Spatio-Temporal distribution and long-term trend of ozone sensitivity over South Korea inferred from OMI data

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Introduction

- Tropospheric ozone is formed in the atmosphere through chemical reactions of its precursors such as nitrogen oxides (NOx), volatile organic compounds (VOCs), etc., in the presence of sunlight.

- Its formation can be determined by the ratio of the columns of formaldehydes to nitrogen oxides (called FNR), which has been used as an indicator to identify NOx-limited or VOC-limited O₃ formation regimes.

- In this study, we investigated spatio-temporal distributions and long-term trends of O₃ and its precursor’s concentrations, and FNR in South Korea during the O₃ season (May-September) and non-O₃ season (October-April), respectively, using OMI data for the past decade (2005-2014).
Tropospheric O₃ data from AURA OMI/MLS [Ziemke et al., 2006]

Tropospheric O₃ data products from OMI in combination with Aura Microwave Limb Sounder (MLS)

- OMI: total column (tropospheric + stratospheric) ozone
- MLS: stratospheric ozone

<table>
<thead>
<tr>
<th>Trop. O₃</th>
<th>Trop. NO₂</th>
<th>Trop. HCHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMI/MLS</td>
<td>OMI</td>
<td>OMI</td>
</tr>
<tr>
<td>Level 3 (Monthly)</td>
<td>Level 3 (Monthly)</td>
<td>Level 3 (Monthly)</td>
</tr>
<tr>
<td>1.0°x1.25°</td>
<td>0.25°x0.25°</td>
<td>0.25°x0.25°</td>
</tr>
</tbody>
</table>

[Morris et al., 2006]
### Data and Methods

- **HCHO to NO₂ ratio (FNR) [Duncan et al., 2010]**

  - Space-based indicator to understand efficient way to reduce ozone concentration

<table>
<thead>
<tr>
<th>VOC-regime</th>
<th>HCHO/NO₂</th>
<th>VOC control is more effective for ozone reduction (The effect of Local area)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HCHO/NO₂ &lt; 1</td>
<td></td>
</tr>
<tr>
<td>NOx-regime</td>
<td>HCHO/NO₂ &gt; 2</td>
<td>NOx control is more effective for ozone reduction (The effect of long-range transport)</td>
</tr>
<tr>
<td>Transition or Mixed regime</td>
<td>1 &lt; HCHO/NO₂ &lt; 2</td>
<td>Both NO₂ and VOCs are effective for surface ozone reduction</td>
</tr>
</tbody>
</table>
Results - Trop O₃

- Investigating **spatio-temporal distribution and long-term trend of trop. O₃ for the decade**
- Figure: 1) high concentrations show in Korea, East China, and Japan during the O₃ season
  2) the trends are increasing at all the regions of S. Korea as well as NE Asia. Especially, strong increasing trends represent at Seoul (City) in O₃ season, whereas at Gosan in non-O₃ season

<table>
<thead>
<tr>
<th></th>
<th>NE Asia</th>
<th>KOR</th>
<th>Seoul</th>
<th>Gosan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O₃ Season (DU/year)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O₃ Season</td>
<td>2.8</td>
<td>3.0</td>
<td>5.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Non-O₃ Season</td>
<td>2.5</td>
<td>1.8</td>
<td>1.1</td>
<td>3.2</td>
</tr>
<tr>
<td>ALL</td>
<td>2.2</td>
<td>2.3</td>
<td>2.8</td>
<td>3.1</td>
</tr>
</tbody>
</table>
Results - Precursor

- **NO$_2$**
  - More abundant in cities and industry area during the non-O$_3$ season than O$_3$ season.
  - Has negative trend in Seoul Metropolitan Area in all seasons.
  - N.Korea and Yellow Sea have positive trend by power plants, etc., especially in non-O$_3$ season.

- **HCHO**
  - High concentrated HCHO is also distributed largely in cities, especially in O$_3$ season.
  - Has no significant trend over South Korea.
Results - FNR

- The **averaged FNR for the past decade (2005-2014)**

1) **O₃ season (left)**
   - NOx-regime prevails.
   - VOC- and mixed regimes represent only in big cites and surrounding areas.

2) **Non-O₃ season (right)**
   - VOC- and mixed regimes are expanded to the whole region of South Korea.
Results - FNR

**Trend of FNR** for the past decade

1) **O₃ season**: VOC-regime changed to mixed regime (Seoul)
   - Due to implementation of emission controls, etc.

2) **Non-O₃ season**: NOx regime is transferring slightly to mixed regime (Gosan)
   - Due to increasing NO₂ in North Korea and Yellow sea, and decreasing HCHO in Jeju.
   - Also, we found that FNR decreased rapidly in NE Asia.
**GEMS**

- GEMS is loaded aboard GEO-KOMPSAT2B which is undergoing several tests until the launch period (’20.3).
- Air pollutants and causes of climate change including SO2, NO2, O3, HCHO and aerosols will be observed with UV-Visible hyper-spectral sensor in East Asia.

**Future plan about ozone sensitivity study**

- Changing application platforms from OMI to GEMS data (LEO → GEO)
- Extending study area from South Korea to Asia (GEMS coverage)
- Supporting environmental policy maker by providing science data from satellites
Thank you for your effort!