## Supplementary Material

# Long-term changes of regional ozone in China: implications for human health and ecosystem impacts

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**Table S1** Averages and trends of tropospheric $NO_2$ column over grids (0.5 °×0.5 °) covering different sites (DU: Dobson Unit; values in brackets are p-values) and other station metadata from the TOAR database. The tropospheric $NO_2$ column data are from https://disc.gsfc.nasa.gov/.

| Site Code | google_alt[§] | etopo_relative_alt[§] | population_density_5km[§] | nightlight_5km[§] | OMI NO2 average (DU)[#] | OMI NO2 trend (DU/10yr)[#] |
|---|---|---|---|---|---|---|
| **WLG** | 3568 | 639 | 129 | 0 | 0.025 | **0.012* (0.00)** |
| **XGLL** | 3720 | 325 | 286 | 1.13 | 0.009 | **0.004 * (0.01)** |
| **AKDL** | 558 | 47 | 47 | 0 | 0.032 | **0.003* (0.03)** |
| **LFS** | 220 | 27 | 1622 | 0.15 | 0.131 | 0.009 (0.31) |
| **LA** | 350 | 151 | 2948 | 1.78 | 0.395 | **-0.079* (0.04)** |
| **SDZ** | 185 | 0 | 3205 | 2.83 | 0.418 | -0.013 (0.67) |
| **GCH** | 227 | 56 | 7725 | 0 | 0.560 | -0.023 (0.51) |
| **CMA** | 59 | 8 | 332304 | 63 | 0.663 | **-0.142* (0.00)** |

[§] google_alt, opo_relative_alt, pulation_density_5km, nightlight_5km are metadata defined in TOAR-Database (Schultz et al., 2017, Tropospheric Ozone Assessment Report: Database and metrics data of global surface ozone observations. Elem Sci Anth, 5: 58, DOI: https://doi.org/10.1525/elementa.244).

[#] OMI $NO_2$ Average and OMI $NO_2$ Trend are average and trend of tropospheric NO2 column from Ozone Monitoring Instrument during 2005-2019.

* $p<0.05$.

**Table S2** Percent trends in different annual ozone metrics at different sites with p-values in brackets. The trend values in this table were obtained by dividing the trend values in Table 4 by the multi-year averages of corresponding ozone metrics.

| Site | AAVG (%/yr) | AdAVG (%/yr) | AmaxMDA8 (%/yr) | A4MDA8 (%/yr) | SOMO35 (%/yr) | NDGT90 (%/yr) | NDGT70 (%/yr) |
|---|---|---|---|---|---|---|---|
| **WLG** | **0.39**** | **0.42**** | 0.33 | 0.23 | **1.09**** | - | **5.07**** |
| | **(0.00)** | **(0.00)** | (0.14) | (0.21) | **(0.00)** | | **(0.00)** |
| **XGLL** | -0.72 | -0.51 | 0.21 | 0.15 | 0.70 | - | -1.57 |
| | (0.53) | (0.60) | (0.83) | (0.68) | (0.83) | | (0.74) |
| **AKDL** | **-3.06*** | **-3.71*** | **-3.64*** | **-3.82*** | **-17.4**** | - | - |
| | **(0.05)** | **(0.01)** | **(0.05)** | **(0.05)** | **(0.00)** | | |
| **LFS** | -0.46 | -0.36 | 1.44 | 1.94 | -0.23 | 7.69 | 9.28 |
| | (0.48) | (0.58) | (0.31) | (0.27) | (0.82) | (0.52) | (0.35) |
| **LA** | -0.64 | -0.58 | -0.66 | -0.35 | -1.30 | -3.47 | -1.78 |
| | (0.31) | (0.24) | (0.70) | (0.59) | (0.31) | (0.33) | (0.69) |
| **SDZ** | **1.19**** | **1.49**** | **1.77*** | **1.56*** | **3.17**** | **7.05**** | **4.04**** |
| | **(0.01)** | **(0.01)** | **(0.08)** | **(0.06)** | **(0.02)** | **(0.00)** | **(0.00)** |
| **GCH** | -1.68 | -1.23 | 0.35 | 0.27 | -2.04 | 5.27 | 1.46 |
| | (0.24) | (0.49) | (0.68) | (0.78) | (0.41) | (0.58) | (0.89) |
| **CMA** | **2.96*** | **2.32*** | -0.63 | -0.49 | **3.64*** | 4.19 | 3.28 |
| | **(0.06)** | **(0.10)** | (0.40) | (0.53) | **(0.10)** | (0.34) | (0.14) |

** p<0.05; *p<0.10

**Table S3** Percent trends in different seasonal ozone metrics at different sites with p-values in brackets. The trend values in this table were obtained by dividing the trend values in Table 5 by the multi-year averages of corresponding ozone metrics.

| Site | Season | SAVG (%/yr) | SdAVG (%/yr) | SSOMO35 (%/yr) | AOT40 (%/yr) | W126 (%/yr) |
|---|---|---|---|---|---|---|
| **WLG** | **Spring** | **0.38**** | **0.38**** | **1.06**** | **1.32**** | **2.21**** |
| | | **(0.00)** | **(0.00)** | **(0.00)** | **(0.00)** | **(0.00)** |
| | **Summer** | **0.30**** | **0.31**** | **0.83**** | **0.66*** | **1.30**** |
| | | **(0.03)** | **(0.02)** | **(0.01)** | **(0.10)** | **(0.04)** |
| | **Fall** | **0.57**** | **0.65**** | **1.95**** | **3.06**** | **4.19**** |
| | | **(0.00)** | **(0.00)** | **(0.00)** | **(0.00)** | **(0.00)** |
| | **Winter** | **0.25**** | **0.28**** | **1.08*** | **1.33**** | **1.64**** |
| | | **(0.02)** | **(0.01)** | **(0.05)** | **(0.04)** | **(0.02)** |
| **XGLL** | **Spring** | -0.90 | -1.70 | -1.69 | -3.64 | -3.24 |
| | | (0.40) | (0.21) | (0.53) | (0.21) | (0.21) |
| | **Summer** | 0.00 | -0.98 | 5.73 | -1.85 | -2.34 |
| | | (0.91) | (0.83) | (0.53) | (0.68) | (1.00) |
| | **Fall** | -1.58 | -1.39 | -2.76 | 1.03 | -4.81 |
| | | (0.32) | (0.22) | (0.80) | (0.22) | (0.32) |
| | **Winter** | -0.59 | -0.53 | -1.59 | -3.66 | -5.17 |
| | | (0.62) | (0.62) | (0.80) | (0.46) | (0.62) |
| **AKDL** | **Spring** | **-4.59*** | **-5.76*** | **-18.1*** | **-17.2*** | **-26.8*** |
| | | **(0.09)** | **(0.09)** | **(0.09)** | **(0.09)** | **(0.09)** |
| | **Summer** | **-6.60*** | **-5.92*** | **-34.3*** | **-23.8*** | **-41.0*** |
| | | **(0.05)** | **(0.05)** | **(0.05)** | **(0.05)** | **(0.05)** |
| | **Fall** | -0.88 | -2.86 | -12.3 | 1.66 | -9.06 |
| | | (0.85) | (0.35) | (0.57) | (0.85) | (0.57) |
| | **Winter** | -2.05 | -0.98 | **-21.0*** | -2.45 | -19.3 |
| | | (0.24) | (0.19) | **(0.09)** | (0.35) | (0.19) |
| **LFS** | **Spring** | **-3.88**** | **-3.85**** | **-10.8**** | -0.04 | **-9.71**** |
| | | **(0.04)** | **(0.04)** | **(0.02)** | (0.94) | **(0.02)** |
| | **Summer** | 1.52 | 1.57 | 4.37 | 2.90 | 4.28 |
| | | (0.28) | (0.28) | (0.24) | (0.13) | (0.33) |
| | **Fall** | 1.85 | 1.83 | **8.95**** | **5.30**** | **11.94**** |
| | | (0.10) | (0.10) | **(0.01)** | **(0.01)** | **(0.02)** |
| | **Winter** | -4.45 | **-4.39**** | **-24.8**** | **-14.7**** | **-19.1**** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | (0.18) | **(0.02)** | **(0.03)** | **(0.00)** | **(0.02)** |
| **LA** | **Spring** | **-1.38*** | **-1.69*** | **-2.45*** | -0.06 | **-3.06**** |
| | | **(0.05)** | **(0.05)** | **(0.07)** | (0.94) | **(0.02)** |
| | **Summer** | -0.30 | -0.38 | -0.49 | -0.56 | -1.21 |
| | | (0.59) | (0.59) | (0.59) | (0.48) | (0.48) |
| | **Fall** | -1.04 | **-1.21*** | -1.77 | -0.51 | -1.28 |
| | | (0.13) | **(0.10)** | (0.17) | (0.49) | (0.17) |
| | **Winter** | 1.54 | 1.51 | 4.93 | 3.17 | 5.73 |
| | | (0.24) | (0.19) | (0.24) | (0.31) | (0.39) |
| **SDZ** | **Spring** | 0.73 | **1.23*** | 2.72 | **3.92**** | **5.08*** |
| | | (0.22) | **(0.09)** | (0.14) | **(0.04)** | **(0.05)** |
| | **Summer** | **2.03*** | 2.09 | **3.07**** | 2.01 | **4.53*** |
| | | **(0.07)** | (0.11) | **(0.00)** | (0.11) | **(0.09)** |
| | **Fall** | 0.37 | **0.93*** | **2.78*** | 1.07 | **3.85**** |
| | | (0.21) | **(0.09)** | **(0.09)** | (0.48) | **(0.04)** |
| | **Winter** | -0.32 | 0.18 | -3.26 | -1.59 | -2.56 |
| | | (0.62) | (0.54) | (0.39) | (0.63) | (0.15) |
| **GCH** | **Spring** | -0.36 | 0.43 | 1.12 | 3.57 | 1.91 |
| | | (0.75) | (0.82) | (0.94) | (0.14) | (0.70) |
| | **Summer** | 0.77 | 0.31 | 0.17 | 1.34 | 1.35 |
| | | (0.63) | (0.68) | (1.00) | (0.34) | (0.58) |
| | **Fall** | -3.26 | -2.74 | -1.45 | 1.03 | -0.42 |
| | | (0.34) | (0.58) | (0.78) | (0.89) | (0.89) |
| | **Winter** | -1.91 | -2.03 | -1.14 | 0.39 | -13.1 |
| | | (0.21) | (0.31) | (0.82) | (0.94) | (0.24) |
| **CMA** | **Spring** | 1.77 | 0.89 | 2.41 | -0.43 | 2.47 |
| | | (0.10) | (0.62) | (0.62) | (0.80) | (0.62) |
| | **Summer** | 1.72 | 1.06 | 2.23 | 0.13 | 1.46 |
| | | (0.13) | (0.18) | (0.18) | (0.79) | (0.42) |
| | **Fall** | **4.38*** | 3.18 | 4.56 | 0.03 | 5.97 |
| | | **(0.09)** | (0.24) | (0.33) | (0.93) | (0.42) |
| | **Winter** | **5.04**** | **4.40**** | 0.08 | 0.00 | 3.19 |
| | | **(0.01)** | **(0.01)** | (0.74) | (0.65) | (0.14) |

** p<0.05; *p<0.10