*Supplemental Information for*

# Meteorological influence on surface ozone trends in China: Assessing uncertainties caused by multi-dataset and multi-method

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## Abbreviations[1]

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[1] Abbreviations:
CMA: China Meteorological Administration
ECMWF: European Centre for Medium-Range Weather Forecasts
ERA5: The fifth generation ECMWF atmospheric reanalysis of the global climate
ERA-Interim: ECMWF Reanalysis - Interim
FNL: National Centers for Environmental Prediction Final Operational Global Analysis data (1.0°×1.0°)
FNL025: National Centers for Environmental Prediction Final Operational Global Analysis data (0.25°×0.25°)
MERRA2: Modern-Era Retrospective analysis for Research and Applications Version 2
KZ: Kolmogorov–Zurbenko filter
MLR: Multiple Linear Regression
RF: Random Forest
XGBoost: eXtreme Gradient Boosting
LightGBM: Light Gradient Boosting Machine
Lowess: Locally Weighted Linear Regression
GEOS: Goddard Earth Observing System
WRF: Weather Research and Forecast
CMAQ: Community Multiscale Air Quality
WRF-Chem: WRF model coupled with Chemistry
RegCM-Chem-YIBs: Regional Climate-Chemistry-Ecology Coupling Model
NCP: North China Plain
BTH: Beijing-Tianjin-Hebei Region
YRD: Yangtze River Delta Region
PRD: Pearl River Delta
SCB: Sichuan Basin
FWP: Fenwei Plain
THB: Twain-Hu Basin

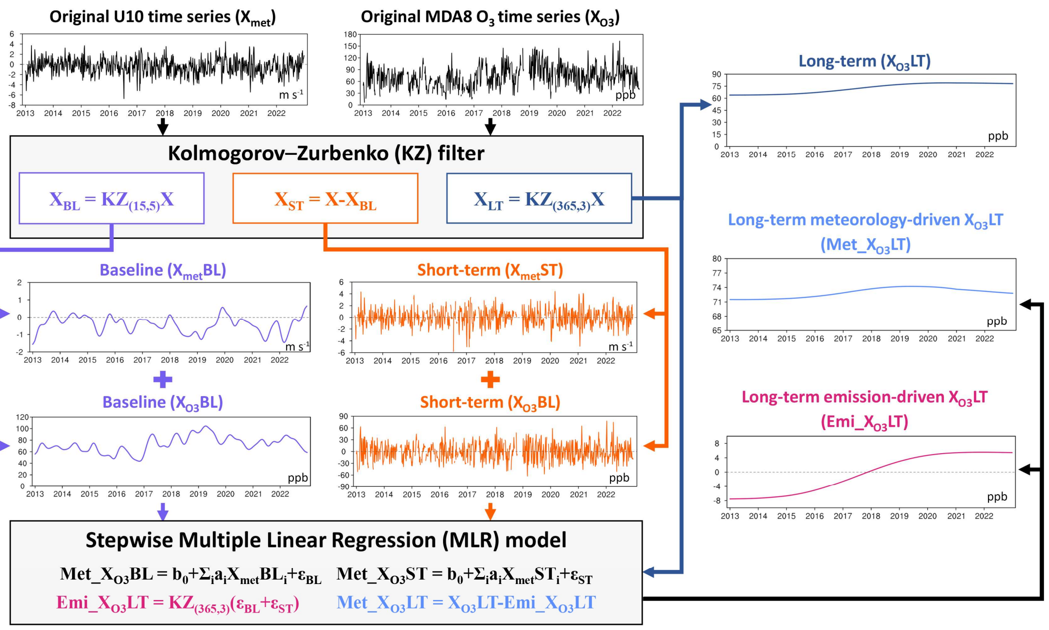


**Figure S1.** Flowchart of temporal decomposition of observed MDA8 $O_3$ time series into meteorology-driven and emission-driven long-term components (an example of the MDA8 $O_3$ data from Station_1015A and U10 data from ERA5).

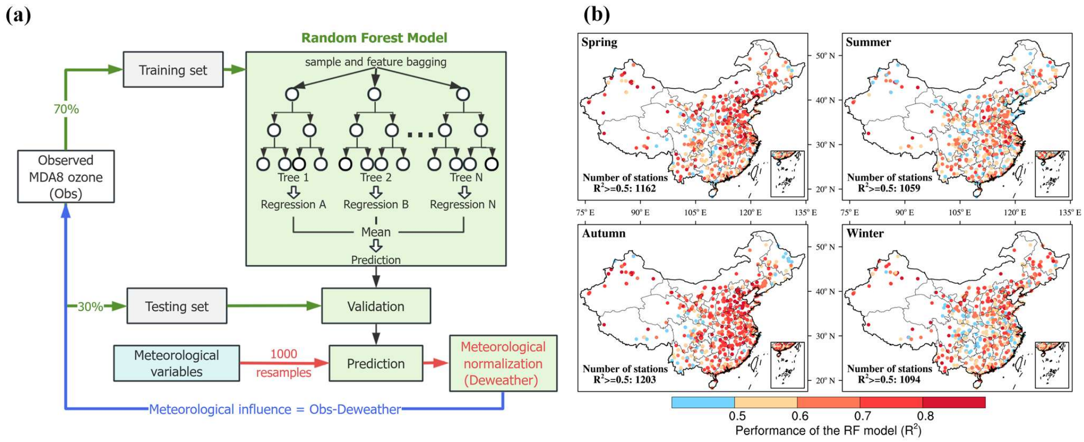


**Figure S2.** (a) Conceptual diagram of obtaining the meteorological influence based on the Random Forest (RF) algorithm, and (b) the performance of the RF model for the testing dataset at each state-controlled station during four seasons. The number of state-controlled monitoring stations with the coefficient of determination ($R^2$) greater than or equal to 0.5 is also presented.

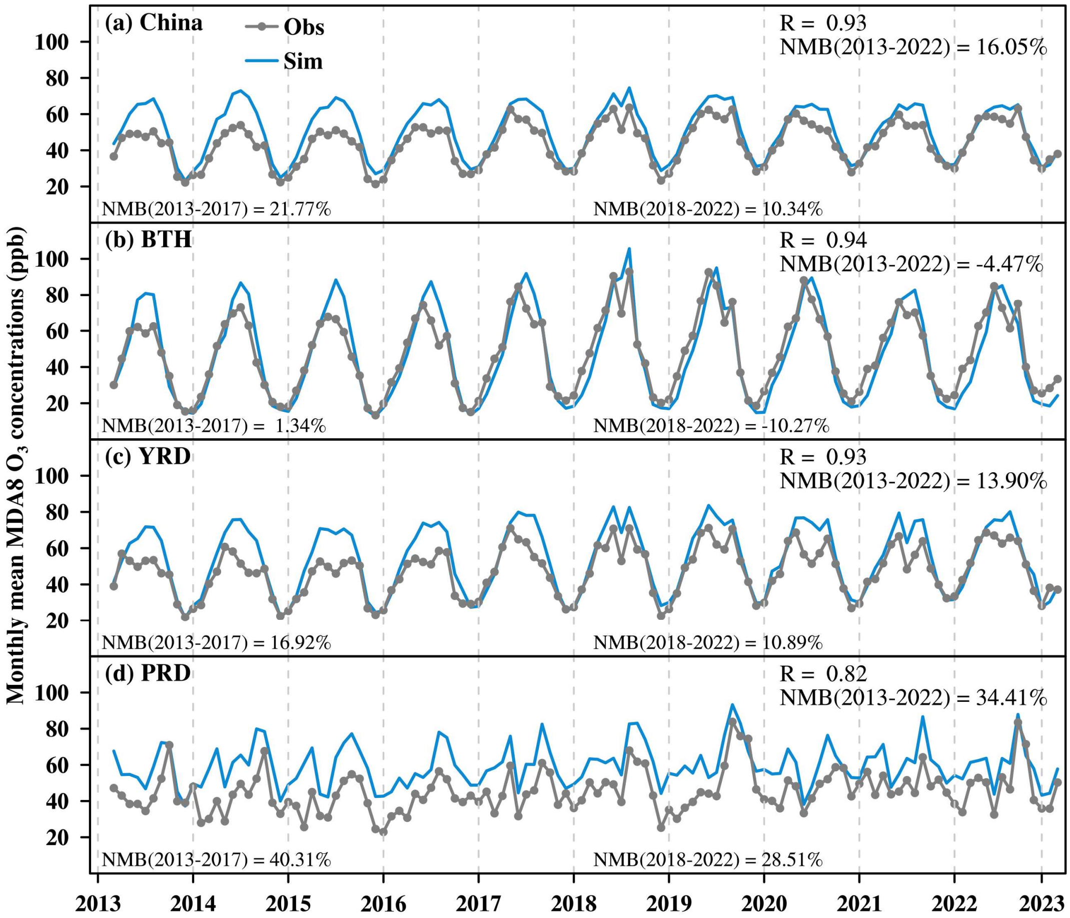


**Figure S3.** Comparison of simulated (blue) and observed (grey) monthly mean MDA8 $O_3$ concentrations averaged over (a) China, (b) BTH, (c) YRD, and (d) PRD from 2013 to 2022. The correlation coefficient (R) and normalized mean bias (NMB) values are shown. The NMB for 2013–2017 and 2018–2022 are also calculated and shown in order to test the performance of GEOS-Chem at different time periods.

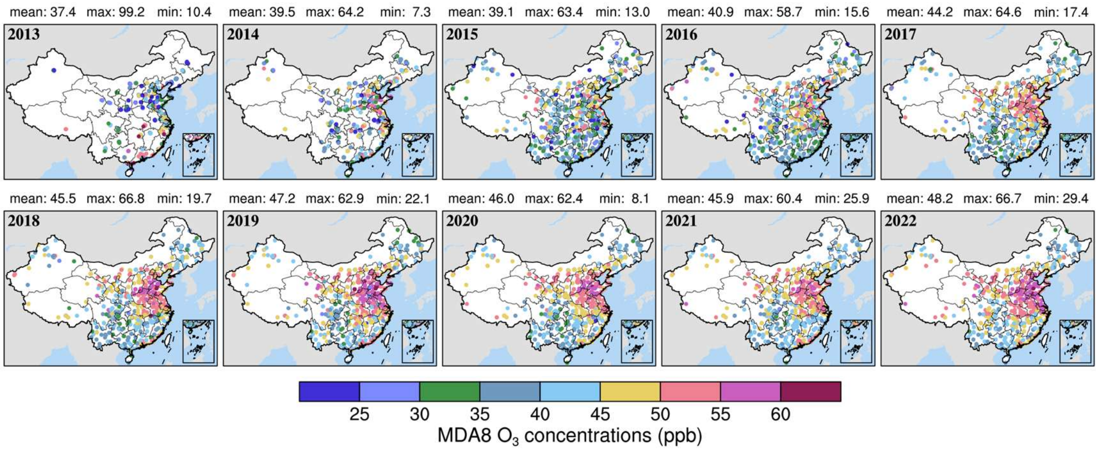


**Figure S4.** Annual mean MDA8 $O_3$ concentrations in China from 2013 to 2022. The mean, maximum, and minimum MDA8 $O_3$ concentrations for the whole China are shown.

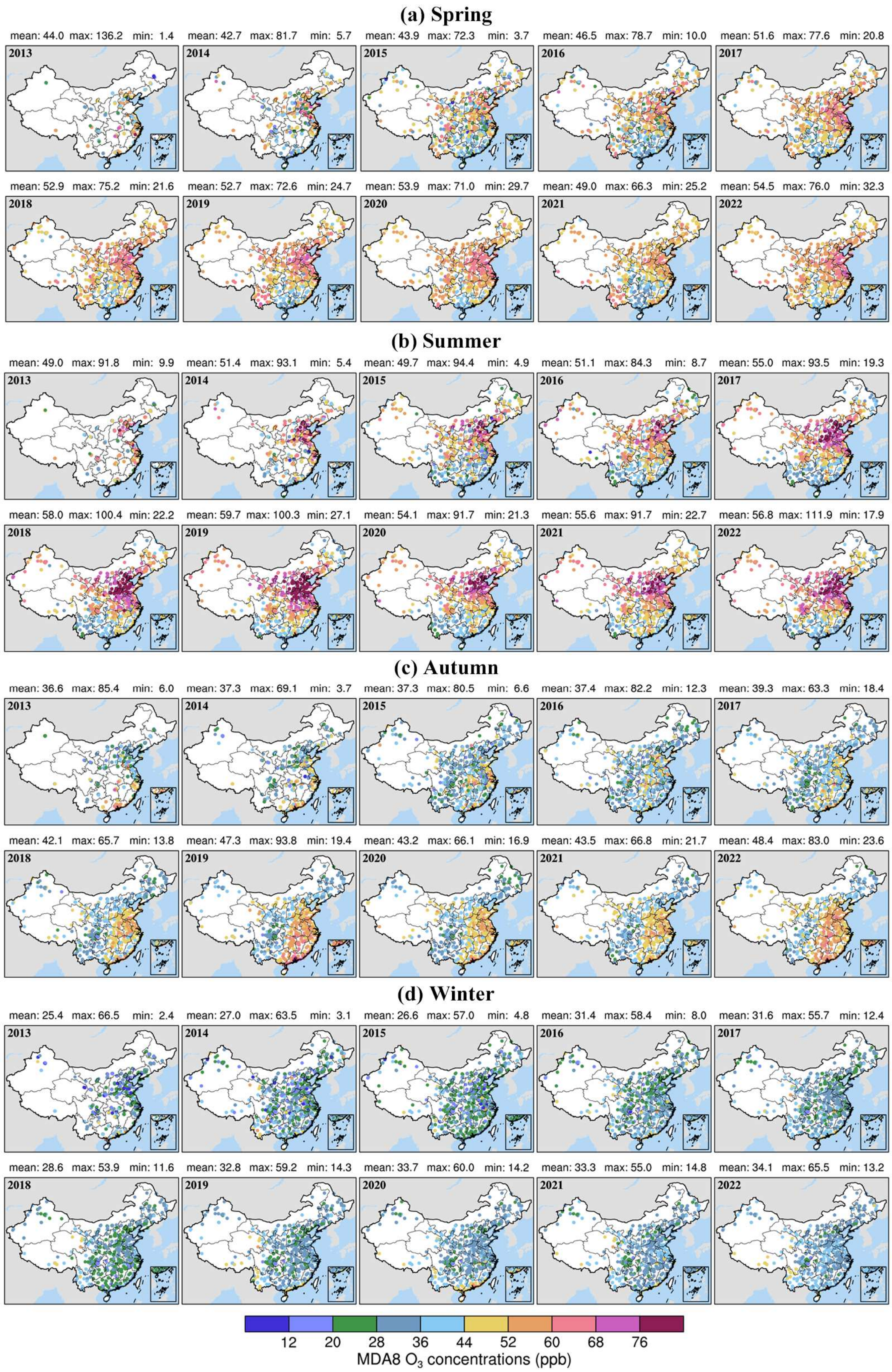


**Figure S5.** Seasonal mean MDA8 $O_3$ concentrations in China during (a) spring, (b) summer, (c) autumn, and (d) winter. The mean, maximum, and minimum MDA8 $O_3$ concentrations for the whole China are shown.

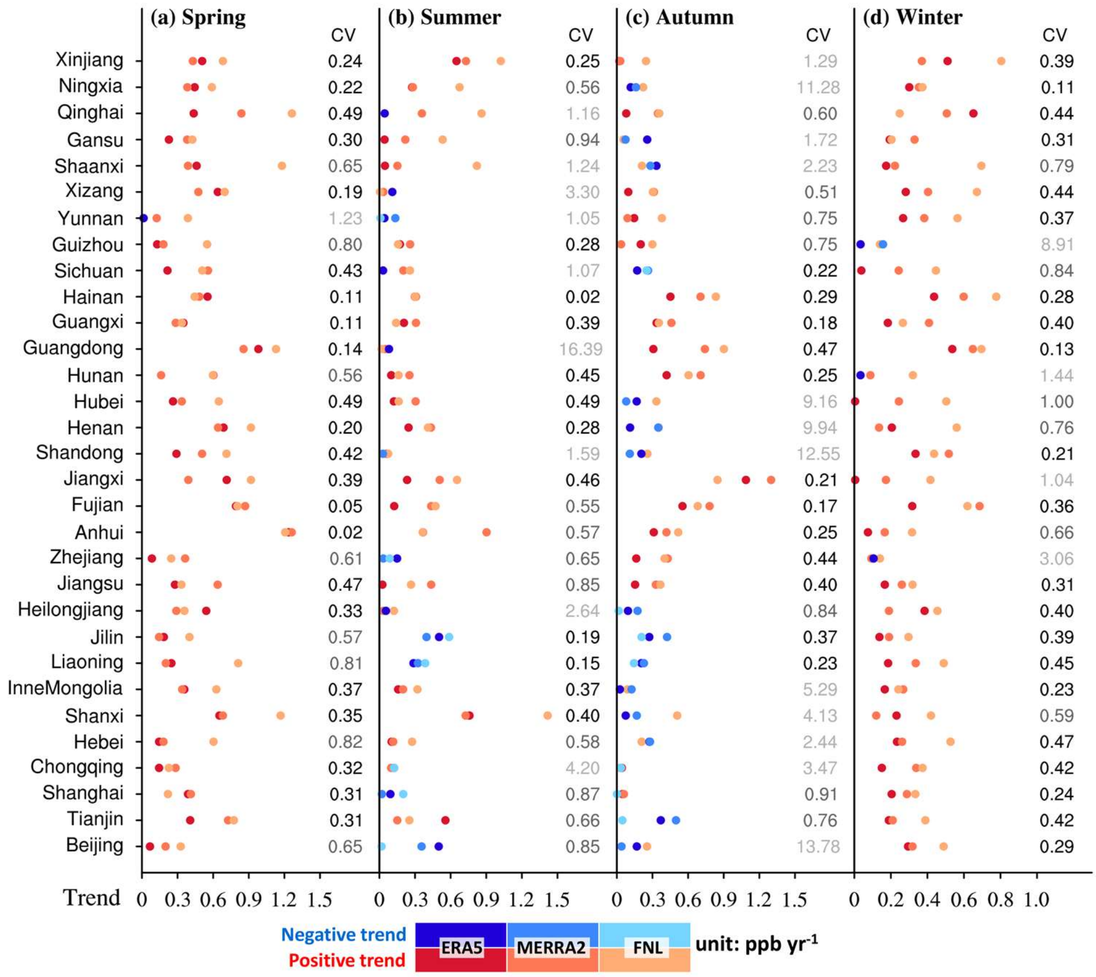


**Figure S6.** Trends in meteorology-driven MDA8 $O_3$ concentrations calculated by ERA5-, MERRA2-, and FNL-driven MLR models in China's 31 mainland provinces during (a) spring, (b) summer, (c) autumn, and (d) winter. Markers in red and blue represent the positive and negative trends, respectively. The absolute value of coefficient of variation (CV) are shown. The CV is calculated by the standard deviation of trends derived from ERA5-, MERRA2-, and FNL-driven MLR models divided by the mean. The darker colour means the lower uncertainty in quantifying the meteorological impact on observed $O_3$ trends.

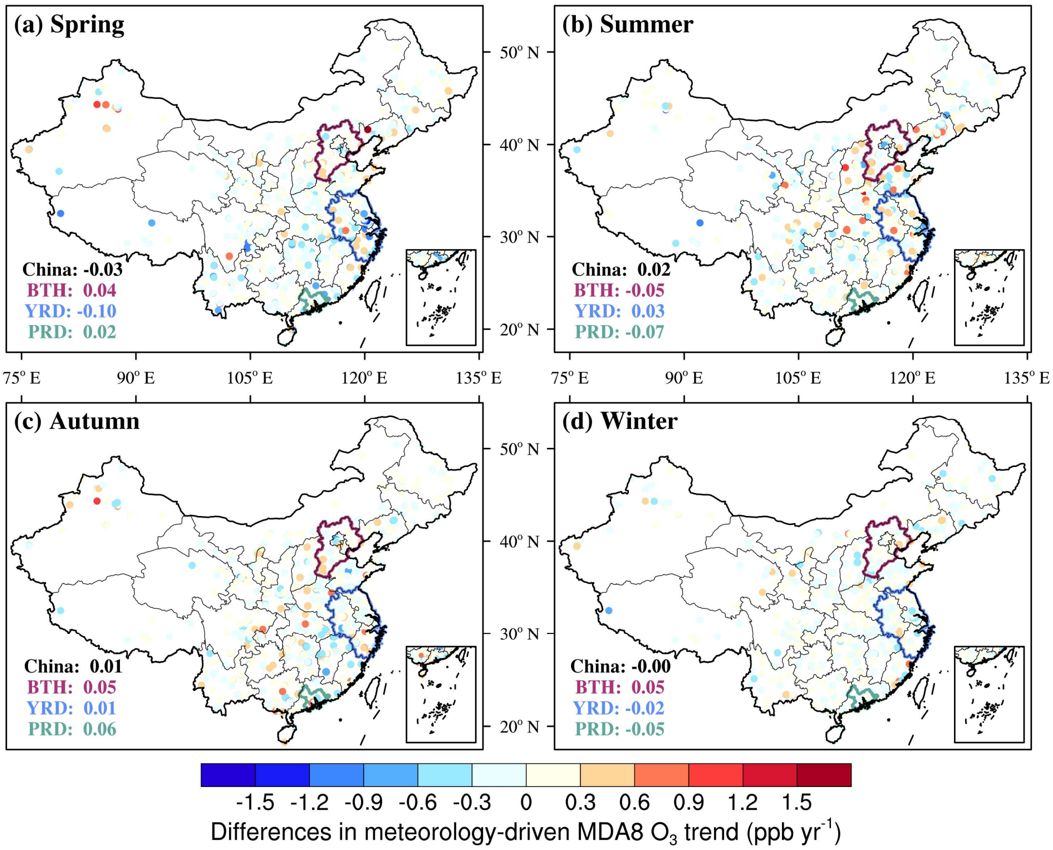


**Figure S7.** Differences between meteorology-driven MDA8 $O_3$ trends calculated by FNL- and FNL025-driven MLR model in China during (a) spring, (b) summer, (c) autumn, and (d) winter. Values in black, purple, blue, and green represent the average difference for the whole China, BTH, YRD, and PRD, respectively.

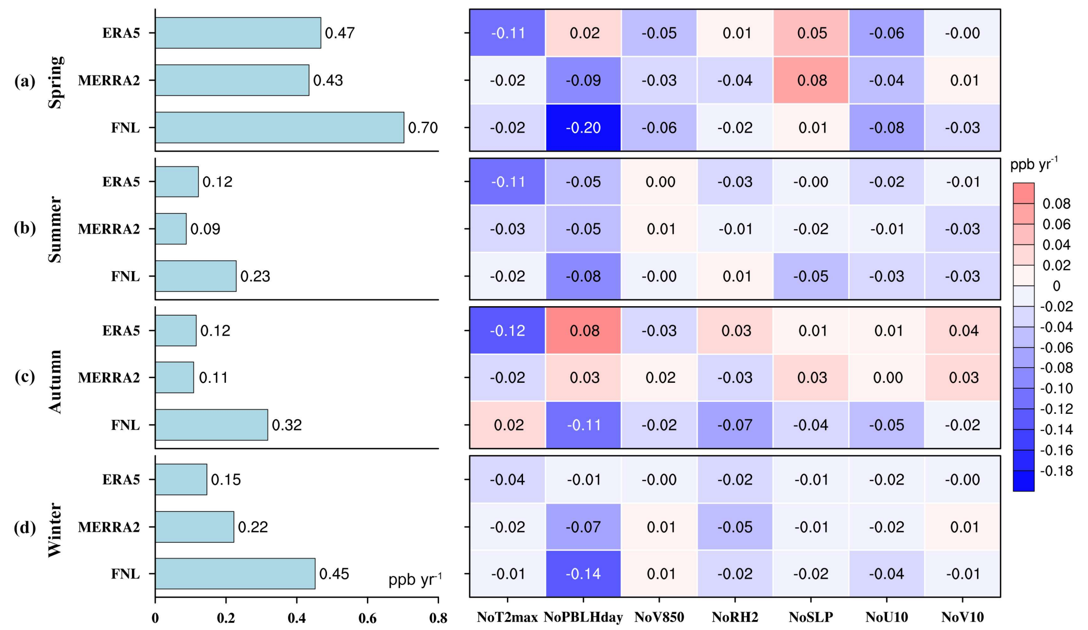


**Figure S8.** Construction of a multiple linear regression (MLR) model using seven common meteorological variables (i.e. T2max, PBLHday, V850, RH2, SLP, U10, V10) from ERA5, MERRA2, and FNL to quantify the meteorological influence on the MDA8 $O_3$ trends during (a) spring, (b) summer, (c) autumn, and (d) winter. Bars on the left represent the meteorology-driven $O_3$ trends derived from the three data-driven MLR models. The heatmap on the right represents the difference between the results obtained by constructing an MLR model after removing a certain meteorological variable in sequence.

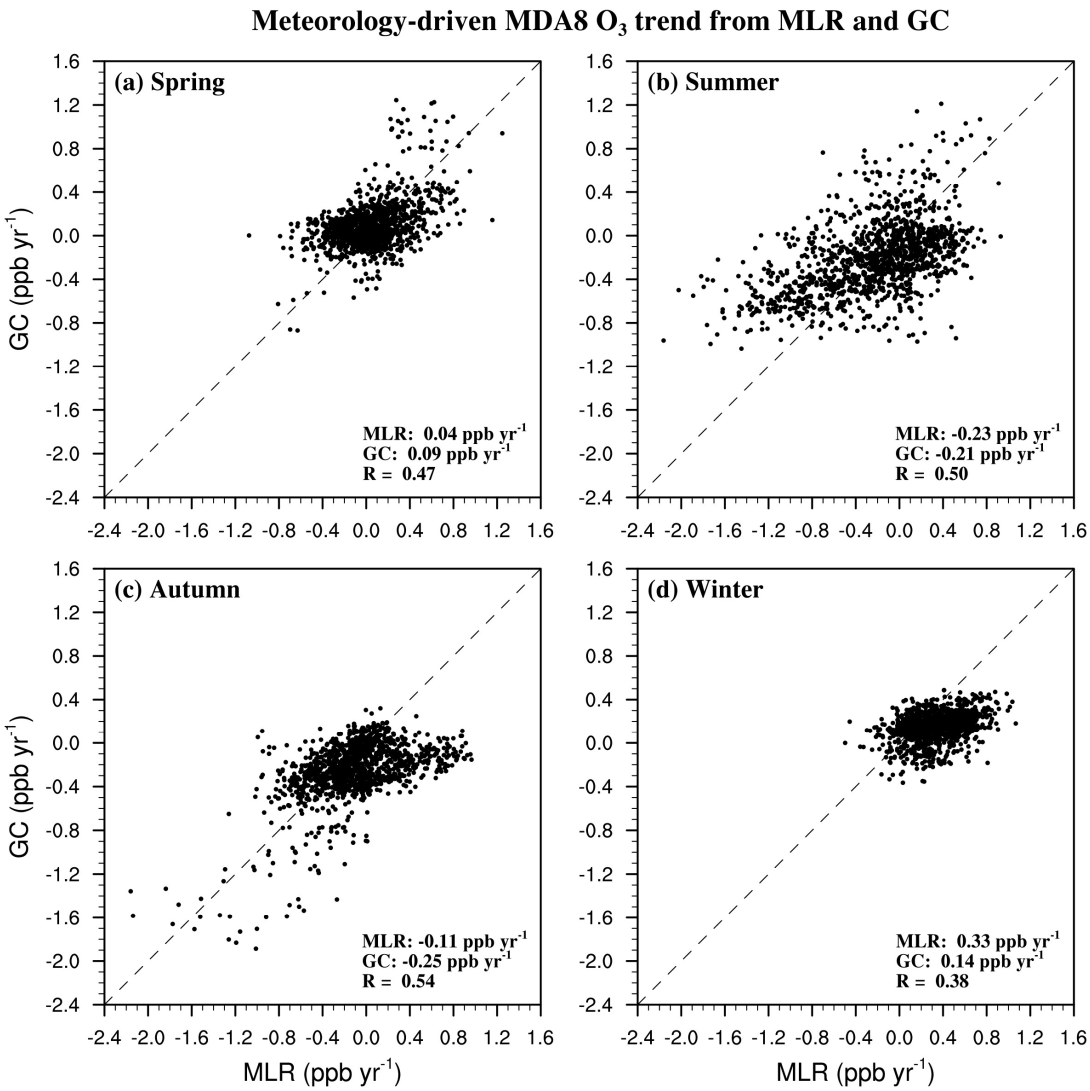


**Figure S9.** The comparison of meteorology-driven $O_3$ trends from the MERRA2-driven multiple linear regression (MLR) vs. GEOS-Chem (GC) model averaged over China for 2018–2022 during (a) spring, (b) summer, (c) autumn, and (d) winter. The dashed line is a 1:1 line. Coefficient of correlation (R) is also shown.

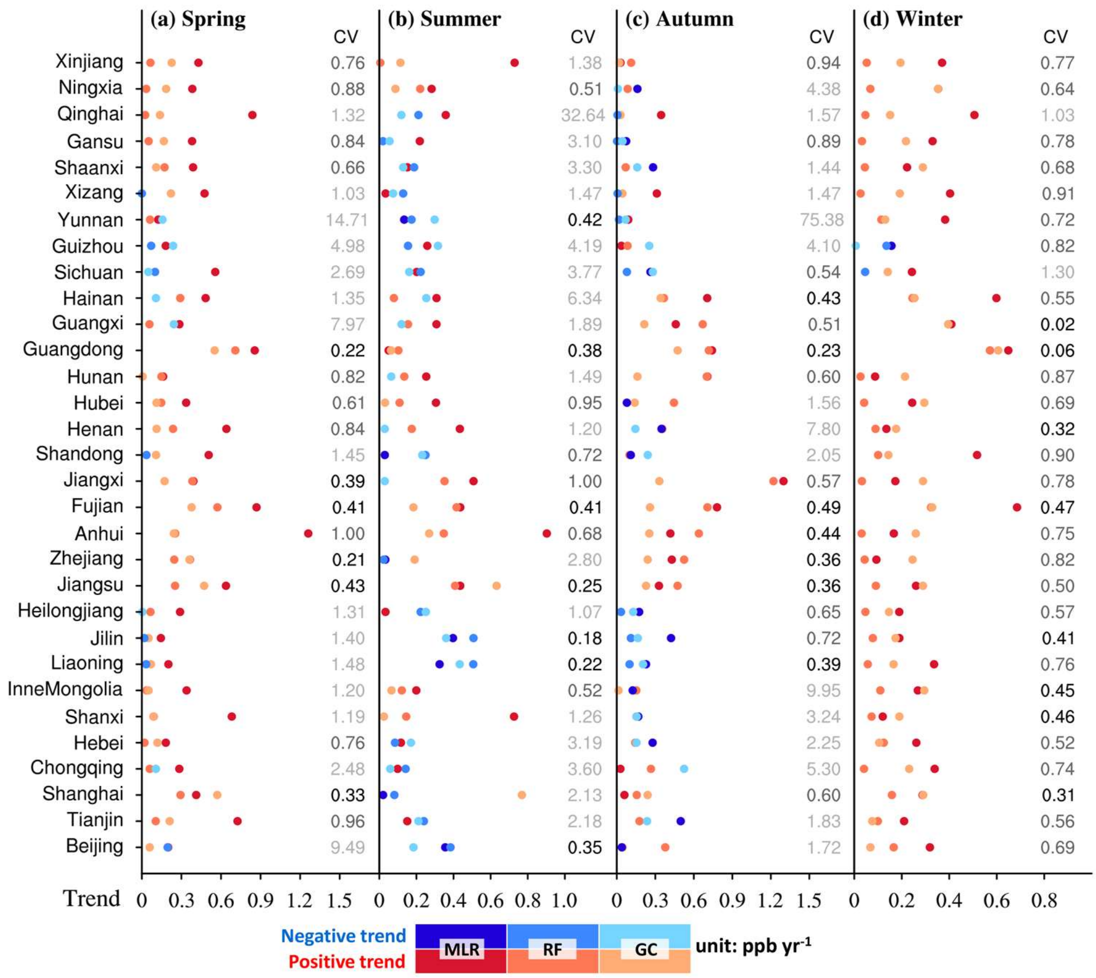


**Figure S10.** Trends in meteorology-driven MDA8 $O_3$ concentrations calculated by multiple linear regression (MLR), random forest (RF), and GEOS-Chem (GC) models in China's 31 mainland provinces during (a) spring, (b) summer, (c) autumn, and (d) winter. Markers in red and blue represent the positive and negative trends, respectively. The CV is calculated by the standard deviation of the trends derived from MLR, RF, and GC models divided by the mean. The darker colour means the lower uncertainty in quantifying the meteorological impact on observed $O_3$ trends.

**Table S1.** Reported studies using traditional statistical, machine learning, and chemical transport models to obtain the meteorological impact on surface $O_3$ in the past six years.

| Region/City | Study period [a] | Model | Meteorological data | Meteorological impact [b] | Reference |
|---|---|---|---|---|---|
| Shanghai | 2013–2017 | KZ | N/A | +0.75 μg $m^{-3}$ $yr^{-1}$ | Yu et al., 2019 |
| Tianjin | Spring, 2009–2015 | Generalized additive model | Site observation | –1.11 ppb $yr^{-1}$ | Yang et al., 2019a |
| | Summer, 2009–2015 | | | +0.12 ppb $yr^{-1}$ | |
| | Autumn, 2009–2015 | | | –0.99 ppb $yr^{-1}$ | |
| | Winter, 2009–2015 | | | +0.06 ppb $yr^{-1}$ | |
| PRD | 2007–2017 | KZ-MLR | ECMWF reanalysis | –0.8 μg $m^{-3}$ $yr^{-1}$ | Yang et al., 2019b |
| North China | Apr to Sept, 2013/2017 | WRF-CMAQ | N/A | +0.2±1.1 ppb | Ding et al., 2019 |
| Northeast China | | | | +0.3±0.8 ppb | |
| East China | | | | +2.0±1.7 ppb | |
| South China | | | | +0.5±1.5 ppb | |
| China | Summer, 2013/2014 | WRF-CMAQ | FNL | –3.2 ppb | Wang et al., 2019 |
| North China | | | | –8.7 ppb | |
| Northeast China | | | | –4.5 ppb | |
| East China | | | | –1.1 ppb | |
| South central China | | | | –1.5 ppb | |
| Southwest China | | | | –3.7 ppb | |
| Northwest China | | | | –1.6 ppb | |
| China | Summer, 2013/2015 | | | –1.8 ppb | |
| North China | | | | –2.4 ppb | |
| Northeast China | | | | –0.5 ppb | |
| East China | | | | –2.1 ppb | |
| South central China | | | | –4.2 ppb | |
| Southwest China | | | | +0.2 ppb | |
| Northwest China | | | | –0.9 ppb | |

| Region/City | Study period | Model | Meteorological data | Meteorological impact | Reference |
|---|---|---|---|---|---|
| Central eastern China | 2003/2015 | GEOS-Chem | MERRA2 | +3.2 ppb | Sun et al., 2019 |
| Eastern China | Summer, 2013–2018 | MLR | FNL | +0.5 μg $m^{-3}$ $yr^{-1}$ | Han et al., 2020 |
| BTH | | | | +0.7 μg $m^{-3}$ $yr^{-1}$ | |
| YRD | | | | +0.9 μg $m^{-3}$ $yr^{-1}$ | |
| PRD | | | | +0.7 μg $m^{-3}$ $yr^{-1}$ | |
| Eastern China | Summer, 2013–2019 | MLR | MERRA2 | +0.7 ppb $yr^{-1}$ | Li et al., 2020 |
| NCP | | | | +1.4 ppb $yr^{-1}$ | |
| YRD | | | | +0.7 ppb $yr^{-1}$ | |
| PRD | | | | +0.8 ppb $yr^{-1}$ | |
| SCB | | | | –0.2 ppb $yr^{-1}$ | |
| China | Summer, 2013–2017 | WRF-CMAQ | FNL | Meteorological changes dominated the changing rates of $O_3$. | Liu and Wang, 2020 |
| NCP | 2014–2018 | MLR | ERA-Interim | +0.7 μg $m^{-3}$ $yr^{-1}$ | Chen et al., 2020 |
| YRD | | | | +0.7 μg $m^{-3}$ $yr^{-1}$ | |
| FWP | | | | +0.8 μg $m^{-3}$ $yr^{-1}$ | |
| NCP | Spring, 2014–2018 | | | +0.5 μg $m^{-3}$ $yr^{-1}$ | |
| YRD | | | | +1.3 μg $m^{-3}$ $yr^{-1}$ | |
| FWP | | | | +1.1 μg $m^{-3}$ $yr^{-1}$ | |
| NCP | Summer, 2014–2018 | | | +0.8 μg $m^{-3}$ $yr^{-1}$ | |
| YRD | | | | +1.1 μg $m^{-3}$ $yr^{-1}$ | |
| FWP | | | | +0.8 μg $m^{-3}$ $yr^{-1}$ | |
| NCP | Autumn, 2014–2018 | | | +1.0 μg $m^{-3}$ $yr^{-1}$ | |
| YRD | | | | +0.8 μg $m^{-3}$ $yr^{-1}$ | |
| FWP | | | | +1.1 μg $m^{-3}$ $yr^{-1}$ | |

| Region/City | Study period | Model | Meteorological data | Meteorological impact | Reference |
|---|---|---|---|---|---|
| NCP<br>YRD<br>FWP | Winter, 2014–2018 | MLR | ERA-Interim | +0.7 μg $m^{-3}$ $yr^{-1}$<br>–0.5 μg $m^{-3}$ $yr^{-1}$<br>+0.1 μg $m^{-3}$ $yr^{-1}$ | Chen et al., 2020 |
| NCP<br>YRD | Summer, 2012–2017 | GEOS-Chem | MERRA2 | +0.28 ppb $yr^{-1}$<br>+1.47 ppb $yr^{-1}$ | Dang et al., 2021 |
| BTH<br>YRD<br>PRD<br>SCB | 2015–2019 | KZ-MLR | ERA5, FNL | +1.07 μg $m^{-3}$ $yr^{-1}$<br>+0.99 μg $m^{-3}$ $yr^{-1}$<br>+2.52 μg $m^{-3}$ $yr^{-1}$<br>–1.35 μg $m^{-3}$ $yr^{-1}$ | Mousavinezhad et al., 2021 |
| Shandong | Spring, 2013/2015<br>Spring, 2013/2017<br>Spring, 2013/2019<br>Summer, 2013/2015<br>Summer, 2013/2017<br>Summer, 2013/2019<br>Autumn, 2013/2015<br>Autumn, 2013/2017<br>Autumn, 2013/2019<br>Winter, 2013/2015<br>Winter, 2013/2017<br>Winter, 2013/2019 | WRF-Chem | FNL | +8.6%<br>+14.5%<br>+14.0%<br>–7.4%<br>–6.5%<br>–6.2%<br>+6.9%<br>+11.6%<br>+9.6%<br>–1.2%<br>–0.2%<br>–0.5% | Zhao et al., 2021 |
| SCB | May to Jun, 2019/2020 | GEOS-Chem<br>GEOS-Chem-XGBoost | GEOS-FP | 11.57 ppb<br>11.15 ppb | Sun et al., 2021 |
| Handan | Jun, 2013–2018 | WRF-CMAQ | FNL | +2.00 μg $m^{-3}$ $yr^{-1}$ | Yao et al., 2021 |

| Region/City | Study period | Model | Meteorological data | Meteorological impact | Reference |
| --- | --- | --- | --- | --- | --- |
| Eastern China | May to Aug, 2019/2020 | GEOS-Chem | GEOS-FP | –2.9 ppb | Yin et al., 2021 |
| BTH | | | | –1.4 ppb | |
| FWP | | | | –3.2 ppb | |
| YRD | | | | –3.2 ppb | |
| Eastern China | | GEOS-Chem-XGBoost | | –2.3 ppb | |
| BTH | | | | –2.2 ppb | |
| FWP | | | | –2.2 ppb | |
| YRD | | | | –2.7 ppb | |
| Eastern and central China | Summer, 2013/2020 | 4-D meteorology-pollution decomposition model | World Meteorological Organization | Meteorology reduced the $O_3$ concentrations. | Lin et al., 2021 |
| YRD | Apr to Sept, 2014–2018 | KZ-MLR | CMA | Meteorology decreased (increased) $O_3$ from 2014 to the middle of 2016 (from the middle of 2016 to 2018) | Gao et al., 2021a |
| Eastern China | May, Jul, Sept, Dec, 2013/2017 | WRF-Chem | FNL | –8.1 ~ +21.3 μg $m^{-3}$ | Li et al., 2021 |
| NCP | May 1st to Jun 10th, 2014–2019 | MLR | FNL | +1.8 ppb $yr^{-1}$ | Gao et al., 2021b |
| | Jun 11th to Jul 15th, 2014–2019 | | | +2.4 ppb $yr^{-1}$ | |
| | Jul 16th to Aug 31st, 2014–2019 | | | –0.4 ppb $yr^{-1}$ | |
| PRD (urban site) | 2006–2019 | MLR | ERA5 | –0.04 ppb $yr^{-1}$ | Li et al., 2022 |
| PRD (regional site) | | | | –0.11 ppb $yr^{-1}$ | |
| Beijing | 2013–2020 | MLR | CMA, ERA5 | +2.15 μg $m^{-3}$ $yr^{-1}$ | Gong et al., 2022 |

| Region/City | Study period | Model | Meteorological data | Meteorological impact | Reference |
|---|---|---|---|---|---|
| Beijing | 2015–2020 | KZ-MLR | National Climatic Data Center | +45% | Zhang et al., 2022 |
| Shenzhen | | | | +20% | |
| Wuhan | | | | +60% | |
| Nanjing | | | | +75% | |
| YRD | Summer, 2015–2019 | MLR | MERRA2 | +5.0 μg $m^{-3}$ $yr^{-1}$ | Qian et al., 2022 |
| Shanghai | | | | +1.0 μg $m^{-3}$ $yr^{-1}$ | |
| Nanjing | | | | +11.3 μg $m^{-3}$ $yr^{-1}$ | |
| Hangzhou | | | | +1.9 μg $m^{-3}$ $yr^{-1}$ | |
| Heifei | | | | +6.0 μg $m^{-3}$ $yr^{-1}$ | |
| BTH | Summer, 2015–2019 | RF | ERA5 | +0.74 ppb $yr^{-1}$ | Weng et al., 2022 |
| YRD | | | | +1.35 ppb $yr^{-1}$ | |
| PRD | | | | –0.75 ppb $yr^{-1}$ | |
| Sichuan | | | | –0.91 ppb $yr^{-1}$ | |
| BTH | | Ridge regression | | +0.54 ppb $yr^{-1}$ | |
| YRD | | | | +1.38 ppb $yr^{-1}$ | |
| PRD | | | | –1.13 ppb $yr^{-1}$ | |
| Sichuan | | | | –0.84 ppb $yr^{-1}$ | |
| BTH | | MLR | | +0.55 ppb $yr^{-1}$ | |
| YRD | | | | +1.42 ppb $yr^{-1}$ | |
| PRD | | | | –1.1 ppb $yr^{-1}$ | |
| Sichuan | | | | –0.86 ppb $yr^{-1}$ | |
| SCB | Apr to Aug, 2016/2019 | WRF-CMAQ | FNL | +6.4 μg $m^{-3}$ | Wu et al., 2022 |
| | Jun to Aug, 2019/2020 | | | –12.6 μg $m^{-3}$ | |
| Tianjin | 2015–2021 | Lowess and RF | CMA | +2.1 μg $m^{-3}$ $yr^{-1}$ | Ding et al., 2023 |

| Region/City | Study period | Model | Meteorological data | Meteorological impact | Reference |
|---|---|---|---|---|---|
| BTH | Summer, 2014–2021/2022 | RF | ERA5 | –0.02 ± 2.9 μg $m^{-3}$ | Zheng et al., 2023 |
| FWP | | | | +7.23 ± 5.97 μg $m^{-3}$ | |
| THB | | | | +3.63 ± 4.51 μg $m^{-3}$ | |
| PRD | | | | –1.81 ± 2.14 μg $m^{-3}$ | |
| SCB | | | | +12.24 ± 4.07 μg $m^{-3}$ | |
| YRD | | | | +10.92 ± 3.24 μg $m^{-3}$ | |
| Xiamen | 2015–2020 | KZ-MLR | ERA5 | +2.71 μg $m^{-3}$ $yr^{-1}$ | Ji et al., 2023 |
| Fuzhou | | | | +2.17 μg $m^{-3}$ $yr^{-1}$ | |
| Longyan | | | | +0.76 μg $m^{-3}$ $yr^{-1}$ | |
| Nanping | | | | +1.78 μg $m^{-3}$ $yr^{-1}$ | |
| Northeast China | 2013–2021 | KZ-MLR | ERA5 | +0.1688 μg $m^{-3}$ $yr^{-1}$ | Shang et al., 2023 |
| Liaoning | | | | –0.0864 μg $m^{-3}$ $yr^{-1}$ | |
| Jilin | | | | +0.093 μg $m^{-3}$ $yr^{-1}$ | |
| Heilongjiang | | | | +0.5562 μg $m^{-3}$ $yr^{-1}$ | |
| Eastern China | Apr to Sept, 2013/2020 | WRF-CMAQ | FNL | +3.60 μg $m^{-3}$ | Liu et al., 2023 |
| BTH | | | | +3.95 μg $m^{-3}$ | |
| YRD | | | | +3.91 μg $m^{-3}$ | |
| FWP | | | | +7.75 μg $m^{-3}$ | |
| Beijing | 2013–2020 | Observation-based model | CMA | +0.52 ppb $yr^{-1}$ | Pan et al., 2023 |
| Chengdu | | | | +0.57 ppb $yr^{-1}$ | |
| Guangzhou | | | | +0.59 ppb $yr^{-1}$ | |
| Shanghai | | | | +0.62 ppb $yr^{-1}$ | |
| NCP | May to Aug, 2008/2009–2013 | RegCM-Chem-YIBs | N/A | –0.88 ppb | Ma et al., 2023 |
| FWP | | | | –1.41 ppb | |
| YRD | | | | –1.03 ppb | |

| Region/City | Study period | Model | Meteorological data | Meteorological impact | Reference |
| --- | --- | --- | --- | --- | --- |
| PRD | May to Aug, 2008/2009–2013 | RegCM-Chem-YIBs | N/A | –0.23 ppb | Ma et al., 2023 |
| SCB | | | | –0.41 ppb | |
| NCP | May to Aug, 2008/2014–2018 | | | –0.04 ppb | |
| FWP | | | | –0.09 ppb | |
| YRD | | | | –0.96 ppb | |
| PRD | | | | –1.08 ppb | |
| SCB | | | | +0.71 ppb | |
| NCP | Summer, 2015–2019 | GEOS-Chem | MERRA2 | +0.26 ppb $yr^{-1}$ | Wang et al., 2024 |
| | | XGBoost | | +0.19 ppb $yr^{-1}$ | |
| | | Deep learning model | | +0.14 ppb $yr^{-1}$ | |
| | Summer, 2019–2021 | GEOS-Chem | | –0.74 ppb $yr^{-1}$ | |
| | | XGBoost | | –1.55 ppb $yr^{-1}$ | |
| | | Deep learning model | | –1.74 ppb $yr^{-1}$ | |
| China | 2015–2022 | KZ-XGBoost | ERA5 | Meteorology increased $O_3$. | Yao et al., 2024 |
| Eastern China | 2019/2021 | GEOS-Chem | MERRA2 | –7.3 μg $m^{-3}$ | Ni et al., 2024 |
| | | LightGBM | | –6.8 μg $m^{-3}$ | |
| BTH | 2015–2022 | XGBoost | ERA5 | Meteorology led a slight $O_3$ increase. | Luo et al., 2024 |
| | Spring, 2015–2022<br>Summer, 2015–2022<br>Autumn, 2015–2022<br>Winter, 2015–2022 | | | Meteorology increased $O_3$ by 8.2 μg $m^{-3}$/0.01 μg $m^{-3}$/2.7 μg $m^{-3}$ in spring/summer/winter, and decreased $O_3$ by –0.3 μg $m^{-3}$ in autumn. | |
| China | Summer, 2013–2022 | MLR | ERA5 | +0.2 μg $m^{-3}$ $yr^{-1}$ | Yan et al., 2024 |
| BTH | Summer, 2013–2019 | | | +0.9 μg $m^{-3}$ $yr^{-1}$ | |
| YRD | | | | –0.3 μg $m^{-3}$ $yr^{-1}$ | |

| Region/City | Study period | Model | Meteorological data | Meteorological impact | Reference |
|---|---|---|---|---|---|
| BTH | Summer, 2019–2021 | MLR | ERA5 | –3.9 μg $m^{-3}$ $yr^{-1}$ | Yan et al., 2024 |
| YRD | Summer, 2019–2021 | MLR | ERA5 | –4.1 μg $m^{-3}$ $yr^{-1}$ | Yan et al., 2024 |
| BTH | Summer, 2021–2022 | MLR | ERA5 | +4.3 μg $m^{-3}$ $yr^{-1}$ | Yan et al., 2024 |
| YRD | Summer, 2021–2022 | MLR | ERA5 | +10.4 μg $m^{-3}$ $yr^{-1}$ | Yan et al., 2024 |
| YRD | 2016–2023 | KZ-MLR | ERA5 | Meteorology decreased (increased) $O_3$ in 2016, 2020, 2021, 2023 (2017–2019, 2022). | Hu et al., 2024 |
| YRD | Spring, 2016–2023 | KZ-MLR | ERA5 | Meteorology decreased (increased) $O_3$ in 2016, 2018, 2021, 2023 (2017, 2019, 2020, 2022). | Hu et al., 2024 |
| YRD | Summer, 2016–2023 | KZ-MLR | ERA5 | Meteorology decreased (increased) $O_3$ in 2020, 2021, 2023 (2016–2019, 2022). | Hu et al., 2024 |
| YRD | Autumn, 2016–2023 | KZ-MLR | ERA5 | Meteorology decreased (increased) $O_3$ in 2016–2017 (2018–2023). | Hu et al., 2024 |
| YRD | Winter, 2016–2023 | KZ-MLR | ERA5 | Meteorology decreased (increased)$O_3$ in 2018–2020, 2022 (2016, 2017, 2021, 2023). | Hu et al., 2024 |
| YRD | Spring, 2014/2020 | WRF-Chem | FNL | –0.89 ppb | Li et al., 2024 |
| YRD | Summer, 2014/2020 | WRF-Chem | FNL | +0.23 ppb | Li et al., 2024 |
| YRD | Autumn, 2014/2020 | WRF-Chem | FNL | –2.74 ppb | Li et al., 2024 |
| YRD | Winter, 2014/2020 | WRF-Chem | FNL | –3.86 ppb | Li et al., 2024 |
| PRD | Spring, 2013–2022 | MLR | ERA5 | +0.88 ppb $yr^{-1}$ | Cao et al., 2024 |
| YRD | 2015–2022 | KZ-MLR | ERA5 | The meteorological impacts account for an average of 71.8% of $O_3$ | Wu and An, 2025 |

[a] Symbol "–" means the continuous study period from the start year to the end year (left of –) to the end year (right of –); Symbol "/" means the discrete study period.

[b] The meteorological impact expressed by ppb $yr^{-1}$ or μg $m^{-3}$ $yr^{-1}$ means the trend from the start to end year of the study period. Meteorological impact expressed by ppb, μg $m^{-3}$ or % means the difference between the end year and start year (end year – start year).

**Table S2.** Summary of the meteorological variables from the ERA5, MERRA2, FNL and FNL025 reanalysis dataset used to establish MLR models.

| Abbreviations | Description | Meteorological Dataset |
|---|---|---|
| SLP | Daily mean sea level pressure (hPa) | ERA5, MERRA2, FNL, FNL025 |
| TCCday | Total cloud area fraction (%) averaged over 08:00 to 17:00 LT | ERA5, MERRA2 |
| PBLHday | Planetary boundary layer height (m) averaged over 08:00 to 17:00 LT | ERA5, MERRA2, FNL, FNL025 |
| U10 | Daily mean 10-meter eastward wind (m $s^{-1}$) | ERA5, MERRA2, FNL, FNL025 |
| V10 | Daily mean 10-meter northward wind (m $s^{-1}$) | ERA5, MERRA2, FNL, FNL025 |
| T2max | Daily maximum 2-meter air temperature (°C) | ERA5, MERRA2, FNL, FNL025 |
| SSRDday | Surface incoming shortwave flux (W $m^{-2}$) averaged over 08:00 to 17:00 LT | ERA5, MERRA2 |
| TP | Total precipitation (mm $day^{-1}$) | ERA5, MERRA2 |
| PWAT | Daily mean precipitable water considered as a single layer (mm) | FNL, FNL025 |
| RH2 | Daily mean 2-meter relative humidity (%) | ERA5, MERRA2, FNL, FNL025 |
| V850 | Daily mean northward wind at 850 hPa (m $s^{-1}$) | ERA5, MERRA2, FNL, FNL025 |

**Table S3.** The 10-year trend in each meteorological factor used to establish MLR models from the ERA5, MERRA2, and FNL during four seasons.

| Season | Dataset | RH2 (% $yr^{-1}$) | U10 (m $s^{-1}$ $yr^{-1}$) | V10 (m $s^{-1}$ $yr^{-1}$) | SSRDday (W $m^{-2}$ $yr^{-1}$) | PBLHday (m $yr^{-1}$) | TCCday (% $yr^{-1}$) | TP (mm $day^{-1}$ $yr^{-1}$) or PWAT (mm $yr^{-1}$) | SLP (hPa $yr^{-1}$) | T2max (°C $yr^{-1}$) | V850 (m $s^{-1}$ $yr^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spring | ERA5 | +0.08 | +0.01 | –0.00 | +0.68 | +3.89 | +0.00 | –0.02 | –0.02 | +0.18 | –0.01 |
| | MERRA2 | +0.33 | +0.01 | –0.00 | +1.59 | +5.54 | +0.24 | +0.02 | –0.08 | +0.16 | +0.00 |
| | FNL | +0.12 | +0.01 | –0.01 | / | +14.44 | / | +0.20 | –0.09 | +0.12 | –0.01 |
| Summer | ERA5 | +0.18 | –0.00 | +0.01 | –0.72 | –2.10 | +0.18 | +0.03 | +0.02 | +0.08 | +0.03 |
| | MERRA2 | +0.35 | +0.00 | +0.03 | +1.11 | –6.95 | +0.29 | –0.03 | –0.04 | +0.04 | +0.05 |
| | FNL | +0.29 | –0.00 | +0.01 | / | +4.96 | / | +0.23 | –0.08 | –0.01 | +0.05 |
| Autumn | ERA5 | –0.17 | +0.01 | –0.02 | –1.62 | +0.04 | –0.21 | –0.04 | +0.21 | –0.10 | –0.05 |
| | MERRA2 | +0.11 | +0.00 | –0.03 | –0.99 | –2.52 | –0.17 | –0.06 | +0.17 | –0.12 | –0.04 |
| | FNL | –0.29 | +0.00 | –0.03 | / | +6.66 | / | –0.15 | +0.13 | –0.16 | –0.05 |
| Winter | ERA5 | +0.07 | +0.00 | –0.00 | –0.03 | +2.71 | +0.41 | +0.00 | +0.04 | +0.02 | +0.03 |
| | MERRA2 | +0.36 | –0.01 | –0.01 | +0.68 | +5.29 | +0.31 | +0.01 | +0.00 | +0.04 | +0.04 |
| | FNL | +0.15 | –0.01 | –0.01 | / | +8.68 | / | +0.12 | –0.03 | +0.01 | +0.03 |

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