Co-occurrence of high $O_3$ and $PM_{2.5}$ concentrations in the Yangtze River Delta (YRD) region from 2015 to 2018

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Current O$_3$ and PM$_{2.5}$ pollution in China

The 95th percentile of MDA8 O$_3$ in 2018

The 95th percentile of PM$_{2.5}$ in 2018

National air standard:

O$_3$: MDA8 O$_3$ > 160 μg·m$^{-3}$ (~ 80 ppbv)
PM$_{2.5}$: daily PM$_{2.5}$ > 75 μg·m$^{-3}$

YRD is experiencing serious pollution due to local emissions, BVOC emissions, and pollution transport from the North China Plain.
Observed changes of PM$_{2.5}$ and MDA8 O$_3$ in YRD

2015

2016

2017

2018

PM$_{2.5}$

MDA8 O$_3$

μg·m$^{-3}$

35 40 45 50 55 60 65 70 75

μg·m$^{-3}$

50 60 70 80 90 100 110 120 130

Graph showing changes in PM$_{2.5}$ and MDA8 O$_3$ from 2015 to 2018.
Scientific questions

- Did high PM$_{2.5}$ and MDA8 O$_3$ occur simultaneously and how often they co-occurred?

- What were the meteorology conditions that led to co-occurrence of high PM$_{2.5}$ and MDA8 O$_3$?
### Data and methods

#### Observational data

**Observed hourly PM$_{2.5}$ and O$_3$**

**Sites:** 25 cities in the Yangtze River Delta  
**Time period:** 2015-2018  
**Data Sources:** National air quality monitoring network of China [http://www.cnemc.cn/](http://www.cnemc.cn/)

#### GEOS-CHEM, V11-01

**MERRA2 nested Asia simulation**  
**Time period:** 2015-2017  
**Emission:** MEIC  
**Resolution:** 0.5° x 0.625°

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**Definition of deviation of concentration of MDA8 O$_3$ (or PM$_{2.5}$)**

\[
DC_{mi} = C_{mi} - \sum_{i=1}^{n} \frac{C_{mi}}{n}
\]

- $C_{mi}$ is the concentration on day $i$ in month $m$,  
- $n$ is the number of days in this month $m$,  
- $\sum_{i=1}^{n} \frac{C_{mi}}{n}$ is the average concentration of month $m$.

**DC MDA8 O$_3$ (PM$_{2.5}$) >0** indicates:  
MDA8 O$_3$ (PM$_{2.5}$) is higher relative to the average of this month.

**DC MDA8 O$_3$ (PM$_{2.5}$) <0** indicates:  
MDA8 O$_3$ (PM$_{2.5}$) is lower relative to the average of this month.
When O$_3$ deviation increased, the percentage of days with positive PM$_{2.5}$ deviation increased in 25 cities of YRD;

when O$_3$ deviations were above 40 $\mu$g·m$^{-3}$, the percentage of days with positive PM$_{2.5}$ deviation reached 91%.
Number of days in 2015-2017 with the co-occurrence of high MDA8 O$_3$ and PM$_{2.5}$

National air quality standard:
- O$_3$ : MDA8 O$_3$ > 160 μg·m$^{-3}$ (~80 ppbv)
- PM$_{2.5}$ : Daily average PM$_{2.5}$ > 35 μg·m$^{-3}$

National air quality standard:
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Relative humidity (RH) associated with different levels of $\text{PM}_{2.5}$ deviation and $\text{O}_3$ deviation

The $\text{O}_3$ deviations > 40 $\mu\text{g} \cdot \text{m}^{-3}$ and the $\text{PM}_{2.5}$ deviations > 60 $\mu\text{g} \cdot \text{m}^{-3}$

The $\text{O}_3$ deviations > 40 $\mu\text{g} \cdot \text{m}^{-3}$ and the $\text{PM}_{2.5}$ deviations < -20 $\mu\text{g} \cdot \text{m}^{-3}$
Simulated daily MDA8 O₃ and PM₂.₅ for 2015 - 2017

- Well performed day-to-day variation with R above 0.5 in the Yangtze River Delta (YRD)
- Underestimate maximum values
Percentage of days with positive PM$_{2.5}$ deviation days when O$_3$ deviation > 0

From observation (2015-2018)
Different levels of positive O$_3$ deviation

Different levels of positive O$_3$ deviation
The number of days of the co-occurrence of high MDA8 O₃ and PM₂.₅

- **Threshold:**
  - PM₂.₅ > 35 μg·m⁻³ (30 μg·m⁻³)
  - MDA8 O₃ > 160 μg·m⁻³

- **Threshold:**
  - PM₂.₅ > 75 μg·m⁻³ (65 μg·m⁻³)
  - MDA8 O₃ > 160 μg·m⁻³

( PM₂.₅ NMB: -13.2% )
With the increase of MDA8 O₃ deviation, the percentage of days with positive PM₂.₅ deviation days are rising, up to 91%. Co-occurrence of high MDA8 O₃ and PM₂.₅ are most serious in the eastern cities of the YRD, with a maximum of 141 days from 2015 to 2017.

When MDA8 O₃ deviation > 0, the RH (when PM₂.₅ deviation > 0) are higher than the RH (when PM₂.₅ deviation < 0). High RH (63 - 80%) leads to the co-occurrence of high PM₂.₅ and MDA8 O₃.

Model can well capture the trend of the deviation, but underestimate the absolute value (the number of days of co-pollution).
THANKS