

Supplementary Information for

MODIS Collection 6.1 3 km resolution aerosol optical depth product: global evaluation and uncertainty analysis

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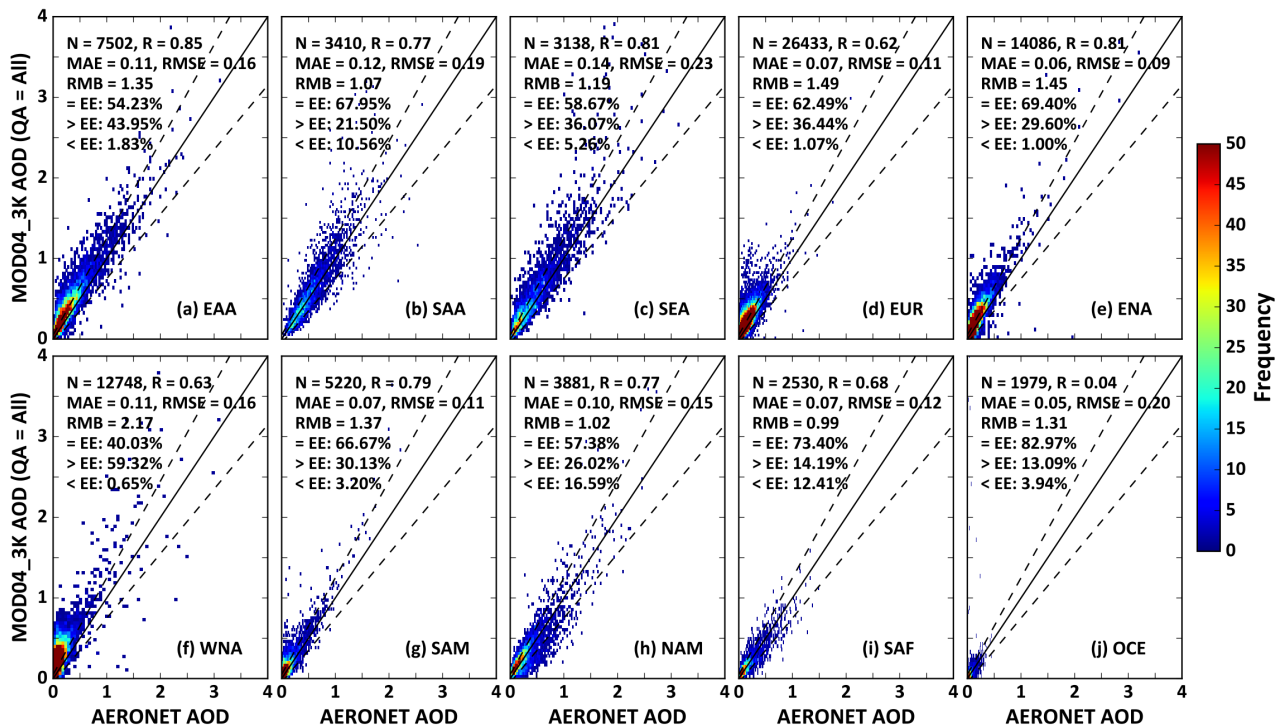


Figure S1. Validation of MOD04_3K all-quality (QA=All) AOD retrievals as a function of AERONET AODs for each region of interest from 2013 to 2017.

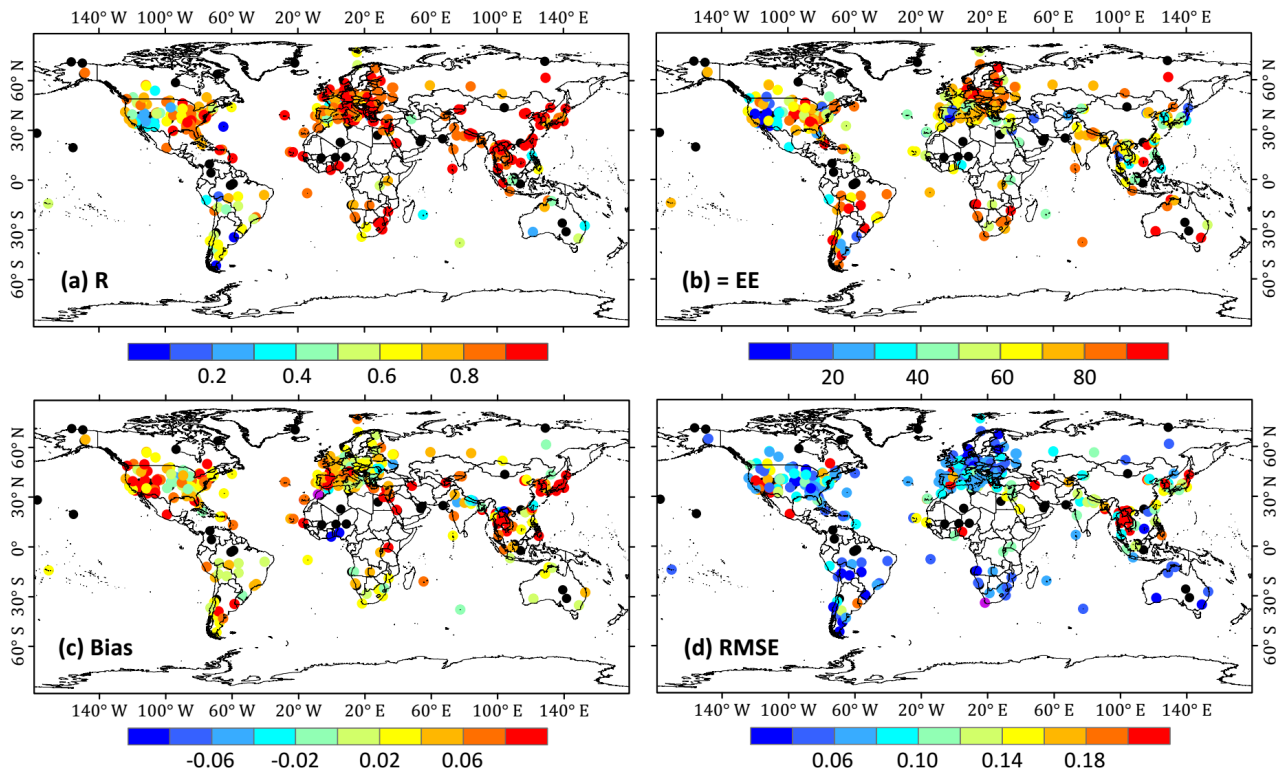


Figure S2. Validation parameters: (a) correlation coefficient (R), (b) percentage of retrievals falling within the expected error envelope (= EE), (c) mean bias, and (d) root-mean-square error (RMSE) at each AERONET station based on scatter plots of MODIS-retrieved 3-km AODs as a function of AERONET-retrieved mean AODs from the spatiotemporally collocated data set. Data are from March, April, and May (MAM) of 2013–2017. Only the MODIS/Terra 3-km best-quality (QA = 3) AOD product is used. Black dots show those sites with no or too few AOD retrievals.

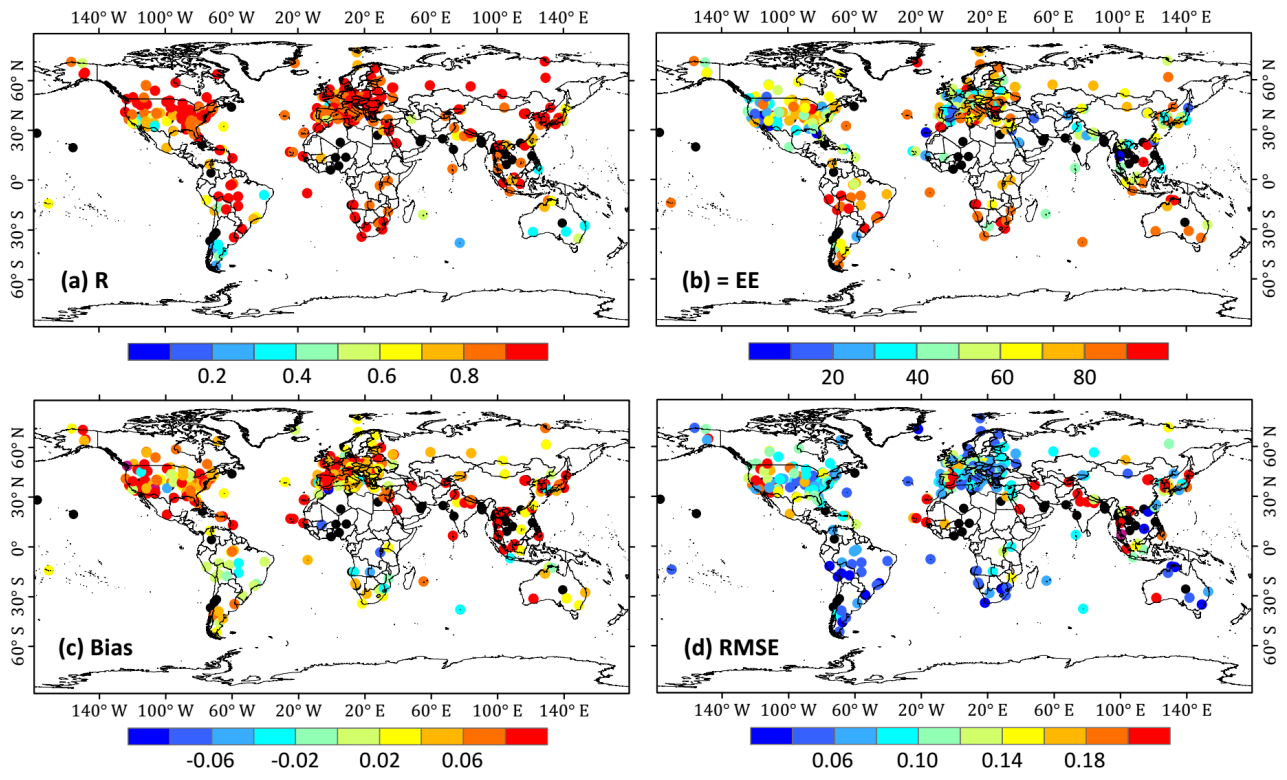


Figure S3. Same as Figure S3 but for data from June, July, and August (JJA) of 2013–2017.

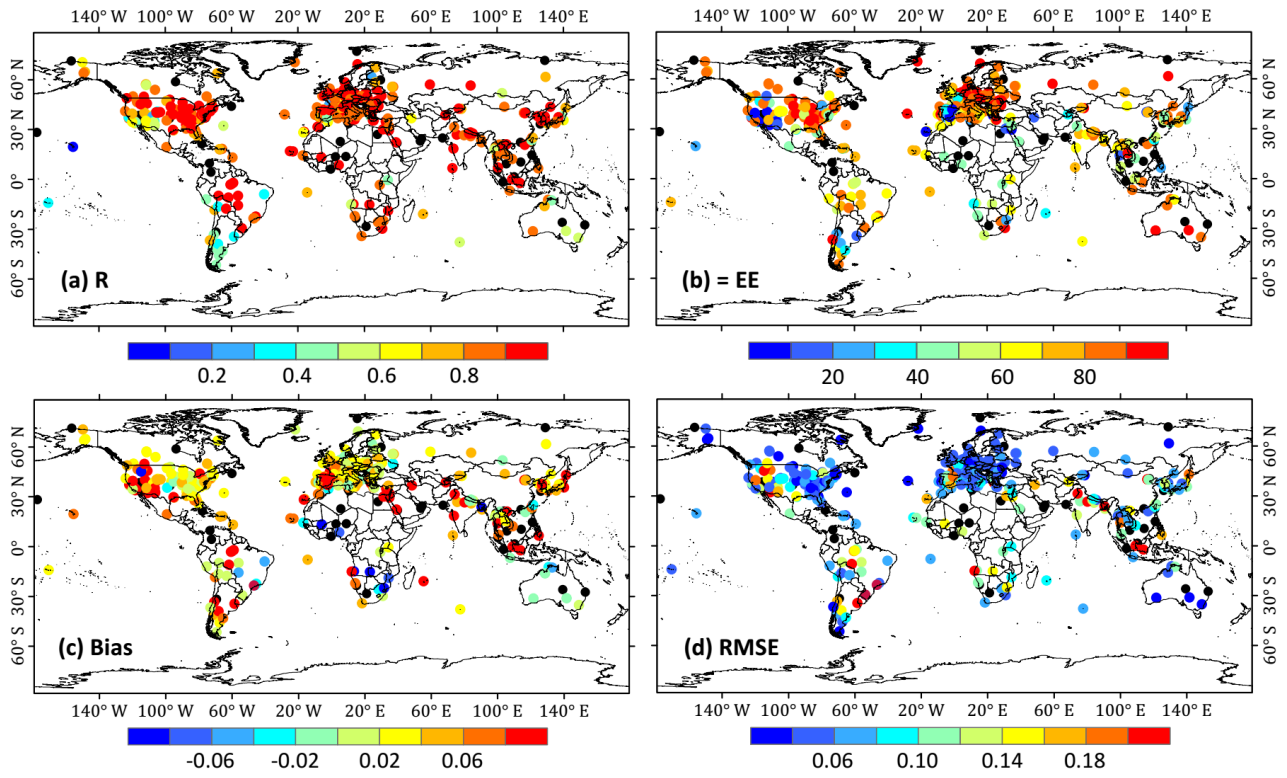


Figure S4. Same as Figure S3 but for data from September, October, and November (SON) of 2013–2017.

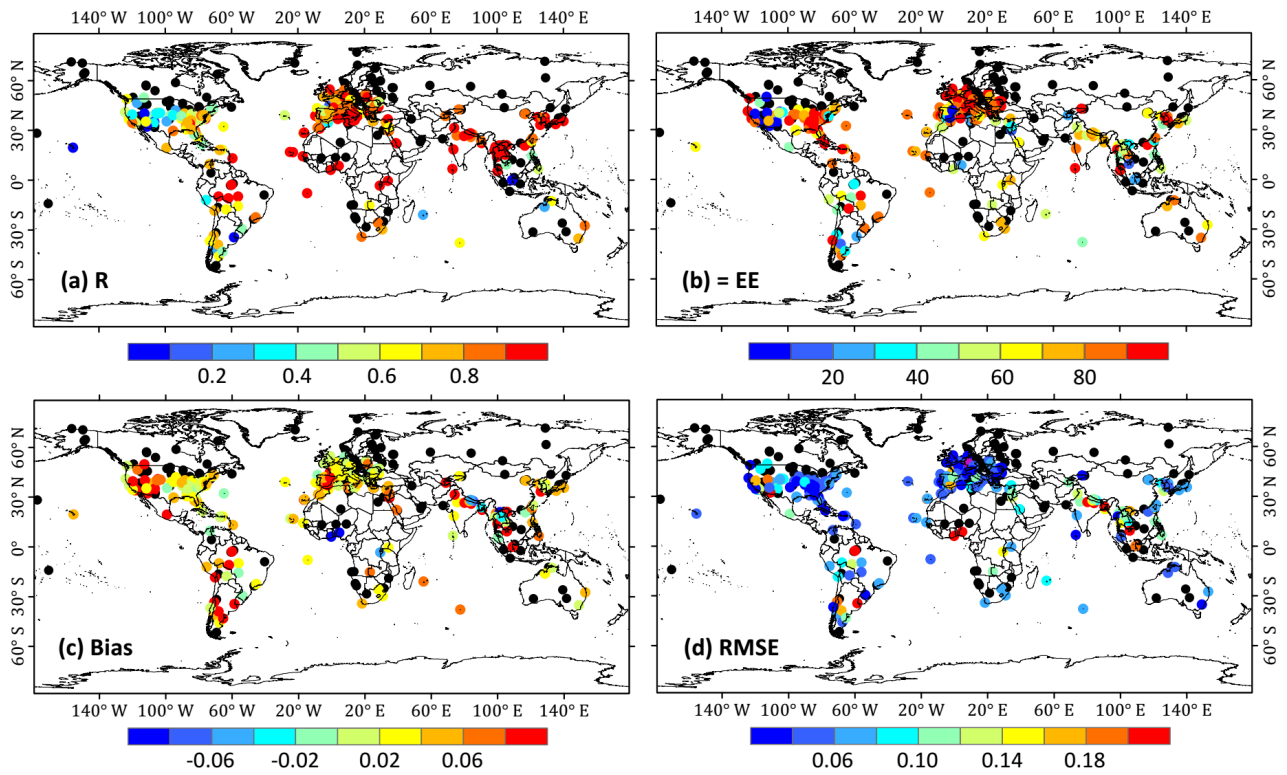


Figure S5. Same as Figure S3 but for data from December, January, and February (DJF) of 2013–2017.

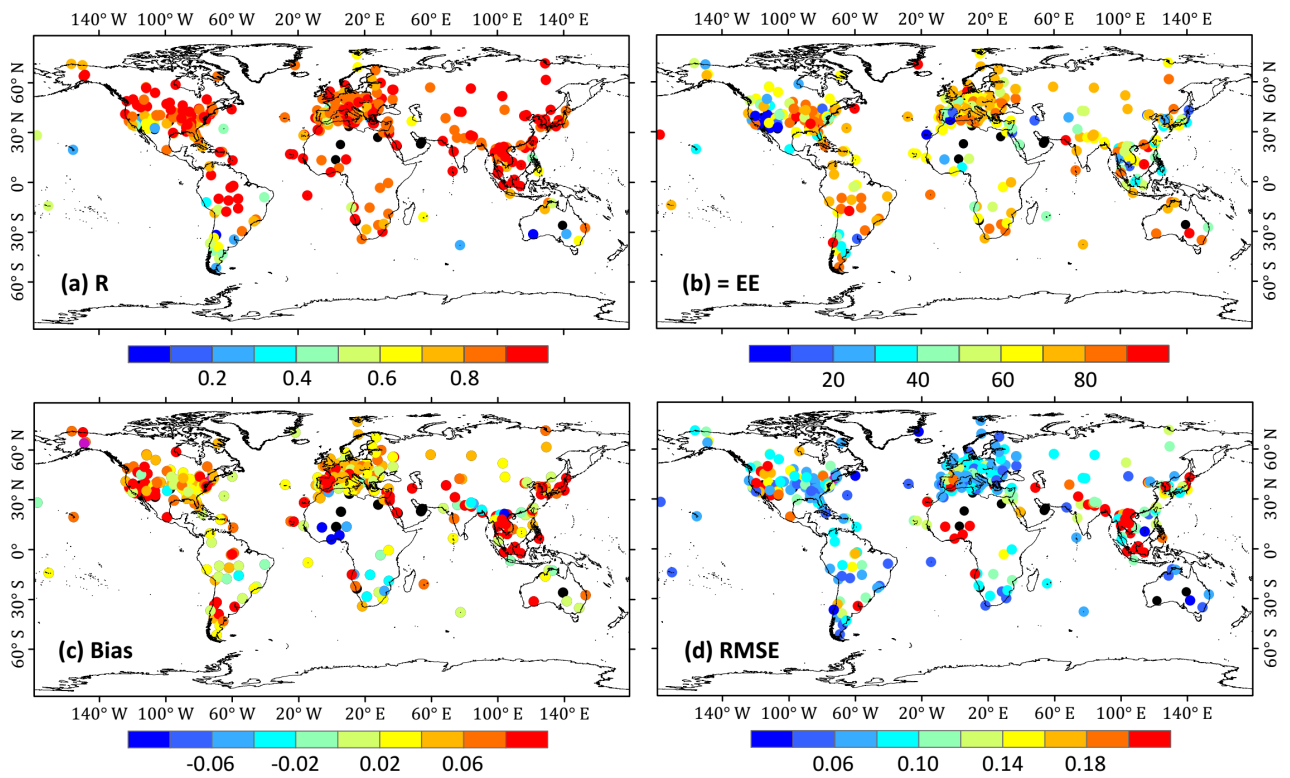


Figure S6. Same as Figure S3 but for MODIS/Terra 3-km all-quality (QA = All) AOD product from 2013 to 2017.

Table S1. Statistics of the accuracy and uncertainty of MOD04_3K best-quality AOD retrievals (QA = 3) as a function of NDVI. Data are from 2013 to 2017. The metrics are number of retrievals (N), correlation coefficient (R), bias, mean absolute error (MAE), root-mean-square error (RMSE), and the percentage of retrievals falling within (= EE), above (> EE), and below (< EE) the expected error envelope (EE).

NDVI	N	R	Bias	MAE	RMSE	RMB	= EE	> EE	< EE
< 0	647	0.89	0.06	0.07	0.13	1.35	64.91	32.92	2.16
0–0.05	79	0.08	0.04	0.05	0.07	2.49	54.43	44.30	1.27
0.05–0.10	797	0.68	0.13	0.13	0.28	1.61	37.89	61.86	0.25
0.10–0.15	753	0.82	0.10	0.11	0.15	1.65	39.31	57.37	3.32
0.15–0.20	2239	0.73	0.11	0.12	0.19	1.89	40.38	57.97	1.65
0.20–0.25	4009	0.84	0.09	0.10	0.14	1.57	48.84	49.24	1.92
0.25–0.30	5203	0.87	0.07	0.10	0.15	1.41	55.64	41.80	2.56
0.30–0.35	7483	0.88	0.07	0.10	0.14	1.36	56.31	39.93	3.76
0.35–0.40	8013	0.88	0.07	0.10	0.15	1.35	55.48	39.95	4.57
0.40–0.45	7535	0.92	0.05	0.08	0.13	1.29	65.03	31.61	3.36
0.45–0.50	8774	0.92	0.05	0.07	0.11	1.28	68.77	28.58	2.64
0.50–0.55	6891	0.92	0.05	0.07	0.11	1.25	69.22	28.44	2.34
0.55–0.60	5862	0.94	0.05	0.06	0.10	1.28	69.58	28.63	1.79
0.60–0.65	4576	0.95	0.05	0.07	0.10	1.28	67.50	30.68	1.81
0.65–0.70	3388	0.92	0.04	0.06	0.10	1.26	71.75	26.30	1.95
> 0.7	7840	0.93	0.05	0.06	0.10	1.30	71.52	27.04	1.44

Table S2. Same as Table S1 but for different land-use types.

Surface type	N	R	Bias	MAE	RMSE	RMB	= EE	> EE	< EE
Water	8739	0.93	0.05	0.06	0.09	1.30	70.63	27.63	1.74
Forest	7313	0.93	0.05	0.06	0.09	1.32	69.42	28.85	1.72
Grassland	24,572	0.88	0.05	0.07	0.11	1.38	62.22	34.66	3.12
Cropland	10,755	0.94	0.05	0.08	0.13	1.21	68.21	28.09	3.70
Urban	28,530	0.89	0.07	0.09	0.14	1.39	59.65	38.40	1.96
Bare land	1287	0.70	0.12	0.13	0.27	1.70	39.01	60.68	0.31

Table S3. Same as Table S1 but as a function of land surface reflectance (LSR).

LSR	N	R	Bias	MAE	RMSE	RMB	= EE	> EE	< EE
0.00–0.01	611	0.92	0.06	0.06	0.08	1.59	59.90	39.77	0.33
0.01–0.02	3903	0.91	0.04	0.06	0.08	1.28	71.84	24.93	3.23
0.02–0.03	11,314	0.93	0.05	0.07	0.11	1.25	71.66	26.37	1.96
0.03–0.04	17,917	0.91	0.05	0.07	0.12	1.28	66.26	31.03	2.72
0.04–0.05	14,136	0.89	0.07	0.09	0.14	1.34	59.65	37.51	2.84
0.05–0.06	8096	0.90	0.06	0.09	0.15	1.27	57.93	37.09	4.98
0.06–0.07	4935	0.90	0.09	0.10	0.14	1.60	49.42	49.36	1.22
0.07–0.08	1432	0.85	0.09	0.10	0.15	1.89	41.76	56.70	1.54
0.08–0.09	681	0.56	0.08	0.12	0.28	1.48	48.46	44.79	6.75
0.09–0.10	585	0.39	0.13	0.13	0.24	2.43	41.03	58.80	0.17

Table S4. Same as Table S1 but as a function of surface relief (km).

Surface relief	N	R	Bias	MAE	RMSE	RMB	= EE	> EE	< EE
< 0.1	16,160	0.93	0.05	0.08	0.13	1.22	69.15	27.30	3.55
0.1–0.2	12,130	0.85	0.05	0.07	0.13	1.30	68.17	28.73	3.10
0.2–0.3	6806	0.91	0.05	0.07	0.12	1.34	68.63	28.83	2.54
0.3–0.4	3329	0.87	0.03	0.06	0.09	1.21	77.68	19.59	2.73
0.4–0.5	2077	0.88	0.08	0.09	0.13	1.42	55.75	41.79	2.46
0.5–0.6	2827	0.89	0.09	0.11	0.16	1.47	47.40	50.48	2.12
0.6–0.8	4136	0.94	0.04	0.05	0.09	1.26	73.91	24.18	1.91
0.8–1.0	4803	0.88	0.07	0.08	0.13	1.46	56.38	42.35	1.27
1.0–1.5	10,069	0.87	0.08	0.09	0.13	1.54	54.08	44.17	1.76
1.5–2.0	2795	0.72	0.07	0.10	0.15	1.44	52.59	42.65	4.76
2.0–3.0	1923	0.88	0.08	0.11	0.14	1.31	46.59	49.19	4.21
3.0–4.0	57	-0.07	0.07	0.07	0.08	9.76	42.11	57.89	0.00

Table S5. Same as Table S1 but as a function of AERONET AOD (550 nm) measurements.

AOD	N	R	Bias	MAE	RMSE	RMB	= EE	> EE	< EE
< 0.05	19,368	0.06	0.06	0.06	0.09	2.74	63.44	36.56	0.00
0.05–0.10	22,186	0.19	0.05	0.06	0.10	1.71	66.84	32.86	0.30
0.10–0.15	12,226	0.18	0.06	0.07	0.10	1.47	63.10	34.94	1.95
0.15–0.20	7776	0.17	0.06	0.08	0.11	1.36	61.03	35.48	3.49
0.20–0.25	4924	0.17	0.06	0.09	0.12	1.29	60.52	35.56	3.92
0.25–0.30	3334	0.14	0.07	0.10	0.13	1.24	59.12	35.66	5.22
0.30–0.35	2270	0.13	0.07	0.10	0.13	1.20	60.57	33.35	6.08
0.35–0.40	1690	0.08	0.06	0.10	0.14	1.16	61.89	30.59	7.51
0.40–0.45	1301	0.10	0.06	0.11	0.15	1.14	61.11	29.82	9.07
0.45–0.50	1048	0.09	0.07	0.12	0.16	1.14	60.88	31.77	7.35
0.50–0.55	819	0.11	0.06	0.13	0.17	1.11	60.07	29.79	10.13
0.55–0.60	642	0.12	0.08	0.13	0.18	1.13	62.15	31.15	6.70
0.60–0.65	524	0.02	0.07	0.15	0.20	1.11	59.35	30.73	9.92
0.65–0.70	419	0.11	0.05	0.15	0.20	1.07	56.80	28.88	14.32
0.70–0.75	350	0.02	0.08	0.17	0.29	1.11	59.43	29.71	10.86
0.75–0.80	304	0.03	0.07	0.17	0.23	1.09	64.14	25.33	10.53
0.80–0.85	253	0.12	0.05	0.18	0.23	1.06	58.50	24.51	17.00
0.85–0.90	227	0.10	0.07	0.19	0.25	1.08	59.47	27.31	13.22
0.90–0.95	198	-0.02	0.09	0.21	0.30	1.09	55.56	30.81	13.64
0.90–1.00	193	0.02	0.09	0.22	0.29	1.09	54.40	32.64	12.95
1.0–1.1	294	0.11	0.07	0.21	0.30	1.07	61.22	26.19	12.59
1.1–1.2	204	0.09	0.07	0.26	0.36	1.06	57.84	25.00	17.16
1.2–1.3	151	-0.07	0.05	0.24	0.32	1.04	60.26	23.84	15.89
1.3–1.4	127	0.18	0.13	0.33	0.47	1.10	51.18	33.07	15.75
1.4–1.6	144	0.17	0.11	0.27	0.38	1.07	65.97	24.31	9.72
1.6–1.8	89	0.21	0.20	0.45	0.62	1.12	51.69	32.58	15.73
> 1.8	134	0.54	0.16	0.49	0.69	1.07	55.22	27.61	17.16

Table S6. Same as Table S1 but as a function of AERONET Ångström exponent (AE, 440–675 nm) measurements.

AE	N	R	Bias	MAE	RMSE	RMB	= EE	> EE	< EE
< 0.4	2986	0.90	0.07	0.11	0.17	1.24	57.17	37.41	5.43
0.4–0.5	3058	0.86	0.06	0.09	0.13	1.30	59.48	35.48	5.04
0.5–0.6	1957	0.72	0.06	0.09	0.18	1.34	58.87	36.18	4.96
0.6–0.7	2134	0.83	0.05	0.08	0.13	1.35	60.54	35.43	4.03
0.7–0.8	2459	0.87	0.06	0.08	0.12	1.38	61.37	35.14	3.50
0.8–0.9	2912	0.90	0.06	0.08	0.12	1.35	59.99	36.98	3.02
0.9–1.0	3493	0.91	0.06	0.08	0.12	1.34	61.32	35.10	3.58
1.00–1.05	1995	0.90	0.06	0.08	0.13	1.36	62.56	34.49	2.96
1.05–1.10	2262	0.92	0.05	0.08	0.13	1.30	63.40	33.33	3.27
1.10–1.15	2485	0.91	0.06	0.08	0.15	1.30	62.70	34.33	2.98
1.15–1.20	2866	0.92	0.06	0.08	0.13	1.30	64.34	33.22	2.44
1.20–1.25	2967	0.91	0.06	0.08	0.13	1.27	65.39	32.02	2.60
1.25–1.30	3273	0.91	0.06	0.08	0.12	1.31	65.29	32.66	2.05
1.30–1.35	3501	0.91	0.06	0.08	0.12	1.31	65.72	32.22	2.06
1.35–1.40	3683	0.91	0.06	0.08	0.12	1.33	64.95	33.13	1.93
1.40–1.45	3636	0.92	0.05	0.07	0.12	1.31	68.12	29.98	1.90
1.45–1.50	3918	0.92	0.06	0.07	0.11	1.34	66.23	32.18	1.58
1.50–1.55	3894	0.92	0.06	0.08	0.13	1.34	66.54	31.61	1.85
1.55–1.60	3902	0.90	0.06	0.07	0.12	1.34	66.56	31.45	2.00
1.60–1.65	3870	0.91	0.06	0.07	0.12	1.33	65.94	31.94	2.12
1.65–1.70	3585	0.90	0.06	0.07	0.13	1.34	66.36	31.52	2.12
1.70–1.75	3303	0.90	0.06	0.08	0.12	1.35	65.36	32.64	2.00
1.75–1.80	2890	0.87	0.06	0.07	0.11	1.40	62.60	35.74	1.66
1.80–1.85	2339	0.87	0.06	0.07	0.11	1.44	61.74	36.55	1.71
1.85–1.90	1899	0.90	0.07	0.08	0.11	1.48	61.40	37.39	1.21
1.90–1.95	1486	0.91	0.07	0.07	0.11	1.57	57.87	41.72	0.40
1.95–2.0	1118	0.86	0.07	0.07	0.10	1.60	59.03	40.52	0.45
2.0–2.1	1362	0.79	0.06	0.07	0.10	1.73	58.59	40.97	0.44
2.1–2.2	735	0.66	0.06	0.07	0.10	1.91	56.05	43.13	0.82
2.3–2.3	401	0.65	0.06	0.07	0.10	2.18	59.85	39.65	0.50
2.3–2.5	381	0.46	0.06	0.06	0.09	2.67	59.06	40.68	0.26
2.5–2.8	229	0.46	0.07	0.07	0.11	3.52	48.47	51.53	0.00
> 2.8	217	0.26	0.07	0.07	0.09	5.22	44.24	55.76	0.00

Table S7. Same as Table S1 but as a function of AERONET single scattering albedo (SSA, 550 nm) measurements.

SSA	N	R	Bias	MAE	RMSE	RMB	= EE	> EE	< EE
0.00–0.80	1979	0.07	0.09	0.70	0.03	0.04	0.06	1.38	79.18
0.80–0.81	230	0.08	0.11	0.73	0.03	0.04	0.07	1.43	76.09
0.81–0.82	277	0.08	0.11	0.70	0.03	0.05	0.07	1.37	75.09
0.82–0.83	313	0.08	0.12	0.68	0.04	0.05	0.08	1.44	74.44
0.83–0.84	357	0.10	0.13	0.72	0.03	0.05	0.08	1.25	76.19
0.84–0.85	397	0.10	0.13	0.76	0.03	0.05	0.09	1.27	73.55
0.85–0.86	491	0.11	0.13	0.81	0.03	0.05	0.08	1.26	76.78
0.86–0.87	516	0.11	0.14	0.83	0.03	0.05	0.07	1.30	76.55
0.87–0.88	607	0.12	0.15	0.88	0.03	0.05	0.08	1.25	76.94
0.88–0.89	681	0.14	0.17	0.92	0.03	0.06	0.08	1.23	74.01
0.89–0.90	750	0.15	0.18	0.91	0.03	0.06	0.09	1.22	73.60
0.90–0.91	875	0.16	0.20	0.93	0.04	0.06	0.09	1.24	73.71
0.91–0.92	934	0.18	0.22	0.95	0.04	0.06	0.09	1.22	74.84
0.92–0.93	1078	0.18	0.23	0.95	0.05	0.07	0.10	1.28	71.80
0.93–0.94	1129	0.20	0.25	0.95	0.06	0.07	0.12	1.29	71.92
0.94–0.95	1242	0.15	0.21	0.94	0.06	0.07	0.11	1.38	73.35
0.95–0.96	1317	0.15	0.20	0.95	0.05	0.06	0.09	1.33	71.60
0.96–0.97	1302	0.15	0.21	0.91	0.06	0.07	0.14	1.40	69.12
0.97–0.98	1220	0.12	0.17	0.92	0.05	0.06	0.09	1.47	66.48
0.98–0.99	1771	0.09	0.15	0.89	0.06	0.06	0.09	1.60	66.06
0.99–1.00	2804	0.09	0.15	0.74	0.06	0.06	0.10	1.60	65.12