Evaluating the efficacy of autumn-winter emission controls in the Beijing-Tianjin-Hebei region

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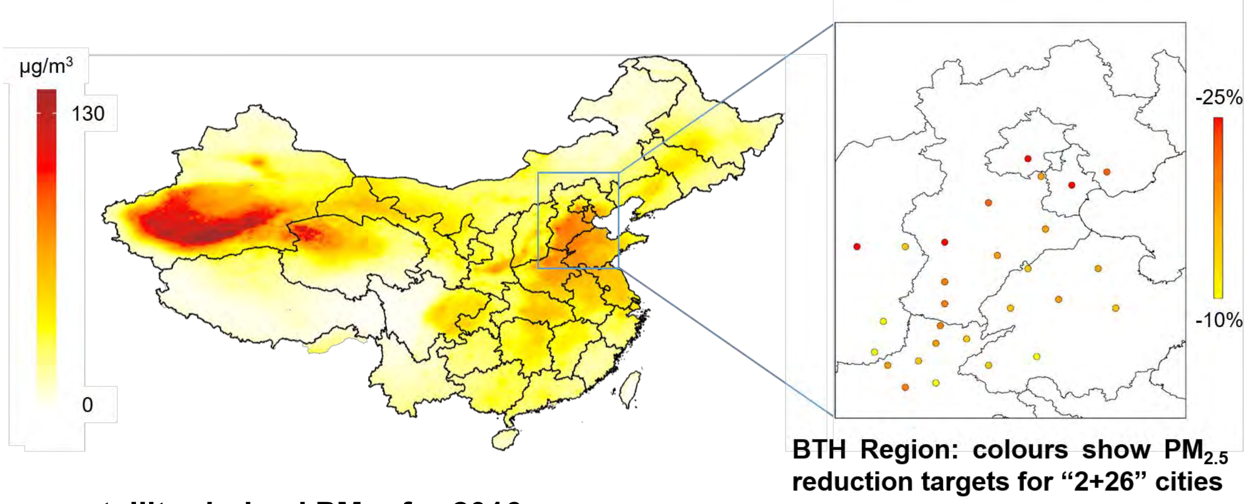
Introduction

The Beijing-Tianjin-Hebei (BTH) region experiences severely degraded air quality in autumn-winter due to anthropogenic emissions from various sources. In autumn-winter 2017-2018 (AW2017), strict 10-25% $PM_{2.5}$ reduction targets were imposed in 28 ("2+26") cities to address poor air quality.

Here we use surface observations of air pollutants from the China National Environmental Monitoring Network and the GEOS-Chem model to assess the efficacy of these short-term pollution controls and test the skill of satellite observations in detecting changes in air quality.

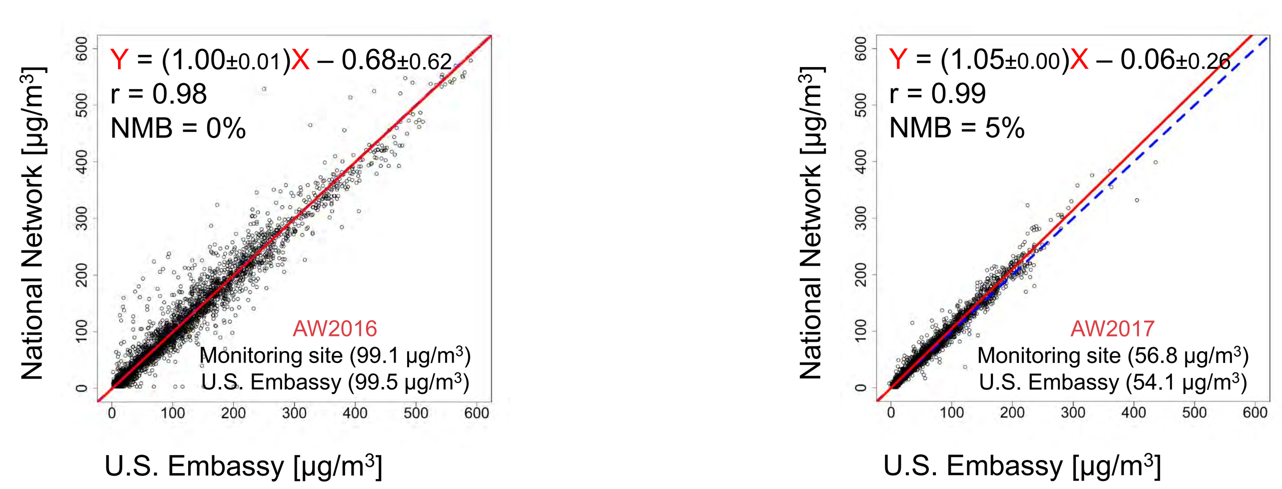


Annual mean satellite-derived $PM_{2.5}$ for 2016
Data source: http://fizz.phys.dal.ca/~atmos/martin/

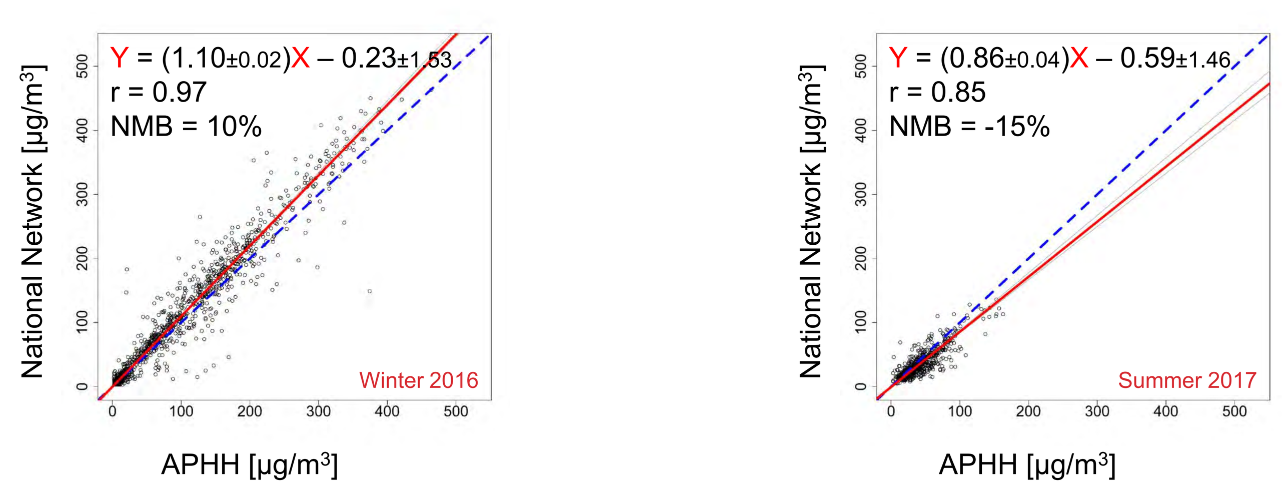
BTH Region: colours show $PM_{2.5}$ reduction targets for "2+26" cities

Validation of China National Environmental Monitoring Network

Comparisons of $PM_{2.5}$ from U.S. Embassy in Beijing and the closest (~ 2 km) national network site



Comparisons of $PM_{2.5}$ from APHH field campaign and the closest (~ 2.5 km) national network site

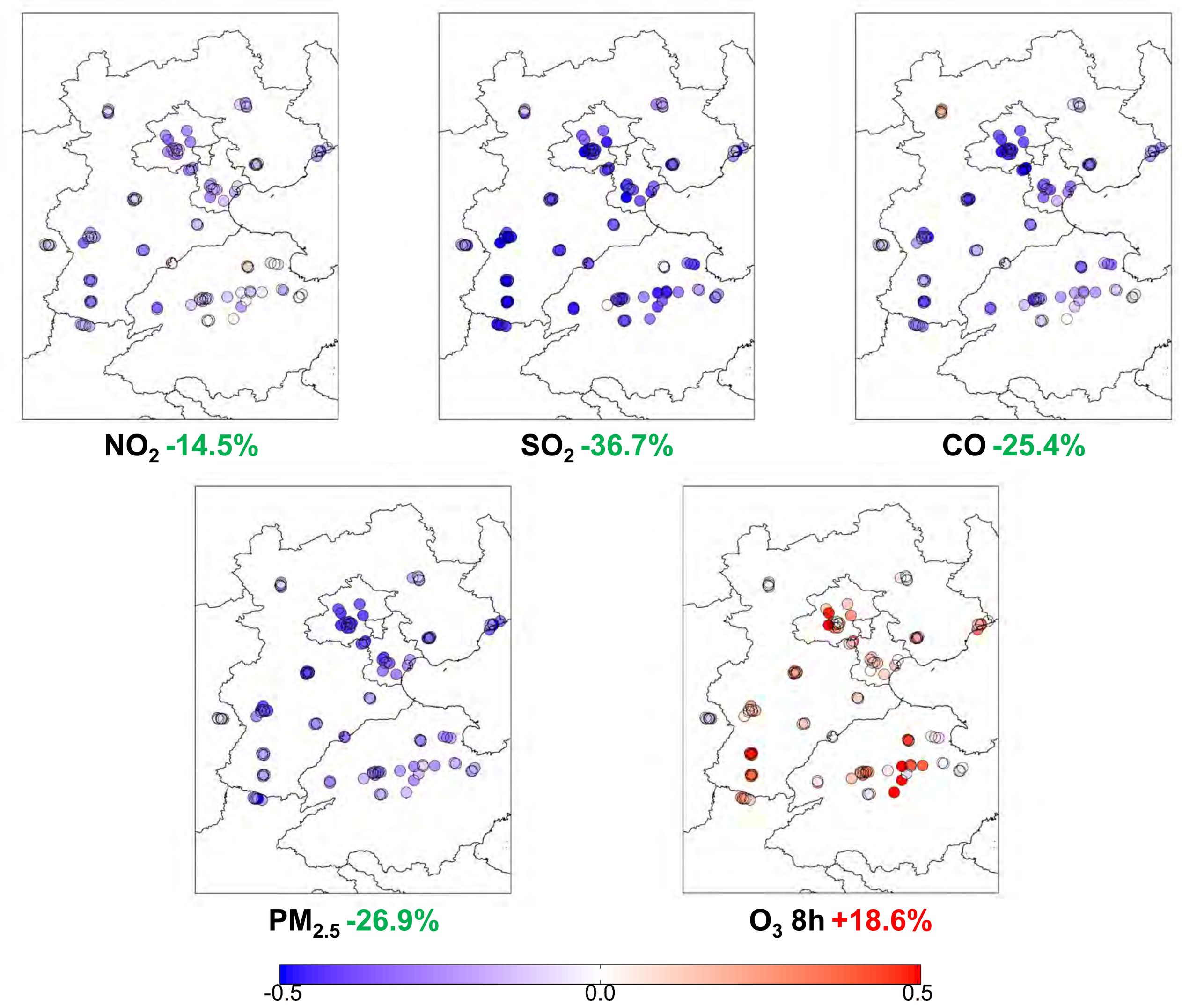


In autumn-winter, hourly observations of $PM_{2.5}$ from the China National Environmental Monitoring Network are consistent (r > 0.95) with independent measurements from the U.S. Embassy in Beijing and the Atmospheric Pollution & Human Health (APHH) China programme. Decline in $PM_{2.5}$ from 2016 to 2017 of 42.3-45.3 μg/m³ (43.7-45.6%) is consistent between the U.S. Embassy and its closest national monitoring site.

Changes in surface air quality

Compare surface observations of air pollutants in autumn-winter 2016-2017 (AW2016) and autumn-winter 2017-2018 (AW2017).

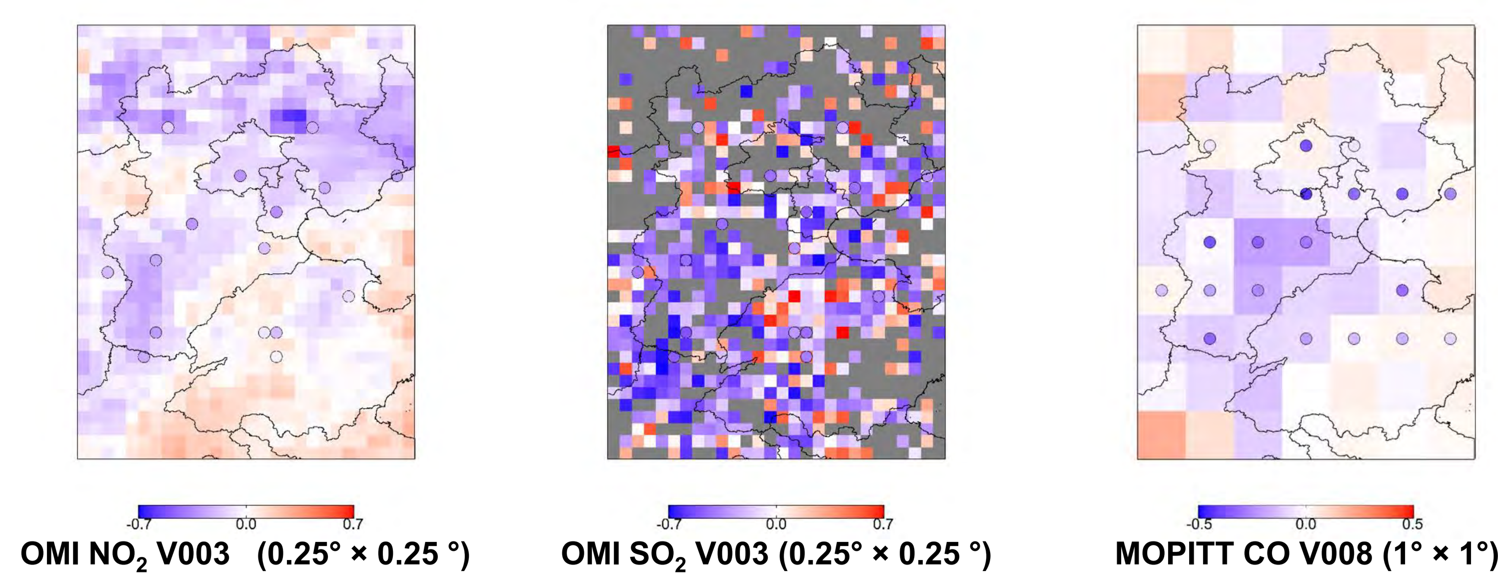
Relative changes in surface observations of air quality. Values inset are domain means.



- **Strict emission controls may have decreased air pollutants by 15% for NO_2, 37% for SO_2, 25% for CO, and 27% for $PM_{2.5}$.**
- **Ozone increases by 19% due to a decrease in NO_x and likely also an increase in VOCs (Li et al., 2019;Shen et al., 2019).**

Changes in satellite observations of air quality

Relative changes in satellite observations of NO_2, SO_2 and CO

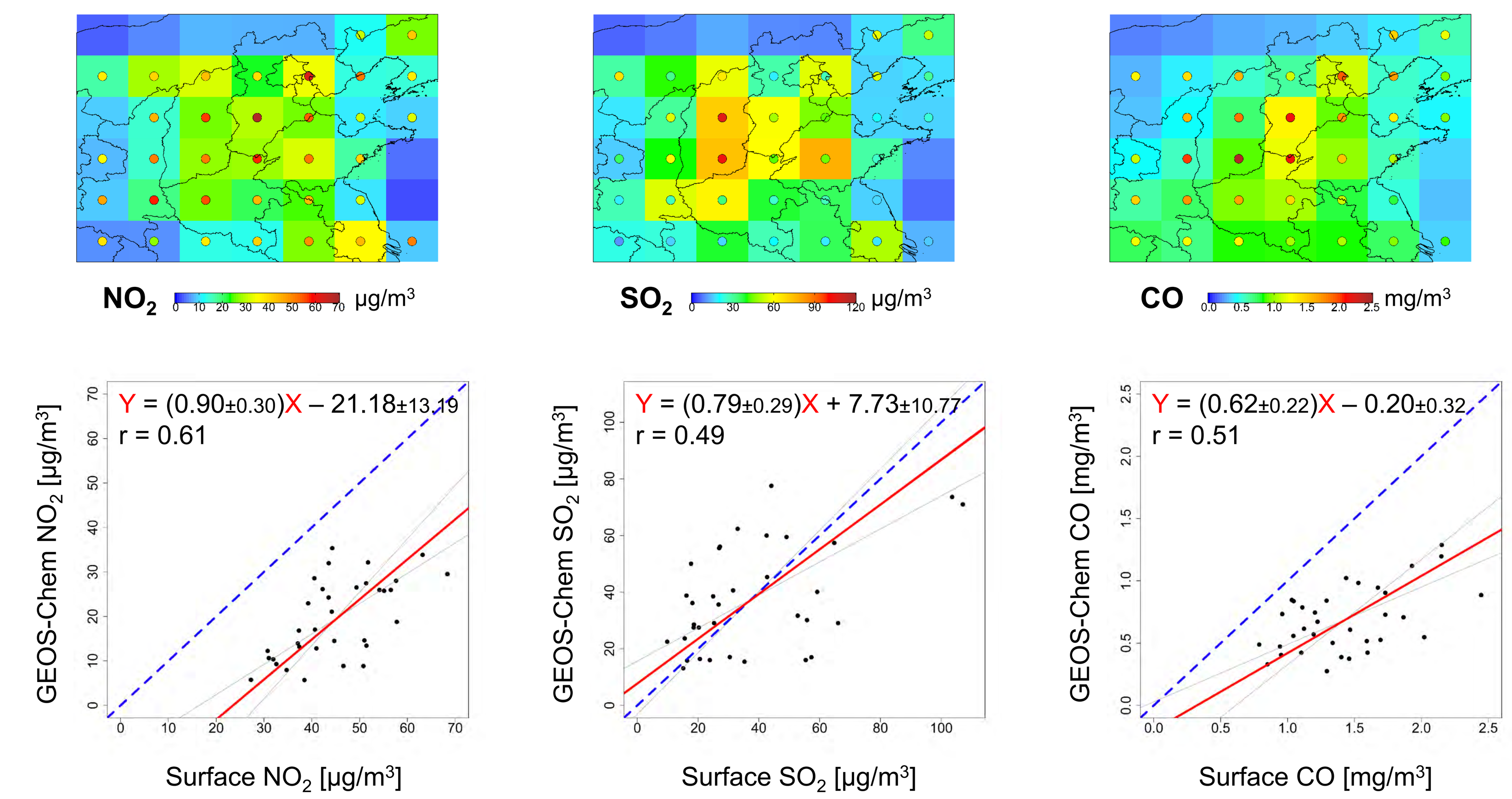


Compare changes in satellite observations of tropospheric NO_2, planetary boundary layer SO_2, and surface CO. NO_2 and SO_2 are from the Ozone Monitoring Instrument (OMI), and CO is from the Measurements of Pollution in the Troposphere (MOPITT).

- **Satellite SO_2 observations are too noisy to yield meaningful results.**
- **Satellite NO_2 and CO show smaller reductions than the re-gridded surface observations averaged around the satellite overpass times. ($\Delta NO_{2\_Satellite}$ = -9.6%, $\Delta NO_{2\_Surface}$ = -21.8%, r = 0.42) ($\Delta CO_{\_Satellite}$ = -4.2%, $\Delta CO_{\_Surface}$ = -24.7%, r = 0.34)**

Initial assessment of GEOS-Chem over China

Comparisons of GEOS-Chem with surface observations for AW2016



GEOS-Chem version: 12.0.0
Meteorological fields: GEOS-FP (47-layers)
Spatial resolution: 2° × 2.5°
Emission inventory: MIX v1.1 (baseline year: 2010)
Simulation time: Oct 2016 to Mar 2017

- **Scaling factors required to reproduce conditions in 2016/2017: increase NO_x emissions by 10% and CO emissions by 38% (assumes primary sources are the cause for the bias).**
- **Analysis suggests no temporal scaling needed for SO_x emissions, but spatial agreement is low (r < 0.5).**
- **Next step will be to conduct the same analysis with the model nested over China at high spatial resolution.**

Next Steps

- **Use additional satellite observations to assess changes in surface pollution: IASI NH_3, OMI HCHO for VOCs, and AOD for aerosols.**
- **Use GEOS-Chem nested China model to estimate the change in emissions due to aggressive air quality policies in the BTH region.**

References

Li, M., et al. (2019). Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-125
Shen, L., et al. (2019). Geophys.Res.Lett., 46. https://doi.org/10.1029/2019GL082172

Data Sources

China National Environmental Monitoring Network Data: https://beijingair.sinaapp.com/
U.S. Embassy $PM_{2.5}$ Historical Data (Beijing): https://openaq.org/#/location/Beijing%20US%20Embassy?_k=lupud9
OMI NO_2 Data (OMNO2d): https://disc.gsfc.nasa.gov/datasets/OMNO2d_V003/summary
OMI SO_2 Data (OMSO2e): https://disc.gsfc.nasa.gov/datasets/OMSO2e_V003/summary
MOPITT CO Data (V008 TIR-NIR): https://www2.acom.ucar.edu/mopitt/products