Article

Supplement for "Ambient ozone and fine particular matter pollution in a megacity in South China: Trends, concurrent pollution, and health risk assessment"

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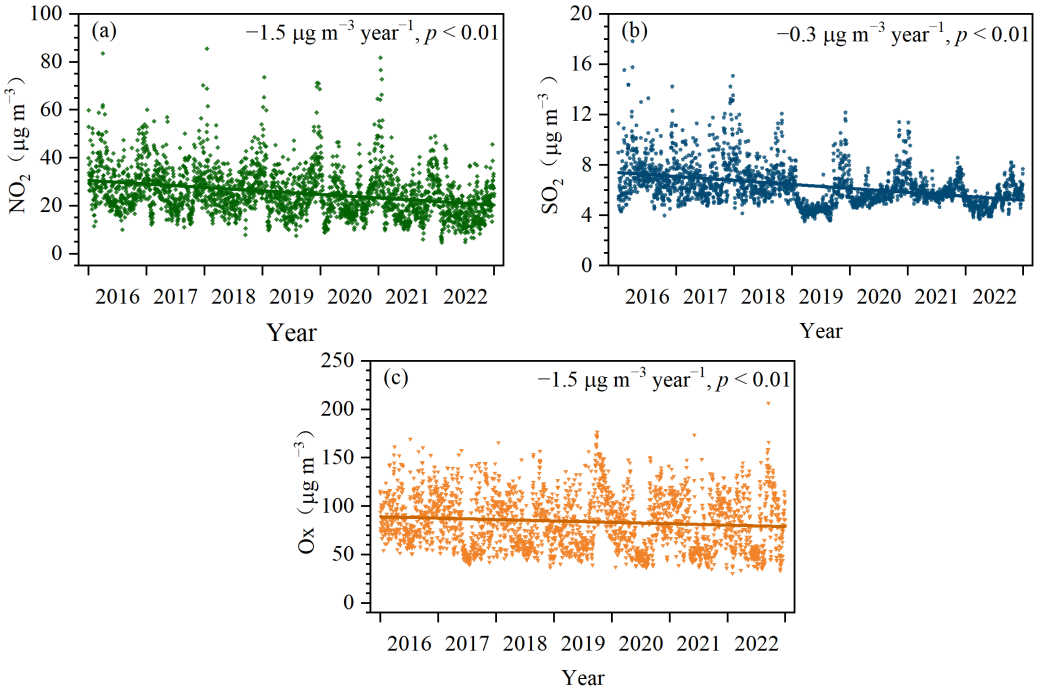

Figure S1. Trends of daily average NO_2, SO_2, and Ox concentrations in Shenzhen from 2016 to 2022.

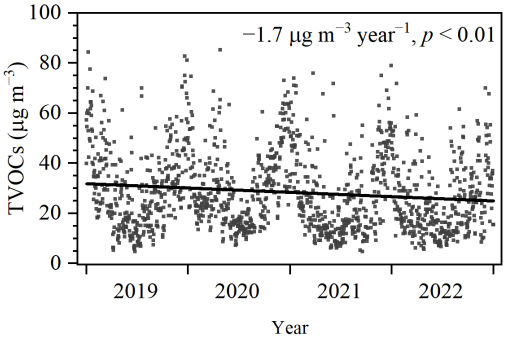

Figure S2. Trends of daily average TVOCs concentrations at the LH site during 2019 and 2022.

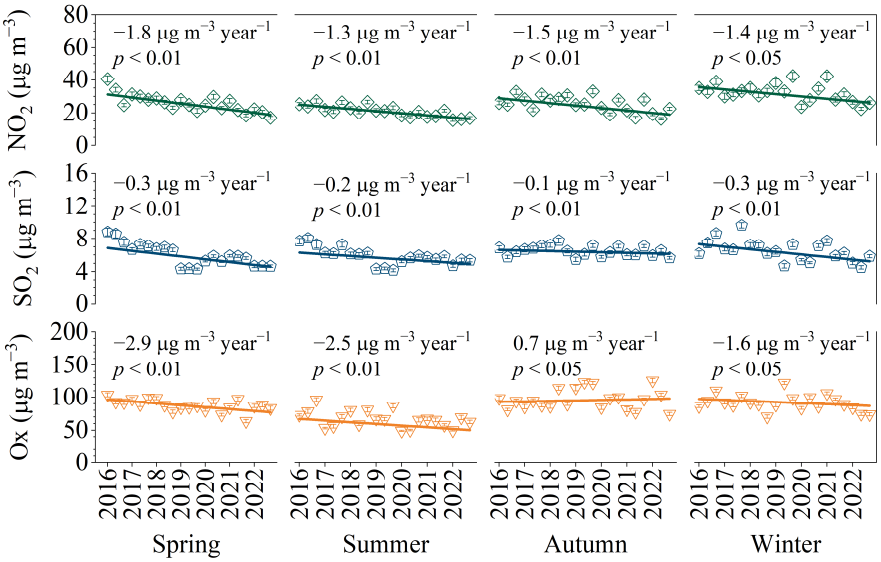

Figure S3. Trends of monthly average NO_2, SO_2, and Ox concentrations in different seasons in Shenzhen from 2016 to 2022. The error bar represents the 95% CI of the monthly averages.

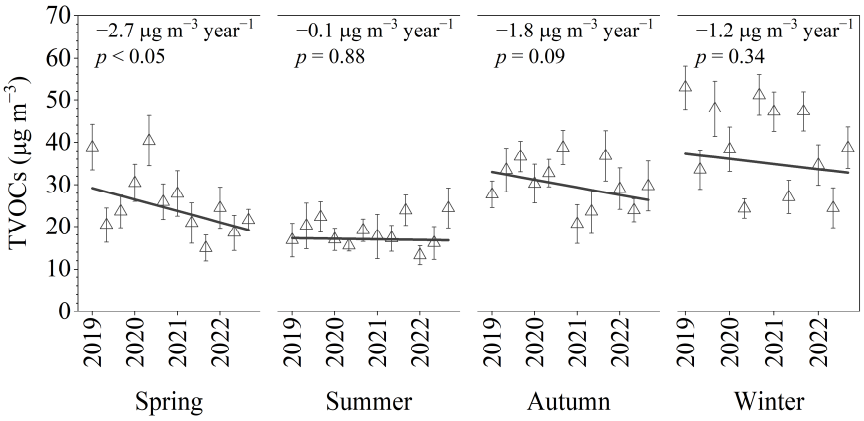

Figure S4. Trends of monthly average TVOCs concentrations in different seasons at the LH site from 2019 to 2022. The error bar represents the 95% CI of the monthly averages.

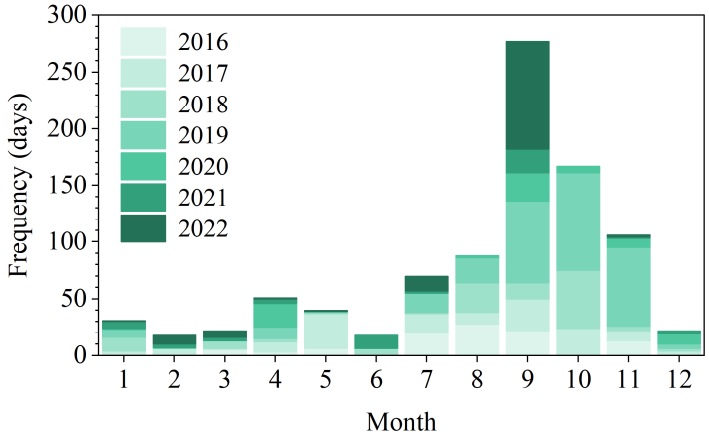

Figure S5. Frequency of high-O_3-and-$PM_{2.5}$ days at 13 BAQM sites from 2016 to 2022.

Table S1. Detailed information of the of 14 air quality monitoring sites in Shenzhen.

Site name	Administrative district	Geographical coordinate	Site type	Site details
Guanlan (GL)	Longhua	114.07° E, 22.74° N	National air quality monitoring station	Urban site, surrounded by residential and industrial blocks
Guangming (GM)	Guangming	113.95° E, 22.76° N	Municipal air quality monitoring station	Urban site, surrounded by parkland and residential blocks
Honghu (HH)	Luohu	114.13° E, 22.57° N	National air quality monitoring station	Urban site, surrounded by parkland, residential and commercial blocks
Huaqiaocheng (HQC)	Nanshan	113.99° E, 22.54° N	National air quality monitoring station	Urban site, surrounded by parkland, residential and commercial blocks
Kuichong (KC)	Dapeng	114.42° E, 22.64° N	National air quality monitoring station	Urban site, surrounded by residential blocks
Longgang (LG)	Longgang	114.23° E, 22.72° N	National air quality monitoring station	Urban site, surrounded by parkland, residential and commercial blocks
Meisha (MS)	Yantian	114.31° E, 22.60° N	National air quality monitoring station	Urban site, surrounded by residential and commercial blocks
Nanao (NA)	Dapeng	114.50° E, 22.54° N	National air quality monitoring station	Urban site, surrounded by residential and commercial blocks
Nanhai (NH)	Nanshan	113.93° E, 22.52° N	National air quality monitoring station	Urban site, surrounded by residential and commercial blocks
Pingshan (PS)	Pingshan	114.36° E, 22.72° N	National air quality monitoring station	Urban site, surrounded by parkland and commercial blocks
Tongxinling (TXL)	Futian	114.11° E, 22.55° N	National air quality monitoring station	Urban site, surrounded by parkland, residential and commercial blocks
Xixiang (XX)	Baoan	113.91° E, 22.58° N	National air quality monitoring station	Urban site, surrounded by parkland, residential and commercial blocks
Yantian (YT)	Yantian	114.25° E, 22.57° N	National air quality monitoring station	Urban site, surrounded by parkland, residential and industrial blocks
Lianhua (LH)	Futian	114.07° E, 22.56° N	National air quality monitoring station	Urban site, surrounded by parkland, residential and commercial blocks

Table S2. Exposure-response coefficients for the long-term mortality effects of $PM_{2.5}$ and O_3.

Health endpoint		β (%)	95% CI (%)
$PM_{2.5}$-related	Non-accidental all-cause premature mortality [1]	7.70	(5.83，8.62)
	Cardiovascular mortality [2]	13.10	(7.70，19.06)
	Respiratory mortality [1]	9.53	(2.96，16.55)

Health endpoint		β (%)	95% CI (%)
O_3-related	Non-accidental all-cause premature mortality [3]	1.39	(0.90，1.88)
	Cardiovascular mortality [3]	1.88	(0.40，3.44)
	Respiratory mortality [3]	2.47	(1.00，3.92)

Table S3. Statistical descriptions of meteorological parameters in different seasons

Levels (mean ± 95% CI)	Spring	Summer	Autumn	Winter
Temperature (°C)	23.3 ± 0.02	29.0 ± 0.01	25.4 ± 0.02	16.9 ± 0.02
Relative humidity (%)	78.9 ± 0.1	80.4 ± 0.1	71.8 ± 0.1	68.8 ± 0.1
Days with precipitation (days)	34.9 ± 7.8	53.0 ± 3.4	29.1 ± 5.2	17.9 ± 5.3
Wind speed (m s^{-1})	1.8 ± 0.01	1.9 ± 0.01	1.9 ± 0.01	1.9 ± 0.01

Table S4. Statistical descriptions of air pollutants under different scenarios.

Concentrations (μg m^{-3}) (mean ± 95% CI)	High-O_3-and-$PM_{2.5}$ days	High-O_3 days
MDA8 O_3	195.6 ± 2.1	184.7 ± 1.7
$PM_{2.5}$	47.2 ± 0.9	26.2 ± 0.4
O_X	154.2 ± 1.5	137.6 ± 1.3
NO_2	41.0 ± 1.3	28.1 ± 0.8
SO_2	8.3 ± 0.2	7.0 ± 0.2
TVOCs	38.9 ± 5.1	34.4 ± 3.8

Table S5. Statistical descriptions of meteorological parameters under different scenarios.

Levels (mean ± 95% CI)	High-O_3-and-$PM_{2.5}$ days	High-O_3 days
Temperature (°C)	27.1 ± 0.3	28.1 ± 0.2
Wind speed (m s^{-1})	1.4 ± 0.04	1.6 ± 0.05
Relative humidity (%)	66.4 ± 0.7	66.8 ± 0.7
Boundary layer height (m) [a]	1241.9 ± 72.3	1230.4 ± 81.9

[a] The boundary layer heights were obtained from the ERAS dataset of the European Centre for Medium-range Weather Forecasts (ECMWF) (accessible at https://cds.climate.copernicus.eu/).

Table S6. Statistics of synoptic systems during high-O_3-and-$PM_{2.5}$ days from 2017 to 2022.

Synoptic system pattern	Date [b]	Number of days	Ratio (%)
Typhoon periphery	7/29/2017, 7/30/2017, 9/16/2017, 8/24/2018, 8/25/2018, 10/6/2018, 8/24/2019, 9/28/2019, 9/29/2019, 9/30/2019, 10/1/2019, 10/2/2019, 10/11/2019, 10/12/2019, 10/18/2019, 10/19/2019, 10/20/2019, 11/6/2019, 11/13/2019, 9/2/2020, 9/3/2020, 9/30/2021, 9/10/2022, 9/11/2022, 9/12/2022, 9/13/2022, 9/16/2022, 9/17/2022, 9/18/2022	29	65.9
Subtropical high-pressure system	8/30/2017, 9/17/2017, 10/24/2017, 9/25/2019, 9/27/2019, 11/1/2019, 11/6/2019	7	15.9

Synoptic system pattern	Date [b]	Number of days	Ratio (%)
Uniform pressure system	10/7/2018, 10/8/2018, 4/5/2019, 11/10/2019, 4/15/2020, 4/26/2020, 6/6/2021, 7/31/2022	8	18.2

[b] There are 49 high-O_3-and-$PM_{2.5}$ days from 2017 to 2022, with synoptic data missing for 5/5/2017, 5/10/2017, 7/17/2019, 7/18/2019, and 8/9/2019.

Table S7. Statistics on the ratio of trajectories, pathway areas, and the corresponding $PM_{2.5}$ and O_3 concentrations for each Cluster.

Cluster NO.	Ratio of trajectories (%)	Regions passed through	Average concentrations (μg m^{-3})	
			O_3	$PM_{2.5}$
1	23.6%	Guangdong Province, South China Sea.	105.4 ± 11.3	44.1 ± 1.4
2	22.6%	Guangdong Province.	115.1 ± 13.3	45.3 ± 1.4
3	8.5%	Guangxi Province, Guangdong Province, Hunan Province.	103.2 ± 13.0	51.1 ± 1.8
4	8.4%	Guangdong Province.	147.4 ± 11.3	48.8 ± 2.1
5	14.8%	Jiangxi Province, Guangdong Province, Fujian Province.	133.8 ± 10.2	40.2 ± 1.4
6	10.5%	Guangdong Province.	113.4 ± 10.9	42.7 ± 1.3
7	11.6%	Guangdong Province, Fujian Province, South China Sea.	99.6 ± 8.0	36.9 ± 1.2
		Average	115.7 ± 11.7	44.0 ± 0.6

References

1. Chen, J.; Hoek, G. Long-Term Exposure to PM and All-Cause and Cause-Specific Mortality: A Systematic Review and Meta-Analysis. *Environ. Int.* **2020**, *143*, 105974, doi:10.1016/j.envint.2020.105974.
2. Alexeeff, S.E.; Liao, N.S.; Liu, X.; Van Den Eeden, S.K.; Sidney, S. Long-Term PM2.5 Exposure and Risks of Ischemic Heart Disease and Stroke Events: Review and Meta-Analysis. *J. Am. Heart Assoc.* **2021**, *10*, 1–22, doi:10.1161/JAHA.120.016890.
3. Sun, H.Z.; Yu, P.; Lan, C.; Wan, M.W.L.; Hickman, S.; Murulitharan, J.; Shen, H.; Yuan, L.; Guo, Y.; Archibald, A.T. Cohort-Based Long-Term Ozone Exposure-Associated Mortality Risks with Adjusted Metrics: A Systematic Review and Meta-Analysis. *Innovation* **2022**, *3*, 100246, doi:10.1016/j.xinn.2022.100246.