Joint research Project on Long-range transboundary air pollutants
- progress, outcomes, and future plan -

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NIER, KOREA
Progress
### Air quality in 1980s in ROK

<table>
<thead>
<tr>
<th>Year</th>
<th>SO$_2$ (ppb)</th>
<th>CO$_2$ (ppm)</th>
<th>TSP ($\mu$g/m$^3$)</th>
<th>NO$_2$ (ppb)</th>
<th>O$_3$ (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>54</td>
<td>3.0</td>
<td>183</td>
<td>33</td>
<td>30</td>
</tr>
<tr>
<td>1987</td>
<td>56</td>
<td>3.0</td>
<td>175</td>
<td>33</td>
<td>10</td>
</tr>
<tr>
<td>1988</td>
<td>62</td>
<td>3.0</td>
<td>179</td>
<td>33</td>
<td>9</td>
</tr>
<tr>
<td>1989</td>
<td>56</td>
<td>3.2</td>
<td>149</td>
<td>27</td>
<td>8</td>
</tr>
<tr>
<td>Annual Standard</td>
<td>30</td>
<td>25(1hr)</td>
<td>150</td>
<td>50</td>
<td>100(1hr)</td>
</tr>
</tbody>
</table>
History of LTP Project

Sep. 1995
- Hosting a workshop on LTP in Seoul, Korea
- Launching a working group consisting of government officials and experts
- Establishing an interim secretariat of LTP Project at NIER, Korea

July 1996
- Agreements of the 1st LTP Expert Meeting
  - Conduct a joint research of modeling and monitoring on LTP
  - Upgrade the interim secretariat to an official secretariat to support the Working Group more efficiently
  - Adopt the operational principles of Working Group
  - Appoint Korea, China, and Japan as the member countries of the Working Group for LTP

Nov. 1997
- The 2nd LTP Expert Meeting
  - Launch sub-working groups for modeling and monitoring

2000 ~ 2004
- The 1st stage joint study
- The 2nd stage joint study

2005 ~ 2007
- The 3rd stage joint study

2008 ~ present
Questions in LTP project

- Movement and diffusion
- Anthropogenic emissions
- Synoptic wind

Transport patterns?

How much?

How?

- Only SO₂
- SO₂ + Sulfate?
- SO₂ → Sulfate?
International cooperation for improving air quality in Northeast Asia

Outline of LTP Project

1st stage ('00~'04)
- Establish a foundation for joint research
- Establish database on the concentration, emissions of air pollutants and a modeling system

2nd stage ('05~'07)
- Estimate emissions among three countries
- Research on monitoring and modeling
- Produce S-R relationships quantitatively among countries

3rd stage ('08~'12)
- Research on the impacts of NOx, O3, and PM

Expected effects
- Predict the impacts of long-range air pollutants on the air quality of Korea
- Predict the cross impacts of LTP
- Construct air pollutant monitoring system in Northeast Asia
- Make an emission reduction scenario in Northeast Asia

최종 목표
- Predict the impacts of long-range air pollutants on the air quality of Korea
- Predict the cross impacts of LTP
- Construct air pollutant monitoring system in Northeast Asia
- Make an emission reduction scenario in Northeast Asia
LTP has made many achievements in the fields of monitoring, modeling and emission inventory up until now. However, it still needs some systematic enhancement, for example, by restructuring the organization into Working Group and Task Force Team.
History of LTP

MOEK, NIER, KIST, Yunsei Univ, Konkuk Univ, GIST, MEP, CRAES, Pecking Univ, CNEMC, MOEJ, ACAP, Tokyo Univ and etc.
Outcomes
Surface measurement sites

[Map showing surface measurement sites in Asia, including cities like Xiamen, Gosan, DeokJok, Seoul, Dalian, Oki, and Rishiri.]
<table>
<thead>
<tr>
<th>items</th>
<th>Size</th>
<th>Sampler</th>
<th>instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass concentrations</td>
<td>PM₁₀, PM₂.₅</td>
<td>URG sampler</td>
<td>Microbalance (Sartorius AG, SC2)</td>
</tr>
<tr>
<td></td>
<td>0.056~18 μm, 8 channel</td>
<td>MOUDI sampler</td>
<td></td>
</tr>
<tr>
<td>Ion (SO₄²⁻, NO₃⁻, Cl⁻, Na⁺, NH₄⁺, K⁺, Mg²⁺, Ca²⁺)</td>
<td>PM₁₀, PM₂.₅</td>
<td>URG sampler</td>
<td>Ion chromatography (Dionex, DX-120)</td>
</tr>
<tr>
<td></td>
<td>0.056~18 μm, 8 channel</td>
<td>MOUDI sampler</td>
<td></td>
</tr>
<tr>
<td>Gas (NH₃, HNO₃ etc)</td>
<td></td>
<td>URG sampler</td>
<td>Ion chromatography (Dionex, DX-120)</td>
</tr>
<tr>
<td>Molecule (Al, Fe, Mg, Mn, Cu, Zn, Pb, Ni, Cd, Cr, Ba, Ti, S, Be, Co, Se, Sr, As)</td>
<td>PM₁₀, PM₂.₅</td>
<td>URG sampler</td>
<td>PIXE</td>
</tr>
<tr>
<td>Carbon (OC, EC)</td>
<td>PM₂.₅</td>
<td>URG sampler</td>
<td>OC/EC analyzer (Sunset, 3014)</td>
</tr>
<tr>
<td>Number concentrations</td>
<td>0.25~32 μm</td>
<td></td>
<td>Grimm aerosol spectrometer</td>
</tr>
<tr>
<td>VOCs</td>
<td>TO-14A (31)</td>
<td>Mini sampler</td>
<td>Gas chromatography</td>
</tr>
<tr>
<td>Gas species (SO₂, O₃, NOₓ, CO)</td>
<td></td>
<td></td>
<td>Mandatory</td>
</tr>
<tr>
<td>Meteorological variables</td>
<td></td>
<td></td>
<td>Mandatory</td>
</tr>
</tbody>
</table>
Annual mean [SO$_2$] trends in background sites in ROK (1997~2007)
Effect of LRT sulfur on acid rain

Still acid rain in NE Asia

<table>
<thead>
<tr>
<th>Year</th>
<th>pH</th>
<th>China</th>
<th>Japan</th>
<th>ROK</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>5.23</td>
<td>4.76</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>5.17</td>
<td>4.78</td>
<td>4.99</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>5.11</td>
<td>4.77</td>
<td>4.86</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>5.16</td>
<td>4.79</td>
<td>4.75</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>5.13</td>
<td>4.67</td>
<td>4.93</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>5.13</td>
<td>4.78</td>
<td>4.74</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>5.00</td>
<td>4.71</td>
<td>4.95</td>
<td></td>
</tr>
</tbody>
</table>

(EANET data report)
Tendency of $F_S$ : China<Korea<Japan

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Korea</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dalian</td>
<td>Xiaman</td>
<td>Gangwha</td>
</tr>
<tr>
<td></td>
<td>SO4(ppb)</td>
<td>SO2(ppb)</td>
<td>S-ratio</td>
</tr>
<tr>
<td>1995</td>
<td>55.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>60.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>47.00</td>
<td></td>
<td></td>
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<tr>
<td>1998</td>
<td>47.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>28.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>4.20</td>
<td>12.00</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>5.10</td>
<td>14.00</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>12.10</td>
<td>34.00</td>
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<tr>
<td>2003</td>
<td>3.69</td>
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<td>2004</td>
<td>8.08</td>
<td>13.70</td>
<td>39.00</td>
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<tr>
<td>2005</td>
<td>8.59</td>
<td>16.00</td>
<td>46.00</td>
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<tr>
<td>2006</td>
<td>7.91</td>
<td>20.20</td>
<td>58.00</td>
</tr>
<tr>
<td>2007</td>
<td>8.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>7.28</td>
<td>11.88</td>
<td>40.00</td>
</tr>
</tbody>
</table>
Conversion ratio for sulfur $F_S$

China
SO$_4^{2-}$: 2003 – 2007

Korea
SO$_2$: 2000년 – 2005
SO$_4^{2-}$: 1997 – 2007
S-ratio: 2000년 – 2005

Japan
SO$_2$: 2004 – 2007
The conversion of SO2 was more enhanced in remote region than in rural region due to longer time for photochemical reaction.
Indicating photochemical reaction is important for the oxidation of SO2 to sulfate.

Conversion ratio for sulfur $F_s$
[SO$_4^{2-}$] increased greatly when affected by long-range transport.

- In lower concentration, in Dukjeokdo, OC was the highest (~33.2%), while in Gosan, OC (~22.2%) and sulfate (~25.2%) showed the highest.
- In high concentration, in both Dukjeokdo and Gosan, sulfate showed the highest fractions (at ~27.9% in Dukjeokdo and ~32.1% in Gosan).
<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Japan</th>
<th>Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model system</strong></td>
<td>Models-3 / CMAQ coordinate</td>
<td>RAQM (Regional Air quality Model) terrain following coordinate</td>
<td>CADM (Comprehensive Acid Deposition Model) terrain following coordinates</td>
</tr>
<tr>
<td></td>
<td>14 layers, 70\times66 grids, 60km resolution</td>
<td>12 layers, 110\times80 grids, 60km resolution</td>
<td>12 layers, 110\times80 grids, 60km resolution</td>
</tr>
<tr>
<td><strong>Domain</strong></td>
<td>20～50N, 100～150E</td>
<td>20～50N, 100～150E</td>
<td>20～50N, 100～150E</td>
</tr>
<tr>
<td><strong>Meteorological Model</strong></td>
<td>MM5 34 layers with FDDA using NCEP reanalysis</td>
<td>MM5 125\times95 (45km), 23 layers, FDDA using NCEP FNL reanalysis</td>
<td>CSU-RAMS 110\times80, 29 vertical layer FDDA using NCEP FNL reanalysis</td>
</tr>
<tr>
<td><strong>Chemical Mechanism</strong></td>
<td>RADM Chemistry</td>
<td>CBM-IV mechanism</td>
<td>RADM Chemistry</td>
</tr>
<tr>
<td><strong>Cloud Model</strong></td>
<td>Diagnostic cloud model in RADM Simple explicit moisture scheme Grell cumulus schemes, MRF</td>
<td>Cloud model in MM5 Betts-Miller cumulus scheme, MRF RRTM</td>
<td>Cloud model in CSU-RAMS Anthes-Kuo cumulus scheme, MRF</td>
</tr>
<tr>
<td><strong>Emission</strong></td>
<td>SO₂, NOx, VOC, NH₃, CO, PM₁₀, biogenic VOC provided by LTP for the base year of 1998 (1°×1° resolution)</td>
<td>Same as China</td>
<td>Same as China</td>
</tr>
<tr>
<td><strong>Land use type</strong></td>
<td>EPA/NOAA global ecosystem (11 categories)</td>
<td>DeFries &amp; Townshend (1994)</td>
<td>EPA/NOAA global ecosystem (11 categories)</td>
</tr>
</tbody>
</table>
China requests excluding ocean sector in Region V.

Regions for estimating S-R Relationship

SO₂: 2,540,189 ton/yr
NOₓ: 1,281,384 ton/yr
NH₃: 1,543,209 ton/yr

SO₂: 12,238,715 ton/yr
NOₓ: 6,173,751 ton/yr
NH₃: 6,833,277 ton/yr

SO₂: 5,893,221 ton/yr
NOₓ: 2,972,802 ton/yr
NH₃: 4,088,017 ton/yr

SO₂: 1,146,000 ton/yr
NOₓ: 1,083,800 ton/yr
NH₃: 78,403 ton/yr
Source-Receptor Relationship in 2002 using emission data of 1996.
Source-Receptor Relationship in 2002 using emission data of 1996.

Seasonal variation of source contribution
Future plan
Teams and Roles for Post-2012 LTP Plan

1. Organizer
   • LTP Secretariat (incl. Dr. Jong-Choon Kim and Ms. Su-jin Heo, National Institute of Environmental Research)

2. Executive Authors
   • Dr. Shang Gyoo Shim, Korea Institute of Science and Technology
   • Prof. Jung-Hun Woo, Dept. of Advanced Technology Fusion, Konkuk University
   • Prof. Cheol-Hee KIM, Dept. of Atmospheric Sciences, Pusan National University
   • Prof. Dong-Young Kim, KDI School of Public Policy and Management

3. Advisory Committee (pool)
   • All LTP Participants
1. Background and Objectives

2. Suggested Topics for LTP Post-2012 Plan
   • Air Quality Forecast for Northeast Asia
   • Implementation of Advanced S-R Methodologies

3. Post-Meeting Milestone

4. Discussion
1. Background and Objectives
Background

- LTP was started in year 2000 as a government-based air pollution research framework among China, Japan, and Korea.

- LTP’s activities have been mostly focusing on understanding transboundary air pollution and S-R relationship among three countries, using modeling and monitoring techniques.

- Now LTP members are planning the 4th year of the 3rd Stage (2011).
Similarities and uniqueness of LTP Framework to other activities

• Similarity
  - Air Quality Monitoring for Asia (to EANET)
  - Air Quality S-R Modeling for Asia (to MICS-Asia)
  - Target pollutants – Sulfur, Nitrogen, and others (EANET and MICS-Asia)
  - RAINS-Asia, GAINS-Asia, ABC, Global-Chem Modeling, and others…

• Uniqueness
  - Government-initiated scientific research collaboration framework in support of regional air quality issues
    - Both modeling and monitoring
    - Both pure science and policy supporting science
    - Strictly focus on East Asia(Three countries)
    - Long lasting geo-scientific collaboration in East Asia
New Challenges

- Transboundary air pollution
  - Long-term S-R
  - Base-year modeling
  - Periodic monitoring
New Challenges

- Transboundary air pollution
  - Long-term S-R
  - Base-year modeling
  - Periodic monitoring

- Climate change

- Local and regional air pollution

- Category Integration

- Understand pollution events
  - Climate influence on air quality
  - Future scenario
  - Co-benefits
  - Inter- vs. intra-national S-R
  - Megacity impacts
  - CAPs + GHGs + HAPs
  - Impact study
  - Dust storm, wildfire, storms, heat
  - Air quality forecasting
New Challenges

- The LTP research framework has been working great, but the data and methodology for research are outdated from scientific viewpoint and research components are not complete in policy supporting viewpoint.

• Climate change
  - Climate influence on air quality
  - Future scenario
  - Co-benefits

• Local and regional air pollution
  - Inter- vs. intra- national S-R
  - Megacity impacts

• Category Integration
  - CAPs + GHGs + HAPs
  - Impact study

• Understand pollution events
  - Dust storm, wildfire, storms, heat
  - Air quality forecasting
Time, LTP, and Emissions

SO₂

NO₂

Aerosols

CO₂
Time, LTP, and Emissions

SO$_2$

NO$_2$

Aerosols

CO$_2$

Pre-historic

Pre-historic
Time, LTP, and Emissions

**SO₂**

- Zhang et al., 2009
- Streets et al., 2003

**NO₂**

- Zhang et al., 2009
- Streets et al., 2003

**Aerosols**

**CO₂**

**LTP born**

**Pre-historic**

Here comes your footer ▪ Page

2011年11月11일 공여일
Time, LTP, and Emissions

SO₂

NO₂

CO₂

Aerosols

Pre-historic 1st phase LTP

Pre-historic LTP born
Time, LTP, and Emissions

SO$_2$

NO$_2$

Aerosols

CO$_2$

Pre-historic  1$^{st}$ phase LTP  2$^{nd}$ phase  LTP born

Pre-historic  1$^{st}$ phase LTP  2$^{nd}$ phase  LTP born
Time, LTP, and Emissions

SO$_2$

NO$_2$

Pre-historic  1st phase LTP

LTP born  2nd phase

Aerosols

CO$_2$

LTP born  2nd phase

Pre-historic  1st phase LTP

Here comes your footer.
New Objectives

- Two major and one supplemental objectives

: Understand air quality issues in East Asia in consideration of new challenges, such as secondary pollutants, HAPs, climate change, and etc. Decide what we want to pursue and what we won’t (State-of-art science)

: Use our understanding to prioritize our actions to mitigate adverse AQ effects for another decade. Health/environmental impact and mitigation policy study need to be initiated (Policy supporting science)

: How can we improve our collaborative research framework to accomplish these objectives effectively?
2. Suggested Topics for LTP Post-2012 Plan

- Air Quality Forecast for Northeast Asia
- Implementation of Advanced S-R Methodologies
- Assessment of O\textsubscript{3} and PM for the future LTP Project
- Scenario-based Collaboration Simulation Approach
2.1 Chemical Air Quality Forecast for Northeast Asia

Shang Gyoo Shim

*Korea Institute of Science and Technology*
Air Quality Forecast - Existing Efforts (examples)

- **Modeling Frameworks**
  - Meteorological Models: MM5, RAMS, WRF
  - Chemical Models: CMAQ, CFORS, CAMx
  - Domain, Grid, and Emissions

  - **China**
    - Horizontal Grid Spacing:
      - Asia: 36km, China and Korea: 12km, Beijing Metropolitan Area: 4km
    - Vertical Layer: 14 layers
    - Emissions: Trace-P 2000 + Statistical Books

  - **Japan**
    - Horizontal Grid Spacing:
      - Asia: 80km, 15 km (in preparation)
    - Vertical Layer: 23 layers to 20km
    - Emissions: Trace-P 2000 + dust, sea salt, lightening, volcano, radon, Biomass burning

  - **Korea**
    - Horizontal Grid Spacing:
      - East Asia: 27km, Korea: 9km, SMA: 3 km
    - Vertical Layer: 11 layers to 14.7km
    - Emissions: INTEX-B 2006+ CAPSS 2007+ fugitive dust, biogenic, biomass burning
- Three country generate the common metrological/emissions data for the simulation
- Each country uses its’ own chemical model(s)
- Cooperation with other fields (ground and airborne monitoring, satellite data retrieval, LIDAR networks)
Air Quality Forecast – a Framework (Draft)

- Three country generate the common metrological/emissions data for the simulation
- Each country uses its’ own chemical model(s)
- Cooperation with other fields (ground and airborne monitoring, satellite data retrieval, LIDAR networks)

- Integrated performance testing during Intensive Monitoring Period (ex. forecast for 72 hours for the entire month of IMP)
  - National Air Quality Index (API)
  - Concentration of air pollutants: $O_3$, $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$, sulfate, nitrate, ammonia, mercury etc.
Three country generate the common metrological/emissions data for the simulation

Each country uses its’ own chemical model(s)

Cooperation with other fields (ground and airborne monitoring, satellite data retrieval, LIDAR networks)

Integrated performance testing during Intensive Monitoring Period (ex. forecast for 72 hours for the entire month of IMP)
  - National Air Quality Index (API)
  - Concentration of air pollutants: $O_3$, $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$, sulfate, nitrate, ammonia, mercury etc.

Need common /integrated modeling/monitoring framework and may need a modeling center
Air Quality Forecast – Necessary collaborations

For performance enhancement

- Input data update (Emission Inventory, Land Use, Terrain)
- More detailed emission Inventory (Fugitive dust, Sand storm, Forest fire, Biomass burning, Volcano, Biogenic emission)
- Emission inventory for North Korea
- Background, Boundary Conditions

For implementation - Arrangements

- Each country secures its financial support from Government and/or International Organizations.
- Each country reports to the Environmental Minister and endeavors to bring this matter to the Tripartite Environment Ministers Meeting Among China, Japan, and Korea (TEMM)
2.2 Implementation of Advanced S-R Methodologies

Jung-Hun Woo

Dept. of Advanced Technology Fusion, Konkuk University
Why Do We Need Advanced S-R Methodologies?

- To conduct more sophisticated S-R research
  - Simultaneous analysis for regions-sectors, ICs, BCs
  - Finer S-R (e.g. megacity impact study)
  - Control measure testing …

- To understand various sensitivities
  - Precursor to product sensitivity
  - Region to region sensitivities…

- Benefits
  - Save time, effort, and space (faster and simpler)
  - Avoid non-linearity

What’s available?

- Source tagging (REMSAD, CAMx-PSAT, CMAQ-PPTM)
- Forward Sensitivity (CMAQ-DDM)
- and more…
Source Tagging (CMAQ-PPTM)

- PPTM: Particle and Precursor Tagging Methodology
- Assessment of the source contribution by source tagging method
- Emissions from selected sources, source categories, or source regions are (numerically) tagged and then tracked throughout a simulation

**Flowchart:**
- Source tagging
- Emissions Model (SMOKE-Asia)
- Meteorology Model (MM5 or WRF)
- MCIP
- CMAQ Simulation
- CMAQ-PPTM Source Tagging analysis

**Diagram:**
- Source tagging
  - Emission
  - 1
  - 2
  - 3
  - 4
- Emissions Model (SMOKE-Asia)
- Meteorology Model (MM5 or WRF)
- MCIP
- CMAQ Simulation
- CMAQ-PPTM Source Tagging analysis

**Legend:**
- Tag 1
- Tag 2
- Tag 3
- Tag 4
- Tag 5
- Tag 6
- Tag 7
- Tag 8
- Tag 9
- Tag 10
- Great Smoky Mountains
Forward Sensitivity (CMAQ-DDM)

- Calculates sensitivity of concentrations to input parameters along with the concentrations themselves.
- Can provide sensitivity to:
  - species
  - regions or individual sources
  - other model parameters (e.g. reaction rates)
Source Tagging(REMSAD-tagging)

- Use Tagging method based on REMSAD model for Northeast US

Advanced S-R Methods - Source Tagging

Source Tagging(REMSAD-tagging)

Woo et al.(2006)

- Use Tagging method based on REMSAD model for Northeast US

**Contribution to PM sulfate in a receptor site**

Source Tagging (REMSAD-tagging)

Woo et al. (2006)

- Use Tagging method based on REMSAD model for Northeast US

**Contribution to PM sulfate in a receptor site**

Can be combined with AQF!
Source Tagging (REMSAD-tagging)


Assessment of megacity impacts

Can be combined with AQF!
2.3 Assessment of O$_3$ and PM for the future LTP Project

Cheol-Hee KIM
Dept. of Atmospheric Sciences, Pusan National University
Key Findings of O3 Impacts (from TF-HTAP 2010)
(TF-HTAP : Task Force on Hemispheric Transport of Air Pollution)

O3 Impacts on Health Impacts

- One study based on the HTAP multi-model comparison estimated that O3 resulting from emissions from foreign regions contributes 20% to >50% of O3 mortalities, subject to large uncertainty.
- Three studies estimate that reductions in O3 precursor emissions may avoid more premature mortalities outside of some source regions than within, mainly because of larger populations outside of the source regions.

O3 Impacts on Climate Change

- O3 contributes significantly to climate forcing,
  - Directly as a greenhouse gas that causes warming
  - And indirectly by damaging plants inhibiting their natural uptake of CO2.
- Among ozone precursors, widespread reductions in emissions of CH4, CO, and VOCs better reduce net climate forcing than reducing NOX, which may increase forcing over decadal time scales.
Key Findings of PM Impacts (from HTAP 2010)

PM Impacts on Health

- Contributions to PM from emissions within a region are much more important for health than emissions from foreign continents.
- Intercontinental transport of PM can cause more mortalities than intercontinental transport of O3, due to the stronger PM-mortality relationship.
- Emissions from North America and Europe have much greater impacts on foreign regions than do emissions from East Asia and South Asia.

<table>
<thead>
<tr>
<th>Source Region</th>
<th>NA</th>
<th>EA</th>
<th>SA</th>
<th>EU</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA</td>
<td>502</td>
<td>20</td>
<td>9</td>
<td>49</td>
<td>590</td>
</tr>
<tr>
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Key Findings of PM Impacts (from HTAP 2010)

PM Impacts on Climate Change

- Change of global annual average TOA all-sky aerosol direct RF in response to the 20% reduction of anthropogenic emissions
- BC activity under EMEP/CLRTAP: Focus country specific contribution to direct radiative forcing by BC aerosols

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2.4 Scenario-based Collaboration Simulation Approach

Dong-Young Kim

*KDI School of Public Policy and Management*
Roadblocks for international environmental cooperation

- **Among countries**
  - Lack of trust, data sharing
  - Different (political and economic) interests
  - Lack of legitimacy of independent modeling

- **Among decision makers and scientists**
  - Lack of understanding
  - Different assumption, languages and interests

Conditions for effective collaboration

- **Existence of on-going (effective and flexible) communication channels** for domestic and international decisionmakers, key stakeholders, and scientists

- **Joint Fact-finding mechanism**
  - Shared assumptions in modelling
  - Shared data and research methods

- **Shared roadmap** from the beginning
Alternative approach to conventional ways

- **Conventional channels**
  - Government-initiated (established) meetings
  - Scientists-oriented meetings

- **Alternative channels**
  - Workshop environment where decisionmakers, key stakeholders, and scientists get together
  - More flexible and creative environment
  - For learning about the relationships between science and policies and politics
Alternative approach to conventional ways

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- **Alternative channels**
  - Workshop environment where decisionmakers, key stakeholders, and scientists get together
  - More flexible and creative environment
  - For learning about the relationships between science and policies and politics

Scenario-based simulation method

- Construction of potential scenarios regarding transboundary air pollution (and/or) climate change with scenario development team among three countries (China, Japan, and Korea)

- Integration of Scenario with Modeling

- Utilization of scenario-based modeling with collaboration simulation exercise
Potential benefits of alternative approach

- Lower the tension among participants
- Promote comprehensive understanding about complex relationships on the issue
- Focus on future rather than the past
- Facilitate understanding of non-scientists on the model and its outcome
- Improve model design with inputs from other stakeholders and decisionmakers
- Maintain the communication among various actors
- Bridge the flexible communications with formal ones

Pre-requisite

- Acknowledgement of the potential benefits by key decision makers in three countries
- Identification of neutral convener or facilitators, experts on scenario-based planning in each country
- Knowledge on scientific, economic, political, policy factors
Milestone (tentative)

- Get other ideas, comments from all advisory committee members
- Hold a special task force meeting to prepare LTP Post-2012 draft
- First revision process (Summer, 2012)
- Finalize LTP Post-2012 plan at 15th Expert Meeting
Thank you and let’s start to think for the future!