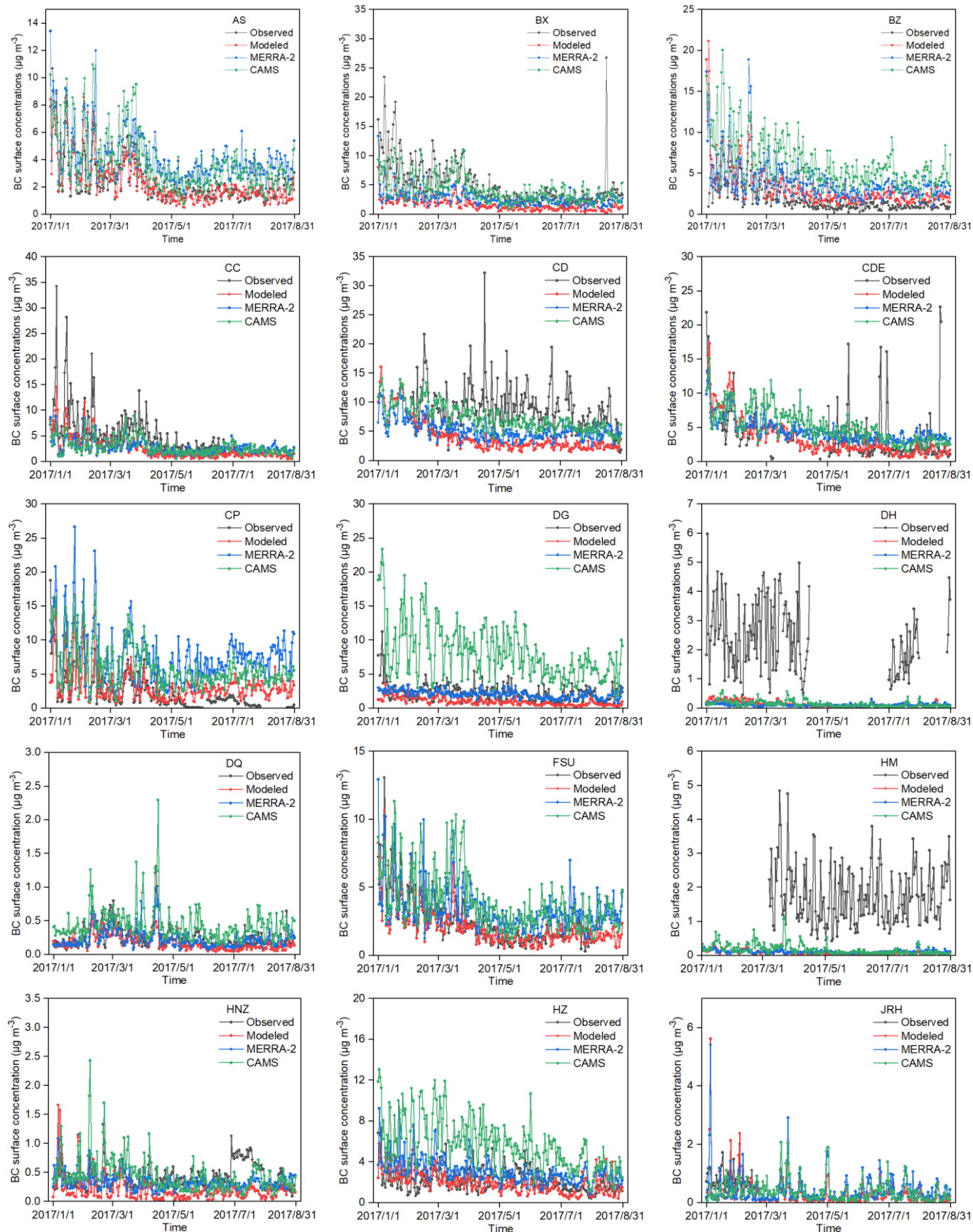
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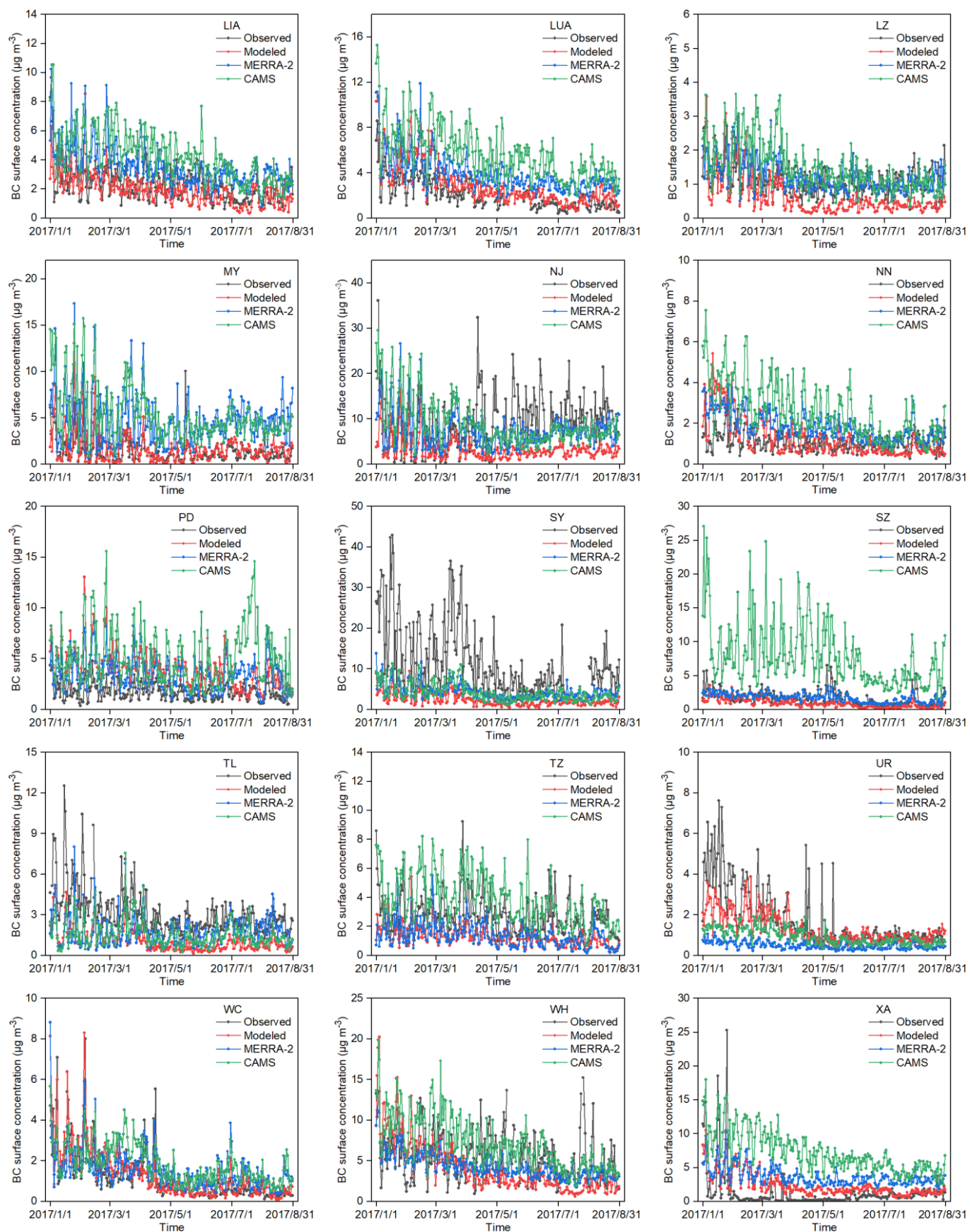
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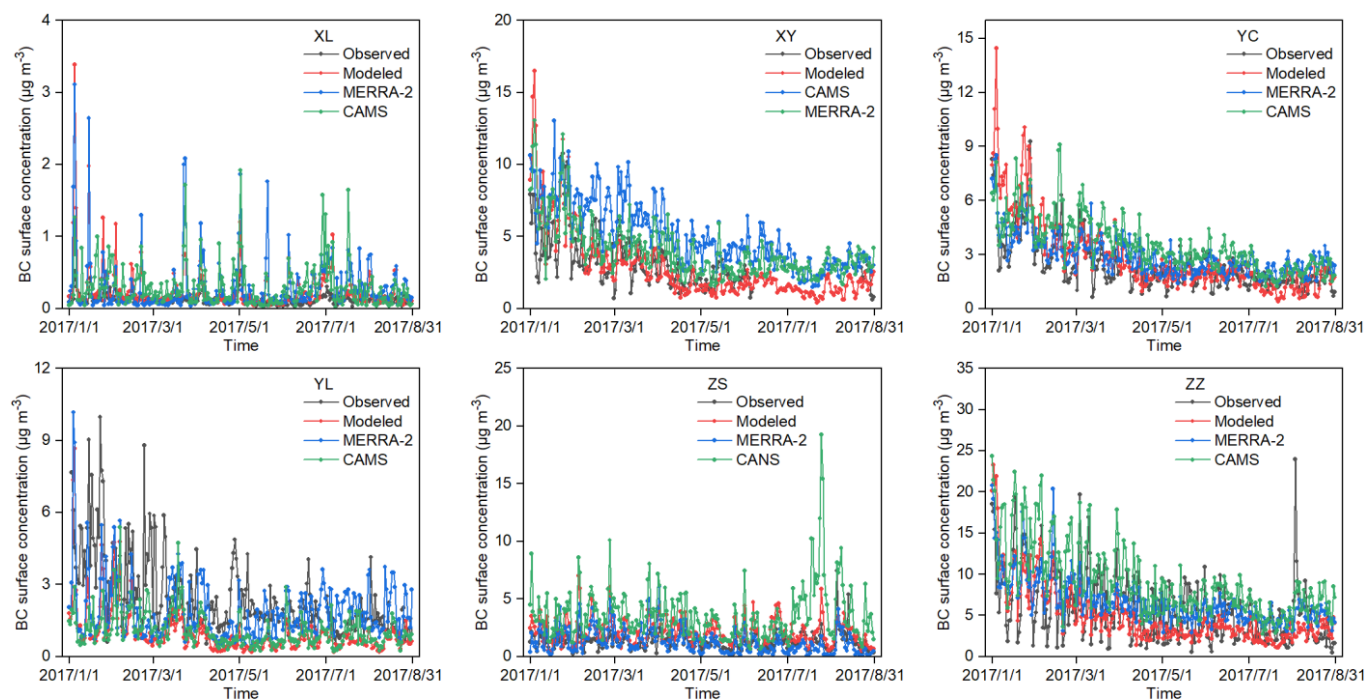


Figure S1. Time series plots of simulated daily mean BC concentrations versus observed and reanalysis data at each site. Dark line represents the monitoring data obtained from the AE-31 aethalometer and red line represents the estimates from the GEOS-Chem model. Blue and green lines represent the data derived from MERRA-2 and CAMS, respectively.

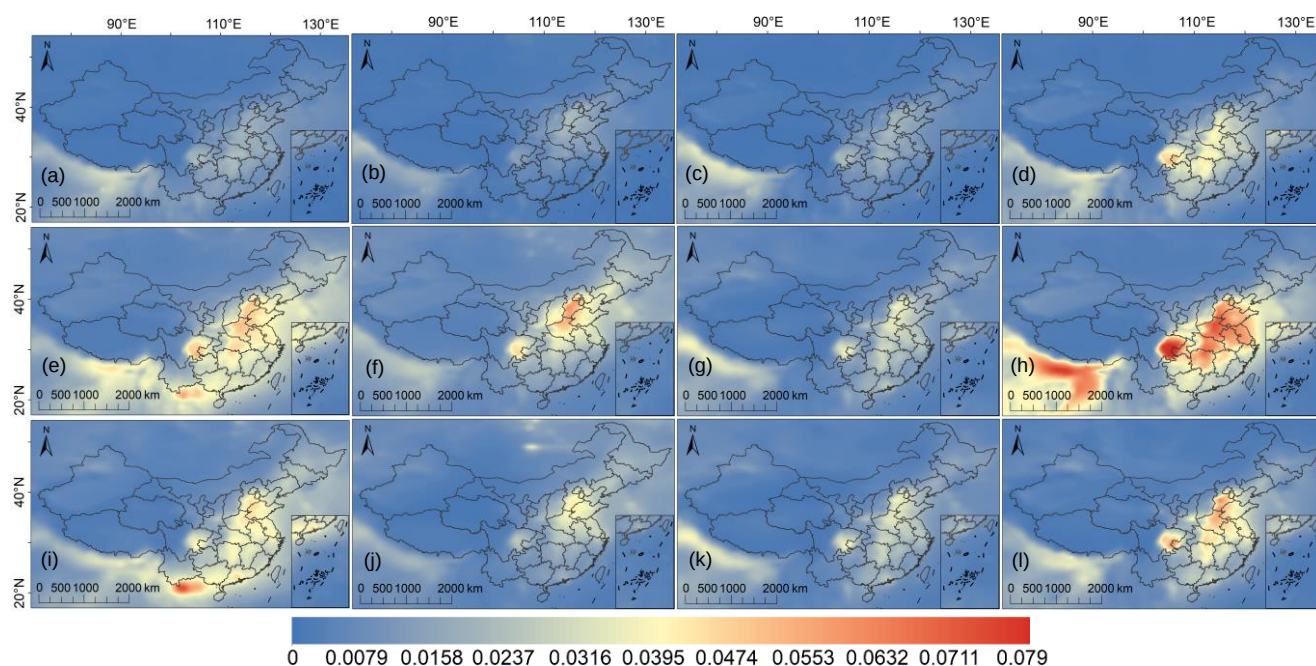


Figure S2. Spatial distribution of BC AOD over China. Seasonal BC AOD at 550 nm obtained from the GEOS-Chem simulation (a-d), MERRA-2 (e-h), and CAMS (i-l) in spring (a, e, and i), summer (b, f, and j), fall (c, g, k) and winter (d, h, l).

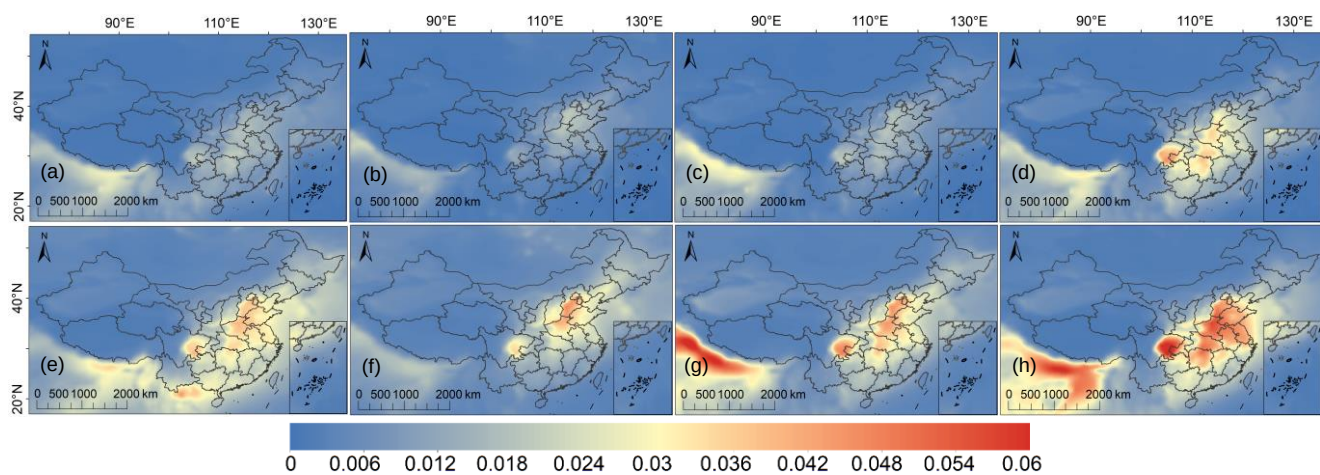
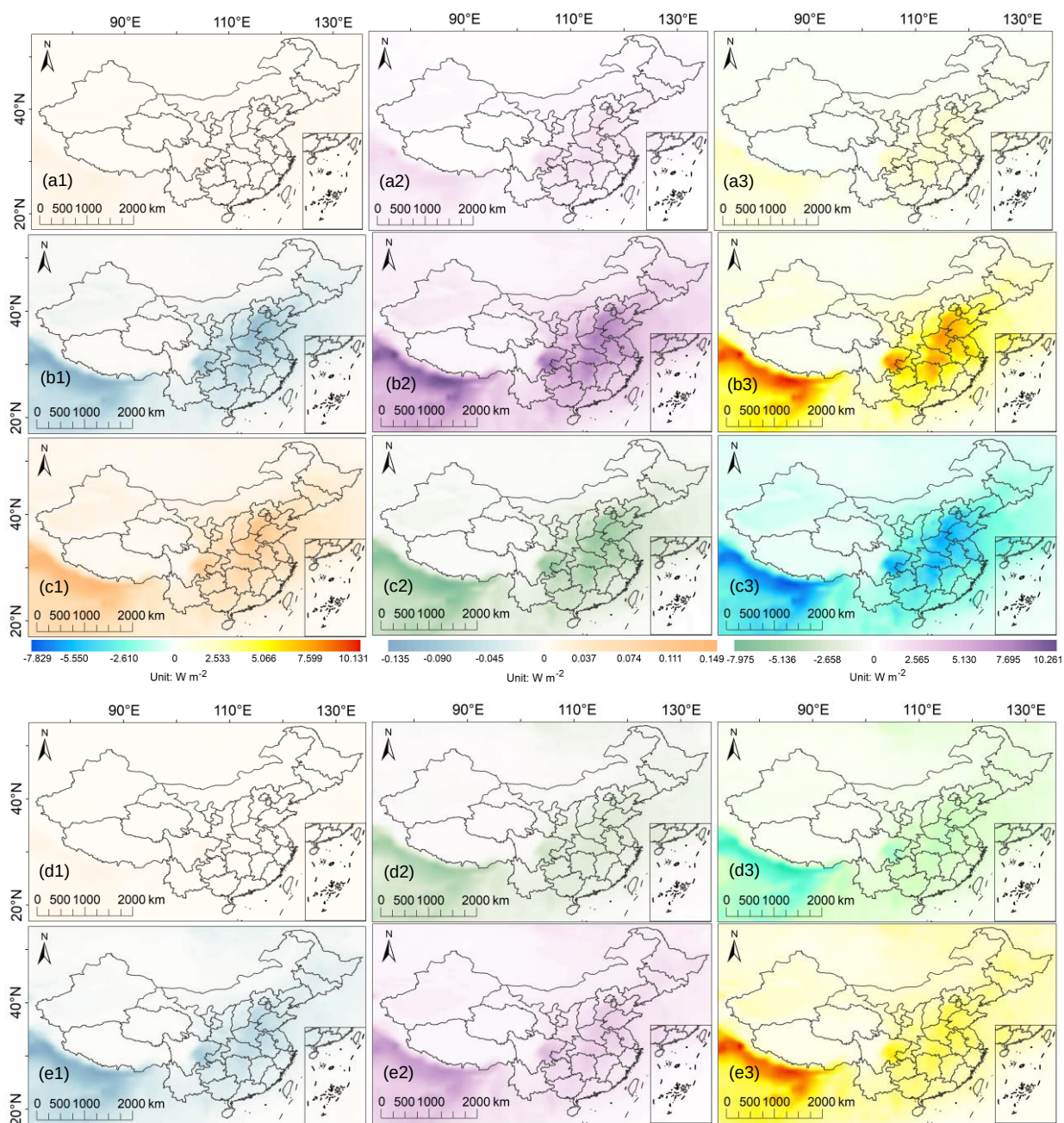


Figure S3. Spatial distribution of BC AAOD over China. Seasonal BC AAOD at 550 nm obtained from the GEOS-Chem simulation (a-d) and MERRA-2 (e-h) in spring (a, e, and i), summer (b, f, and j), fall (c, g, k) and winter (d, h, l).



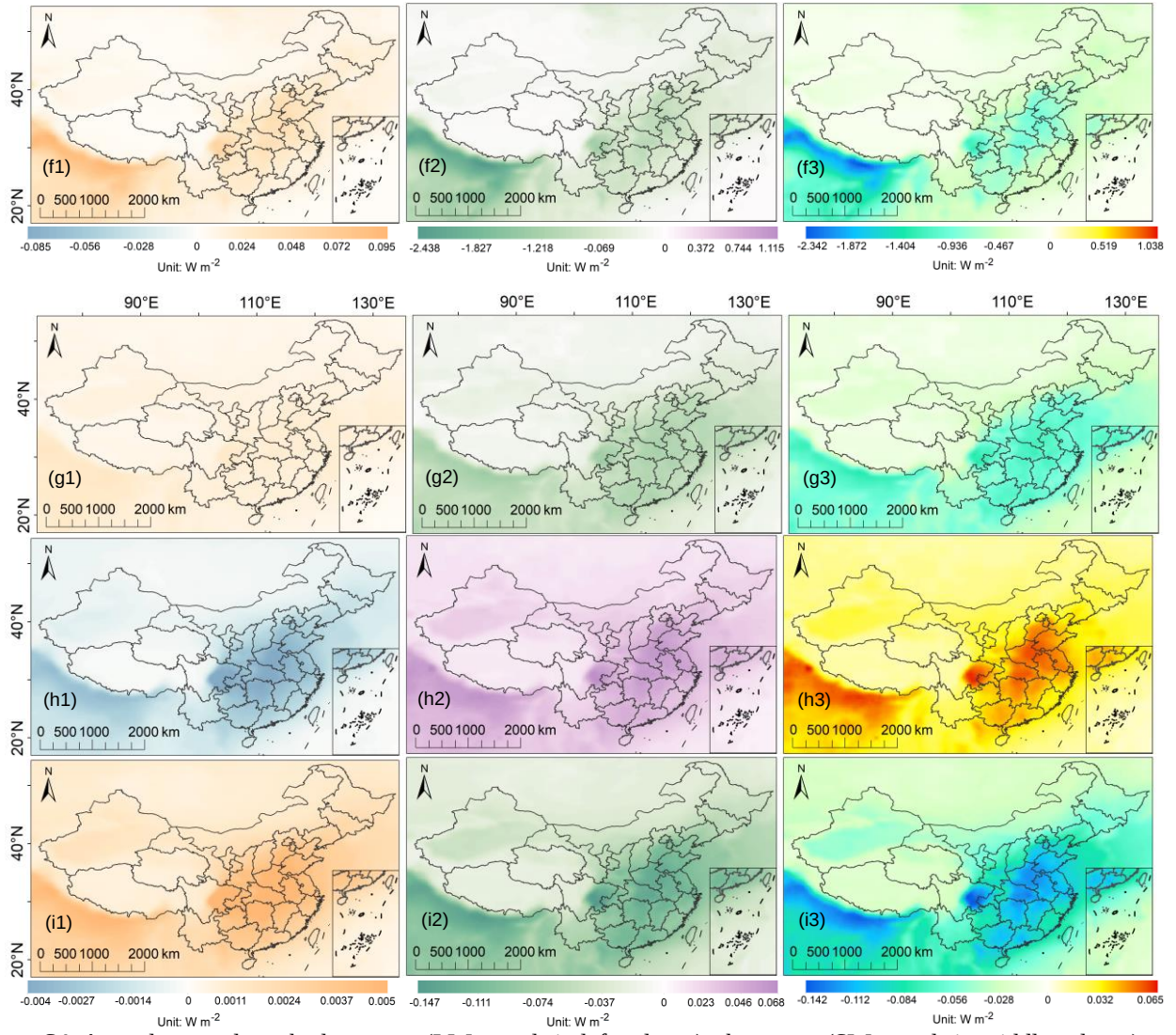
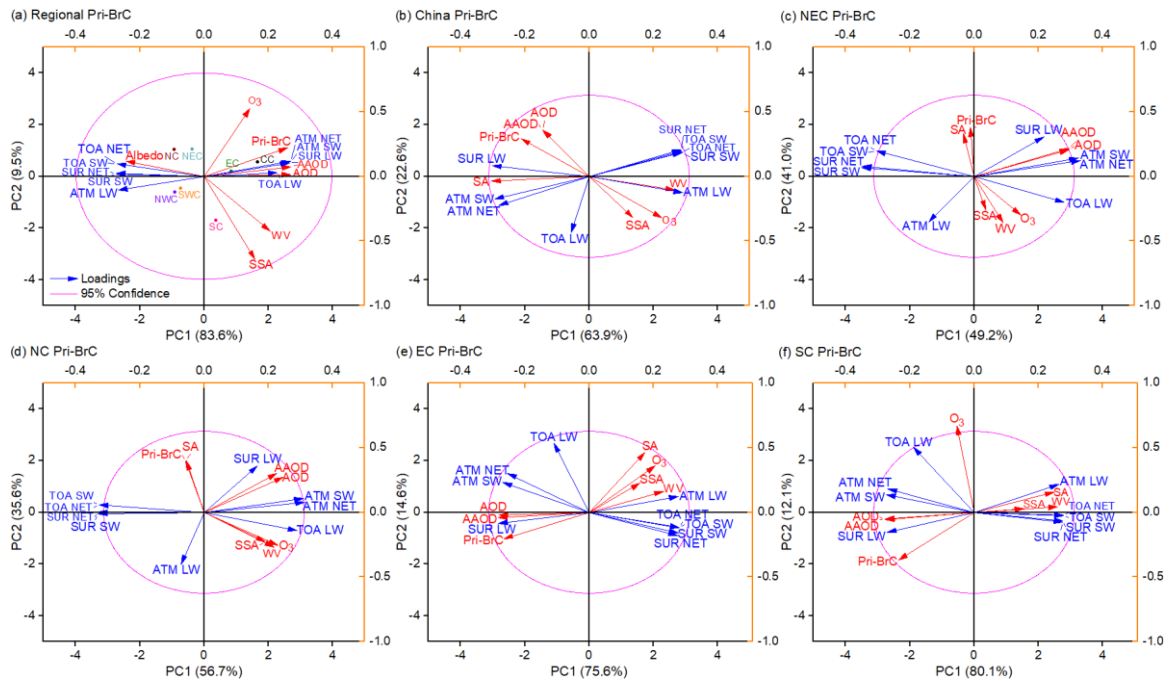


Figure S4. Annual mean clear-sky longwave (LW, panels in left column), shortwave (SW, panels in middle column), and LW + SW (NET, panels in right column) DRF at the TOA (first, fifth and ninth row panels), in the ATM (second, sixth and tenth row panels), and at the SUR (third, seventh and eleventh row panel) over China for BC (panels in rows first to fourth), Pri-BrC (panels in rows five to eight), and Sec-BrC (panels in rows nine to twelve).



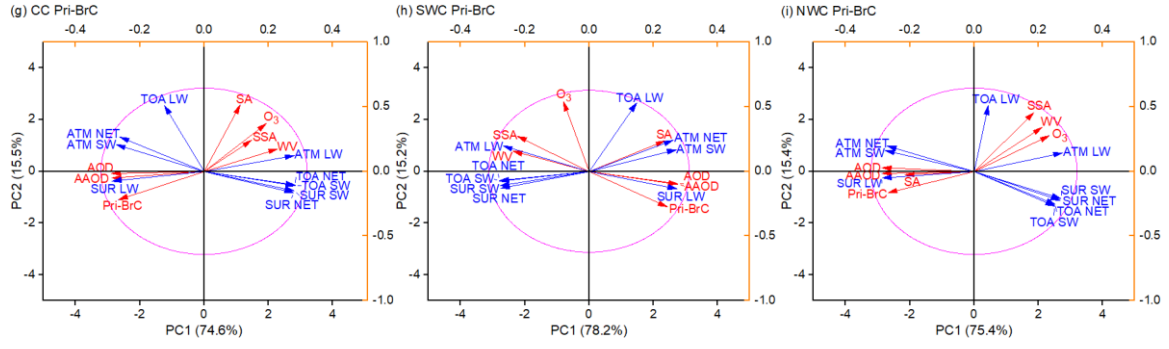


Figure S5. Principal component analysis biplots for Pri-BrC DRFs and the influencing factors over seven regions in China (a), entire China (b), Northeast China (NEC, c), North China (NC, d), East China (EC, e), South China (SC, f), Central China (CC, g), Southwest China (SWC, h), and Northwest China (NWC, i). Blue and red arrows represent Pri-BrC DRFs and their influencing factors, respectively. SA and WV are surface albedo and water vapor, respectively.

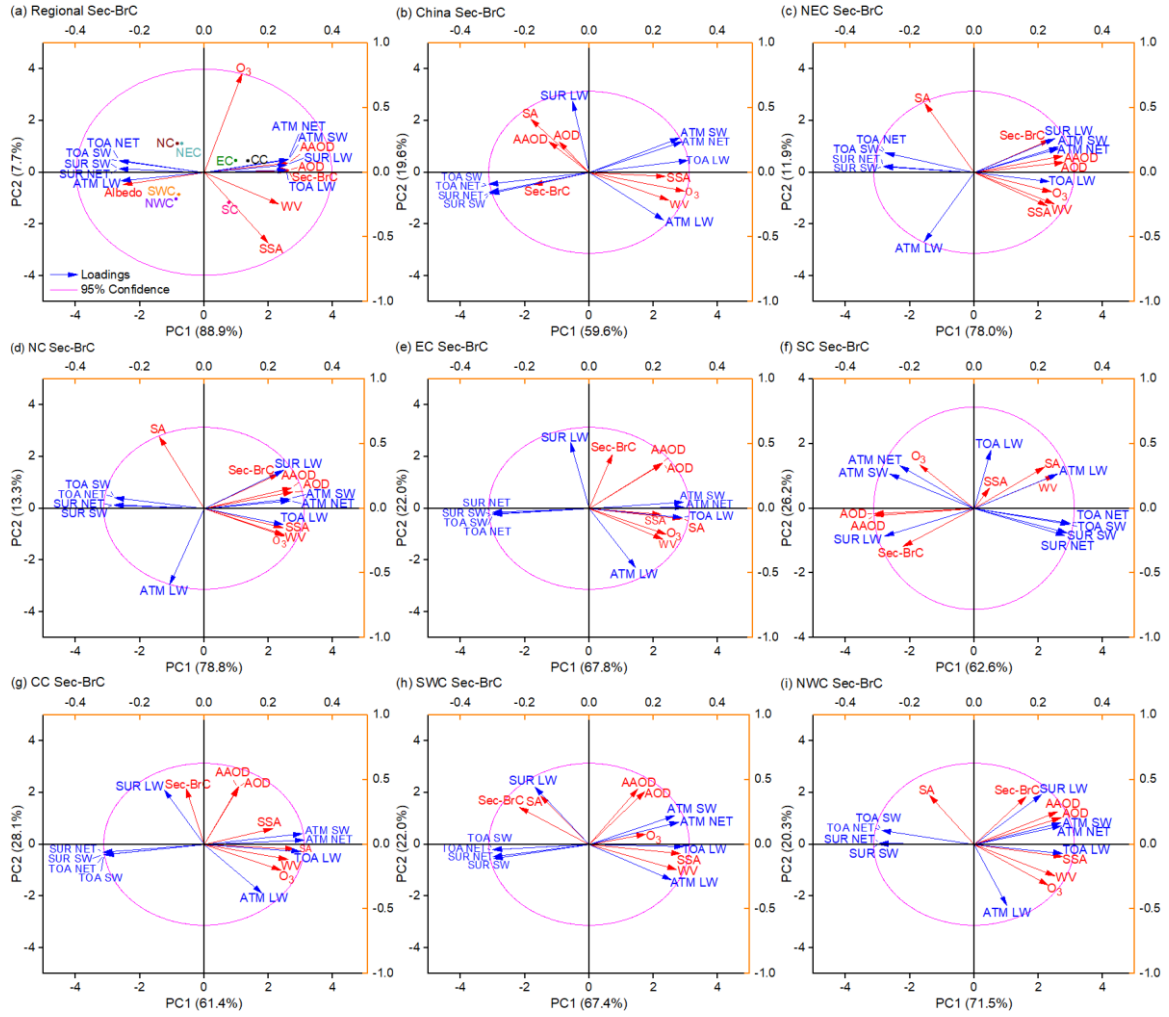


Figure S6. Principal component analysis biplots for Sec-BrC DRFs and the influencing factors over seven regions in China (a), entire China (b), Northeast China (NEC, c), North China (NC, d), East China (EC, e), South China (SC, f), Central China (CC, g), Southwest China (SWC, h), and Northwest China (NWC, i). Blue and red arrows represent Sec-BrC DRFs and their influencing factors, respectively. SA and WV are surface albedo and water vapor, respectively.

Table S1. Values of the compensation parameter (f) and mass attenuation cross-section (MAC, m² g⁻¹) at seven different wavelengths (λ , nm) for AE-31 aethalometer.

λ (nm)	f	MAC
370	1.322	39.5
470	1.292	31.1
520	1.254	28.1
590	1.233	24.8
660	1.230	22.2
880	1.212	16.6
950	1.210	15.4

Table S2. Parameters and emission factors (EF; unit: g/kg) of biomass burning used in this study.

Source Type	EF _{CO₂}	EF _{CO}	EF _{BC}	EF _{OC}	AAE _{LACs}	R _{BrC,abs}	R _{BrC,EF}
Savanna grassland	1686	63	0.37	2.62	1.822	0.128	0.153
Boreal forest	1489	127	0.50	9.60	2.909	0.586	0.258
Temperate forest	1647	88	0.50	9.60	2.203	0.235	0.104
Tropical Forest	1643	93	0.52	4.71	2.276	0.262	0.245
Peat fires	1549	210	0.04	6.02	3.905	0.999	0.056
Agricultural waste	1585	102	0.75	2.30	2.452	0.330	0.911

Table S3. The monthly mean values of atmospheric variables in each region.

Region	Month	O ₃ concentration (DU)	Surface albedo	Water vapor (mm)
Northeast China (NEC)	Jan	38.555	0.383	265.213
	Feb	35.852	0.387	314.468
	Mar	35.890	0.284	484.053
	Apr	41.245	0.161	733.691
	May	42.568	0.155	1280.617
	Jun	44.851	0.160	1904.745
	Jul	51.005	0.167	2504.064
	Agu	46.520	0.163	2410.426
	Sep	39.557	0.146	1248.330
	Oct	34.858	0.147	756.968
	Nov	37.615	0.235	443.809
	Dec	37.055	0.312	255.319
North China (NC)	Jan	34.007	0.291	266.958
	Feb	30.803	0.294	309.566
	Mar	35.420	0.254	387.428
	Apr	36.827	0.219	643.892
	May	43.020	0.212	1097.229
	Jun	45.125	0.207	1818.753
	Jul	49.348	0.202	2395.217
	Agu	45.631	0.198	2120.199
	Sep	40.374	0.191	1171.127
	Oct	34.013	0.209	640.036
	Nov	31.841	0.228	399.386
	Dec	32.677	0.252	277.608
East China (EC)	Jan	31.503	0.127	1195.642
	Feb	32.367	0.140	1080.778
	Mar	36.269	0.135	1141.704

	Apr	44.223	0.144	1537.630
	May	49.644	0.150	2231.272
	Jun	44.415	0.155	3792.667
	Jul	44.859	0.155	4510.741
	Agu	43.553	0.154	4700.568
	Sep	39.879	0.145	3524.827
	Oct	37.836	0.134	2265.519
	Nov	33.412	0.126	1648.568
	Dec	32.500	0.124	1073.753
Central China (CC)	Jan	32.009	0.129	1088.926
	Feb	33.751	0.151	1045.741
	Mar	37.104	0.139	1192.167
	Apr	45.396	0.145	1598.259
	May	48.102	0.154	2047.241
	Jun	44.451	0.160	3898.778
	Jul	46.734	0.159	4469.944
	Agu	43.247	0.157	4799.537
	Sep	38.419	0.142	3664.167
	Oct	35.853	0.132	2042.926
	Nov	33.725	0.124	1474.519
	Dec	31.868	0.123	1067.519
South China (SC)	Jan	30.233	0.123	2087.949
	Feb	37.659	0.125	1588.333
	Mar	39.362	0.130	2011.128
	Apr	44.010	0.137	2803.179
	May	44.585	0.149	3737.385
	Jun	34.151	0.159	5552.436
	Jul	32.646	0.163	5392.077
	Agu	32.397	0.163	4853.256

	Sep	33.769	0.155	4776.128
	Oct	34.708	0.141	3321.795
	Nov	30.638	0.127	2778.077
	Dec	32.446	0.124	1838.308
Southwest China (SWC)	Jan	25.909	0.289	391.151
	Feb	26.440	0.304	395.594
	Mar	29.578	0.359	534.402
	Apr	36.263	0.304	711.521
	May	38.411	0.279	1020.566
	Jun	35.625	0.234	1452.498
	Jul	31.794	0.192	1888.027
	Agu	29.369	0.182	1835.091
	Sep	27.983	0.185	1532.507
	Oct	27.298	0.208	914.676
	Nov	25.981	0.261	562.160
	Dec	25.352	0.251	426.534
Northwest China (NWC)	Jan	25.779	0.365	248.039
	Feb	27.079	0.379	304.469
	Mar	30.266	0.393	386.135
	Apr	32.914	0.348	694.350
	May	40.767	0.299	892.965
	Jun	43.554	0.271	1540.907
	Jul	44.652	0.226	1999.685
	Agu	41.304	0.223	1678.379
	Sep	36.597	0.244	1146.299
	Oct	32.069	0.287	605.643
	Nov	26.190	0.308	388.225
	Dec	28.602	0.306	280.717

Table S4. The monthly mean values for BC concentrations ($\mu\text{g m}^{-3}$), optical properties at 550 nm (AOD, AAOD, and SSA), and DRFs (W m^{-2}) in each region.

Region	Month	BC concentration	BC AOD	BC AAOD	BC SSA	TOA LW	TOA SW	TOA NET	ATM LW	ATM SW	ATM NET	SUR LW	SUR SW	SUR NET
Northeast China (NEC)	Jan	2.171	0.008	0.007	0.100	0.0003	0.862	0.863	-0.045	2.445	2.400	0.046	-1.583	-1.538
	Feb	1.768	0.008	0.007	0.104	0.001	0.942	0.944	-0.044	2.748	2.703	0.046	-1.805	-1.760
	Mar	1.329	0.007	0.006	0.102	0.006	0.758	0.764	-0.038	2.967	2.929	0.044	-2.209	-2.165
	Apr	0.877	0.006	0.006	0.101	0.006	0.824	0.830	-0.032	3.063	3.031	0.039	-2.239	-2.200
	May	0.492	0.005	0.005	0.102	0.006	0.533	0.540	-0.024	2.592	2.568	0.030	-2.059	-2.029
	Jun	0.523	0.006	0.006	0.107	0.007	0.586	0.593	-0.023	3.076	3.053	0.031	-2.490	-2.46
	Jul	0.603	0.006	0.006	0.106	0.006	0.537	0.543	-0.021	2.998	2.976	0.027	-2.460	-2.433
	Agu	0.514	0.005	0.004	0.114	0.004	0.362	0.366	-0.016	2.087	2.071	0.021	-1.725	-1.705
	Sep	0.584	0.006	0.005	0.106	0.005	0.432	0.437	-0.024	2.082	2.057	0.029	-1.650	-1.621
	Oct	0.983	0.006	0.005	0.104	0.003	0.324	0.326	-0.031	1.681	1.650	0.034	-1.357	-1.323
	Nov	1.296	0.006	0.006	0.104	0.002	0.392	0.394	-0.036	1.707	1.671	0.038	-1.357	-1.277
	Dec	1.831	0.006	0.005	0.100	0.001	0.499	0.499	-0.032	1.604	1.572	0.033	-1.106	-1.073
North China (NC)	Jan	1.556	0.008	0.007	0.095	0.001	0.604	0.604	-0.047	2.053	2.006	0.048	-1.449	-1.401
	Feb	1.148	0.006	0.006	0.098	0.002	0.617	0.619	-0.037	2.199	2.162	0.039	-1.582	-1.543
	Mar	0.836	0.006	0.006	0.098	0.007	0.739	0.746	-0.031	2.734	2.704	0.038	-1.995	-1.957
	Apr	0.502	0.004	0.004	0.096	0.005	0.547	0.553	-0.019	1.975	1.956	0.024	-1.428	-1.404
	May	0.426	0.004	0.004	0.096	0.006	0.488	0.494	-0.018	2.041	2.023	0.024	-1.553	-1.529
	Jun	0.566	0.006	0.006	0.099	0.009	0.699	0.708	-0.025	3.128	3.102	0.034	-2.429	-2.394
	Jul	0.584	0.006	0.006	0.103	0.007	0.664	0.671	-0.021	3.044	3.023	0.028	-2.380	-2.352
	Agu	0.548	0.005	0.005	0.105	0.005	0.495	0.501	-0.019	2.350	2.331	0.024	-1.854	-1.830
	Sep	0.606	0.005	0.004	0.100	0.005	0.442	0.447	-0.022	1.978	1.956	0.026	-1.536	-1.509
	Oct	0.769	0.005	0.005	0.102	0.003	0.427	0.431	-0.028	1.823	1.795	0.031	-1.396	-1.365
	Nov	0.844	0.004	0.003	0.098	0.001	0.267	0.269	-0.022	1.135	1.113	0.024	-1.396	-0.844
	Dec	1.161	0.005	0.004	0.096	0.0002	0.342	0.342	-0.028	1.212	1.184	0.029	-0.870	-0.841
East China (EC)	Jan	3.732	0.025	0.022	0.114	0.007	1.606	1.612	-0.142	7.053	6.911	0.149	-5.447	-5.298
	Feb	3.374	0.022	0.019	0.111	0.008	1.532	1.540	-0.126	7.466	7.340	0.134	-5.933	-5.800

	Mar	2.158	0.017	0.015	0.114	0.014	1.500	1.514	-0.085	7.057	6.972	0.099	-5.557	-5.458
	Apr	1.720	0.013	0.012	0.108	0.010	1.215	1.225	-0.060	5.826	5.766	0.070	-4.611	-4.541
	May	1.433	0.012	0.010	0.108	0.011	1.110	1.121	-0.047	5.289	5.242	0.057	-4.179	-4.121
	Jun	1.344	0.012	0.010	0.116	0.011	1.119	1.130	-0.038	5.442	5.404	0.048	-4.323	-4.275
	Jul	1.034	0.008	0.007	0.112	0.005	0.674	0.679	-0.022	3.66	3.639	0.027	-2.987	-2.96
	Agu	1.228	0.009	0.008	0.115	0.006	0.730	0.736	-0.024	3.994	3.970	0.030	-3.264	-3.234
	Sep	1.525	0.010	0.009	0.116	0.007	0.786	0.792	-0.036	4.119	4.084	0.042	-3.334	-3.292
	Oct	1.584	0.009	0.008	0.115	0.004	0.604	0.609	-0.045	3.354	3.310	0.049	-2.750	-2.701
	Nov	2.371	0.013	0.012	0.114	0.004	0.719	0.723	-0.072	3.879	3.807	0.076	-2.750	-3.084
	Dec	3.638	0.019	0.017	0.108	0.002	1.005	1.008	-0.118	5.051	4.933	0.121	-4.046	-3.925
Central China (CC)	Jan	6.701	0.044	0.039	0.115	0.008	3.020	3.028	-0.246	12.014	11.767	0.254	-8.994	-8.739
	Feb	4.098	0.029	0.025	0.113	0.010	2.159	2.169	-0.161	9.853	9.691	0.171	-7.694	-7.522
	Mar	3.094	0.025	0.022	0.117	0.017	2.260	2.277	-0.118	9.741	9.623	0.135	-7.481	-7.346
	Apr	1.810	0.015	0.013	0.110	0.012	1.441	1.453	-0.061	6.459	6.398	0.073	-5.018	-4.945
	May	1.586	0.012	0.011	0.107	0.011	1.210	1.221	-0.049	5.658	5.609	0.060	-4.448	-4.389
	Jun	1.678	0.015	0.013	0.116	0.012	1.370	1.382	-0.047	6.855	6.808	0.059	-5.484	-5.426
	Jul	1.080	0.009	0.008	0.112	0.006	0.712	0.718	-0.024	3.921	3.897	0.030	-3.208	-3.178
	Agu	1.351	0.011	0.010	0.116	0.007	0.884	0.891	-0.028	4.721	4.693	0.036	-3.838	-3.802
	Sep	1.922	0.013	0.012	0.121	0.007	1.124	1.131	-0.043	5.416	5.373	0.051	-4.292	-4.241
	Oct	2.180	0.014	0.012	0.122	0.005	0.982	0.988	-0.064	4.962	4.898	0.070	-3.980	-3.911
	Nov	3.238	0.019	0.017	0.112	0.004	1.168	1.172	-0.105	5.796	5.691	0.109	-3.980	-4.519
	Dec	4.873	0.026	0.023	0.109	0.002	1.521	1.523	-0.162	7.160	6.998	0.164	-5.640	-5.475
South China (SC)	Jan	2.485	0.020	0.018	0.122	0.005	1.259	1.264	-0.106	6.574	6.469	0.111	-5.315	-5.204
	Feb	1.532	0.017	0.015	0.117	0.009	1.189	1.198	-0.081	6.216	6.135	0.090	-5.027	-4.937
	Mar	1.129	0.014	0.012	0.124	0.011	1.281	1.291	-0.055	6.019	5.963	0.066	-4.738	-4.672
	Apr	0.806	0.011	0.010	0.116	0.009	1.065	1.075	-0.036	5.054	5.018	0.045	-3.989	-3.943
	May	0.723	0.008	0.007	0.118	0.006	0.682	0.687	-0.023	3.471	3.447	0.029	-2.789	-2.760
	Jun	0.493	0.004	0.003	0.125	0.003	0.292	0.295	-0.008	1.717	1.709	0.011	-1.426	-1.415
	Jul	0.432	0.003	0.003	0.122	0.002	0.242	0.244	-0.008	1.423	1.416	0.010	-1.181	-1.171

Southwest China (SWC)	Agu	0.452	0.003	0.003	0.121	0.002	0.223	0.225	-0.007	1.355	1.348	0.009	-1.133	-1.123
	Sep	0.619	0.005	0.004	0.125	0.003	0.332	0.335	-0.013	2.006	1.993	0.016	-1.674	-1.658
	Oct	0.972	0.008	0.007	0.119	0.003	0.482	0.485	-0.031	2.904	2.873	0.034	-2.422	-2.388
	Nov	1.279	0.009	0.008	0.124	0.002	0.484	0.486	-0.039	2.998	2.959	0.040	-2.422	-2.474
	Dec	2.187	0.017	0.015	0.113	0.004	1.013	1.017	-0.096	5.580	5.484	0.100	-4.567	-4.467
	Jan	1.269	0.010	0.009	0.105	0.005	0.647	0.651	-0.057	2.889	2.832	0.061	-2.242	-2.181
	Feb	0.789	0.007	0.006	0.106	0.005	0.552	0.557	-0.040	2.599	2.559	0.045	-2.047	-2.002
	Mar	0.626	0.007	0.006	0.107	0.007	0.648	0.656	-0.033	2.850	2.816	0.041	-2.201	-2.160
	Apr	0.441	0.005	0.004	0.106	0.006	0.482	0.489	-0.021	2.224	2.203	0.027	-1.742	-1.714
	May	0.373	0.004	0.004	0.109	0.005	0.407	0.412	-0.015	1.893	1.877	0.020	-1.486	-1.465
	Jun	0.346	0.003	0.003	0.114	0.004	0.312	0.316	-0.011	1.603	1.592	0.015	-1.291	-1.276
	Jul	0.298	0.003	0.002	0.115	0.003	0.235	0.238	-0.008	1.271	1.262	0.012	-1.036	-1.024
Northwest China (NWC)	Agu	0.312	0.003	0.003	0.115	0.004	0.249	0.253	-0.008	1.329	1.320	0.012	-1.079	-1.067
	Sep	0.370	0.003	0.003	0.119	0.003	0.244	0.247	-0.010	1.278	1.268	0.013	-1.035	-1.021
	Oct	0.457	0.004	0.003	0.114	0.003	0.270	0.273	-0.017	1.364	1.347	0.020	-1.094	-1.074
	Nov	0.591	0.005	0.004	0.109	0.003	0.316	0.319	-0.026	1.544	1.518	0.029	-1.094	-1.200
	Dec	0.985	0.007	0.006	0.108	0.002	0.406	0.408	-0.043	2.025	1.982	0.045	-1.619	-1.574
	Jan	0.515	0.005	0.004	0.094	0.002	0.505	0.507	-0.026	1.620	1.594	0.028	-1.115	-1.087
	Feb	0.416	0.004	0.003	0.097	0.003	0.448	0.451	-0.020	1.505	1.485	0.023	-1.057	-1.034
	Mar	0.286	0.003	0.003	0.097	0.005	0.485	0.490	-0.014	1.598	1.583	0.020	-1.113	-1.093
	Apr	0.155	0.002	0.002	0.098	0.004	0.344	0.348	-0.007	1.129	1.122	0.012	-0.785	-0.774
	May	0.118	0.002	0.001	0.095	0.003	0.231	0.235	-0.005	0.858	0.853	0.009	-0.627	-0.619
	Jun	0.152	0.002	0.002	0.100	0.004	0.288	0.292	-0.007	1.148	1.141	0.011	-0.860	-0.849
	Jul	0.142	0.002	0.002	0.101	0.004	0.277	0.281	-0.006	1.121	1.114	0.011	-0.844	-0.833
	Agu	0.153	0.002	0.002	0.102	0.004	0.270	0.274	-0.007	1.092	1.085	0.011	-0.822	-0.811
	Sep	0.181	0.002	0.002	0.101	0.004	0.257	0.261	-0.009	1.010	1.001	0.012	-0.753	-0.741
	Oct	0.220	0.002	0.002	0.098	0.003	0.256	0.259	-0.012	0.965	0.953	0.014	-0.709	-0.695
	Nov	0.348	0.003	0.003	0.096	0.002	0.291	0.294	-0.017	1.097	1.079	0.020	-0.709	-0.786
	Dec	0.448	0.003	0.003	0.096	0.001	0.309	0.310	-0.019	1.073	1.054	0.020	-0.764	-0.744

Table S5. The relationships between BC DRFs and optical properties and atmospheric variables in each region. The symbols “+” and “-” mean positive and negative correlation respectively.

	BC DRF	BC concentration	BC AOD	BC AAOD	BC SSA	O ₃ concentration	Surface albedo	Water vapor
Northeast China (NEC)	TOA LW	-	-	-	+	+	-	+
	TOA SW	+	+	+	-	-	+	-
	TOA NET	+	+	+	-	-	+	-
	ATM LW	-	-	-	+	+	-	+
	ATM SW	-	+	+	-	+	-	+
	ATM NET	-	+	+	-	+	-	+
	SUR LW	+	+	+	-	-	+	-
	SUR SW	+	-	-	-	-	+	-
	SUR NET	+	-	-	-	-	+	-
North China (NC)	TOA LW	-	+	+	+	+	-	+
	TOA SW	-	+	+	+	+	+	+
	TOA NET	-	+	+	+	+	+	+
	ATM LW	-	-	-	+	+	-	+
	ATM SW	-	+	+	+	+	-	+
	ATM NET	-	+	+	+	+	-	+
	SUR LW	+	+	+	-	-	+	-
	SUR SW	+	-	-	-	-	+	-
	SUR NET	+	-	-	-	-	+	-
East China (EC)	TOA LW	-	+	+	-	+	+	-
	TOA SW	+	+	+	-	-	-	-
	TOA NET	+	+	+	-	-	-	-
	ATM LW	-	-	-	+	+	+	+
	ATM SW	+	+	+	-	-	-	-
	ATM NET	+	+	+	-	-	-	-
	SUR LW	+	+	+	-	-	-	-
	SUR SW	-	-	-	+	+	+	+

	SUR NET	-	-	-	+	+	+	+
Central China (CC)	TOA LW	-	+	+	+	+	+	-
	TOA SW	+	+	+	-	-	-	-
	TOA NET	+	+	+	-	-	-	-
	ATM LW	-	-	-	+	+	+	+
	ATM SW	+	+	+	-	-	-	-
	ATM NET	+	+	+	-	-	-	-
	SUR LW	+	+	+	-	-	-	-
	SUR SW	-	-	-	+	+	+	+
	SUR NET	-	-	-	+	+	+	+
South China (SC)	TOA LW	+	+	+	-	+	-	-
	TOA SW	+	+	+	-	+	-	-
	TOA NET	+	+	+	-	+	-	-
	ATM LW	-	-	-	+	+	+	+
	ATM SW	+	+	+	-	+	-	-
	ATM NET	+	+	+	-	+	-	-
	SUR LW	+	+	+	-	-	-	-
	SUR SW	-	-	-	+	-	+	+
	SUR NET	-	-	-	+	-	+	+
Southwest China (SWC)	TOA LW	+	+	+	-	+	+	-
	TOA SW	+	+	+	-	-	+	-
	TOA NET	+	+	+	-	-	+	-
	ATM LW	-	-	-	+	+	-	+
	ATM SW	+	+	+	-	-	+	-
	ATM NET	+	+	+	-	-	+	-
	SUR LW	+	+	+	-	-	+	-
	SUR SW	-	-	-	+	+	-	+
	SUR NET	-	-	-	+	+	-	+
	TOA LW	-	-	-	+	+	-	+

Northwest China (NWC)	TOA SW	+	+	+	-	-	+	-
	TOA NET	+	+	+	-	-	+	-
	ATM LW	-	-	-	+	+	-	+
	ATM SW	+	+	+	-	-	+	-
	ATM NET	+	+	+	-	-	+	-
	SUR LW	+	+	+	-	-	+	-
	SUR SW	-	-	-	+	+	-	+
	SUR NET	-	-	-	+	+	-	+

Table S6. The monthly mean values for Pri-BrC concentrations ($\mu\text{g m}^{-3}$), optical properties at 550 nm (AOD, AAOD, and SSA), and DRFs (W m^{-2}) in each region.

Region	Month	Pri-BrC concentration	Pri-BrC AOD	Pri-BrC AAOD	Pri-BrC SSA	TOA LW	TOA SW	TOA NET	ATM LW	ATM SW	ATM NET	SUR LW	SUR SW	SUR NET
Northeast China (NEC)	Jan	2.325	0.011	0.0003	0.967	0.0002	-0.153	-0.153	-0.027	0.254	0.226	0.028	-0.407	-0.379
	Feb	1.818	0.010	0.0003	0.968	0.001	-0.177	-0.177	-0.026	0.266	0.240	0.027	-0.443	-0.416
	Mar	1.690	0.013	0.0004	0.967	0.004	-0.411	-0.407	-0.028	0.345	0.317	0.032	-0.756	-0.724
	Apr	1.338	0.013	0.0004	0.967	0.005	-0.433	-0.429	-0.026	0.411	0.384	0.031	-0.844	-0.813
	May	0.412	0.007	0.0002	0.967	0.003	-0.302	-0.299	-0.011	0.189	0.178	0.015	-0.492	-0.477
	Jun	0.464	0.010	0.0003	0.969	0.005	-0.480	-0.475	-0.014	0.266	0.252	0.019	-0.746	-0.727
	Jul	0.564	0.010	0.0003	0.969	0.004	-0.494	-0.490	-0.014	0.263	0.250	0.018	-0.757	-0.740
	Agu	0.485	0.008	0.0002	0.971	0.003	-0.354	-0.351	-0.012	0.173	0.161	0.015	-0.527	-0.512
	Sep	0.391	0.005	0.0002	0.968	0.002	-0.189	-0.187	-0.009	0.106	0.097	0.011	-0.295	-0.284
	Oct	1.117	0.007	0.0002	0.967	0.001	-0.212	-0.211	-0.015	0.120	0.105	0.016	-0.332	-0.316
	Nov	1.491	0.009	0.0003	0.967	0.001	-0.224	-0.223	-0.021	0.161	0.140	0.022	-0.385	-0.363
	Dec	1.904	0.008	0.0003	0.967	0.0004	-0.137	-0.137	-0.019	0.180	0.161	0.019	-0.317	-0.298
North China (NC)	Jan	1.404	0.010	0.0003	0.965	0.001	-0.175	-0.175	-0.024	0.178	0.153	0.025	-0.353	-0.328
	Feb	0.980	0.008	0.0003	0.965	0.001	-0.189	-0.187	-0.018	0.176	0.159	0.019	-0.365	-0.346
	Mar	0.733	0.008	0.0003	0.966	0.004	-0.247	-0.243	-0.016	0.233	0.217	0.019	-0.480	-0.46
	Apr	0.466	0.006	0.0002	0.965	0.003	-0.212	-0.209	-0.011	0.205	0.194	0.015	-0.417	-0.403

	May	0.312	0.005	0.0002	0.965	0.003	-0.192	-0.189	-0.008	0.150	0.142	0.011	-0.341	-0.331
	Jun	0.490	0.009	0.0003	0.967	0.006	-0.394	-0.388	-0.014	0.275	0.262	0.020	-0.669	-0.650
	Jul	0.429	0.008	0.0002	0.968	0.004	-0.318	-0.314	-0.010	0.212	0.202	0.013	-0.530	-0.517
	Agu	0.412	0.007	0.0002	0.969	0.003	-0.272	-0.269	-0.010	0.165	0.155	0.013	-0.437	-0.424
	Sep	0.340	0.004	0.0001	0.966	0.002	-0.148	-0.147	-0.007	0.100	0.093	0.009	-0.248	-0.240
	Oct	0.465	0.005	0.0001	0.967	0.001	-0.137	-0.135	-0.009	0.088	0.079	0.010	-0.225	-0.215
	Nov	0.633	0.004	0.0001	0.965	0.001	-0.107	-0.107	-0.009	0.078	0.069	0.010	-0.186	-0.176
	Dec	0.978	0.005	0.0002	0.965	0.0002	-0.106	-0.106	-0.013	0.106	0.093	0.013	-0.212	-0.199
East China (EC)	Jan	3.804	0.035	0.0010	0.970	0.004	-0.814	-0.810	-0.077	0.476	0.399	0.081	-1.290	-1.209
	Feb	3.441	0.030	0.0009	0.969	0.005	-0.916	-0.912	-0.066	0.542	0.476	0.070	-1.459	-1.388
	Mar	1.813	0.022	0.0006	0.970	0.007	-0.731	-0.724	-0.039	0.460	0.421	0.046	-1.191	-1.145
	Apr	1.195	0.015	0.0004	0.969	0.005	-0.524	-0.518	-0.023	0.354	0.331	0.028	-0.878	-0.849
	May	0.980	0.011	0.0004	0.969	0.005	-0.406	-0.401	-0.016	0.294	0.278	0.021	-0.699	-0.679
	Jun	0.852	0.011	0.0003	0.971	0.004	-0.409	-0.404	-0.013	0.288	0.276	0.017	-0.697	-0.680
	Jul	0.741	0.009	0.0003	0.970	0.002	-0.339	-0.337	-0.009	0.215	0.206	0.011	-0.554	-0.543
	Agu	0.855	0.010	0.0003	0.971	0.002	-0.369	-0.366	-0.009	0.218	0.209	0.012	-0.587	-0.575
	Sep	0.972	0.010	0.0003	0.971	0.003	-0.345	-0.343	-0.012	0.199	0.187	0.014	-0.544	-0.530
	Oct	0.992	0.008	0.0002	0.970	0.002	-0.299	-0.298	-0.014	0.157	0.143	0.016	-0.456	-0.440
	Nov	1.798	0.014	0.0004	0.969	0.002	-0.403	-0.401	-0.029	0.216	0.187	0.030	-0.618	-0.588
	Dec	3.451	0.023	0.0007	0.967	0.001	-0.611	-0.609	-0.056	0.349	0.292	0.058	-0.959	-0.902
Central China (CC)	Jan	6.518	0.062	0.0018	0.970	0.005	-1.219	-1.214	-0.136	0.785	0.649	0.141	-2.004	-1.863
	Feb	3.734	0.039	0.0011	0.969	0.006	-1.090	-1.084	-0.083	0.669	0.586	0.089	-1.759	-1.670
	Mar	2.535	0.031	0.0009	0.971	0.009	-0.906	-0.897	-0.057	0.614	0.557	0.066	-1.520	-1.454
	Apr	1.238	0.017	0.0005	0.969	0.006	-0.562	-0.556	-0.024	0.385	0.361	0.030	-0.947	-0.917
	May	1.083	0.013	0.0004	0.968	0.005	-0.446	-0.441	-0.017	0.319	0.301	0.022	-0.765	-0.742
	Jun	1.085	0.014	0.0004	0.971	0.005	-0.530	-0.525	-0.016	0.354	0.338	0.021	-0.884	-0.863
	Jul	0.745	0.009	0.0003	0.970	0.003	-0.366	-0.363	-0.009	0.224	0.215	0.012	-0.590	-0.578
	Agu	0.888	0.011	0.0003	0.972	0.003	-0.42	-0.416	-0.01	0.249	0.239	0.013	-0.669	-0.655
	Sep	1.185	0.013	0.0003	0.972	0.003	-0.430	-0.427	-0.015	0.255	0.240	0.018	-0.685	-0.667

	Oct	1.340	0.013	0.0004	0.972	0.002	-0.415	-0.413	-0.022	0.226	0.204	0.024	-0.641	-0.617
	Nov	2.331	0.021	0.0006	0.969	0.002	-0.555	-0.553	-0.042	0.308	0.266	0.044	-0.863	-0.819
	Dec	4.213	0.032	0.0010	0.967	0.001	-0.777	-0.776	-0.075	0.460	0.385	0.076	-1.237	-1.161
South China (SC)	Jan	2.427	0.028	0.0008	0.973	0.003	-0.835	-0.832	-0.057	0.434	0.377	0.060	-1.270	-1.209
	Feb	1.506	0.023	0.0007	0.971	0.005	-0.817	-0.811	-0.044	0.443	0.400	0.049	-1.260	-1.211
	Mar	1.052	0.021	0.0006	0.973	0.006	-0.752	-0.745	-0.031	0.442	0.411	0.038	-1.194	-1.157
	Apr	0.768	0.017	0.0005	0.971	0.006	-0.625	-0.619	-0.020	0.388	0.368	0.026	-1.013	-0.987
	May	0.654	0.010	0.0003	0.972	0.003	-0.378	-0.375	-0.011	0.230	0.219	0.014	-0.607	-0.594
	Jun	0.489	0.006	0.0001	0.974	0.002	-0.232	-0.231	-0.004	0.123	0.118	0.006	-0.355	-0.349
	Jul	0.442	0.005	0.0001	0.973	0.001	-0.186	-0.184	-0.004	0.101	0.097	0.005	-0.286	-0.281
	Agu	0.483	0.005	0.0001	0.973	0.001	-0.196	-0.195	-0.004	0.102	0.097	0.005	-0.298	-0.293
	Sep	0.582	0.006	0.0002	0.973	0.002	-0.257	-0.256	-0.006	0.130	0.124	0.008	-0.388	-0.380
	Oct	0.771	0.008	0.0002	0.972	0.001	-0.312	-0.311	-0.012	0.158	0.146	0.013	-0.471	-0.457
	Nov	1.055	0.010	0.0003	0.973	0.001	-0.358	-0.357	-0.017	0.170	0.153	0.017	-0.528	-0.511
	Dec	1.990	0.021	0.0006	0.969	0.002	-0.687	-0.685	-0.045	0.353	0.308	0.047	-1.040	-0.993
Southwest China (SWC)	Jan	1.464	0.016	0.0004	0.967	0.003	-0.396	-0.393	-0.037	0.232	0.195	0.040	-0.629	-0.589
	Feb	0.872	0.012	0.0003	0.967	0.003	-0.365	-0.362	-0.025	0.213	0.188	0.029	-0.578	-0.549
	Mar	0.638	0.011	0.0003	0.968	0.005	-0.353	-0.348	-0.021	0.228	0.207	0.025	-0.581	-0.555
	Apr	0.459	0.008	0.0002	0.968	0.004	-0.284	-0.280	-0.013	0.182	0.169	0.017	-0.466	-0.449
	May	0.368	0.006	0.0002	0.970	0.003	-0.230	-0.226	-0.008	0.147	0.139	0.012	-0.377	-0.365
	Jun	0.316	0.005	0.0001	0.971	0.003	-0.200	-0.198	-0.006	0.113	0.108	0.008	-0.313	-0.305
	Jul	0.280	0.004	0.0001	0.971	0.002	-0.169	-0.167	-0.004	0.092	0.088	0.006	-0.262	-0.255
	Agu	0.290	0.004	0.0001	0.971	0.003	-0.181	-0.179	-0.004	0.096	0.092	0.007	-0.277	-0.270
	Sep	0.326	0.004	0.0001	0.971	0.002	-0.162	-0.160	-0.005	0.083	0.078	0.007	-0.245	-0.238
	Oct	0.399	0.005	0.0001	0.969	0.001	-0.162	-0.161	-0.008	0.088	0.079	0.010	-0.250	-0.240
	Nov	0.532	0.006	0.0002	0.967	0.001	-0.185	-0.183	-0.013	0.103	0.090	0.015	-0.288	-0.274
	Dec	1.023	0.010	0.0003	0.966	0.001	-0.277	-0.276	-0.024	0.148	0.123	0.026	-0.425	-0.399
	Jan	0.518	0.007	0.0002	0.965	0.002	-0.151	-0.150	-0.015	0.169	0.154	0.016	-0.320	-0.304
	Feb	0.398	0.005	0.0002	0.965	0.002	-0.137	-0.136	-0.011	0.137	0.127	0.012	-0.275	-0.263

Northwest China (NWC)	Mar	0.248	0.004	0.0001	0.966	0.003	-0.125	-0.122	-0.007	0.130	0.123	0.010	-0.256	-0.246
	Apr	0.120	0.003	0.0001	0.966	0.002	-0.082	-0.08	-0.003	0.081	0.078	0.005	-0.162	-0.157
	May	0.089	0.002	0.0001	0.965	0.002	-0.070	-0.069	-0.002	0.058	0.056	0.004	-0.128	-0.125
	Jun	0.108	0.002	0.0001	0.967	0.002	-0.094	-0.092	-0.003	0.072	0.069	0.005	-0.165	-0.161
	Jul	0.106	0.002	0.0001	0.967	0.002	-0.099	-0.097	-0.002	0.072	0.069	0.004	-0.170	-0.166
	Agu	0.108	0.002	0.0001	0.968	0.002	-0.101	-0.099	-0.003	0.072	0.070	0.005	-0.173	-0.169
	Sep	0.128	0.003	0.0001	0.967	0.002	-0.091	-0.089	-0.004	0.069	0.065	0.005	-0.160	-0.154
	Oct	0.146	0.003	0.0001	0.966	0.001	-0.081	-0.079	-0.004	0.062	0.058	0.006	-0.143	-0.138
	Nov	0.287	0.004	0.0001	0.965	0.001	-0.105	-0.104	-0.007	0.088	0.081	0.009	-0.193	-0.185
	Dec	0.421	0.004	0.0001	0.964	0.001	-0.108	-0.108	-0.010	0.107	0.097	0.011	-0.215	-0.204

Table S7. The relationships between Pri-BrC DRFs and optical properties and atmospheric variables in each region. The symbols “+” and “-” mean positive and negative correlation respectively.

		Pri-BrC concentration	Pri-BrC AOD	Pri-BrC AAOD	Pri-BrC SSA	O ₃ concentration	Surface albedo	Water vapor
Northeast China (NEC)	TOA LW	-	+	+	+	+	-	+
	TOA SW	+	-	-	-	-	+	-
	TOA NET	+	-	-	-	-	+	-
	ATM LW	-	-	-	+	+	-	+
	ATM SW	+	+	+	-	+	+	-
	ATM NET	+	+	+	-	+	+	-
	SUR LW	+	+	+	-	-	+	-
	SUR SW	+	-	-	-	-	+	-
	SUR NET	+	-	-	-	-	+	-
North China (NC)	TOA LW	-	+	+	+	+	-	+
	TOA SW	+	-	-	-	-	+	-
	TOA NET	+	-	-	-	-	+	-
	ATM LW	-	-	-	+	+	-	+

	ATM SW	+	+	+	+	+	+	+
	ATM NET	-	+	+	+	+	+	+
	SUR LW	+	+	+	-	-	+	-
	SUR SW	+	-	-	-	-	+	-
	SUR NET	+	-	-	-	-	+	-
East China (EC)	TOA LW	+	+	+	+	+	+	-
	TOA SW	-	-	-	+	+	+	+
	TOA NET	-	-	-	+	+	+	+
	ATM LW	-	-	-	+	+	+	+
	ATM SW	+	+	+	-	-	-	-
	ATM NET	+	+	+	-	-	-	-
	SUR LW	+	+	+	-	-	-	-
	SUR SW	-	-	-	+	+	+	+
	SUR NET	-	-	-	+	+	+	+
Central China (CC)	TOA LW	+	+	+	+	+	+	-
	TOA SW	-	-	-	+	+	+	+
	TOA NET	-	-	-	+	+	+	+
	ATM LW	-	-	-	+	+	+	+
	ATM SW	+	+	+	-	-	-	-
	ATM NET	+	+	+	-	-	-	-
	SUR LW	+	+	+	-	-	-	-
	SUR SW	-	-	-	+	+	+	+
	SUR NET	-	-	-	+	+	+	+
South China (SC)	TOA LW	+	+	+	-	+	-	-
	TOA SW	-	-	-	+	-	+	+
	TOA NET	-	-	-	+	-	+	+
	ATM LW	-	-	-	+	+	+	+
	ATM SW	+	+	+	-	+	-	-
	ATM NET	+	+	+	-	+	-	-

		SUR LW	+	+	+	-	-	-	-
		SUR SW	-	-	-	+	-	+	+
		SUR NET	-	-	-	+	-	+	+
		TOA LW	+	+	+	-	+	+	-
		TOA SW	-	-	-	+	+	-	+
		TOA NET	-	-	-	+	+	-	+
Southwest		ATM LW	-	-	-	+	+	-	+
China		ATM SW	+	+	+	-	-	+	-
(SWC)		ATM NET	+	+	+	-	+	+	-
		SUR LW	+	+	+	-	-	+	-
		SUR SW	-	-	-	+	+	-	+
		SUR NET	-	-	-	+	+	-	+
		TOA LW	-	-	-	+	+	+	+
		TOA SW	-	-	-	+	+	-	+
		TOA NET	-	-	-	+	+	-	+
Northwest		ATM LW	-	-	-	+	+	-	+
China		ATM SW	+	+	+	-	-	+	-
(NWC)		ATM NET	+	+	+	-	-	+	-
		SUR LW	+	+	+	-	-	+	-
		SUR SW	-	-	-	+	+	-	+
		SUR NET	-	-	-	+	+	-	+

Table S8. The monthly mean values for Sec-BrC concentrations ($\mu\text{g m}^{-3}$), optical properties at 550 nm (AOD, AAOD, and SSA), and DRFs (W m^{-2}) in each region.

Region	Month	Sec-BrC concentration	Sec-BrC AOD	Sec-BrC AAOD	Sec-BrC SSA	TOA LW	TOA SW	TOA NET	ATM LW	ATM SW	ATM NET	SUR LW	SUR SW	SUR NET
Northeast China (NEC)	Jan	0.046	0.0008	0.00003	0.966	0.0003	-0.013	-0.013	-0.001	0.020	0.019	0.002	-0.033	-0.031
	Feb	0.041	0.0010	0.00003	0.966	0.0005	-0.018	-0.018	-0.002	0.028	0.026	0.002	-0.046	-0.044
	Mar	0.036	0.0012	0.00004	0.966	0.0011	-0.038	-0.037	-0.001	0.033	0.032	0.002	-0.072	-0.069
	Apr	0.033	0.0011	0.00004	0.966	0.0012	-0.042	-0.040	-0.001	0.033	0.032	0.002	-0.075	-0.073
	May	0.034	0.0011	0.00004	0.967	0.0011	-0.051	-0.050	-0.001	0.031	0.030	0.002	-0.082	-0.080
	Jun	0.051	0.0015	0.00005	0.969	0.0012	-0.070	-0.069	-0.002	0.040	0.038	0.003	-0.110	-0.107
	Jul	0.068	0.0017	0.00005	0.968	0.0010	-0.079	-0.078	-0.002	0.043	0.041	0.003	-0.122	-0.119
	Agu	0.050	0.0014	0.00004	0.970	0.0010	-0.065	-0.064	-0.001	0.031	0.030	0.002	-0.097	-0.095
	Sep	0.037	0.0011	0.00003	0.968	0.0008	-0.040	-0.039	-0.001	0.022	0.021	0.002	-0.062	-0.060
	Oct	0.029	0.0007	0.00002	0.966	0.0005	-0.025	-0.025	-0.001	0.013	0.012	0.002	-0.038	-0.037
	Nov	0.019	0.0006	0.00002	0.966	0.0003	-0.015	-0.015	-0.001	0.010	0.009	0.001	-0.025	-0.024
	Dec	0.022	0.0005	0.00002	0.966	0.0003	-0.009	-0.009	-0.001	0.012	0.011	0.001	-0.021	-0.020
North China (NC)	Jan	0.045	0.0009	0.00003	0.965	0.0004	-0.017	-0.016	-0.002	0.019	0.018	0.002	-0.036	-0.034
	Feb	0.035	0.0009	0.00003	0.965	0.0005	-0.024	-0.023	-0.001	0.025	0.024	0.002	-0.049	-0.047
	Mar	0.034	0.0012	0.00004	0.965	0.0012	-0.038	-0.037	-0.001	0.037	0.035	0.002	-0.075	-0.073
	Apr	0.024	0.0009	0.00003	0.965	0.0011	-0.032	-0.030	-0.001	0.030	0.029	0.002	-0.062	-0.060
	May	0.025	0.0009	0.00003	0.965	0.0011	-0.035	-0.034	-0.001	0.027	0.027	0.002	-0.062	-0.060
	Jun	0.045	0.0013	0.00004	0.967	0.0012	-0.051	-0.050	-0.001	0.038	0.036	0.002	-0.089	-0.086
	Jul	0.060	0.0016	0.00005	0.968	0.0012	-0.064	-0.063	-0.001	0.045	0.044	0.003	-0.110	-0.107
	Agu	0.051	0.0014	0.00004	0.968	0.0011	-0.055	-0.054	-0.001	0.035	0.034	0.002	-0.091	-0.089
	Sep	0.036	0.0010	0.00003	0.966	0.0008	-0.035	-0.034	-0.001	0.023	0.022	0.002	-0.058	-0.056
	Oct	0.030	0.0008	0.00002	0.966	0.0005	-0.025	-0.025	-0.001	0.016	0.015	0.002	-0.041	-0.039
	Nov	0.017	0.0005	0.00002	0.965	0.0003	-0.014	-0.013	-0.001	0.010	0.010	0.001	-0.024	-0.023
	Dec	0.022	0.0005	0.00002	0.964	0.0002	-0.010	-0.009	-0.001	0.011	0.010	0.001	-0.020	-0.019
East China (EC)	Jan	0.138	0.0028	0.00008	0.969	0.0007	-0.070	-0.070	-0.005	0.037	0.032	0.006	-0.108	-0.102
	Feb	0.124	0.0027	0.00008	0.968	0.0010	-0.088	-0.087	-0.005	0.048	0.043	0.006	-0.136	-0.130

	Mar	0.089	0.0026	0.00008	0.970	0.0014	-0.091	-0.090	-0.004	0.055	0.051	0.005	-0.146	-0.140
	Apr	0.096	0.0024	0.00007	0.968	0.0014	-0.089	-0.088	-0.003	0.058	0.055	0.004	-0.148	-0.143
	May	0.099	0.0025	0.00008	0.969	0.0016	-0.094	-0.093	-0.003	0.065	0.062	0.004	-0.159	-0.155
	Jun	0.105	0.0028	0.00008	0.971	0.0017	-0.108	-0.107	-0.002	0.072	0.070	0.004	-0.181	-0.177
	Jul	0.102	0.0024	0.00007	0.970	0.0015	-0.099	-0.097	-0.001	0.06	0.059	0.003	-0.159	-0.157
	Agu	0.119	0.0028	0.00008	0.970	0.0017	-0.115	-0.113	-0.001	0.065	0.064	0.003	-0.180	-0.177
	Sep	0.106	0.0026	0.00008	0.970	0.0017	-0.103	-0.102	-0.002	0.055	0.053	0.003	-0.158	-0.155
	Oct	0.076	0.0018	0.00005	0.969	0.0010	-0.070	-0.069	-0.002	0.034	0.032	0.003	-0.104	-0.101
	Nov	0.077	0.0016	0.00005	0.969	0.0007	-0.054	-0.053	-0.003	0.025	0.022	0.003	-0.079	-0.075
	Dec	0.103	0.0017	0.00005	0.967	0.0005	-0.048	-0.048	-0.003	0.024	0.021	0.004	-0.072	-0.068
Central China (CC)	Jan	0.232	0.0040	0.00011	0.970	0.0008	-0.081	-0.081	-0.008	0.048	0.040	0.009	-0.130	-0.121
	Feb	0.143	0.0032	0.00009	0.969	0.0011	-0.093	-0.092	-0.006	0.053	0.047	0.007	-0.146	-0.139
	Mar	0.117	0.0031	0.00009	0.970	0.0016	-0.093	-0.092	-0.005	0.061	0.057	0.006	-0.155	-0.149
	Apr	0.092	0.0025	0.00007	0.969	0.0015	-0.087	-0.085	-0.003	0.058	0.055	0.004	-0.145	-0.141
	May	0.101	0.0025	0.00007	0.968	0.0015	-0.090	-0.089	-0.003	0.063	0.06	0.004	-0.153	-0.149
	Jun	0.136	0.0034	0.00010	0.971	0.0018	-0.130	-0.128	-0.003	0.085	0.082	0.005	-0.214	-0.210
	Jul	0.108	0.0025	0.00007	0.970	0.0016	-0.103	-0.102	-0.001	0.062	0.061	0.003	-0.166	-0.163
	Agu	0.121	0.0030	0.00009	0.971	0.0019	-0.121	-0.119	-0.002	0.070	0.069	0.003	-0.191	-0.188
	Sep	0.126	0.0031	0.00009	0.971	0.0019	-0.113	-0.111	-0.002	0.063	0.061	0.004	-0.176	-0.172
	Oct	0.103	0.0024	0.00007	0.971	0.0011	-0.083	-0.082	-0.003	0.042	0.039	0.004	-0.126	-0.122
	Nov	0.104	0.0021	0.00006	0.969	0.0007	-0.062	-0.061	-0.004	0.031	0.027	0.004	-0.093	-0.088
	Dec	0.130	0.0022	0.00007	0.967	0.0005	-0.055	-0.054	-0.004	0.029	0.025	0.005	-0.084	-0.079
South China (SC)	Jan	0.150	0.0028	0.00008	0.972	0.0007	-0.091	-0.090	-0.005	0.043	0.038	0.006	-0.134	-0.128
	Feb	0.119	0.0029	0.00008	0.971	0.0010	-0.106	-0.105	-0.005	0.056	0.051	0.006	-0.162	-0.156
	Mar	0.087	0.0025	0.00007	0.972	0.0011	-0.092	-0.091	-0.003	0.053	0.050	0.004	-0.146	-0.141
	Apr	0.083	0.0025	0.00007	0.971	0.0012	-0.095	-0.094	-0.003	0.058	0.056	0.004	-0.154	-0.150
	May	0.088	0.0024	0.00007	0.972	0.0013	-0.094	-0.093	-0.002	0.057	0.055	0.003	-0.151	-0.148
	Jun	0.055	0.0015	0.00004	0.972	0.0012	-0.067	-0.066	-0.0002	0.035	0.035	0.001	-0.102	-0.101
	Jul	0.065	0.0015	0.00004	0.972	0.0012	-0.065	-0.064	-0.0004	0.035	0.035	0.002	-0.101	-0.099

Southwest China (SWC)	Agu	0.065	0.0015	0.00004	0.971	0.0013	-0.069	-0.068	-0.0002	0.035	0.035	0.001	-0.105	-0.103
	Sep	0.091	0.0021	0.00006	0.971	0.0016	-0.091	-0.090	-0.001	0.045	0.045	0.002	-0.137	-0.134
	Oct	0.095	0.0020	0.00006	0.970	0.0010	-0.084	-0.083	-0.002	0.041	0.039	0.003	-0.125	-0.122
	Nov	0.086	0.0017	0.00005	0.972	0.0006	-0.067	-0.067	-0.002	0.029	0.027	0.003	-0.096	-0.094
	Dec	0.123	0.0023	0.00007	0.969	0.0007	-0.078	-0.077	-0.004	0.037	0.033	0.005	-0.114	-0.110
	Jan	0.051	0.0011	0.00003	0.967	0.0005	-0.031	-0.031	-0.002	0.018	0.016	0.003	-0.049	-0.047
	Feb	0.044	0.001	0.00003	0.967	0.0006	-0.035	-0.035	-0.002	0.021	0.019	0.002	-0.056	-0.054
	Mar	0.037	0.0011	0.00003	0.968	0.0008	-0.037	-0.036	-0.002	0.025	0.024	0.002	-0.062	-0.059
	Apr	0.035	0.0010	0.00003	0.968	0.0008	-0.038	-0.037	-0.001	0.025	0.024	0.002	-0.064	-0.061
	May	0.034	0.0010	0.00003	0.969	0.0009	-0.041	-0.040	-0.001	0.026	0.025	0.002	-0.068	-0.066
	Jun	0.033	0.0010	0.00003	0.970	0.0009	-0.045	-0.044	-0.001	0.025	0.024	0.002	-0.070	-0.069
	Jul	0.031	0.0009	0.00003	0.970	0.0011	-0.045	-0.044	-0.0004	0.024	0.024	0.001	-0.069	-0.068
	Agu	0.032	0.0011	0.00003	0.970	0.0014	-0.053	-0.052	-0.0002	0.028	0.027	0.002	-0.081	-0.079
	Sep	0.032	0.0011	0.00003	0.969	0.0013	-0.047	-0.046	-0.0003	0.024	0.023	0.002	-0.071	-0.069
	Oct	0.032	0.0009	0.00002	0.968	0.0007	-0.034	-0.033	-0.001	0.017	0.016	0.002	-0.051	-0.049
	Nov	0.035	0.0008	0.00002	0.967	0.0004	-0.026	-0.026	-0.001	0.014	0.013	0.002	-0.041	-0.039
	Dec	0.044	0.0008	0.00003	0.966	0.0004	-0.027	-0.026	-0.002	0.014	0.012	0.002	-0.041	-0.039
Northwest China (NWC)	Jan	0.029	0.0008	0.00003	0.965	0.0005	-0.018	-0.017	-0.001	0.022	0.021	0.002	-0.040	-0.038
	Feb	0.027	0.0007	0.00002	0.965	0.0005	-0.019	-0.019	-0.001	0.023	0.022	0.002	-0.042	-0.041
	Mar	0.024	0.0009	0.00003	0.966	0.0009	-0.025	-0.024	-0.001	0.028	0.027	0.002	-0.053	-0.051
	Apr	0.018	0.0007	0.00002	0.966	0.0009	-0.024	-0.023	-0.0004	0.024	0.024	0.001	-0.048	-0.047
	May	0.017	0.0006	0.00002	0.965	0.0008	-0.024	-0.023	-0.0003	0.021	0.021	0.001	-0.045	-0.044
	Jun	0.025	0.0008	0.00002	0.967	0.0009	-0.032	-0.032	-0.001	0.026	0.025	0.002	-0.058	-0.057
	Jul	0.028	0.0009	0.00003	0.967	0.0011	-0.039	-0.038	-0.001	0.030	0.029	0.002	-0.069	-0.067
	Agu	0.027	0.0009	0.00003	0.967	0.0011	-0.039	-0.038	-0.001	0.028	0.027	0.002	-0.067	-0.065
	Sep	0.023	0.0007	0.00002	0.966	0.0008	-0.028	-0.027	-0.001	0.021	0.020	0.001	-0.049	-0.047
	Oct	0.018	0.0006	0.00002	0.965	0.0005	-0.018	-0.018	-0.001	0.014	0.013	0.001	-0.033	-0.031
	Nov	0.020	0.0005	0.00002	0.965	0.0004	-0.017	-0.016	-0.001	0.014	0.014	0.001	-0.031	-0.030
	Dec	0.019	0.0005	0.00002	0.964	0.0003	-0.012	-0.012	-0.001	0.013	0.012	0.001	-0.025	-0.024

Table S9. The relationships between Sec-BrC DRFs and for optical properties and atmospheric variables in each region. The symbols “+” and “-” mean positive and negative correlation respectively.

	Sec-BrC DRF	Sec-BrC concentration	Sec-BrC AOD	Sec-BrC AAOD	Sec-BrC SSA	O ₃ concentration	Surface albedo	Water vapor
Northeast China (NEC)	TOA LW	+	+	+	+	+	-	+
	TOA SW	-	-	-	-	-	+	-
	TOA NET	-	-	-	-	-	+	-
	ATM LW	-	-	-	-	-	-	-
	ATM SW	+	+	+	+	+	-	+
	ATM NET	+	+	+	+	+	-	+
	SUR LW	+	+	+	+	+	-	+
	SUR SW	-	-	-	-	-	+	-
	SUR NET	-	-	-	-	-	+	-
North China (NC)	TOA LW	+	+	+	+	+	-	+
	TOA SW	-	-	-	-	-	+	-
	TOA NET	-	-	-	-	-	+	-
	ATM LW	-	-	-	-	-	-	-
	ATM SW	+	+	+	+	+	-	+
	ATM NET	+	+	+	+	+	-	+
	SUR LW	+	+	+	+	+	-	+
	SUR SW	-	-	-	-	-	+	-
	SUR NET	-	-	-	-	-	+	-
East China (EC)	TOA LW	+	+	+	+	+	+	+
	TOA SW	-	-	-	-	-	-	-
	TOA NET	-	-	-	-	-	-	-
	ATM LW	-	-	-	+	+	+	+
	ATM SW	+	+	+	+	+	+	+
	ATM NET	+	+	+	+	+	+	+
	SUR LW	+	+	+	-	-	-	-

	SUR SW	-	-	-	-	-	-	-
	SUR NET	-	-	-	-	-	-	-
Central China (CC)	TOA LW	-	+	+	+	+	+	+
	TOA SW	+	-	-	-	-	-	-
	TOA NET	+	-	-	-	-	-	-
	ATM LW	-	-	-	+	+	+	+
	ATM SW	-	+	+	+	+	+	+
	ATM NET	-	+	+	+	+	+	+
	SUR LW	+	+	+	-	-	-	-
	SUR SW	+	-	-	-	-	-	-
	SUR NET	+	-	-	-	-	-	-
South China (SC)	TOA LW	-	-	-	+	+	+	+
	TOA SW	-	-	-	+	-	+	+
	TOA NET	-	-	-	+	-	+	+
	ATM LW	-	-	-	+	-	+	+
	ATM SW	+	+	+	+	+	-	-
	ATM NET	+	+	+	+	+	-	-
	SUR LW	+	+	+	-	+	-	-
	SUR SW	-	-	-	+	-	+	+
	SUR NET	-	-	-	+	-	+	+
Southwest China (SWC)	TOA LW	-	+	+	+	+	-	+
	TOA SW	+	-	-	-	-	+	-
	TOA NET	+	-	-	-	-	+	-
	ATM LW	-	+	+	+	+	-	+
	ATM SW	-	+	+	+	+	-	+
	ATM NET	-	+	+	+	+	-	+
	SUR LW	+	+	+	-	-	+	-
	SUR SW	+	-	-	-	-	+	-
	SUR NET	+	-	-	-	-	+	-

Northwest China (NWC)	TOA LW	+	+	+	+	+	-	+
	TOA SW	-	-	-	-	-	+	-
	TOA NET	-	-	-	-	-	+	-
	ATM LW	-	+	-	+	+	-	+
	ATM SW	+	+	+	+	+	-	+
	ATM NET	+	+	+	+	+	-	+
	SUR LW	+	+	+	+	+	+	+
	SUR SW	-	-	-	-	-	+	-
	SUR NET	-	-	-	-	-	+	-