The 9th International GEOS-Chem Meeting (IGC9)

The effect of emission control measures on ozone concentration in Hangzhou during G20 meeting in 2016

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Current status of O₃ pollution in China

Ke Li et al., PNAS, 2018

National standard: MDA8 O₃ > 160 μg m⁻³ (≈ 80 ppbv)
Observed air pollutants in Hangzhou during G20 under emission control

G20: 4-5 September, 2016
Period of emission control: 24 August to 6 September, 2016
Scientific questions

- Did emission control measures carried out during G20 reduce $O_3$ effectively?
- Is it necessary to implement district-joint control measures?
- How sensitive is $O_3$ concentration to emission reductions in different sectors?
### Areas in YRD under emission control

CRA: Core area  
SCA: Strictly controlled area  
CA (ZJ): Controlled area in Zhejiang province  
CA (YRD): Controlled area in YRD

### Emission reductions by sectors during G20

<table>
<thead>
<tr>
<th>Periods</th>
<th>Sectors</th>
<th>CRA</th>
<th>SCA</th>
<th>CA (ZJ)</th>
<th>CA (YRD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Emission</td>
<td>Reduction</td>
<td>Emission</td>
<td>Reduction</td>
<td>Emission</td>
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<tr>
<td></td>
<td>NOx (kt)</td>
<td>NOx (ktC)</td>
<td>NOx (kt)</td>
<td>NOx (ktC)</td>
<td>NOx (kt)</td>
</tr>
<tr>
<td>8/24-8/27</td>
<td>Industry</td>
<td>1.37 2.43 100%</td>
<td>1.64 2.83 50%</td>
<td>0.87 1.56 50%</td>
<td>10.58 10.63 40%</td>
</tr>
<tr>
<td></td>
<td>Power</td>
<td>0.54 0.003 50%</td>
<td>1.35 0.01 30%</td>
<td>0.50 0.003 30%</td>
<td>7.50 0.04 30%</td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td>0.02 0.17 50%</td>
<td>0.03 0.24 30%</td>
<td>0.02 0.19 30%</td>
<td>0.41 2.14 0%</td>
</tr>
<tr>
<td></td>
<td>Transport</td>
<td>0.98 0.66 0%</td>
<td>1.46 0.91 0%</td>
<td>0.90 0.58 0%</td>
<td>10.96 3.38 0%</td>
</tr>
<tr>
<td>8/28-9/6</td>
<td>Industry</td>
<td>3.53 5.03 100%</td>
<td>4.24 5.86 50%</td>
<td>2.26 3.23 50%</td>
<td>27.81 22.29 40%</td>
</tr>
<tr>
<td></td>
<td>Power</td>
<td>1.15 0.01 50%</td>
<td>2.89 0.01 30%</td>
<td>1.09 0.01 30%</td>
<td>16.61 0.08 30%</td>
</tr>
<tr>
<td></td>
<td>Residential</td>
<td>0.04 0.35 50%</td>
<td>0.07 0.49 30%</td>
<td>0.06 0.38 30%</td>
<td>1.03 4.30 0%</td>
</tr>
<tr>
<td></td>
<td>Transport</td>
<td>2.50 1.28 50%</td>
<td>3.72 1.78 50%</td>
<td>2.30 1.12 0%</td>
<td>27.94 6.86 0%</td>
</tr>
</tbody>
</table>

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Environmental Quality Guarantee Scheme, 2016.
GEOS-Chem simulation

Nested simulation over Asia

- Version: v11-01
- MET: MERRA2
  - Spatial resolution: 0.5° x 0.625°
  - Vertical resolution: 72 levels
- Resolution: 0.5° x 0.625°
- Emission: MEIC_2016
- Time: 8 August-30 September

Numerical experiments

To quantify the necessity of district-joint control measures

- CTRLCRA
- CTRLZJ
- CTRLYRD

To quantify how sensitive is O₃ concentration to emission reductions in different sectors

- CTRLIND
- CTRLPOW
- CTRLRES
- CTRLTRA
Model evaluation: MDA8 O$_3$

**Comparison of MDA8 O$_3$ in Hangzhou between obs. and sim.**

- **Observation**
- **Simulation**

**NMB:**
- Before G20: 21.7%
- During G20: 6.1%
- After G20: 25.0%

**Comparison of distribution of MDA8 O$_3$**

- **Dots:** observed values
- **Contour:** simulated values
Results: the effect of emission controls on O\textsubscript{3} during G20

Mean difference of MDA\textsubscript{8} O\textsubscript{3} in Hangzhou:
-21.0 µg m\textsuperscript{-3} (-11.6%)
Results: impact of area and district-joint control on O₃ during G20

Reduction (Experiments-BASE) in MDA8 O₃ in Hangzhou during G20:
-CTRLCRA (Controlling core area): -12.5 µg m⁻³
-CTRLZJ (Controlling Zhejiang province): -16.1 µg m⁻³
-CTRLYRD (Controlling Yangtze River Delta): -21.0 µg m⁻³

Difference in MDA8 O₃ during G20 from control measures
Results: Why did $O_3$ concentration decrease so effectively?

**VOCs/NO$_x$ (Base)**

- **NO$_x$:** NO + NO$_2$
- **VOCs:** $C_2H_6 + C_3H_8 + ALK_4 + PRPE + ACET + MEK + ISOP$

**Core area and most of Zhejiang province were in transition zone; reductions in either NO$_x$ or VOCs reduce $O_3$**

- **VOCs/NO$_x$ > 15:** NO$_x$-limited zone
- **VOCs/NO$_x$ < 4:** VOC-limited zone
- **4 ≤ VOCs/NO$_x$ ≤ 15:** transition zone

Carrillotorres et al., 2017
Results: impact of emission reductions by sectors on O₃

Mean reductions of MDA8 O₃ in Hangzhou during G20:
- CTRLIND: 18.85 μg m⁻³
- CTRLPOW: 5.25 μg m⁻³
- CTRLTRA: 12.98 μg m⁻³
- CTRLRES: 3.14 μg m⁻³
The mean difference of simulated MDA8 O₃ in Hangzhou between Base and CTRLYRD during G20 is -21.0 μg m⁻³ (-11.6%). The control measures reduced O₃ in Hangzhou effectively during G20.

Comparing mean reductions in MDA8 O₃ in Hangzhou during G20 in CTRLCRA, CTRLZJ and CTRLYRD, it is necessary to carry out district-joint emission control measures during G20.

Comparing mean reductions in MDA8 O₃ in Hangzhou during G20 in CTRLIND, CTRLPOW, CTRLRES and CTRLTRA, the control of emissions from industry and transport can be effective to keep O₃ below national standard.
THANK YOU