Atmospheric
Chemistry
and Physics

Supplement of

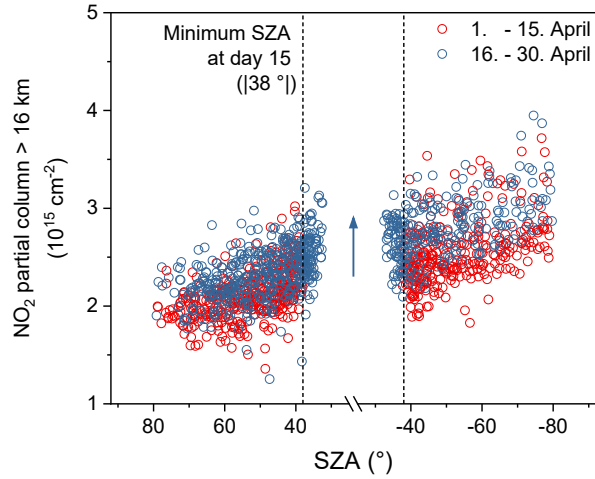# Solar FTIR measurements of NO$_x$ vertical distributions – Part 2: Experiment-based scaling factors describing the daytime variation in stratospheric NO$_x$

Pinchas Nürnberg et al.

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S1 boundary layer problem

Figure S1. Retrieved NO$_2$ partial column above 16 km altitude measured at Zugspitze for the first half of April (red symbols) and the second half of April (blue symbols) in dependence of SZA. Additionally, the minimum SZA at day 15 is marked by a dashed line.

5   S2 mean scaling factors

Table S1. Calculated normed NO$_2$ scaling factors $SF_{exp}(NO_2)$ above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\,\sigma/\sqrt{(n)}$) value for January, February, and March.

January			**February**			**March**		
SZA (°)	**$SF_{exp}(NO_2)$**	**$2\,\sigma/\sqrt{(n)}$**	**SZA (°)**	**$SF_{exp}(NO_2)$**	**$2\,\sigma/\sqrt{(n)}$**	**SZA (°)**	**$SF_{exp}(NO_2)$**	**$2\,\sigma/\sqrt{(n)}$**
79.8628	0.8609	0.10332	80.2933	0.85196	0.06523	80.0148	0.81042	0.15869
77.8628	0.8629	0.0497	78.2933	0.85694	0.06758	78.0148	0.87114	0.07196
75.8628	0.91803	0.04041	76.2933	0.86365	0.04967	76.0148	0.85799	0.08681
73.8628	0.92299	0.04593	74.2933	0.88583	0.03848	74.0148	0.85554	0.05147
71.8628	0.93731	0.03641	72.2933	0.91001	0.04077	72.0148	0.84576	0.0568
69.8628	1.00967	0.02779	70.2933	0.89456	0.03133	70.0148	0.89932	0.04136
67.8628	1.0127	0.0453	68.2933	0.9218	0.03694	68.0148	0.84878	0.0425
-68.9952	1.09874	0.03385	66.2933	0.91769	0.03454	66.0148	0.88568	0.03673
-70.9952	1.13089	0.03829	64.2933	0.9364	0.03152	64.0148	0.85467	0.03493
-72.9952	1.17689	0.05184	62.2933	0.98584	0.02744	62.0148	0.91176	0.03469
-74.9952	1.18733	0.05711	60.2933	0.96027	0.03316	60.0148	0.87012	0.02892
-76.9952	1.23675	0.07391	-60.9975	1.06005	0.03036	58.0148	0.90005	0.03227
-78.9952	1.29887	0.06092	-62.9975	1.07529	0.03139	56.0148	0.91143	0.02613
			-64.9975	1.09696	0.04151	54.0148	0.92831	0.02907
			-66.9975	1.15304	0.04205	52.0148	0.97825	0.026
			-68.9975	1.16225	0.0427	50.0148	0.99046	0.02767
			-70.9975	1.14234	0.04087	-50.9706	1.06745	0.03342
			-72.9975	1.21832	0.05073	-52.9706	1.04987	0.03114
			-74.9975	1.20237	0.04752	-54.9706	1.0661	0.03364

-76.9975	1.27948	0.0545	-56.9706	1.08214	0.03808
-78.9975	1.27693	0.06528	-58.9706	1.1172	0.04157
			-60.9706	1.10248	0.03756
			-62.9706	1.11829	0.04507
			-64.9706	1.12568	0.04182
			-66.9706	1.16326	0.06217
			-68.9706	1.15608	0.05881
			-70.9706	1.19419	0.04381
			-72.9706	1.17792	0.06886
			-74.9706	1.20611	0.05006
			-76.9706	1.2466	0.06007
			-78.9706	1.24241	0.05735

Table S2. Calculated normed NO_2 scaling factors $SF_{exp}(NO_2)$ above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\ \sigma/\sqrt{n}$) value for April, May, and June.

April			May			June		
SZA (°)	$SF_{exp}(NO_2)$	$2\ \sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO_2)$	$2\ \sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO_2)$	$2\ \sigma/\sqrt{n}$
77.5016	0.84277	0.05751	72.7344	0.87344	0.02653	70.9703	0.83315	0.01557
75.5016	0.83318	0.05393	70.7344	0.88085	0.03964	68.9703	0.87299	0.02605
73.5016	0.85401	0.05891	68.7344	0.86837	0.02092	66.9703	0.87725	0.04142
71.5016	0.81582	0.03671	66.7344	0.88184	0.04545	64.9703	0.84098	0.02755
69.5016	0.81049	0.02875	64.7344	0.86588	0.04005	62.9703	0.8486	0.0198
67.5016	0.84729	0.03835	62.7344	0.88458	0.02836	60.9703	0.86533	0.02312
65.5016	0.8653	0.03638	60.7344	0.88287	0.03599	58.9703	0.87051	0.02465
63.5016	0.85327	0.02847	58.7344	0.86687	0.02838	56.9703	0.88146	0.02033
61.5016	0.84977	0.02741	56.7344	0.91376	0.04102	54.9703	0.88082	0.02371
59.5016	0.85726	0.02243	54.7344	0.90022	0.03079	52.9703	0.89846	0.02394
57.5016	0.87645	0.02787	52.7344	0.90825	0.02175	50.9703	0.86853	0.02297
55.5016	0.88093	0.03667	50.7344	0.90799	0.02742	48.9703	0.8917	0.02918
53.5016	0.87031	0.03176	48.7344	0.91735	0.02802	46.9703	0.89337	0.03079
51.5016	0.92263	0.02917	46.7344	0.93795	0.02644	44.9703	0.9078	0.03271
49.5016	0.87537	0.0306	44.7344	0.9119	0.02803	42.9703	0.91627	0.03771
47.5016	0.9152	0.02984	42.7344	0.93014	0.02787	40.9703	0.92033	0.02848
45.5016	0.92673	0.02523	40.7344	0.93654	0.03069	38.9703	0.89731	0.03227
43.5016	0.93768	0.02253	38.7344	0.94295	0.02304	36.9703	0.94566	0.03456
41.5016	0.94563	0.02329	36.7344	0.95456	0.0359	34.9703	0.94996	0.02799
39.5016	1.00297	0.02525	34.7344	0.98178	0.03185	32.9703	0.9467	0.02657
37.5016	0.99489	0.03004	32.7344	0.9564	0.02902	30.9703	0.96044	0.02262
-38.6812	1.03922	0.03442	30.7344	0.97765	0.02345	28.9703	0.97577	0.02617
-40.6812	1.0039	0.03353	-30.3329	1.03519	0.03216	26.9703	0.96565	0.04504
-42.6812	1.03035	0.03988	-32.3329	1.02788	0.0298	24.9703	1.01303	0.01958
-44.6812	1.05199	0.04686	-34.3329	1.01254	0.04961	-24.9901	1.0252	0.01984
-46.6812	1.06996	0.04091	-36.3329	1.06711	0.03026	-26.9901	1.0624	0.03288
-48.6812	1.03256	0.03966	-38.3329	1.04212	0.04656	-28.9901	0.98452	0.06149
-50.6812	1.04936	0.04607	-40.3329	1.0725	0.03561	-30.9901	1.04985	0.02103
-52.6812	1.11061	0.05641	-42.3329	1.04911	0.06663	-32.9901	1.06122	0.03926
-54.6812	1.10615	0.05025	-44.3329	1.05143	0.06185	-34.9901	1.06019	0.04514
-56.6812	1.10494	0.08446	-46.3329	1.10587	0.053	-36.9901	1.07833	0.05566
-58.6812	1.11218	0.0477	-48.3329	1.10799	0.04264	-38.9901	1.07485	0.11201
-60.6812	1.09669	0.06202	-50.3329	1.10632	0.04288	-40.9901	1.06128	0.07097
-62.6812	1.15682	0.108	-52.3329	1.08353	0.08587	-42.9901	1.10667	0.05838
-64.6812	1.11912	0.0543	-54.3329	1.14408	0.0557	-44.9901	1.1617	0.11299
-66.6812	1.12382	0.05203	-56.3329	1.16044	0.07291	-46.9901	1.09641	0.06687
-68.6812	1.17333	0.06753	-58.3329	1.13513	0.10878	-48.9901	1.19961	0.16496
-70.6812	1.20216	0.09159	-60.3329	1.197	0.06557	-50.9901	1.08957	0.07246
-72.6812	1.14098	0.06277	-62.3329	1.20467	0.07221	-52.9901	1.17041	0.05769
-74.6812	1.22897	0.09065	-64.3329	1.18173	0.08591	-54.9901	1.14718	0.07128
-76.6812	1.23012	0.07329	-66.3329	1.15348	0.11758	-56.9901	1.15633	0.09404
-78.6812	1.21253	0.0785	-68.3329	1.20311	0.05054	-58.9901	1.07291	0.06883
			-70.3329	1.19317	0.02358	-60.9901	1.15485	0.03001
			-72.3329	1.23451	0.11272	-62.9901	1.1662	0.08239
			-74.3329	1.17633	0.03759	-64.9901	1.16966	0.06264
			-76.3329	1.32012	0.02207	-66.9901	1.1286	0.07203
			-78.3329	1.30478	0.05275	-70.9901	1.18662	0.05803
						-72.9901	1.20195	0.06309
						-74.9901	1.22341	0.05422
						-76.9901	1.25296	0.03381
						-78.9901	1.23631	0.10304

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Table S3. Calculated normed NO_2 scaling factors $SF_{exp}(NO_2)$ above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\,\sigma/\sqrt{n}$) value for July, August, and September.

	July			August			September	
SZA (°)	$SF_{exp}(NO_2)$	$2\,\sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO_2)$	$2\,\sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO_2)$	$2\,\sigma/\sqrt{n}$
75.353	0.82834	0.01848	74.4798	0.79234	0.08036	78.2258	0.82362	0.03968
73.353	0.85443	0.04885	72.4798	0.84377	0.05538	76.2258	0.82823	0.02471
71.353	0.841	0.01913	70.4798	0.78461	0.03093	74.2258	0.81019	0.02696
69.353	0.85032	0.0206	68.4798	0.80711	0.03653	72.2258	0.80877	0.02086
67.353	0.84617	0.03488	66.4798	0.80728	0.03341	70.2258	0.82596	0.02427
65.353	0.8629	0.02341	64.4798	0.82433	0.02322	68.2258	0.81925	0.01589
63.353	0.84505	0.01856	62.4798	0.83089	0.03011	66.2258	0.83956	0.01676
61.353	0.84434	0.01638	60.4798	0.83369	0.01821	64.2258	0.842	0.01407
59.353	0.86145	0.01983	58.4798	0.84791	0.02427	62.2258	0.86903	0.0156
57.353	0.87449	0.01494	56.4798	0.87257	0.02076	60.2258	0.87041	0.0135
55.353	0.87253	0.02514	54.4798	0.8948	0.01814	58.2258	0.88666	0.01902
53.353	0.88563	0.01699	52.4798	0.88688	0.01954	56.2258	0.90745	0.01885
51.353	0.88019	0.01975	50.4798	0.87899	0.02492	54.2258	0.90506	0.0202
49.353	0.88057	0.02729	48.4798	0.90206	0.01904	52.2258	0.92504	0.02025
47.353	0.91584	0.02059	46.4798	0.91157	0.02865	50.2258	0.94497	0.01545
45.353	0.91082	0.02634	44.4798	0.93999	0.02388	48.2258	0.97069	0.01772
43.353	0.91634	0.02591	42.4798	0.94949	0.0197	46.2258	0.99562	0.01799
41.353	0.94706	0.01898	40.4798	0.95686	0.02107	-46.9838	1.06824	0.02243
39.353	0.95194	0.02238	38.4798	0.96153	0.02239	-48.9838	1.05325	0.03313
37.353	0.91854	0.02896	36.4798	0.98701	0.01817	-50.9838	1.02683	0.02946
35.353	0.96988	0.02307	-35.6087	1.0365	0.03443	-52.9838	1.06325	0.03093
33.353	0.95902	0.01891	-37.6087	1.02947	0.0254	-54.9838	1.09088	0.041
31.353	0.96155	0.02388	-39.6087	1.03533	0.02689	-56.9838	1.10666	0.03061
29.353	0.99983	0.0198	-41.6087	0.99891	0.03708	-58.9838	1.11589	0.03662
27.353	1.01225	0.01923	-43.6087	1.02298	0.03332	-60.9838	1.12821	0.04465
-30.7082	1.04162	0.03189	-45.6087	1.06616	0.04438	-62.9838	1.11752	0.0599
-32.7082	1.01328	0.06614	-47.6087	1.1029	0.04702	-64.9838	1.15775	0.03787
-34.7082	1.11099	0.04638	-49.6087	1.09821	0.04022	-66.9838	1.14845	0.04542
-36.7082	1.04837	0.08175	-51.6087	1.06292	0.07514	-68.9838	1.13741	0.04343
-38.7082	1.05629	0.0357	-53.6087	1.10271	0.06252	-70.9838	1.15064	0.05126
-40.7082	1.07339	0.0368	-55.6087	1.07198	0.03101	-72.9838	1.20576	0.03371
-42.7082	1.0818	0.06106	-57.6087	1.02472	0.05598	-74.9838	1.17139	0.03386
-44.7082	1.09226	0.05594	-59.6087	1.14793	0.03245	-76.9838	1.20672	0.04768
-46.7082	1.09736	0.09328	-61.6087	1.05714	0.10877	-78.9838	1.2373	0.03983
-48.7082	1.0582	0.04651	-63.6087	1.13389	0.06445			
-50.7082	1.10717	0.03697	-65.6087	1.15648	0.04294			
-52.7082	1.13552	0.09197	-67.6087	1.11284	0.06006			
-54.7082	1.09354	0.05034	-69.6087	1.13797	0.02992			
-58.7082	1.12344	0.05795	-73.6087	1.16097	0.04372			
-60.7082	1.08571	0.04032	-75.6087	1.15808	0.02633			
-62.7082	1.1129	0.09786	-77.6087	1.18357	0.01469			
-64.7082	1.03585	0.19198						
-66.7082	1.07196	0.22352						
-68.7082	1.19209	0.05456						
-72.7082	1.17135	0.04875						
-74.7082	1.16443	0.05968						
-76.7082	1.22361	0.0238						
-78.7082	1.20802	0.0584						

Table S4. Calculated normed NO_2 scaling factors $SF_{exp}(NO_2)$ above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\ \sigma/\sqrt{n}$) value for October, November, and December.

October			November			December		
SZA (°)	$SF_{exp}(NO_2)$	$2\ \sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO_2)$	$2\ \sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO_2)$	$2\ \sigma/\sqrt{n}$
77.8311	0.85948	0.01789	80.8135	0.91187	0.01259	80.2144	0.95054	0.1185
75.8311	0.86549	0.0242	78.8135	0.90845	0.04073	78.2144	0.9099	0.0478
73.8311	0.8711	0.0206	76.8135	0.90704	0.0335	76.2144	0.9514	0.04449
71.8311	0.87421	0.01761	74.8135	0.91886	0.03083	74.2144	0.96605	0.03633
69.8311	0.88063	0.01642	72.8135	0.91657	0.02751	72.2144	1.0059	0.03048
67.8311	0.88486	0.02519	70.8135	0.93032	0.02379	-72.9706	1.13988	0.03437
65.8311	0.89335	0.0187	68.8135	0.96987	0.0184	-74.9706	1.16504	0.04175
63.8311	0.90878	0.01737	-68.9998	1.06791	0.02535	-76.9706	1.22972	0.04518
61.8311	0.91498	0.01689	-70.9998	1.13591	0.03244	-78.9706	1.24095	0.05079
59.8311	0.95187	0.01331	-72.9998	1.11506	0.03416			
57.8311	0.99892	0.01577	-74.9998	1.16664	0.04066			
-58.9918	1.06722	0.02231	-76.9998	1.19842	0.03961			
-60.9918	1.02973	0.02267	-78.9998	1.22292	0.04717			
-62.9918	1.06165	0.02896						
-64.9918	1.08991	0.03208						
-66.9918	1.09458	0.02878						
-68.9918	1.1168	0.03293						
-70.9918	1.14102	0.03087						
-72.9918	1.15353	0.03128						
-74.9918	1.18321	0.03506						
-76.9918	1.16943	0.03838						
-78.9918	1.21163	0.04026						

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Table S5. Calculated normed NO scaling factors $SF_{exp}(NO)$ above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\,\sigma/\sqrt{(n)}$) value for January, February, and March.

	January			February			March	
SZA (°)	$SF_{exp}(NO)$	$2\,\sigma/\sqrt{(n)}$	SZA (°)	$SF_{exp}(NO)$	$2\,\sigma/\sqrt{(n)}$	SZA (°)	$SF_{exp}(NO)$	$2\,\sigma/\sqrt{(n)}$
79.8474	0.90889	0.06344	78.291	0.88664	0.04743	80.1374	0.74267	0.0569
77.8474	0.84047	0.04912	76.291	0.83596	0.05724	78.1374	0.7749	0.04105
75.8474	0.87271	0.04026	74.291	0.84109	0.06897	76.1374	0.86701	0.07491
73.8474	0.89184	0.04741	72.291	0.86247	0.05742	74.1374	0.84219	0.07562
71.8474	0.9471	0.05446	70.291	0.89744	0.04598	72.1374	0.81723	0.05536
69.8474	0.9395	0.02945	68.291	0.89688	0.05596	70.1374	0.79139	0.05182
67.8474	0.98981	0.04104	66.291	0.93184	0.03419	68.1374	0.83046	0.04842
-68.8348	1.04624	0.04201	64.291	0.92284	0.03087	66.1374	0.84867	0.06
-70.8348	1.05042	0.04569	62.291	0.9611	0.04138	64.1374	0.88383	0.0471
-72.8348	1.04918	0.04091	60.291	0.97787	0.05025	62.1374	0.84654	0.04362
-74.8348	1.0246	0.04794	-60.707	1.01165	0.05898	60.1374	0.90523	0.04791
-76.8348	1.07348	0.05535	-62.707	1.03043	0.0324	58.1374	0.88073	0.04392
-78.8348	1.01799	0.08339	-64.707	0.97835	0.03839	56.1374	0.90456	0.04167
			-66.707	1.02286	0.04894	54.1374	0.91552	0.04797
			-68.707	1.0503	0.06696	52.1374	0.9096	0.04304
			-70.707	1.06745	0.03075	50.1374	0.99792	0.03793
			-72.707	1.03016	0.0447	-50.813	1.06577	0.04035
			-74.707	1.06825	0.06286	-52.813	1.00764	0.0552
			-76.707	1.03722	0.04854	-54.813	0.99326	0.03869
			-78.707	0.94843	0.05734	-56.813	1.05332	0.04217
						-58.813	0.98296	0.05469
						-60.813	1.05414	0.09749
						-62.813	1.07491	0.05621
						-64.813	1.04774	0.04223
						-66.813	0.99753	0.03494
						-68.813	0.95869	0.08701
						-70.813	1.04026	0.04362
						-72.813	0.9924	0.08024
						-74.813	1.01735	0.04637
						-76.813	0.99636	0.05216
						-78.813	1.05101	0.09898

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Table S6. Calculated normed NO scaling factors $SF_{exp}(NO)$ above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\ \sigma/\sqrt{n}$) value for April, May, and June.

	April			May			June	
SZA (°)	$SF_{exp}(NO)$	$2\ \sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO)$	$2\ \sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO)$	$2\ \sigma/\sqrt{n}$
76.5948	0.76425	0.01315	70.6782	0.81322	0.01846	71.0447	0.76415	0.02317
74.5948	0.77819	0.06419	68.6782	0.81266	0.0215	69.0447	0.929	0.12677
72.5948	0.77796	0.06635	66.6782	0.82495	0.03306	67.0447	0.80688	0.04407
70.5948	0.81399	0.04395	64.6782	0.8212	0.04712	65.0447	0.84458	0.03093
68.5948	0.78508	0.0514	62.6782	0.86996	0.02729	63.0447	0.82362	0.06167
66.5948	0.79006	0.0296	60.6782	0.80377	0.05518	61.0447	0.82289	0.02985
64.5948	0.877	0.07752	58.6782	0.86595	0.02878	59.0447	0.84471	0.03318
62.5948	0.83592	0.02882	56.6782	0.84655	0.03217	57.0447	0.85047	0.02934
60.5948	0.86046	0.04606	52.6782	0.91465	0.06288	55.0447	0.82103	0.05085
58.5948	0.87064	0.03911	50.6782	0.89507	0.04395	53.0447	0.85451	0.03447
56.5948	0.84651	0.03042	48.6782	0.90072	0.03363	51.0447	0.89606	0.03494
54.5948	0.91755	0.04993	46.6782	0.92534	0.02655	49.0447	0.86365	0.03096
52.5948	0.87481	0.04834	44.6782	0.93814	0.03808	47.0447	0.90126	0.03886
50.5948	0.85543	0.03059	42.6782	0.96432	0.04146	45.0447	0.91158	0.03967
48.5948	0.922	0.04741	40.6782	0.94664	0.0343	43.0447	0.90698	0.05612
46.5948	0.92676	0.03225	38.6782	0.92505	0.05553	41.0447	0.89896	0.07416
44.5948	0.95991	0.02687	36.6782	0.969	0.04779	39.0447	0.89556	0.03411
42.5948	0.93424	0.03139	34.6782	0.957	0.04711	37.0447	0.91928	0.03277
40.5948	0.97506	0.03725	32.6782	0.98015	0.04628	35.0447	0.98363	0.0565
38.5948	1.0053	0.05356	30.6782	1.05914	0.06183	33.0447	1.00038	0.03095
-38.9087	1.02398	0.03116	-31.2945	1.03566	0.0451	31.0447	0.93713	0.03044
-40.9087	0.99894	0.03316	-33.2945	1.00077	0.03015	29.0447	0.97134	0.03838
-42.9087	1.04262	0.04006	-35.2945	1.03811	0.06994	27.0447	0.95165	0.04093
-44.9087	0.99359	0.06463	-37.2945	1.03819	0.07894	25.0447	0.99507	0.03546
-46.9087	1.05051	0.06359	-39.2945	1.09061	0.1332	-27.4853	1.01564	0.04768
-48.9087	1.08962	0.07405	-41.2945	1.00553	0.05132	-29.4853	0.99636	0.03505
-50.9087	1.02405	0.03134	-43.2945	1.04228	0.10971	-31.4853	1.07208	0.04097
-52.9087	0.97401	0.01725	-47.2945	0.99753	0.00572	-33.4853	1.1184	0.08467
-54.9087	1.04272	0.0796	-49.2945	1.02116	0.08414	-35.4853	1.10719	0.05608
-56.9087	1.02399	0.083	-51.2945	1.06921	0.04524	-37.4853	1.04508	0.07809
-58.9087	0.97583	0.03804	-61.2945	0.9953	0.0335	-39.4853	1.03941	0.18063
-60.9087	1.00245	0.06177	-69.2945	1.03577	0.07377	-41.4853	1.0719	0.03556
-62.9087	1.14124	0.04193	-75.2945	1.01729	0.09394	-43.4853	0.93504	0.06519
-64.9087	1.02761	0.06845				-45.4853	1.02641	0.06679
-66.9087	1.01674	0.07783				-47.4853	1.12465	0.00746
-68.9087	1.05477	0.11387				-55.4853	0.90112	0.07688
-70.9087	1.02334	0.07862				-57.4853	1.07415	0.04216
-72.9087	1.00419	0.10636				-59.4853	1.08097	0.09822
-74.9087	0.93143	0.0291				-61.4853	1.06966	0.06805
-76.9087	0.99868	0.13261				-63.4853	0.99611	0.22651
-78.9087	0.96028	0.0474				-65.4853	1.02675	0.08894
						-67.4853	1.12051	0.02673
						-69.4853	0.94452	0.08637
						-71.4853	0.98328	0.08856
						-75.4853	0.94757	0.1709

25 **Table S7.** Calculated normed NO scaling factors $SF_{exp}(NO)$ above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\,\sigma/\sqrt{n}$) value for July, August, and September.

July			August			September		
SZA (°)	$SF_{exp}(NO)$	$2\,\sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO)$	$2\,\sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO)$	$2\,\sigma/\sqrt{n}$
73.3811	0.77755	0.13052	70.9262	0.85427	0.04812	76.1915	0.8543	0.04599
71.3811	0.89023	0.10821	68.9262	0.80621	0.02876	74.1915	0.85829	0.05644
69.3811	0.82987	0.04801	66.9262	0.86827	0.03821	72.1915	0.81986	0.02982
67.3811	0.85044	0.05308	64.9262	0.88533	0.06383	70.1915	0.83693	0.03461
65.3811	0.86154	0.04882	62.9262	0.86948	0.05345	68.1915	0.87635	0.03453
63.3811	0.83198	0.02911	60.9262	0.90935	0.0987	66.1915	0.85839	0.03445
61.3811	0.86842	0.06228	58.9262	0.89511	0.03995	64.1915	0.87615	0.06287
59.3811	0.87616	0.03724	56.9262	0.88549	0.0392	62.1915	0.8882	0.04712
57.3811	0.87194	0.04044	54.9262	0.93635	0.02625	60.1915	0.9252	0.03717
55.3811	0.89517	0.02366	52.9262	0.92343	0.04161	58.1915	0.92784	0.04286
53.3811	0.86891	0.03817	50.9262	0.88793	0.03995	56.1915	0.95481	0.04273
51.3811	0.89018	0.03075	48.9262	0.94205	0.05579	54.1915	0.97766	0.04445
49.3811	0.91466	0.03993	46.9262	0.98876	0.06372	52.1915	1.00999	0.03535
47.3811	0.92985	0.03823	44.9262	0.98281	0.06004	50.1915	0.98952	0.03221
45.3811	0.92553	0.02816	42.9262	0.96842	0.03122	48.1915	1.00359	0.04532
43.3811	0.99872	0.08229	40.9262	0.98853	0.03522	46.1915	1.038	0.04081
41.3811	0.92331	0.03681	38.9262	1.04147	0.04183	-46.7815	1.08067	0.0366
39.3811	0.96519	0.06915	36.9262	1.01329	0.03008	-48.7815	1.08284	0.03741
37.3811	1.00522	0.0619	34.9262	1.01199	0.04108	-50.7815	1.04286	0.03993
35.3811	0.9769	0.04918	-37.7221	1.0463	0.19587	-52.7815	1.11087	0.04677
33.3811	1.01398	0.0385	-39.7221	1.07482	0.10677	-54.7815	1.11016	0.0462
31.3811	1.01425	0.05731	-41.7221	1.12316	0.04162	-56.7815	1.09237	0.0543
29.3811	0.97257	0.02974	-43.7221	1.07971	0.05974	-58.7815	1.11109	0.06757
-28.8772	1.05384	0.06651	-45.7221	1.05909	0.06802	-60.7815	1.09956	0.0525
-30.8772	1.09591	0.07065	-47.7221	1.08238	0.05102	-62.7815	1.02523	0.03625
-32.8772	1.08897	0.06985	-49.7221	1.14618	0.07076	-64.7815	1.15814	0.06242
-36.8772	1.12212	0.06385	-51.7221	1.1541	0.09148	-66.7815	1.08641	0.05687
-38.8772	0.91148	0.06993	-55.7221	1.05207	0.06778	-68.7815	1.10012	0.09481
-40.8772	1.04319	0.06258	-57.7221	1.07315	0.09238	-70.7815	1.00562	0.06712
-42.8772	1.11777	0.06396	-59.7221	1.07104	0.13185	-72.7815	1.08733	0.04173
-44.8772	0.98087	0.02473	-61.7221	1.10632	0.09899	-74.7815	1.1044	0.06901
-48.8772	1.0313	0.07431	-63.7221	1.07298	0.00805	-76.7815	1.09542	0.08796
-50.8772	1.08766	0.13023	-67.7221	1.08779	0.10252	-78.7815	1.09179	0.07267
-56.8772	1.00872	0.17725	-69.7221	1.01884	0.00087			
-60.8772	0.96188	0.04519						
-62.8772	0.98426	0.06983						
-64.8772	1.00466	0.00744						
-66.8772	1.04738	0.09398						
-68.8772	0.98948	0.14009						
-72.8772	1.05546	0.12036						

Table S8. Calculated normed NO scaling factors $SF_{exp}(NO)$ above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\,\sigma/\sqrt{n}$) value for October, November, and December.

	October			November			December	
SZA (°)	$SF_{exp}(NO)$	$2\,\sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO)$	$2\,\sigma/\sqrt{n}$	SZA (°)	$SF_{exp}(NO)$	$2\,\sigma/\sqrt{n}$
80.0769	0.8787	0.06814	79.398	0.87437	0.05067	80.3428	0.96444	0.07141
78.0769	0.83234	0.03178	77.398	0.9116	0.04617	78.3428	0.95694	0.05632
76.0769	0.8872	0.02758	75.398	0.93192	0.03904	76.3428	0.94008	0.06549
74.0769	0.87976	0.04125	73.398	0.89215	0.0359	74.3428	0.96567	0.03396
72.0769	0.88301	0.05262	71.398	0.95909	0.04464	72.3428	0.97282	0.04396
70.0769	0.8882	0.04173	69.398	0.95888	0.03096	-72.9104	1.10974	0.04859
68.0769	0.90667	0.04524	-68.9276	1.04963	0.03372	-74.9104	1.08188	0.04459
66.0769	0.95886	0.03792	-70.9276	1.06593	0.03884	-76.9104	1.13186	0.10294
64.0769	0.96427	0.03138	-72.9276	1.08005	0.03428	-78.9104	1.08526	0.06882
62.0769	0.96116	0.02947	-74.9276	1.08601	0.04365			
60.0769	1.00615	0.04027	-76.9276	1.05912	0.06136			
58.0769	1.0202	0.04691	-78.9276	1.05216	0.05427			
-58.7488	1.1135	0.03532						
-60.7488	1.07427	0.03409						
-62.7488	1.02723	0.03038						
-64.7488	1.09113	0.03743						
-66.7488	1.07506	0.06742						
-68.7488	1.06264	0.03464						
-70.7488	1.10263	0.03691						
-72.7488	1.05618	0.03819						
-74.7488	1.06954	0.03705						
-76.7488	1.05673	0.03798						
-78.7488	1.08839	0.0577						

S3 binned and filtered partial columns > 16 km

Table S9. NO_2 partial column above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\,\sigma/\sqrt{n}$) value for January, February, and March.

	January			February			March	
SZA (°)	NO_2 partial column	$2\,\sigma/\sqrt{n}$	SZA (°)	NO_2 partial column	$2\,\sigma/\sqrt{n}$	SZA (°)	NO_2 partial column	$2\,\sigma/\sqrt{n}$
79.8628	1.11E+15	1.34E+14	80.2933	1.32E+15	1.01E+14	80.0148	1.63E+15	3.20E+14
77.8628	1.12E+15	6.42E+13	78.2933	1.33E+15	1.05E+14	78.0148	1.76E+15	1.45E+14
75.8628	1.19E+15	5.22E+13	76.2933	1.34E+15	7.72E+13	76.0148	1.73E+15	1.75E+14
73.8628	1.19E+15	5.94E+13	74.2933	1.38E+15	5.98E+13	74.0148	1.72E+15	1.04E+14
71.8628	1.21E+15	4.71E+13	72.2933	1.42E+15	6.34E+13	72.0148	1.71E+15	1.15E+14
69.8628	1.30E+15	3.59E+13	70.2933	1.39E+15	4.87E+13	70.0148	1.81E+15	8.34E+13
-68.9952	1.42E+15	4.37E+13	68.2933	1.43E+15	5.74E+13	68.0148	1.71E+15	8.57E+13
-70.9952	1.46E+15	4.95E+13	66.2933	1.43E+15	5.37E+13	66.0148	1.79E+15	7.40E+13
-72.9952	1.52E+15	6.70E+13	64.2933	1.46E+15	4.90E+13	64.0148	1.72E+15	7.04E+13
-74.9952	1.53E+15	7.38E+13	62.2933	1.53E+15	4.27E+13	62.0148	1.84E+15	6.99E+13
-76.9952	1.60E+15	9.55E+13	60.2933	1.49E+15	5.16E+13	60.0148	1.75E+15	5.83E+13
-78.9952	1.68E+15	7.87E+13	-60.9975	1.65E+15	4.72E+13	58.0148	1.81E+15	6.51E+13
			-62.9975	1.67E+15	4.88E+13	56.0148	1.84E+15	5.27E+13
			-64.9975	1.71E+15	6.46E+13	54.0148	1.87E+15	5.86E+13
			-66.9975	1.79E+15	6.54E+13	52.0148	1.97E+15	5.24E+13

-68.9975	1.81E+15	6.64E+13	50.0148	2.00E+15	5.58E+13
-70.9975	1.78E+15	6.36E+13	-50.9706	2.15E+15	6.74E+13
-72.9975	1.89E+15	7.89E+13	-52.9706	2.12E+15	6.28E+13
-74.9975	1.87E+15	7.39E+13	-54.9706	2.15E+15	6.78E+13
-76.9975	1.99E+15	8.48E+13	-56.9706	2.18E+15	7.68E+13
-78.9975	1.99E+15	1.02E+14	-58.9706	2.25E+15	8.38E+13
			-60.9706	2.22E+15	7.57E+13
			-62.9706	2.25E+15	9.09E+13
			-64.9706	2.27E+15	8.43E+13
			-66.9706	2.35E+15	1.25E+14
			-68.9706	2.33E+15	1.19E+14
			-70.9706	2.41E+15	8.83E+13
			-72.9706	2.37E+15	1.39E+14
			-74.9706	2.43E+15	1.01E+14
			-76.9706	2.51E+15	1.21E+14
			-78.9706	2.50E+15	1.16E+14

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Table S10. NO$_2$ partial column above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\,\sigma/\sqrt{(n)}$) value for April, May, and June.

SZA (°)	April NO$_2$ partial column	$2\,\sigma/\sqrt{(n)}$	SZA (°)	May NO$_2$ partial column	$2\,\sigma/\sqrt{(n)}$	SZA (°)	June NO$_2$ partial column	$2\,\sigma/\sqrt{(n)}$
77.5016	2.06E+15	1.41E+14	72.7344	2.52E+15	7.67E+13	70.9703	2.67E+15	4.98E+13
75.5016	2.04E+15	1.32E+14	70.7344	2.55E+15	1.15E+14	68.9703	2.79E+15	8.33E+13
73.5016	2.09E+15	1.44E+14	68.7344	2.51E+15	6.05E+13	66.9703	2.81E+15	1.32E+14
71.5016	2.00E+15	8.98E+13	66.7344	2.55E+15	1.31E+14	64.9703	2.69E+15	8.81E+13
69.5016	1.98E+15	7.03E+13	64.7344	2.50E+15	1.16E+14	62.9703	2.71E+15	6.34E+13
67.5016	2.07E+15	9.38E+13	62.7344	2.56E+15	8.20E+13	60.9703	2.77E+15	7.40E+13
65.5016	2.12E+15	8.90E+13	60.7344	2.55E+15	1.04E+14	58.9703	2.78E+15	7.89E+13
63.5016	2.09E+15	6.97E+13	58.7344	2.51E+15	8.20E+13	56.9703	2.82E+15	6.50E+13
61.5016	2.08E+15	6.70E+13	56.7344	2.64E+15	1.19E+14	54.9703	2.82E+15	7.59E+13
59.5016	2.10E+15	5.49E+13	54.7344	2.60E+15	8.90E+13	52.9703	2.87E+15	7.66E+13
57.5016	2.14E+15	6.82E+13	52.7344	2.63E+15	6.29E+13	50.9703	2.78E+15	7.35E+13
55.5016	2.16E+15	8.97E+13	50.7344	2.62E+15	7.93E+13	48.9703	2.85E+15	9.33E+13
53.5016	2.13E+15	7.77E+13	48.7344	2.65E+15	8.10E+13	46.9703	2.86E+15	9.85E+13
51.5016	2.26E+15	7.14E+13	46.7344	2.71E+15	7.64E+13	44.9703	2.90E+15	1.05E+14
49.5016	2.14E+15	7.49E+13	44.7344	2.64E+15	8.10E+13	42.9703	2.93E+15	1.21E+14
47.5016	2.24E+15	7.30E+13	42.7344	2.69E+15	8.06E+13	40.9703	2.94E+15	9.11E+13
45.5016	2.27E+15	6.17E+13	40.7344	2.71E+15	8.87E+13	38.9703	2.87E+15	1.03E+14
43.5016	2.29E+15	5.51E+13	38.7344	2.73E+15	6.66E+13	36.9703	3.03E+15	1.11E+14
41.5016	2.31E+15	5.70E+13	36.7344	2.76E+15	1.04E+14	34.9703	3.04E+15	8.95E+13
39.5016	2.45E+15	6.18E+13	34.7344	2.84E+15	9.21E+13	32.9703	3.03E+15	8.50E+13
-38.6812	2.54E+15	8.42E+13	32.7344	2.76E+15	8.39E+13	30.9703	3.07E+15	7.24E+13
-40.6812	2.46E+15	8.20E+13	30.7344	2.83E+15	6.78E+13	28.9703	3.12E+15	8.37E+13
-42.6812	2.52E+15	9.76E+13	-30.3329	2.99E+15	9.30E+13	26.9703	3.09E+15	1.44E+14
-44.6812	2.57E+15	1.15E+14	-32.3329	2.97E+15	8.62E+13	24.9703	3.24E+15	6.26E+13
-46.6812	2.62E+15	1.00E+14	-34.3329	2.93E+15	1.43E+14	-24.9901	3.28E+15	6.35E+13
-48.6812	2.53E+15	9.70E+13	-36.3329	3.08E+15	8.75E+13	-26.9901	3.40E+15	1.05E+14
-50.6812	2.57E+15	1.13E+14	-38.3329	3.01E+15	1.35E+14	-28.9901	3.15E+15	1.97E+14
-52.6812	2.72E+15	1.38E+14	-40.3329	3.10E+15	1.03E+14	-30.9901	3.36E+15	6.73E+13
-54.6812	2.71E+15	1.23E+14	-42.3329	3.03E+15	1.93E+14	-32.9901	3.40E+15	1.26E+14
-56.6812	2.70E+15	2.07E+14	-44.3329	3.04E+15	1.79E+14	-34.9901	3.39E+15	1.44E+14
-58.6812	2.72E+15	1.17E+14	-46.3329	3.20E+15	1.53E+14	-36.9901	3.45E+15	1.78E+14
-60.6812	2.68E+15	1.52E+14	-48.3329	3.20E+15	1.23E+14	-38.9901	3.44E+15	3.58E+14

SZA (°)	NO₂	2σ/√n	SZA (°)	NO₂	2σ/√n	SZA (°)	NO₂	2σ/√n
-62.6812	2.83E+15	2.64E+14	-50.3329	3.20E+15	1.24E+14	-40.9901	3.40E+15	2.27E+14
-64.6812	2.74E+15	1.33E+14	-52.3329	3.13E+15	2.48E+14	-42.9901	3.54E+15	1.87E+14
-66.6812	2.75E+15	1.27E+14	-54.3329	3.31E+15	1.61E+14	-44.9901	3.72E+15	3.61E+14
-68.6812	2.87E+15	1.65E+14	-56.3329	3.35E+15	2.11E+14	-46.9901	3.51E+15	2.14E+14
-70.6812	2.94E+15	2.24E+14	-58.3329	3.28E+15	3.14E+14	-48.9901	3.84E+15	5.28E+14
-72.6812	2.79E+15	1.54E+14	-60.3329	3.46E+15	1.90E+14	-50.9901	3.49E+15	2.32E+14
-74.6812	3.01E+15	2.22E+14	-62.3329	3.48E+15	2.09E+14	-52.9901	3.74E+15	1.85E+14
-76.6812	3.01E+15	1.79E+14	-64.3329	3.42E+15	2.48E+14	-54.9901	3.67E+15	2.28E+14
-78.6812	2.97E+15	1.92E+14	-66.3329	3.33E+15	3.40E+14	-56.9901	3.70E+15	3.01E+14
			-68.3329	3.48E+15	1.46E+14	-58.9901	3.43E+15	2.20E+14
			-70.3329	3.45E+15	6.82E+13	-60.9901	3.69E+15	9.60E+13
			-72.3329	3.57E+15	3.26E+14	-62.9901	3.73E+15	2.64E+14
			-74.3329	3.40E+15	1.09E+14	-64.9901	3.74E+15	2.00E+14
			-76.3329	3.82E+15	6.38E+13	-66.9901	3.61E+15	2.30E+14
			-78.3329	3.77E+15	1.52E+14	-70.9901	3.80E+15	1.86E+14
						-72.9901	3.85E+15	2.02E+14
						-74.9901	3.91E+15	1.73E+14
						-76.9901	4.01E+15	1.08E+14
						-78.9901	3.96E+15	3.30E+14

Table S11. NO₂ partial column above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\,\sigma/\sqrt{n}$) value for July, August, and September.

	July			August			September	
SZA (°)	NO₂ partial column	$2\,\sigma/\sqrt{n}$	SZA (°)	NO₂ partial column	$2\,\sigma/\sqrt{n}$	SZA (°)	NO₂ partial column	$2\,\sigma/\sqrt{n}$
75.353	2.64E+15	5.90E+13	74.4798	2.42E+15	2.45E+14	78.2258	2.22E+15	1.07E+14
73.353	2.73E+15	1.56E+14	72.4798	2.58E+15	1.69E+14	76.2258	2.24E+15	6.67E+13
71.353	2.68E+15	6.10E+13	70.4798	2.40E+15	9.45E+13	74.2258	2.19E+15	7.28E+13
69.353	2.71E+15	6.57E+13	68.4798	2.47E+15	1.12E+14	72.2258	2.18E+15	5.63E+13
67.353	2.70E+15	1.11E+14	66.4798	2.47E+15	1.02E+14	70.2258	2.23E+15	6.55E+13
65.353	2.75E+15	7.47E+13	64.4798	2.52E+15	7.09E+13	68.2258	2.21E+15	4.29E+13
63.353	2.70E+15	5.92E+13	62.4798	2.54E+15	9.20E+13	66.2258	2.27E+15	4.52E+13
61.353	2.69E+15	5.23E+13	60.4798	2.55E+15	5.56E+13	64.2258	2.27E+15	3.80E+13
59.353	2.75E+15	6.32E+13	58.4798	2.59E+15	7.41E+13	62.2258	2.35E+15	4.21E+13
57.353	2.79E+15	4.77E+13	56.4798	2.67E+15	6.34E+13	60.2258	2.35E+15	3.64E+13
55.353	2.78E+15	8.02E+13	54.4798	2.73E+15	5.54E+13	58.2258	2.39E+15	5.13E+13
53.353	2.83E+15	5.42E+13	52.4798	2.71E+15	5.97E+13	56.2258	2.45E+15	5.09E+13
51.353	2.81E+15	6.30E+13	50.4798	2.68E+15	7.61E+13	54.2258	2.44E+15	5.45E+13
49.353	2.81E+15	8.71E+13	48.4798	2.76E+15	5.81E+13	52.2258	2.50E+15	5.46E+13
47.353	2.92E+15	6.57E+13	46.4798	2.78E+15	8.75E+13	50.2258	2.55E+15	4.17E+13
45.353	2.91E+15	8.40E+13	44.4798	2.87E+15	7.30E+13	48.2258	2.62E+15	4.78E+13
43.353	2.92E+15	8.27E+13	42.4798	2.90E+15	6.02E+13	46.2258	2.69E+15	4.86E+13
41.353	3.02E+15	6.06E+13	40.4798	2.92E+15	6.44E+13	-46.9838	2.88E+15	6.05E+13
39.353	3.04E+15	7.14E+13	38.4798	2.94E+15	6.84E+13	-48.9838	2.84E+15	8.94E+13
37.353	2.93E+15	9.24E+13	36.4798	3.01E+15	5.55E+13	-50.9838	2.77E+15	7.95E+13
35.353	3.09E+15	7.36E+13	-31.6087	3.34E+15	1.71E+14	-52.9838	2.87E+15	8.35E+13
33.353	3.06E+15	6.03E+13	-33.6087	3.19E+15	1.24E+14	-54.9838	2.94E+15	1.11E+14
31.353	3.07E+15	7.62E+13	-35.6087	3.17E+15	1.05E+14	-56.9838	2.99E+15	8.26E+13
29.353	3.19E+15	6.32E+13	-37.6087	3.14E+15	7.76E+13	-58.9838	3.01E+15	9.89E+13
27.353	3.23E+15	6.13E+13	-39.6087	3.16E+15	8.21E+13	-60.9838	3.05E+15	1.21E+14
-24.7082	3.34E+15	1.00E+14	-41.6087	3.05E+15	1.13E+14	-62.9838	3.02E+15	1.62E+14
-26.7082	3.21E+15	7.82E+13	-43.6087	3.12E+15	1.02E+14	-64.9838	3.13E+15	1.02E+14
-28.7082	3.33E+15	1.01E+14	-45.6087	3.26E+15	1.36E+14	-66.9838	3.10E+15	1.23E+14
-30.7082	3.32E+15	1.02E+14	-47.6087	3.37E+15	1.44E+14	-68.9838	3.07E+15	1.17E+14

-32.7082	3.23E+15	2.11E+14	-49.6087	3.35E+15	1.23E+14	-70.9838	3.11E+15	1.38E+14
-34.7082	3.54E+15	1.48E+14	-51.6087	3.25E+15	2.29E+14	-72.9838	3.25E+15	9.10E+13
-36.7082	3.34E+15	2.61E+14	-53.6087	3.37E+15	1.91E+14	-74.9838	3.16E+15	9.14E+13
-38.7082	3.37E+15	1.14E+14	-55.6087	3.27E+15	9.47E+13	-76.9838	3.26E+15	1.29E+14
-40.7082	3.42E+15	1.17E+14	-57.6087	3.13E+15	1.71E+14	-78.9838	3.34E+15	1.08E+14
-42.7082	3.45E+15	1.95E+14	-59.6087	3.51E+15	9.91E+13			
-44.7082	3.48E+15	1.78E+14	-61.6087	3.23E+15	3.32E+14			
-46.7082	3.50E+15	2.98E+14	-63.6087	3.46E+15	1.97E+14			
-48.7082	3.38E+15	1.48E+14	-65.6087	3.53E+15	1.31E+14			
-50.7082	3.53E+15	1.18E+14	-67.6087	3.40E+15	1.83E+14			
-52.7082	3.62E+15	2.93E+14	-69.6087	3.48E+15	9.14E+13			
-54.7082	3.49E+15	1.61E+14	-73.6087	3.55E+15	1.34E+14			
-58.7082	3.58E+15	1.85E+14	-75.6087	3.54E+15	8.04E+13			
-60.7082	3.46E+15	1.29E+14	-77.6087	3.62E+15	4.49E+13			
-62.7082	3.55E+15	3.12E+14						
-64.7082	3.30E+15	6.12E+14						
-66.7082	3.42E+15	7.13E+14						
-68.7082	3.80E+15	1.74E+14						
-72.7082	3.74E+15	1.56E+14						
-74.7082	3.71E+15	1.90E+14						
-76.7082	3.90E+15	7.59E+13						
-78.7082	3.85E+15	1.86E+14						

Table S12. NO_2 partial column above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\,\sigma/\sqrt{(n)}$) value for October, November, and December.

	October			November			December	
SZA (°)	NO₂ partial column	$2\,\sigma/\sqrt{(n)}$	SZA (°)	NO₂ partial column	$2\,\sigma/\sqrt{(n)}$	SZA (°)	NO₂ partial column	$2\,\sigma/\sqrt{(n)}$
77.8311	1.87E+15	3.89E+13	80.8135	1.42E+15	1.96E+13	80.2144	1.16E+15	1.45E+14
75.8311	1.88E+15	5.26E+13	78.8135	1.42E+15	6.35E+13	78.2144	1.11E+15	5.83E+13
73.8311	1.89E+15	4.48E+13	76.8135	1.41E+15	5.22E+13	76.2144	1.16E+15	5.43E+13
71.8311	1.90E+15	3.83E+13	74.8135	1.43E+15	4.81E+13	74.2144	1.18E+15	4.43E+13
69.8311	1.91E+15	3.57E+13	72.8135	1.43E+15	4.29E+13	72.2144	1.23E+15	3.72E+13
67.8311	1.92E+15	5.48E+13	70.8135	1.45E+15	3.71E+13	-72.9706	1.39E+15	4.19E+13
65.8311	1.94E+15	4.07E+13	68.8135	1.51E+15	2.87E+13	-74.9706	1.42E+15	5.09E+13
63.8311	1.98E+15	3.78E+13	-68.9998	1.67E+15	3.95E+13	-76.9706	1.50E+15	5.51E+13
61.8311	1.99E+15	3.67E+13	-70.9998	1.77E+15	5.06E+13	-78.9706	1.51E+15	6.19E+13
59.8311	2.07E+15	2.89E+13	-72.9998	1.74E+15	5.33E+13			
57.8311	2.17E+15	3.43E+13	-74.9998	1.82E+15	6.34E+13			
-58.9918	2.32E+15	4.85E+13	-76.9998	1.87E+15	6.18E+13			
-60.9918	2.24E+15	4.93E+13	-78.9998	1.91E+15	7.36E+13			
-62.9918	2.31E+15	6.30E+13						
-64.9918	2.37E+15	6.98E+13						
-66.9918	2.38E+15	6.26E+13						
-68.9918	2.43E+15	7.16E+13						
-70.9918	2.48E+15	6.71E+13						
-72.9918	2.51E+15	6.80E+13						
-74.9918	2.57E+15	7.62E+13						
-76.9918	2.54E+15	8.35E+13						
-78.9918	2.63E+15	8.76E+13						

Table S13. NO partial column above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean (±2 σ/√(n)) value for January, February, and March.

SZA (°)	January NO partial column	2 σ/√(n)	SZA (°)	February NO partial column	2 σ/√(n)	SZA (°)	March NO partial column	2 σ/√(n)
79.8474	2.38E+15	1.66E+14	78.291	2.53E+15	1.36E+14	80.1374	2.39E+15	1.83E+14
77.8474	2.20E+15	1.29E+14	76.291	2.39E+15	1.64E+14	78.1374	2.49E+15	1.32E+14
75.8474	2.29E+15	1.06E+14	74.291	2.40E+15	1.97E+14	76.1374	2.79E+15	2.41E+14
73.8474	2.34E+15	1.24E+14	72.291	2.47E+15	1.64E+14	74.1374	2.71E+15	2.43E+14
71.8474	2.48E+15	1.43E+14	70.291	2.57E+15	1.31E+14	72.1374	2.63E+15	1.78E+14
69.8474	2.46E+15	7.72E+13	68.291	2.56E+15	1.60E+14	70.1374	2.55E+15	1.67E+14
67.8474	2.59E+15	1.08E+14	66.291	2.66E+15	9.77E+13	68.1374	2.67E+15	1.56E+14
-68.8348	2.74E+15	1.10E+14	64.291	2.64E+15	8.82E+13	66.1374	2.73E+15	1.93E+14
-70.8348	2.75E+15	1.20E+14	62.291	2.75E+15	1.18E+14	64.1374	2.84E+15	1.52E+14
-72.8348	2.75E+15	1.07E+14	60.291	2.80E+15	1.44E+14	62.1374	2.72E+15	1.40E+14
-74.8348	2.69E+15	1.26E+14	-60.707	2.89E+15	1.69E+14	60.1374	2.91E+15	1.54E+14
-76.8348	2.81E+15	1.45E+14	-62.707	2.95E+15	9.26E+13	58.1374	2.84E+15	1.41E+14
-78.8348	2.67E+15	2.19E+14	-64.707	2.80E+15	1.10E+14	56.1374	2.91E+15	1.34E+14
			-66.707	2.92E+15	1.40E+14	54.1374	2.95E+15	1.54E+14
			-68.707	3.00E+15	1.91E+14	52.1374	2.93E+15	1.39E+14
			-70.707	3.05E+15	8.79E+13	50.1374	3.21E+15	1.22E+14
			-72.707	2.95E+15	1.28E+14	-50.813	3.43E+15	1.30E+14
			-74.707	3.05E+15	1.80E+14	-52.813	3.24E+15	1.78E+14
			-76.707	2.97E+15	1.39E+14	-54.813	3.20E+15	1.25E+14
			-78.707	2.71E+15	1.64E+14	-56.813	3.39E+15	1.36E+14
						-58.813	3.16E+15	1.76E+14
						-60.813	3.39E+15	3.14E+14
						-62.813	3.46E+15	1.81E+14
						-64.813	3.37E+15	1.36E+14
						-66.813	3.21E+15	1.12E+14
						-68.813	3.09E+15	2.80E+14
						-70.813	3.35E+15	1.40E+14
						-72.813	3.19E+15	2.58E+14
						-74.813	3.27E+15	1.49E+14
						-76.813	3.21E+15	1.68E+14
						-78.813	3.38E+15	3.19E+14

Table S14. NO partial column above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean (±2 σ/√(n)) value for April, May, and June.

SZA (°)	April NO partial column	2 σ/√(n)	SZA (°)	May NO partial column	2 σ/√(n)	SZA (°)	June NO partial column	2 σ/√(n)
76.5948	2.62E+15	4.50E+13	70.6782	2.94E+15	6.68E+13	71.0447	2.89E+15	8.77E+13
74.5948	2.67E+15	2.20E+14	68.6782	2.94E+15	7.78E+13	69.0447	3.52E+15	4.80E+14
72.5948	2.66E+15	2.27E+14	66.6782	2.98E+15	1.20E+14	67.0447	3.06E+15	1.67E+14
70.5948	2.79E+15	1.51E+14	64.6782	2.97E+15	1.70E+14	65.0447	3.20E+15	1.17E+14
68.5948	2.69E+15	1.76E+14	62.6782	3.15E+15	9.87E+13	63.0447	3.12E+15	2.33E+14
66.5948	2.71E+15	1.01E+14	60.6782	2.91E+15	2.00E+14	61.0447	3.12E+15	1.13E+14
64.5948	3.00E+15	2.65E+14	58.6782	3.13E+15	1.04E+14	59.0447	3.20E+15	1.26E+14
62.5948	2.86E+15	9.87E+13	56.6782	3.06E+15	1.16E+14	57.0447	3.22E+15	1.11E+14
60.5948	2.95E+15	1.58E+14	52.6782	3.31E+15	2.28E+14	55.0447	3.11E+15	1.93E+14
58.5948	2.98E+15	1.34E+14	50.6782	3.24E+15	1.59E+14	53.0447	3.24E+15	1.31E+14
56.5948	2.90E+15	1.04E+14	48.6782	3.26E+15	1.22E+14	51.0447	3.39E+15	1.32E+14

SZA (°)	NO partial column	2σ/√(n)	SZA (°)	NO partial column	2σ/√(n)	SZA (°)	NO partial column	2σ/√(n)
54.5948	3.14E+15	1.71E+14	46.6782	3.35E+15	9.61E+13	49.0447	3.27E+15	1.17E+14
52.5948	3.00E+15	1.66E+14	44.6782	3.39E+15	1.38E+14	47.0447	3.41E+15	1.47E+14
50.5948	2.93E+15	1.05E+14	42.6782	3.49E+15	1.50E+14	45.0447	3.45E+15	1.50E+14
48.5948	3.16E+15	1.62E+14	40.6782	3.43E+15	1.24E+14	43.0447	3.43E+15	2.12E+14
46.5948	3.17E+15	1.10E+14	38.6782	3.35E+15	2.01E+14	41.0447	3.40E+15	2.81E+14
44.5948	3.29E+15	9.20E+13	36.6782	3.51E+15	1.73E+14	39.0447	3.39E+15	1.29E+14
42.5948	3.20E+15	1.07E+14	34.6782	3.46E+15	1.70E+14	37.0447	3.48E+15	1.24E+14
40.5948	3.34E+15	1.28E+14	32.6782	3.55E+15	1.67E+14	35.0447	3.72E+15	2.14E+14
38.5948	3.44E+15	1.83E+14	30.6782	3.83E+15	2.24E+14	33.0447	3.79E+15	1.17E+14
-38.9087	3.51E+15	1.07E+14	-31.2945	3.75E+15	1.63E+14	31.0447	3.55E+15	1.15E+14
-40.9087	3.42E+15	1.14E+14	-33.2945	3.62E+15	1.09E+14	29.0447	3.68E+15	1.45E+14
-42.9087	3.57E+15	1.37E+14	-35.2945	3.76E+15	2.53E+14	27.0447	3.60E+15	1.55E+14
-44.9087	3.40E+15	2.21E+14	-37.2945	3.76E+15	2.86E+14	25.0447	3.77E+15	1.34E+14
-46.9087	3.60E+15	2.18E+14	-39.2945	3.95E+15	4.82E+14	-27.4853	3.85E+15	1.81E+14
-48.9087	3.73E+15	2.54E+14	-41.2945	3.64E+15	1.86E+14	-29.4853	3.77E+15	1.33E+14
-50.9087	3.51E+15	1.07E+14	-43.2945	3.77E+15	3.97E+14	-31.4853	4.06E+15	1.55E+14
-52.9087	3.34E+15	5.91E+13	-47.2945	3.61E+15	2.07E+13	-33.4853	4.23E+15	3.21E+14
-54.9087	3.57E+15	2.73E+14	-49.2945	3.69E+15	3.04E+14	-35.4853	4.19E+15	2.12E+14
-56.9087	3.51E+15	2.84E+14	-51.2945	3.87E+15	1.64E+14	-37.4853	3.96E+15	2.96E+14
-58.9087	3.34E+15	1.30E+14	-61.2945	3.60E+15	1.21E+14	-39.4853	3.94E+15	6.84E+14
-60.9087	3.43E+15	2.12E+14	-69.2945	3.75E+15	2.67E+14	-41.4853	4.06E+15	1.35E+14
-62.9087	3.91E+15	1.44E+14	-75.2945	3.68E+15	3.40E+14	-43.4853	3.54E+15	2.47E+14
-64.9087	3.52E+15	2.34E+14				-45.4853	3.89E+15	2.53E+14
-66.9087	3.48E+15	2.67E+14				-47.4853	4.26E+15	2.83E+13
-68.9087	3.61E+15	3.90E+14				-55.4853	3.41E+15	2.91E+14
-70.9087	3.50E+15	2.69E+14				-57.4853	4.07E+15	1.60E+14
-72.9087	3.44E+15	3.64E+14				-59.4853	4.09E+15	3.72E+14
-74.9087	3.19E+15	9.97E+13				-61.4853	4.05E+15	2.58E+14
-76.9087	3.42E+15	4.54E+14				-63.4853	3.77E+15	8.58E+14
-78.9087	3.29E+15	1.62E+14				-65.4853	3.89E+15	3.37E+14
						-67.4853	4.24E+15	1.01E+14
						-69.4853	3.58E+15	3.27E+14
						-71.4853	3.72E+15	3.35E+14
						-75.4853	3.59E+15	6.47E+14

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Table S15. NO partial column above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\,\sigma/\sqrt{n}$) value for July, August, and September.

SZA (°)	July NO partial column	2σ/√(n)	SZA (°)	August NO partial column	2σ/√(n)	SZA (°)	September NO partial column	2σ/√(n)
73.3811	2.93E+15	4.91E+14	70.9262	3.16E+15	1.78E+14	76.1915	3.11E+15	1.67E+14
71.3811	3.35E+15	4.07E+14	68.9262	2.98E+15	1.06E+14	74.1915	3.12E+15	2.05E+14
69.3811	3.12E+15	1.81E+14	66.9262	3.21E+15	1.41E+14	72.1915	2.98E+15	1.09E+14
67.3811	3.20E+15	2.00E+14	64.9262	3.28E+15	2.36E+14	70.1915	3.05E+15	1.26E+14
65.3811	3.24E+15	1.84E+14	62.9262	3.22E+15	1.98E+14	68.1915	3.19E+15	1.26E+14
63.3811	3.13E+15	1.10E+14	60.9262	3.37E+15	3.65E+14	66.1915	3.12E+15	1.25E+14
61.3811	3.27E+15	2.34E+14	58.9262	3.31E+15	1.48E+14	64.1915	3.19E+15	2.29E+14
59.3811	3.30E+15	1.40E+14	56.9262	3.28E+15	1.45E+14	62.1915	3.23E+15	1.71E+14
57.3811	3.28E+15	1.52E+14	54.9262	3.47E+15	9.71E+13	60.1915	3.37E+15	1.35E+14
55.3811	3.37E+15	8.91E+13	52.9262	3.42E+15	1.54E+14	58.1915	3.38E+15	1.56E+14
53.3811	3.27E+15	1.44E+14	50.9262	3.29E+15	1.48E+14	56.1915	3.47E+15	1.56E+14
51.3811	3.35E+15	1.16E+14	48.9262	3.49E+15	2.06E+14	54.1915	3.56E+15	1.62E+14
49.3811	3.44E+15	1.50E+14	46.9262	3.66E+15	2.36E+14	52.1915	3.68E+15	1.29E+14
47.3811	3.50E+15	1.44E+14	44.9262	3.64E+15	2.22E+14	50.1915	3.60E+15	1.17E+14

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SZA (°)	NO partial column	2 σ/√(n)	SZA (°)	NO partial column	2 σ/√(n)	SZA (°)	NO partial column	2 σ/√(n)
45.3811	3.48E+15	1.06E+14	42.9262	3.58E+15	1.16E+14	48.1915	3.65E+15	1.65E+14
43.3811	3.76E+15	3.10E+14	40.9262	3.66E+15	1.30E+14	46.1915	3.78E+15	1.49E+14
41.3811	3.48E+15	1.39E+14	38.9262	3.85E+15	1.55E+14	-46.7815	3.93E+15	1.33E+14
39.3811	3.63E+15	2.60E+14	36.9262	3.75E+15	1.11E+14	-48.7815	3.94E+15	1.36E+14
37.3811	3.78E+15	2.33E+14	-37.7221	3.87E+15	7.25E+14	-50.7815	3.80E+15	1.45E+14
35.3811	3.68E+15	1.85E+14	-39.7221	3.98E+15	3.95E+14	-52.7815	4.04E+15	1.70E+14
33.3811	3.82E+15	1.45E+14	-41.7221	4.16E+15	1.54E+14	-54.7815	4.04E+15	1.68E+14
31.3811	3.82E+15	2.16E+14	-43.7221	4.00E+15	2.21E+14	-56.7815	3.98E+15	1.98E+14
29.3811	3.66E+15	1.12E+14	-45.7221	3.92E+15	2.52E+14	-58.7815	4.04E+15	2.46E+14
-24.8772	3.83E+15	4.21E+14	-47.7221	4.01E+15	1.89E+14	-60.7815	4.00E+15	1.91E+14
-26.8772	3.86E+15	2.30E+14	-49.7221	4.24E+15	2.62E+14	-62.7815	3.73E+15	1.32E+14
-28.8772	3.97E+15	2.50E+14	-51.7221	4.27E+15	3.39E+14	-64.7815	4.21E+15	2.27E+14
-30.8772	4.13E+15	2.66E+14	-55.7221	3.89E+15	2.51E+14	-66.7815	3.95E+15	2.07E+14
-32.8772	4.10E+15	2.63E+14	-57.7221	3.97E+15	3.42E+14	-68.7815	4.00E+15	3.45E+14
-36.8772	4.22E+15	2.40E+14	-59.7221	3.96E+15	4.88E+14	-70.7815	3.66E+15	2.44E+14
-38.8772	3.43E+15	2.63E+14	-61.7221	4.09E+15	3.66E+14	-72.7815	3.96E+15	1.52E+14
-40.8772	3.93E+15	2.36E+14	-63.7221	3.97E+15	2.98E+13	-74.7815	4.02E+15	2.51E+14
-42.8772	4.21E+15	2.41E+14	-67.7221	4.03E+15	3.79E+14	-76.7815	3.99E+15	3.20E+14
-44.8772	3.69E+15	9.31E+13	-69.7221	3.77E+15	3.22E+12	-78.7815	3.97E+15	2.64E+14
-48.8772	3.88E+15	2.80E+14						
-50.8772	4.09E+15	4.90E+14						
-56.8772	3.80E+15	6.67E+14						
-60.8772	3.62E+15	1.70E+14						
-62.8772	3.71E+15	2.63E+14						
-64.8772	3.78E+15	2.80E+13						
-66.8772	3.94E+15	3.54E+14						
-68.8772	3.73E+15	5.27E+14						
-72.8772	3.97E+15	4.53E+14						

Table S16. NO partial column above 16 km altitude measured at Zugspitze with respective solar zenith angle (SZA) and the error which represents two times the standard error of the mean ($\pm 2\,\sigma/\sqrt{(n)}$) value for October, November, and December.

	October			November			December	
SZA (°)	NO partial column	2 σ/√(n)	SZA (°)	NO partial column	2 σ/√(n)	SZA (°)	NO partial column	2 σ/√(n)
80.0769	2.98E+15	2.31E+14	79.398	2.59E+15	1.50E+14	80.3428	2.43E+15	1.80E+14
78.0769	2.83E+15	1.08E+14	77.398	2.70E+15	1.37E+14	78.3428	2.41E+15	1.42E+14
76.0769	3.01E+15	9.37E+13	75.398	2.76E+15	1.15E+14	76.3428	2.37E+15	1.65E+14
74.0769	2.99E+15	1.40E+14	73.398	2.64E+15	1.06E+14	74.3428	2.43E+15	8.55E+13
72.0769	3.00E+15	1.79E+14	71.398	2.84E+15	1.32E+14	72.3428	2.45E+15	1.11E+14
70.0769	3.02E+15	1.42E+14	69.398	2.84E+15	9.15E+13	-70.9104	2.69E+15	8.94E+13
68.0769	3.08E+15	1.54E+14	-68.9276	3.10E+15	9.97E+13	-72.9104	2.79E+15	1.22E+14
66.0769	3.26E+15	1.29E+14	-70.9276	3.15E+15	1.15E+14	-74.9104	2.72E+15	1.12E+14
64.0769	3.28E+15	1.07E+14	-72.9276	3.19E+15	1.01E+14	-76.9104	2.85E+15	2.59E+14
62.0769	3.27E+15	1.00E+14	-74.9276	3.21E+15	1.29E+14	-78.9104	2.73E+15	1.73E+14
60.0769	3.42E+15	1.37E+14	-76.9276	3.13E+15	1.81E+14			
58.0769	3.47E+15	1.59E+14	-78.9276	3.11E+15	1.60E+14			
-58.7488	3.78E+15	1.20E+14						
-60.7488	3.65E+15	1.16E+14						
-62.7488	3.49E+15	1.03E+14						
-64.7488	3.71E+15	1.27E+14						
-66.7488	3.65E+15	2.29E+14						
-68.7488	3.61E+15	1.18E+14						
-70.7488	3.75E+15	1.25E+14						
-72.7488	3.59E+15	1.30E+14						

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-74.7488	3.63E+15	1.26E+14
-76.7488	3.59E+15	1.29E+14
-78.7488	3.70E+15	1.96E+14