Current status of air pollution in Asia and scientific challenge for SLCP mitigation in S-12 project

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1. SLCP and its mitigation in Asia
2. Anthropogenic emissions in Asia
3. Air quality in Asia
4. S-12 project
5. Summary
Outline

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What is SLCPs (Shout-lived Climate Pollutants)

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

1. Air pollution reduction
2. Climate change mitigation

(Akimoto, 2013)
Why SLCP co-benefit now?

(1) Climate Policy Side

CO₂ 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**
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.
- Number of premature death due to PM, O3, and indoor air pollution is 1.3, 0.4, 2.2 millions respectively in global and will increase future.
Premature deaths from exposure to PM

OECD Environmental Outlook to 2050 (2012)

- Number of premature death will increase by 3.5 times during 50 years (1 → 3.5 million people)
- In BRIICS and rest of world, large increase
- In China, the number is maximum and will be doubled until 2050.
- In another Asian countries, the increasing is remarkable.
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Burrows et al. (2007)

Global NO2 distribution from space

USA

Granier et al. (2011)

India

W-Europe

08.21

China
1970 - : SO2 and NOx emissions gradually increased.
2000 - : increasing speed was accelerated.
Recently: SO2 is almost stable (increasing of fuel consumption balances penetration emission control in China). In contrast, NOx is still going up.
Temporal variations of NOx emissions after 2000

- Asian NOx emissions were increased by 50%.
- China’s NOx was more than doubled, but increase rate becomes smaller recently.
- NOx in SE Asia and India also increased rapidly due to the increase of energy consumption in power plants and road transport.
Fuel/sector matrix of NOx emissions in Asia in 2008

East Asia

- Power Plant
- Industry
- Transport
- Domestic
- Soil

Southeast Asia

- Power Plant
- Industry
- Transport
- Domestic
- Soil

South Asia

- Power Plant
- Industry
- Transport
- Domestic
- Soil

• Each colored area is proportional to the NOx emissions by sector and fuel.
• The proportion of sectoral and fuel-typed emissions varies with region.
  [East Asia]
  ① Coal PP & industry  ② Transport
  [Southeast Asia]
  ① Transport  ② Coal PP & industry
  [South Asia]
  ① Transport  ② Coal PP  ③ Soil
Temporal variations of NMVOC emissions after 2000

- Asian NMVOC emissions were increased by 44%.
- Major emission sources are transport, domestic, and paint & solvent use.
- Sectoral % in Asia increased in solvent and paint use while the share of domestic sector decreased due to decreasing of biofuel consumption.
Fuel/sector matrix of NMVOC emissions in Asia

Emission structure in each region is quite different.

[East Asia] Combustion < non-comb. Trans. Solv. & paint use


These regional differences should be specially considered in SLCP mitigation in Asia.
Future trend of SLCP emissions in ‘Current legislation’ scenario

- Two important messages -
  • 2050 emissions doesn’t decrease as compared to current emissions. This prediction is quite different from RCP scenarios which shows future decline.
  • Asian emission trend is a key factor of global emission changes.

Source: GAINS model; ECLIPSE V5 scenario
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Background of ozone pollution (1)
Serious Ozone Pollution in Japan as compared to US and EU

Evaluation of Observed $O_3$ in terms of USEPA-AQS 2008
Should not exceed 75 ppb in 8 hour average

More than 75% of the sites in Japan exceed USEPA AQS 2008

Annual 4th value of 3 year average 2005-2007

Akimoto (2012)

NE Asia including Japan is the highest $O_3$ concentration region in the world.
Background of ozone pollution (2)
Surface ozone is increasing in East Asia

Hong Kong (Wang et al., 2009)
Taiwan (Chou et al., 2006)

Japan (MOEJ, 2014)
Regional view of S/R relationship of surface O₃

- Indochina as well as Japan/Korea are influenced by transboundary O₃ from China. Oppositely China is influenced by Indochina.
- International framework for air pollution management should cover NE and SE Asia.

Nagashima et al. (2012)
Global map of PM$_{2.5}$ based on satellite observation

Donkelaar et al., 2011
Outdoor air pollution causes health impacts in East Asia

Premature death due to ozone and PM2.5 in 2005

Nawahda et al. (2012)
Future surface ozone in Asia

Ozone distribution in present (2005)

- RCP 8.5 is the most pessimistic scenario in RCP families.
- Ozone will increase in most areas due to growing up of global ozone.
- In SE Asia, ozone will decrease due to regional climate change (more cloudy).

Ozone change between 2005 and 2050 (RCP 8.5 scenario)
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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.

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**Diagram: Improving emission inventories through analysis of regional air quality change events**

- **Regional AQ change events:** Regional modeling
- **Emission scenario & Optimum mitigation path:** Socio-economical & technology model (AIM)
- **Global climate impacts:** Climate modeling

- **Improvement of AIM to reflect the SLCP regional change**
- **Upscaling the regional mitigation experiences to global**
- **Assessment of regional and global climate/agriculture, and health environment impacts**

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**Image:**

- **Black Carbon (µg m⁻³):**  
  - Project Surya (India)  
  - Praveen et al (2011)

- **SO₂ future scenarios:**
  - IRS92a
  - RCP2.6
  - RCP4.5
  - RCP6
  - RCP8.5
  - A1
  - A1F1
  - A2
  - B1
  - B1T
  - B2

- **Sea level rise:**
  - Hu et al (2013)
Our approach in S12 project

Theme 1: AQ change event analysis
- Simulation and analysis
- Emission inventory
- Inversion algorithms

Theme 2: Integrated model and upscaling
- Global
- Nations and regions
- Cities and household

Theme 3: SLCP impacts on climate & environment
- Aerosols and gases
- Public health, agriculture, water cycle, sea level

- Improved emission inventory
- Regional emission Inventories and CTMs
- Regional emission scenario

- Asia-Pacific Integrated Model (AIM)
- Upscaling regional mitigation
- Impact evaluation

- Climate/ environmental models

- Integrated analysis of AQ change in Asia

- Technology selection Socio-economical scenario

- 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

- CCAC, UNFCC, IPCC, EANET actions and decision

- MDG • SDG • Future Earth

Regional strategy

Global strategy
1. $O_3$ and PM is a severe environmental issue that make an enormous impact on the human health in Asia.

2. SLCP co-benefit approach is the most logical way to mitigate both climate change and air pollution in mid-term future.

3. Asian approach for SLCP mitigation could be different from EU/NA and should be paid more attention to air pollution reduction.

4. Emission structure of ozone precursors, NOx, NMVOC, and others, is quite different between country/region in Asia. Hence, the SLCP mitigation suitable for each country/region is needed.

5. S-12 project aims to analysis air quality change events such as emission control and social events and to seek the optimal pathway for SLCP mitigation appropriate in Asia.
Analysis of different anthropogenic emission inventories
Granier et al. (2014)

NMVOCs emissions in S.E. Asia:
Very large differences in values and trends

CO and NOx emissions in India: large differences in values and trends