Ozone Air Quality during the 2008 Beijing Olympics: Effectiveness of Emission Restrictions

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8 April 2009
4th GEOS-Chem USERS’ MEETING
Nested-grid GEOS-Chem over East Asia

- 4° x 5°
- 0.5° x 0.667°
- 1° x 1°
- 0.5° x 0.67°
- 0.25° x 0.25°
**Heterogeneous Emission Patterns**

**CO emissions** 0.5° x 0.667°  2° x 2.5°

**CO at a suburban site near Beijing:**

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<th>Obs.</th>
<th>0.5x0.667</th>
<th>2x2.5</th>
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<td></td>
<td>810</td>
<td>710</td>
<td>486 ppb</td>
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Emission Reductions during the Olympics

1. 1 July 1 --- 20 Sep: bans on old, inefficient vehicles
   20 July – 20 Sep: private vehicles on roads every other day

2. Power plants
   ◆ 30% reduction in emissions from their base levels in June
   ◆ Importing more power from outside of Beijing

4. Industries
   ◆ Reducing outputs or close-down
   ◆ 50% industrial boilers close-down

5. Controls on construction sites, fugitive dusts, fugitive VOC emissions, etc

6. Surrounding Provinces
The Miyun Station

1. Measurements since Nov 2004;
2. Species: CO, O₃, CO₂, NO, NOₓ, SO₂, PM, meteorological fields
3. Location chosen to observe both clean continental air and pollution in the Beijing plume.
O₃ Air Quality Improved significantly

SSW, SW, S winds August 2007 August 2008 Reduction (%)
SO₂ 6.2 2.4 61.3
CO 468 352 24.8
NOₓ 11.7 9.2 21.4
O₃ 78 58 25.6
Changes in Species Correlations: August 2007 vs 2008

**CO-SO$_2$**
- $dCO/dSO_2$: 54.7 (2007)
- 93.2 (2008)

**NO$_y$-SO$_2$**
- $dNO_y/dSO_2$: 1.7 (2007)
- 2.7 (2008)
‘top-down’ constraints on emission reductions

1. SO$_2$ concentration changes (considering variations in lifetime) $\rightarrow$ 60% reduction in SO$_2$ emissions.

2. dCO/dSO$_2$ changes $\rightarrow$ 32% reductions in CO emissions

3. dNO$_y$/dSO$_2$ changes $\rightarrow$ 36% reductions in NO$_x$ emissions

Consistent with bottom-up estimates by Tsinghua University
Model Simulations: $O_3$

Regional impact on $O_3$ of the emission reductions
Meteorology variability vs Emission control

(a) Daily O₃ anomaly at Miyun site in 2008

- Total obs. anomaly = -12.7 ppb
- Total model anomaly = -11.2 ppb

(b) Decomposition of modeled O₃ anomaly at Miyun site in 2008

- Mean met. anomaly = -2.3 ppb
- Mean emission anomaly = -8.9 ppb
Conclusions

1. Observations at the Miyun site showed significant improvements in air quality during the Olympics.

2. From species correlations, ‘bottom-up’ inventory estimate and model simulations, emissions of CO, NO$_x$, and SO$_2$ from Beijing must have reduced by 30-60% to explain the differences.

3. Model analysis suggests 20% of the reduction in O$_3$ during the Olympics was due to natural variability in meteorology, while 80% was resulted from emission control measures.