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Supplement of

Analysis and attribution of total column ozone changes over the Tibetan Plateau during 1979–2017

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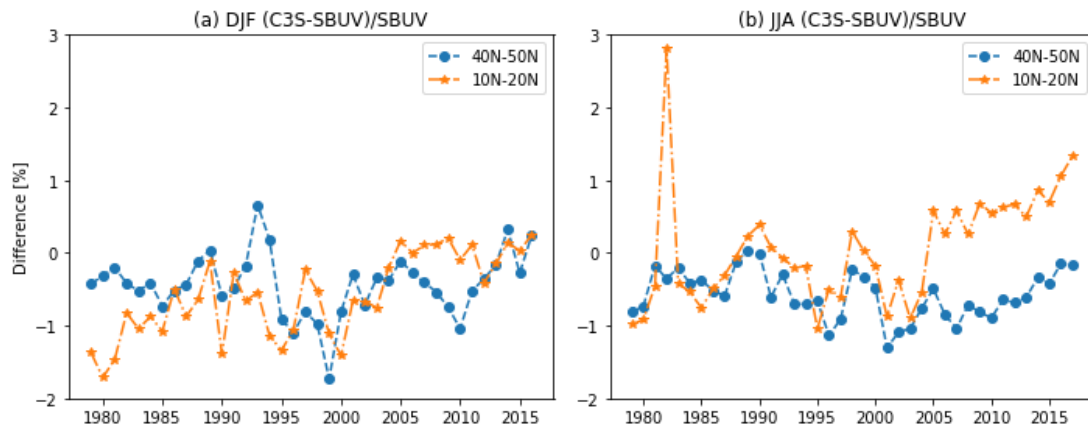


Figure S1. Difference (%) in total column ozone (TCO) between C3S and SBUV datasets averaged in (a) DJF and (b) JJA seasons over the North-TP (40° - 50° N) and the South-TP (10° - 20° N) regions during 1979-2017.

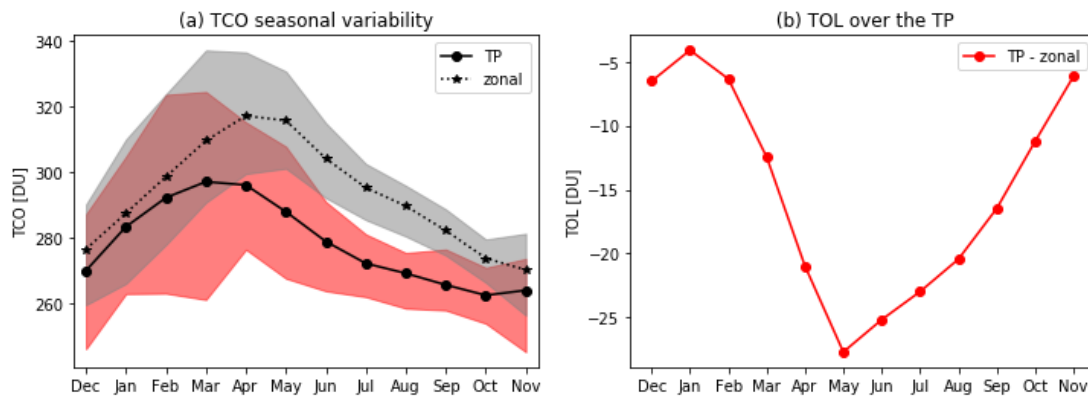


Figure S2. (a) Seasonal variability in TCO over the TP (solid circles, 27.5° - 37.5° N, 75.5° - 105.5° E) and the zonal-TP region (asterisks, 27.5° - 37.5° N) during 1979-2017. The red and grey shaded areas show the maximum-minimum TCO ranges for the TP and the zonal-TP region. (b) The total ozone low (TOL) values (red circles) over the TP relative to the zonal-TP region.

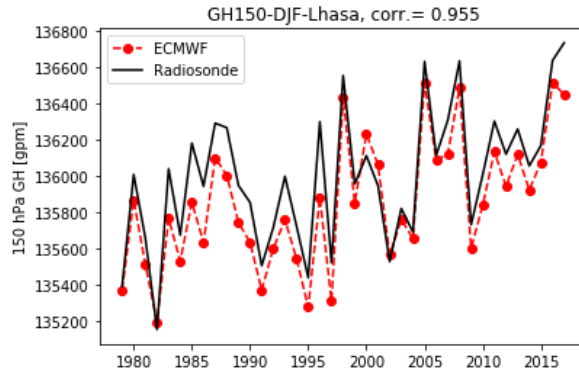


Figure S3. Time series of the DJF mean geopotential height at 150 hPa based on ECMWF ERA-Interim reanalyses (red circles) and radiosonde observations (black solid line) above Lhasa station (30°N, 91°E).

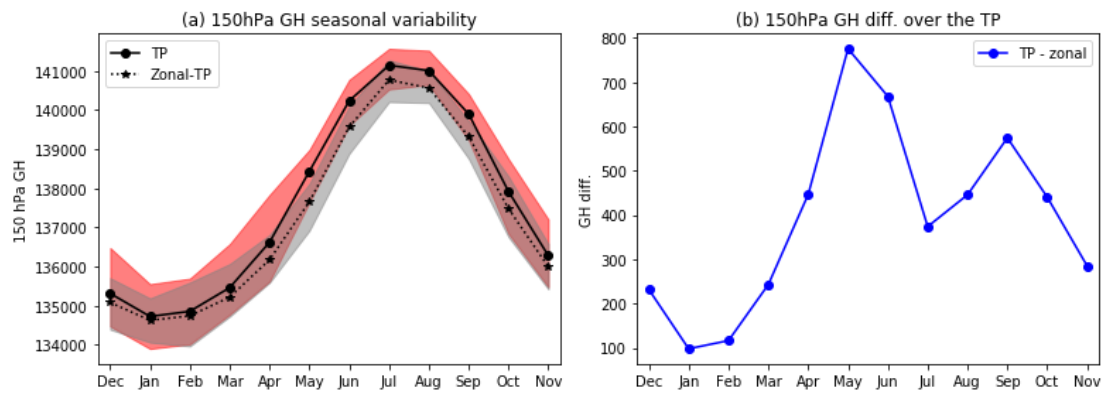


Figure S4. (a) Seasonal variations in geopotential height (GH) at 150 hPa during 1979-2017 over the TP (solid circles, 27.5°–37.5°N, 75.5°–105.5°E) and the zonal-TP region (asterisks, 27.5°–37.5°N). The red and grey shaded areas show the maximum-minimum GH ranges for the TP and the zonal-TP region. (b) The 150 hPa GH differences (blue circles) over the TP relative to the zonal-TP region.

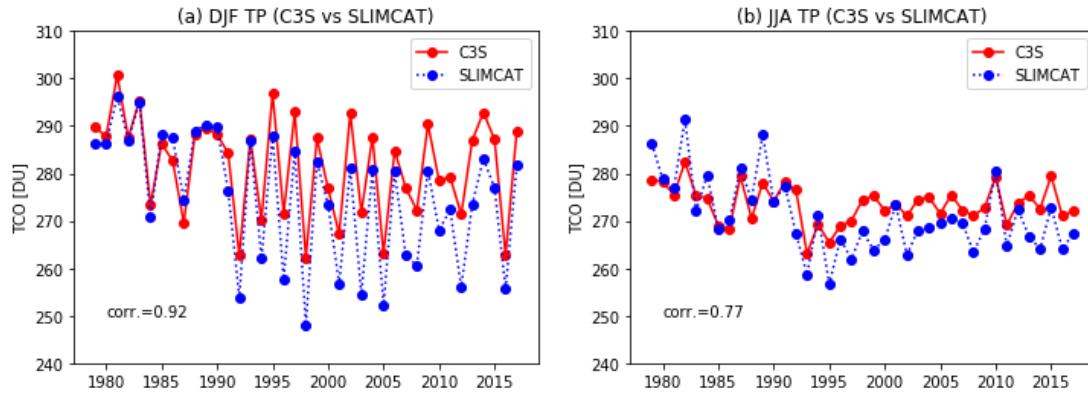


Figure S5. Comparison of the simulated TCO time series with the C3S-based TCO data averaged in DJF and JJA over the TP. Their correlations (0.92 and 0.77 for DJF and JJA, respectively) are statistically significant above the 99% confidence level.

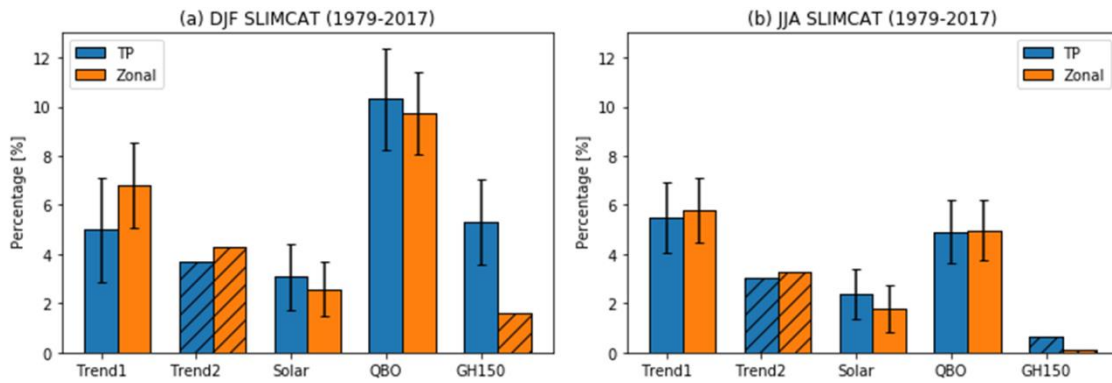


Figure S6. Contributions of various explanatory variables to the total ozone variability (in %) in (a) DJF and (b) JJA over the TP and the zonal-TP region based on SLIMCAT control experiment during 1979-2017. The hatched bars without error bars indicate the contribution is not significant within 2σ level.

Table S1. Correlation coefficients for the JJA mean TCO and explanatory variables over the TP during 1979-2017

Corr.	EESC	Solar	QBO30	QBO10	ENSO	Aerosol	AO	GH150	ST
TCO	-0.442 ***	0.466 ***	-0.070	0.458 ***	0.161	0.266 *	0.036	0.169	0.035
EESC	1	-0.231	0.022	0.007	0.061	-0.248	0.036	-0.153	-0.091
Solar		1	-0.103	-0.117	-0.092	0.132	0.199	0.235	0.076
QBO30			1	0.057	-0.147	-0.073	-0.215	-0.130	-0.150
QBO10				1	0.159	0.030	0.073	0.004	-0.038
ENSO					1	0.189	-0.257	-0.361	-0.249
								**	
Aerosol						1	0.122	-0.332	-0.224
								**	
AO							1	0.254	0.270
GH150								1	0.819

ST									1

*** 99% confidence level; ** 95% confidence level; * 90% confidence level

Table S2. Adjusted determination coefficients of EESC-based regression model for DJF mean TCO over different regions with different proxies

DJF TCO (Adj. R-squared)	EESC, solar, QBO, ENSO based on Eq. (1)	EESC, solar, QBO, ENSO, ST based on Eq. (2)	EESC, solar, QBO, GH150 based on Eq. (3)
TP, 27.5 N -37.5 N, 75.5 E -105.5 E	0.58	0.69	0.76
North-TP, 40 N -50 N	0.58	0.59	0.57
Zonal-TP, 27.5 N -37.5 N	0.68	0.72	0.76
South-TP, 10 N -20 N	0.58	0.65	0.60

Table S3. EESC-based TCO trends (with 2σ uncertainties) over the TP and zonal TP region for the periods 1979-1996 and 1997-2017

TCO Trend (2σ)	DJF		JJA	
	1979-1996	1997-2017	1979-1996	1997-2017
TP	-0.56±0.21	0.21±0.08	-0.30±0.11	0.11±0.04
Zonal	-0.64±0.18	0.24±0.07	-0.35±0.11	0.13±0.04

Table S4. Correlation between ozone values in a given month and the subsequent months

	1	2	3	4	5	6	7	8	9	10	11
N	0.45	0.27	0.35	0.35	0.37	0.49	0.23	0.35	0.34	0.31	0.03
D	0.65	0.49	0.59	0.48	0.47	0.17	0.38	0.48	0.35	0.11	-0.20
J	0.77	0.72	0.61	0.41	0.17	0.12	0.32	0.22	0.12	-0.23	-0.31
F	0.71	0.64	0.45	0.26	0.18	0.33	0.25	0.14	-0.18	-0.07	-0.02
M	0.80	0.66	0.33	0.29	0.46	0.32	0.23	-0.26	-0.26	-0.32	-0.25
A	0.66	0.43	0.39	0.50	0.40	0.29	-0.09	-0.21	-0.21	-0.12	-0.16
M	0.60	0.59	0.63	0.50	0.37	-0.09	-0.17	-0.26	-0.06	-0.14	-0.08
J	0.59	0.57	0.53	0.17	-0.15	-0.15	-0.25	-0.02	-0.12	0.04	0.16
J	0.87	0.74	0.45	0.19	0.06	0.03	0.17	0.07	0.18	0.36	0.41
A	0.83	0.52	0.11	-0.01	0.02	0.16	0.07	0.13	0.30	0.26	0.32
S	0.48	0.21	0.07	0.03	0.32	0.09	0.19	0.17	0.18	0.18	0.17
O	0.45	0.24	0.08	0.22	0.06	0.13	0.38	0.15	0.27	0.26	0.22

(1 lag=1 month, bold numbers are statistically significant within 2σ)