

Supplement

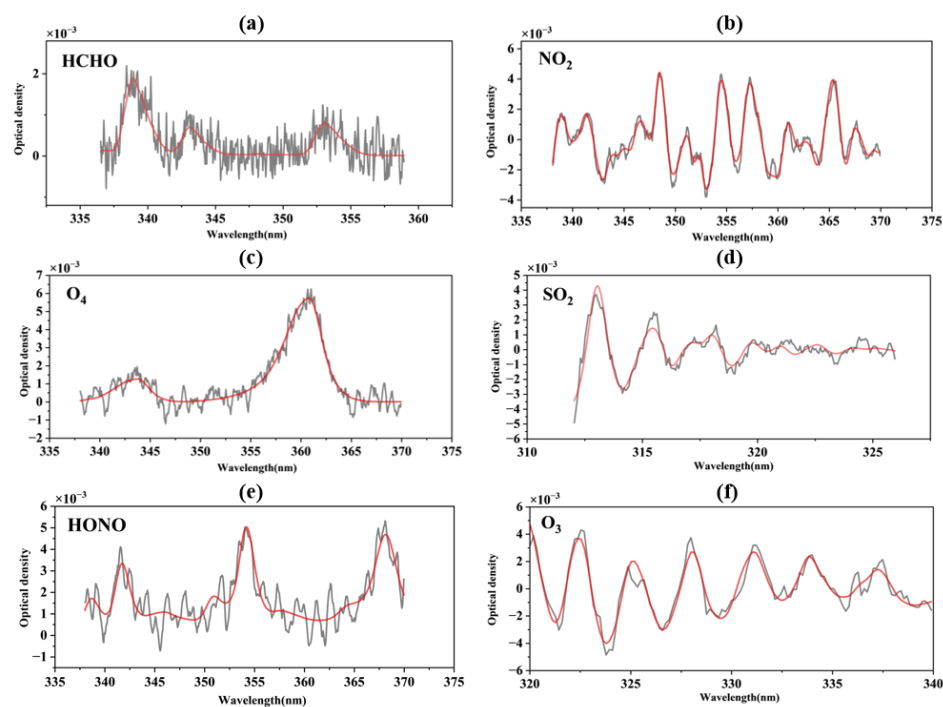


Figure S1. Examples of DOAS fits for (a) HCHO, (b) NO₂, (c) O₄, (d) SO₂, (e) HONO, and (f) O₃.

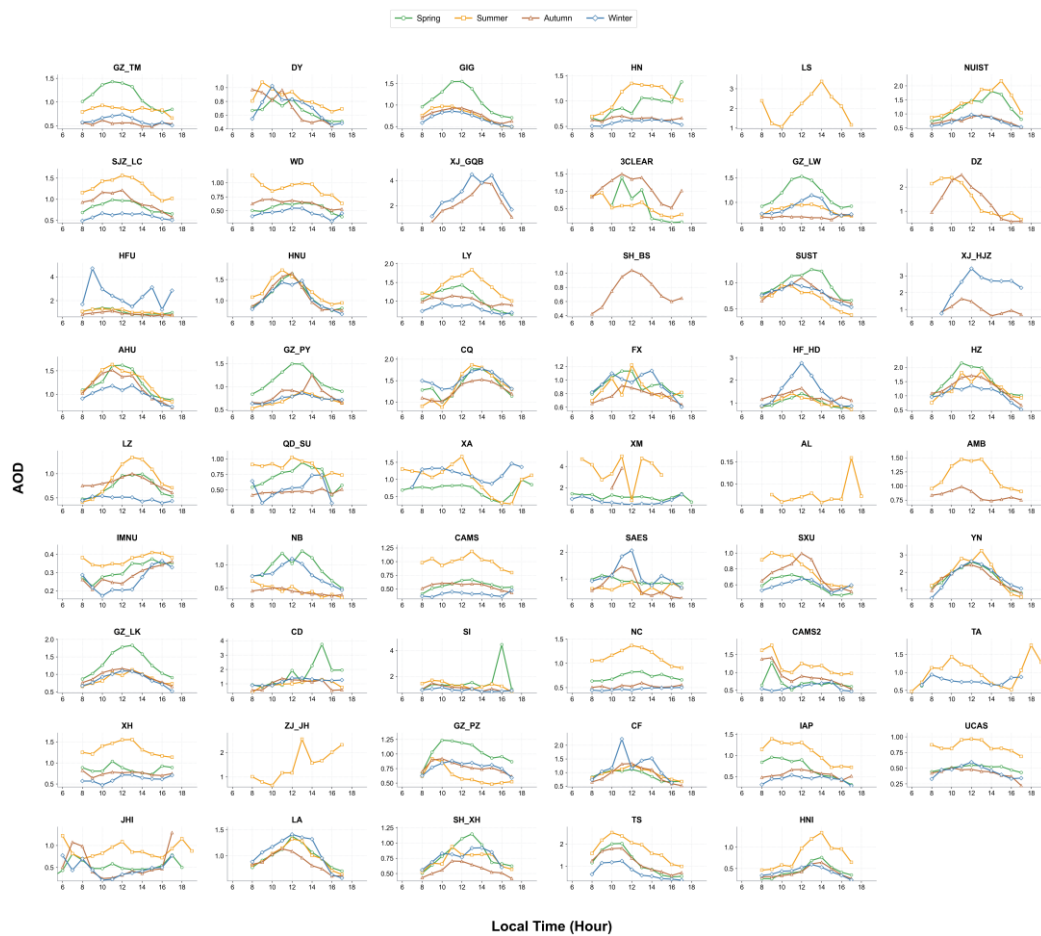


Figure S2. Seasonal diurnal variations of AOD at individual sites from 2020 to 2025.

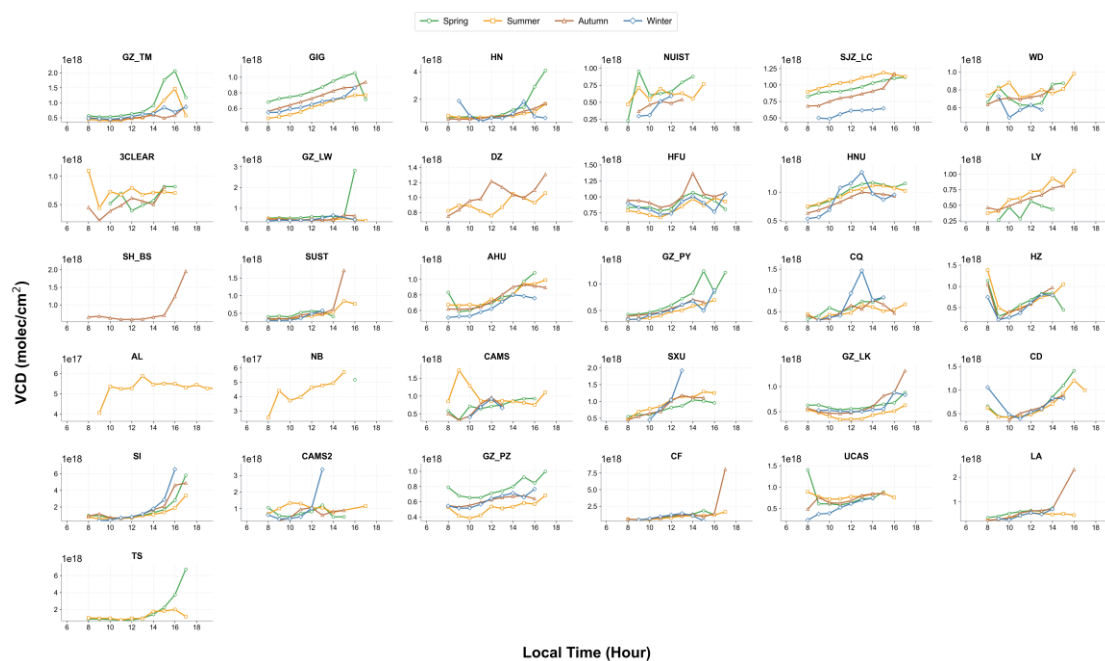


Figure S3. Seasonal diurnal variations of O_3 at individual sites from 2020 to 2025.

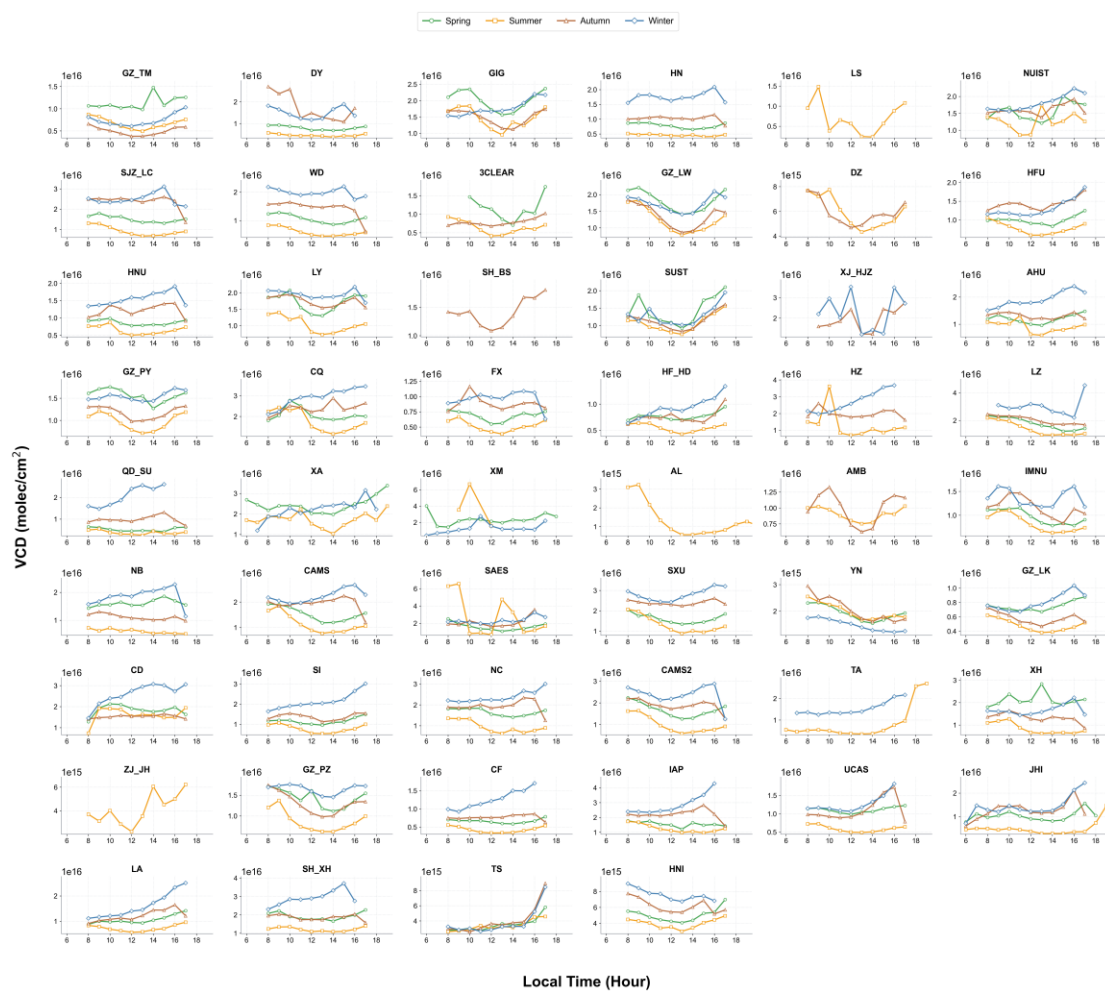


Figure S4. Seasonal diurnal variations of NO_2 at individual sites from 2020 to 2025.

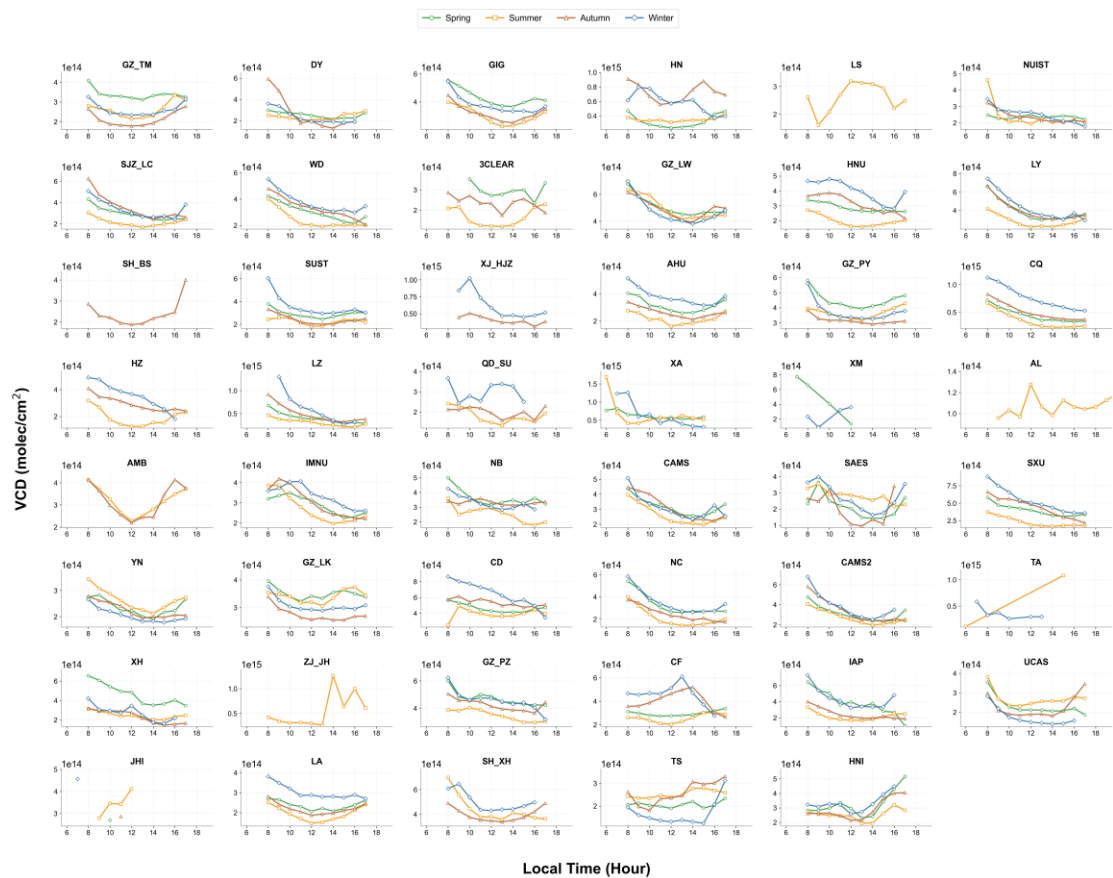


Figure S5. Seasonal diurnal variations of HONO at individual sites from 2020 to 2025.

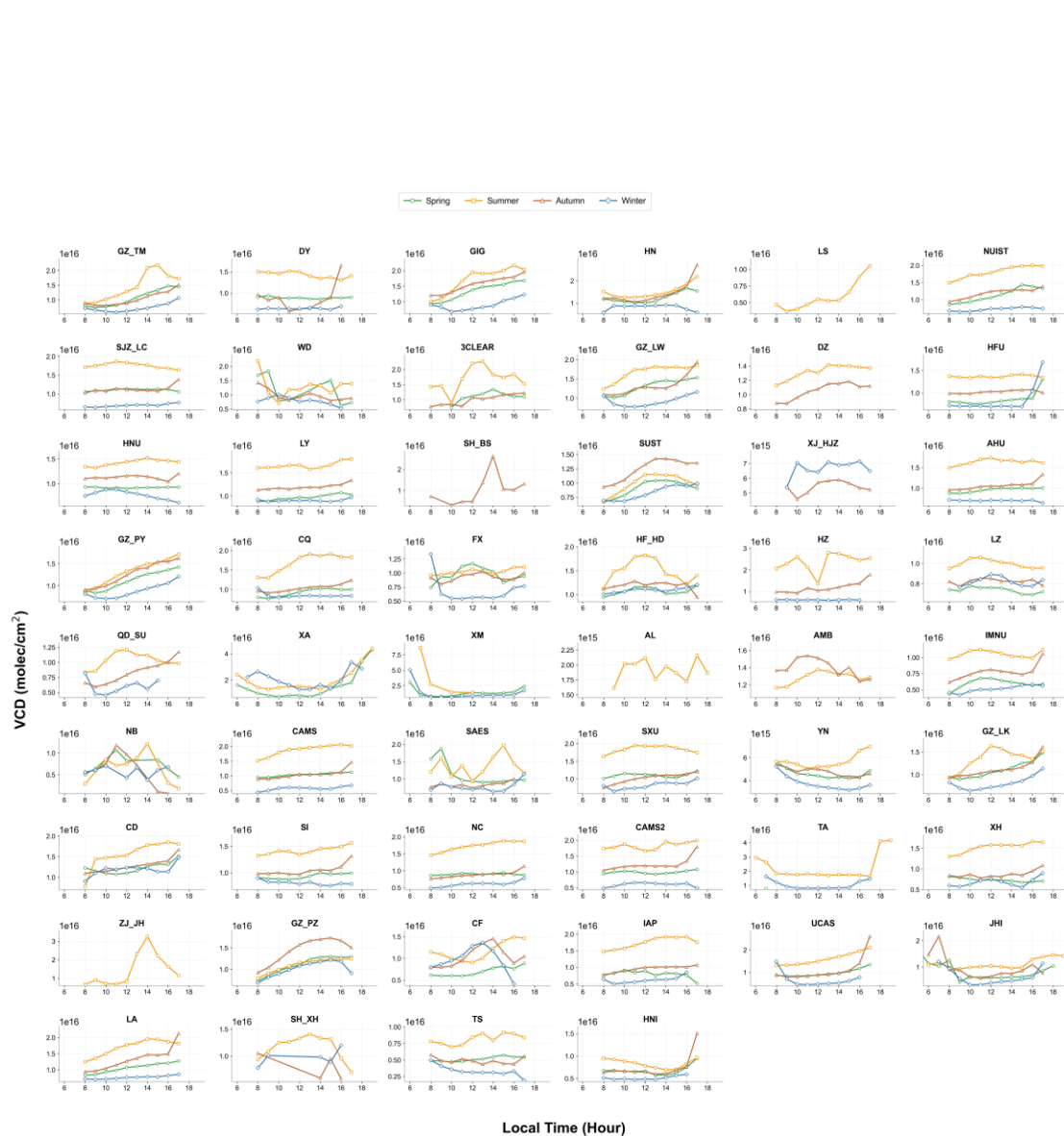


Figure S6. Seasonal diurnal variations of HCHO at individual sites from 2020 to 2025.

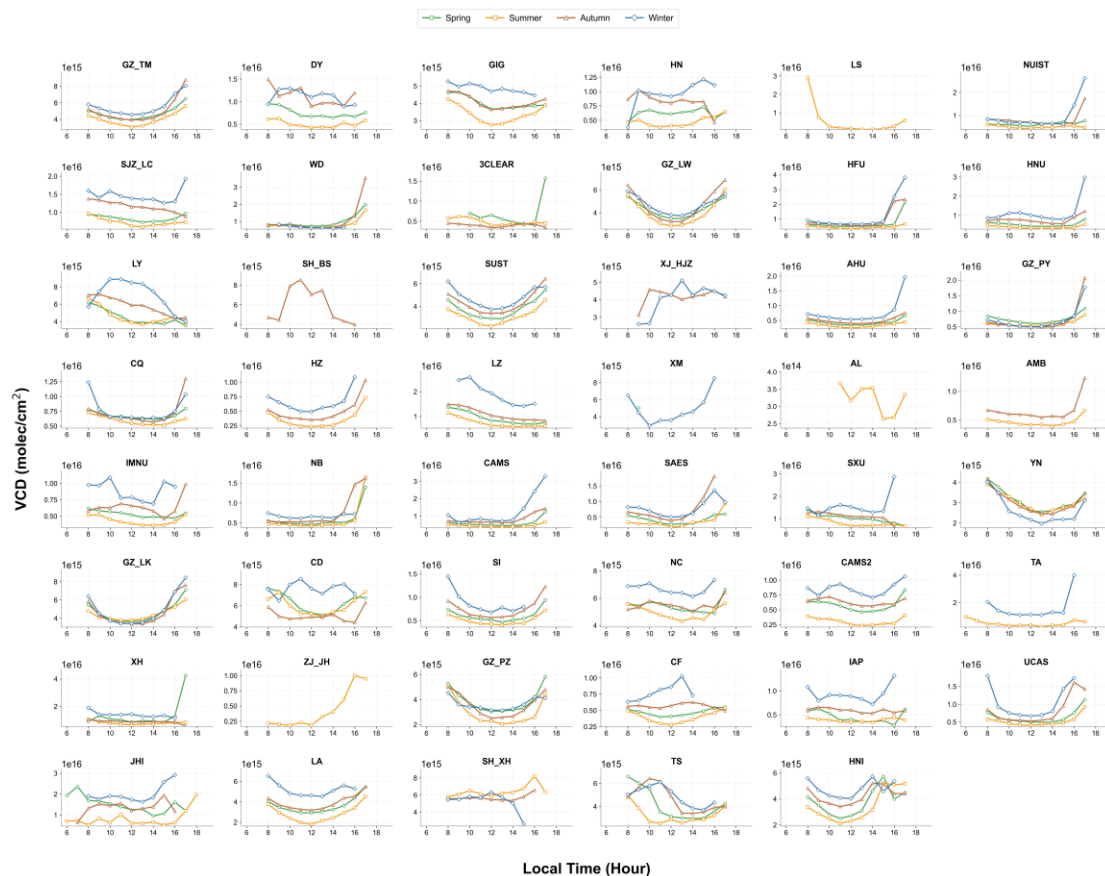


Figure S7. Seasonal diurnal variations of SO₂ at individual sites from 2020 to 2025.

Table S1. Detailed retrieval settings for NO₂, O₄, HONO, SO₂, O₃ and HCHO

Parameter	Cross sections	Fitting window (wavelength)					
		NO ₂	O ₄	HONO	SO ₂	O ₃	HCHO
		338~370 nm	338~370 nm	338~370 nm	312~326	320~340	336~358
NO ₂	220 K, I ₀ correction (SCD of 10 ¹⁷ molec. cm ⁻²); ⁴⁵	√	√	√	√	×	√
NO ₂	294 K, I ₀ correction (SCD of 10 ¹⁷ molec. cm ⁻²); ⁴⁵	√	√	√	√	√	√
O ₃	223 K, I ₀ correction (SCD of 10 ¹⁸ molec. cm ⁻²); ⁴⁶	√	√	√	√	√	√
O ₃	246 K, I ₀ correction (SCD of 10 ¹⁸ molec. cm ⁻²); ⁴⁶	×	×	√	√	×	√
O ₄	293 K, ⁴⁷	√	√	√	√	√	√
SO ₂	298 K, ¹⁸	×	×	×	√	√	×
HCHO	298 K, ²⁰	√	√	√	×	√	√
BrO	223 K, ⁴⁸	√	√	√	√	√	√
HCHO	293 K, ⁴⁹	√	√	√	√	√	√
HONO	296 K, ⁵⁰	×	×	√	√	×	√
H ₂ O	HITEMP, ⁵¹	×	×	√	√	√	√
Ring	calculated with QDOAS	√	√	√	√	√	√

Polynomial order	-	5	5	5	5	5	5
Intensity offset	-	Constant	Constant	Constant	Constant	Constant	Constant

Table S2. Selection of CNEMC sites

MAX-DOAS Site	Latitude	Longitude	CNEMC Site	Distance (km)
CAMS	39.9472	116.3206	1006A	2.53
NC	39.781	116.127	3672A	4.96
IAP	39.975	116.3761	1011A	1.92
SH_XH	31.1705	121.4333	1144A	2.1
SUST	22.6094	113.9964	3306A	3.26
AMB	31.8632	117.2469	1274A	0.74
SI	31.9077	117.1652	1273A	0.53
AHU	31.775	117.1808	1270A	1.8
HFU	31.7497	117.2142	1270A	4.27
HF_HD	31.8758	117.295	1271A	1.15
LZ	36.0419	103.8536	1479A	2.09
GIG	23.15	113.3586	2846A	4.22
SJZ_LC	37.9072	114.6097	3572A	2.94
HNU	33.983	116.806	2282A	1.03
XA	34.2542	108.9889	1463A	1.04
XA_GL	34.5289	109.0992	3605A	1.03
WH_SWJ	30.631	114.323	1329A	4.11
LY	34.673	112.4597	3022A	1.58
IMNU	40.801	111.6869	1091A	2.51
HZ	30.225	120.169	1223A	3.98
TA	36.2028	117.0608	1657A	2.49
DZ	37.4322	116.3717	3371A	0.91
3CLEAR	33.846	109.964	3045A	0.13
CD	30.66	104.04	1437A	0.57
GZ_PY	23.047	113.392	3302A	0.27
GZ_LK	23.54	113.58	3298A	1.32
GZ_TM	23.55	113.29	3443A	0.49
LS	29.65	91.18	1459A	0.52
GZ_LW	23.132	113.259	1352A	0.14
AL	32.5	80.12	2630A	0.37

Table S3. Selection of AERONET sites

MAX-DOAS Site	Latitude	Longitude	AERONET Site	Distance (km)
AMB	31.8632	117.2469	SONET_Hefei	9.23
CAMS	39.9472	116.3206	Beijing-CAMS	1.58
GZ_PY	23.047	113.392	Zhongshan_Univ	1.46
HZ	30.225	120.169	Hangzhou_City	7.28
IAP	39.975	116.3761	Beijing	0.50
LA	30.2972	119.7516	Hangzhou-ZFU	5.01

LZ	36.0419	103.8536	Lanzhou_City	0.68
NUIST	32.2075	118.7167	NUIST	0.12
SH_XH	31.1705	121.4333	Shanghi_Minhang	5.62
SI	31.9056	117.1708	Hefei	0.82
UCAS	40.408	116.675	Yanqihu	0.065
XH	39.761	116.976	XiangHe	1.49
