S-12 project and Regional Emission Inventory in Asia (REAS)

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with
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Contents

1. Needs of SLCP mitigation in Asia
2. S-12 project and its progress
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What is SLCPs (Shout-lived Climate Pollutants)

1. Tropospheric ozone: Its precursors: CH$_4$, NOx/VOC
2. Black carbon (BC)

1. Air pollution reduction
2. Climate change mitigation

(Akimoto, 2013)
Global premature deaths from environmental risks from 2010 to 2050 (Baseline scenario)
OECD Environmental Outlook to 2050 (2012)

- Many kinds of environmental risk factors. Among of all air pollution has higher risk.
- Total number of premature death due to PM, O3, and indoor air pollution is 4 millions in global and will increase future.

In Asian countries, the increasing is remarkable.
Why SLCP mitigation now? (Akimoto, 2013)

(1) Climate Policy Side

CO$_2$ control can mitigate climate change only after 2050 for grand and grand-grand children generation, but the present climate change is more urgent issue and mitigation in mid-term future (2030-2050) should also be concerned for our own and our children generation.

**SLCP control must be useful to accomplish the near future mitigation of climate change.**

(2) Air Pollution Policy Side

Present situation of health and vegetation impact by surface ozone and PM is serious from human health and economic damage point of view.

**This is particular so in Asia!**

In order to facilitate mitigation of air pollution, SLCP control by co-benefit approach must be useful particularly in developing countries giving more incentives.

Much need of SLCP mitigation in Asia
MOEJ-S12: Active evaluation of SLCP impacts and seeking the optimal pathway (2014-2018)  
PI: Terry Nakajima

- Reduction of SLCP is easier than that of LLGHG due to their short lifetime, but the effects are very complex.
- Therefore, search for optimum mitigation paths is important for society.
- It is needed to develop an active evaluation system for LLGHG and SLCP mitigation policy, by overarching emission inventory, integrated models, and climate models.

**Theme 1: Regional AQ change event analysis**
- Improved EI
- Regional emission scenario
- Integrated analysis of AQ change in Asia

**Theme 2: Integrated model and upscaling**
- Asia-Pacific Integrated Model (AIM)
- Upscaling regional mitigation
- Impact evaluation

**Theme 3: SLCP impacts on climate & environment**
- Climate/environmental models
- Global impact assessment of global warming and air pollution

**Theme 4: Integrated operation system (Toolkits, data archive)**
- Science
  - Model improvement
  - Experiment setup
  - Data generation
  - Metric definitions
- Stakeholders
  - Policy makers
  - System use
- Society
  - Cool earth messages
- Global strategy
  - Regional strategy
- CCAC, UNFCC, IPCC, EANET actions and decision
- MDG-SDG-Future Earth
Aim of Theme 1 of S12

(1) The air quality change events caused by air pollution control and socioeconomic variations, which are considered to be social experiments of SLCP mitigation, are analyzed by means of regional/global chemical transport modeling (CTM), inverse modeling (IM) and regional emission inventory (EI).

(2) CTM, IM, and EI are integrated as an analysis/verification system for quantifying the emission reduction and air quality improvements due to SLCP mitigation. The system is validated by the analysis of air quality change events.

(3) The system is applied to assessment for SLCP mitigation policy and future emission scenario.
Schematic diagram of our approach

Regional Air quality change events

Beijing Olympic game, AP mitigations in Japan and China,

Spring festival, weekend effects, economic crisis, SURYA,

Analysis/verification system for SLCP mitigation

Emission Inventory system ↔ Inverse Modeling system

Chemical Transport Modeling system

Global/regional CTM (MIROC/ESM/CHCM/WRF/CMAQ)

Multi-scale seamless CTM (NICAM-Chem)

Analysis/verification of emission reduction and AQ changes due to SLCP mitigation
Structure of analysis/verification system for regional air quality changes

Global CTM

\[ \Delta x = 180 \text{ km (T63)} \]

Regional CTM

Domain 1: \( \Delta x = 60\text{km} \)
Domain 2: \( \Delta x = 15\text{km} \)
Domain 3: \( \Delta x = 5\text{km} \)

Another model: NICAM-Chem (Multi-scale seemless CTM)

Emission inventory

Inverse modeling

Modeled results

A priori emission

A posteriori emission

Ground, Lidar & satellite monitoring data
## Summary of air quality change events in Asia

<table>
<thead>
<tr>
<th>Country</th>
<th>Events</th>
<th>Targeted compounds</th>
<th>Time scale</th>
<th>Spatial scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>Long-term measures</td>
<td>SOx, NOx</td>
<td>Decade(s)</td>
<td>Urban - National</td>
</tr>
<tr>
<td></td>
<td>Vehicle emissions</td>
<td>NOx, PM, VOC</td>
<td></td>
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<td></td>
<td>Evaporative VOC</td>
<td>VOC</td>
<td></td>
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<tr>
<td>Socio-</td>
<td>Weekend effects</td>
<td>NOx, VOC, PM</td>
<td>Years</td>
<td>Urban - National</td>
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<tr>
<td>economical</td>
<td>Fukushima accident</td>
<td>Many comp.</td>
<td></td>
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<tr>
<td>China</td>
<td>Long/mid-term meas.</td>
<td>SOx, NOx</td>
<td>Decade</td>
<td>Urban - National</td>
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<tr>
<td></td>
<td>Urban pollution</td>
<td>SOx, NOx</td>
<td></td>
<td>National</td>
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<td></td>
<td>12nd five years plan</td>
<td>Many comp.</td>
<td></td>
<td>National</td>
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<tr>
<td>Short-term</td>
<td>Beijing Olympic</td>
<td>Many comp.</td>
<td>Months</td>
<td>Urban - Regional</td>
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<tr>
<td>measures</td>
<td>Shanghai Expo.</td>
<td>Many comp.</td>
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<td></td>
<td>Guangzhou Asian game</td>
<td>Many comp.</td>
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<td>Socio-</td>
<td>Spring festival</td>
<td>Many comp.</td>
<td>Weeks</td>
<td>National</td>
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<td>economical</td>
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<td>SE Asia</td>
<td>Measures</td>
<td>Bio-energy in Thailand</td>
<td>Many comp.</td>
<td>Years</td>
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<td></td>
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<td>Open burning</td>
<td>PM, VOC</td>
<td>National</td>
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<tr>
<td>Others</td>
<td>Social experiments</td>
<td>Surya etc.</td>
<td>BC</td>
<td>Years</td>
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<td>Local</td>
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</table>
Impact of Chinese emission control on AQ in Japan

SO₂ emissions in China

Measured & modeled SO₄²⁻ at Okinawa (Cape Hedo)

Evidence of the impacts of Chinese emission control on AQ in Japan.

Going down from 2006

This declining may cause AQ improvement in Japan.

Nagashima, Takami et al. (2015)
Regional Emission inventory in ASia (REAS)


<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
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<tbody>
<tr>
<td>Emission sources</td>
<td>Anthropogenic</td>
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<tr>
<td>Areas</td>
<td>E, SE, and S Asia + Russian &amp; Central Asia</td>
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<tr>
<td>Years</td>
<td>2000-2008</td>
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<td>Spatial Resolution</td>
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<td>Temporal Resolution</td>
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<table>
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<th>SO₂</th>
<th>NOₓ</th>
<th>CO</th>
<th>PM₁₀</th>
<th>PM₂.₅</th>
<th>BC</th>
<th>OC</th>
<th>NMV</th>
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<td>Livestock</td>
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<td>Others</td>
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Recent progress of REAS update

✓ Developing emission inventory system

✓ Update for recent years (2000 – 2011)

✓ Historical emissions (1950 – 2011)

✓ Collaboration with inverse modeling
Anthropogenic emissions for recent years (2000 – 2011)

**Asia (by region)**

- SO$_2$ [Tg/yr]
- NO$_x$ [Tg/yr]

**Indonesia (by sector)**

- SO$_2$ [Gg/yr]
- NO$_x$ [Gg/yr]

Kurokawa (2015)
• Asian emissions were going up in the last half century.
• 1970 - : SO2 and NOx emissions gradually increased.
• 2000 - : The increasing speed was accelerated.
• Recently: SO2 is fluctuating and NOx is still going up.

• Having a peak around 1975 and then going down.

_Kurokawa (2015)_
Schematic diagram of inversion modeling system

Yumimoto et al. (2015)

- Emission inventory (EI)
- CTM
- Satellite measurement

Inversion model
Top-down approach

Development of better EI with lower uncertainties
Semi-real time update of EI
Analysis of air quality change events
NOx emission trend in China from top-down and bottom-up approaches

Yumimoto et al. (2015)

By combination of two approaches, we can update emissions with two years lag.
Summary

1. Air pollution, such as O$_3$ and PM, is a severe environmental issue that make an enormous impact on the human health in Asia. Asian approach for SLCP mitigation should be paid attention to air pollution reduction.

2. S-12 project aims to analysis air quality change events such as emission control and social events and to develop an analysis/verification system for quantifying the emission reduction and air quality improvements due to SLCP mitigation.

3. Regional Emission Inventory in Asia (REAS) are being updated to historical and latest emissions, and improved using top-down approach.