Primary study on the characteristics of trace gases in a clean area of North China

Bai Jianhui  Wang Gengchen  Wang Pucai
Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China
1. Trace gases and/or greenhouse gases

- $O_3$, $NO_x (NO, NO_2)$, $SO_2$, $VOC$, $CO_2$ …
  - $O_3$ - chemistry & photochemistry, health, environment…
  - $NO_x (NO, NO_2)$ - $O_3$ precursor
  - $VOC$ - $O_3$ precursor, reactive gases, Secondary Organic Aerosols, carbon cycle, climate change …
  - $SO_2$ - pollutant
  - $CO_2$ - greenhouse gases

- To know their concentrations and variation trends
- To understand the quantitative inter-reactions between gases, radiation, aerosols …
2. Experiment site - Xinglong station

- Xinglong Station: (40° 23’N, 117° 35’E, 960m)

~150 km northeast of Beijing city
a relative clean region
atmospheric background observation network
of Chinese Academy of Sciences
3. Measured items

- Trace gases: $O_3$, NO, NO$_2$ (NO$_x$), SO$_2$, CO$_2$

- Instruments: Gas analyzer (TE comp.)
  
  $O_3$, NO$_x$, SO$_2$, CO$_2$

  49C, 42CTL, 43C, 41CTL

- Calibration: ~ every 2 or 3 months

49CPS $O_3$, 146C, Model 111 zero air generator

Standard gases: NO, SO$_2$, CO$_2$
4. **Data process**

- All data are processed, except for:
  - thunder storm
  - no power
  - 2 hours’ data after turning on the analyzer
5. Hourly concentrations of trace gases

Fig. Hourly averages of trace gases from May 2005 to Dec. 2007 at XingLong station

<table>
<thead>
<tr>
<th></th>
<th>O3</th>
<th>NO</th>
<th>NOx</th>
<th>SO2</th>
<th>CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005.05-2007.12</td>
<td>42.6</td>
<td>0.4</td>
<td>11.4</td>
<td>8.4</td>
<td>395.6</td>
</tr>
<tr>
<td>AVG</td>
<td>172.1</td>
<td>45.3</td>
<td>118.0</td>
<td>164.3</td>
<td>474.5</td>
</tr>
</tbody>
</table>
6. Daily averages of trace gases

Figure: Daily averages of trace gases at Xinglong station.
Fig. Daily averages of trace gases at Xinglong station.

<table>
<thead>
<tr>
<th>Date</th>
<th>O3</th>
<th>NO</th>
<th>NOx</th>
<th>SO2</th>
<th>CO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005.05-2007.12</td>
<td>42.7</td>
<td>0.4</td>
<td>11.3</td>
<td>8.2</td>
<td>395.4</td>
</tr>
<tr>
<td>AVG</td>
<td>105.6</td>
<td>3.8</td>
<td>55.4</td>
<td>82.2</td>
<td>452.3</td>
</tr>
</tbody>
</table>
7. Monthly variations of trace gases

![Diagram showing monthly variations of trace gases concentration at XingLong station](image)

- NO con. is very low
• All trace gases showed an evident seasonal variations
• Better air quality – summer season
8. Trace gas variations in different years

**O₃ AVG**
2005: 46.9
2006: 36.1
2007: 43.8

**NOₓ AVG**
2005: 10.8
2006: 12.0
2007: 13.2

**Fig. Monthly variations of trace gases concentration at XingLong station**
Fig. Monthly variations of trace gases concentration at XingLong station.
- The relation between O$_3$ and NO$_x$ is complicated, other factors such as VOC, UV, and aerosols should be considered.
9. The interaction between hourly $\text{O}_3$, $\text{NO}_x$ and UV

UV energy is an important triggering energy for $\text{O}_3$ photochemistry.
10. An empirical model for analyzing the relation between O₃ and its affecting factors

(Energy conservation- UV is attenuated by gases and aerosols…)

\[ e^{-k_3 n_3 m} = B_1 e^{-k_1 n_1 m} + B_2 e^{-k_2 n_2 m} + B_3 e^{-k_4 w m} + B_4 e^{-H_d/H_Q} + B_5 H_{uv} + B_0 \]

O₃, NO, NO₂, photochemical, scattering, UV

11. CO$_2$ long-term variation (1994-2007)

Fig. Monthly averages of CO$_2$ at Xinglong station
Fig. Yearly averages of CO₂ at XingLong Station

\[ y = 2.9524x + 358.29 \]

\[ R^2 = 0.7223 \]

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Incre. amou. /year (ppm)</th>
<th>Incre. rate /year (%)</th>
<th>Analyzing method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994-2000</td>
<td>2.91</td>
<td>0.81</td>
<td>Flask, GC</td>
</tr>
<tr>
<td>1994-2007</td>
<td>2.95</td>
<td>0.82</td>
<td>Gas Analyzer (2005-2007)</td>
</tr>
</tbody>
</table>
Main measurements at Xinglong Station

1) Solar radiation: Spectral solar radiation (UV, Visible, NIR), direct, diffuse, global radiation

2) Trace gas: surface $O_3$, NO$_x$ (NO, NO$_2$), SO$_2$, CO$_2$, CO

3) Aerosol: PM2.5, Black carbon

4) Meteorological parameters: T, e, P, wind
Thanks!

Welcome to visit Xinglong station!