Suggestions on TAP

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CONTENT

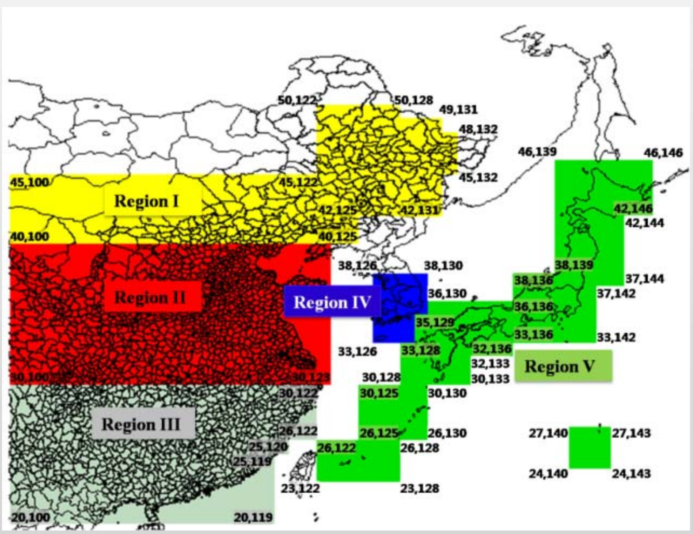
1. Background and Objectives

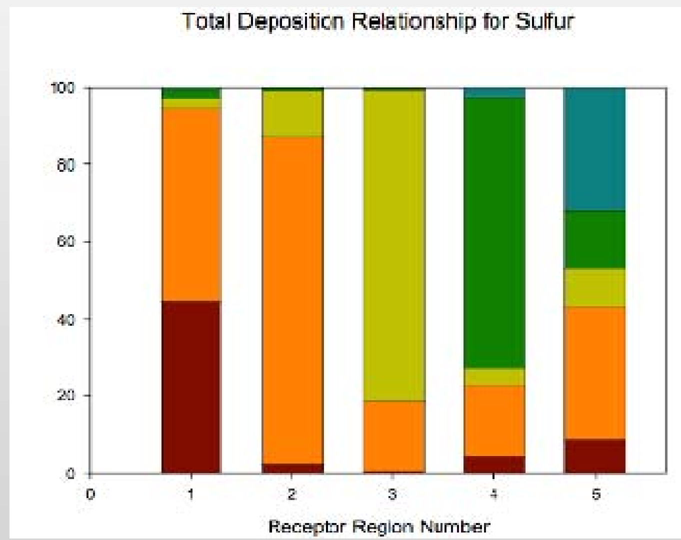
No Comprehensive mechanism in NE Asia

Targets	NE Asia	Europe
1. Acid deposition, Eeutrophication	○(EANET, **LTP)**	**EMEP**
2.Photochemical Oxidnats	○ (LTP, TEMM Project)	**EMEP**
3.Heavy metals	○**(LTP)**	**EMEP**
4.POPs	△(East Asia POPs Monitoring)	**EMEP**
5.PM	○**(LTP)**	**EMEP**
6. Integrated Modeling	×	**EMEP**
7.Emission Inventory	△**(LTP, MICS-ASIA)**	**EMEP**
8.Emission Process Model	○**(LTP)**	**EMEP**
9.Openness	×	**EMEP**
10.Collboration with HF-TAP	×	**EMEP (HTAP)**

LTP 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 (2012)**





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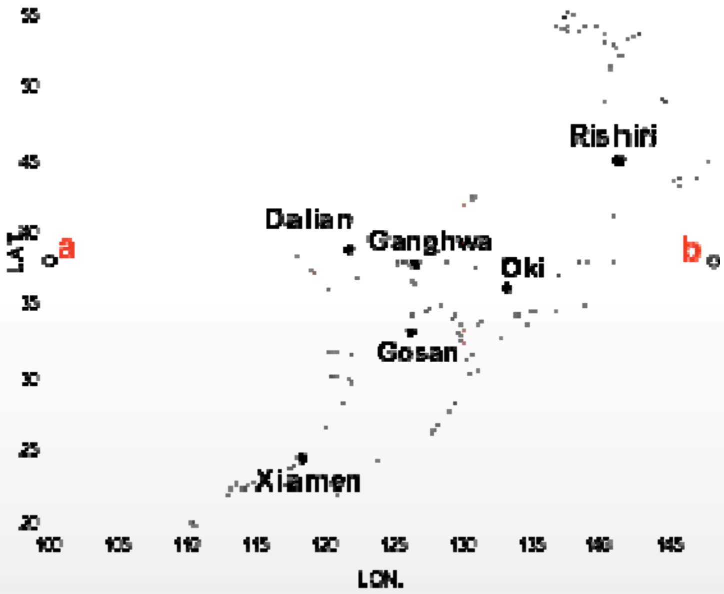
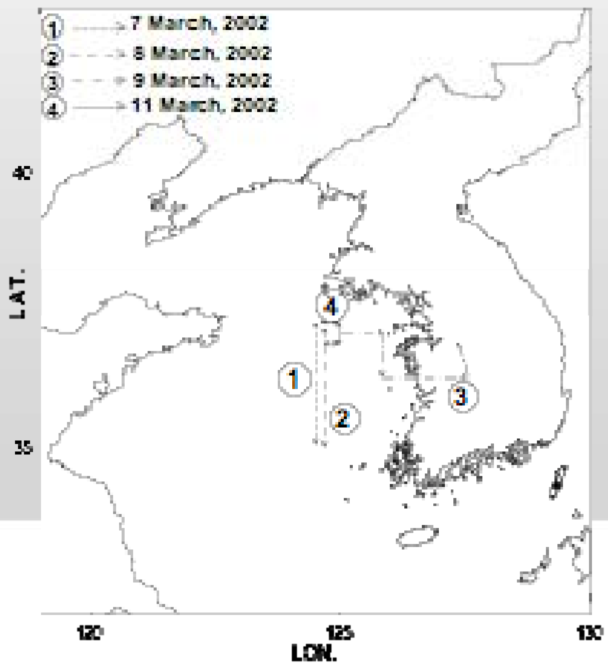
Similarities and uniqueness of LTP Framework to other activities

- **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

Model weakness (Model domain and locations of measurement)





- six SO_2 monitoring sites, and aircraft pathways

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LTP Modeling framework

	China	Japan	Korea
Model system	Models-3 / CMAQ σ coordinate 14 layers, 70×66 grids, 60km resolution (Byun and Ching, 1999)	RAQM (Regional Air quality Model) terrain following coordinate 12 layers, 110×80 grids, 60km resolution (An et al., 2002)	CADM (Comprehensive Acid Deposition Model) terrain following coordinates 12 layers, 110×80 grids, 60km resolution (Lee et al., 1998)
Domain	20～50N, 100～150E	20～50N, 100～150E	20～50N, 100～150E
Meteorological Model	MM5 34 layers with FDDA using NCEP reanalysis	MM5 125×95 (45km), 23 layers, FDDA using NCEP FNL reanalysis	CSU-RAMS 110×80, 29 vertical layer FDDA using NCEP FNL reanalysis
Chemical Mechanism	RADM Chemistry	CBM-IV mechanism	RADM Chemistry
Cloud Model Physical option	Diagnostic cloud model in RADM Simple explicit moisture scheme Grell cumulus schemes, MRF	Cloud model in MM5 Betts-Miller cumulus scheme, MRF RRTM	Cloud model in CSU-RAMS Anthes-Kuo cumulus scheme, MRF
Emission	SO_2, NOx, VOC, NH_3, CO, PM_{10}, biogenic VOC provided by LTP for the base year of 1998 (1°×1° resolution)	Same as China	Same as China
Dry deposition	Wesely's parameterization (Wesely, 1989)	Modified Wesely's parameterization (Walmsley & Wesely, 1996)	Dry deposition module in RADM (Lee et al, 1998)
Wet deposition	RADM Module (Chang et al, 1987)	RADM Module (Chang et al, 1987)	RADM Module (Chang et al, 1987)
Land use type	EPA/NOAA global ecosystem (11 categories)	DeFries & Townshend (1994)	EPA/NOAA global ecosystem (11 categories)

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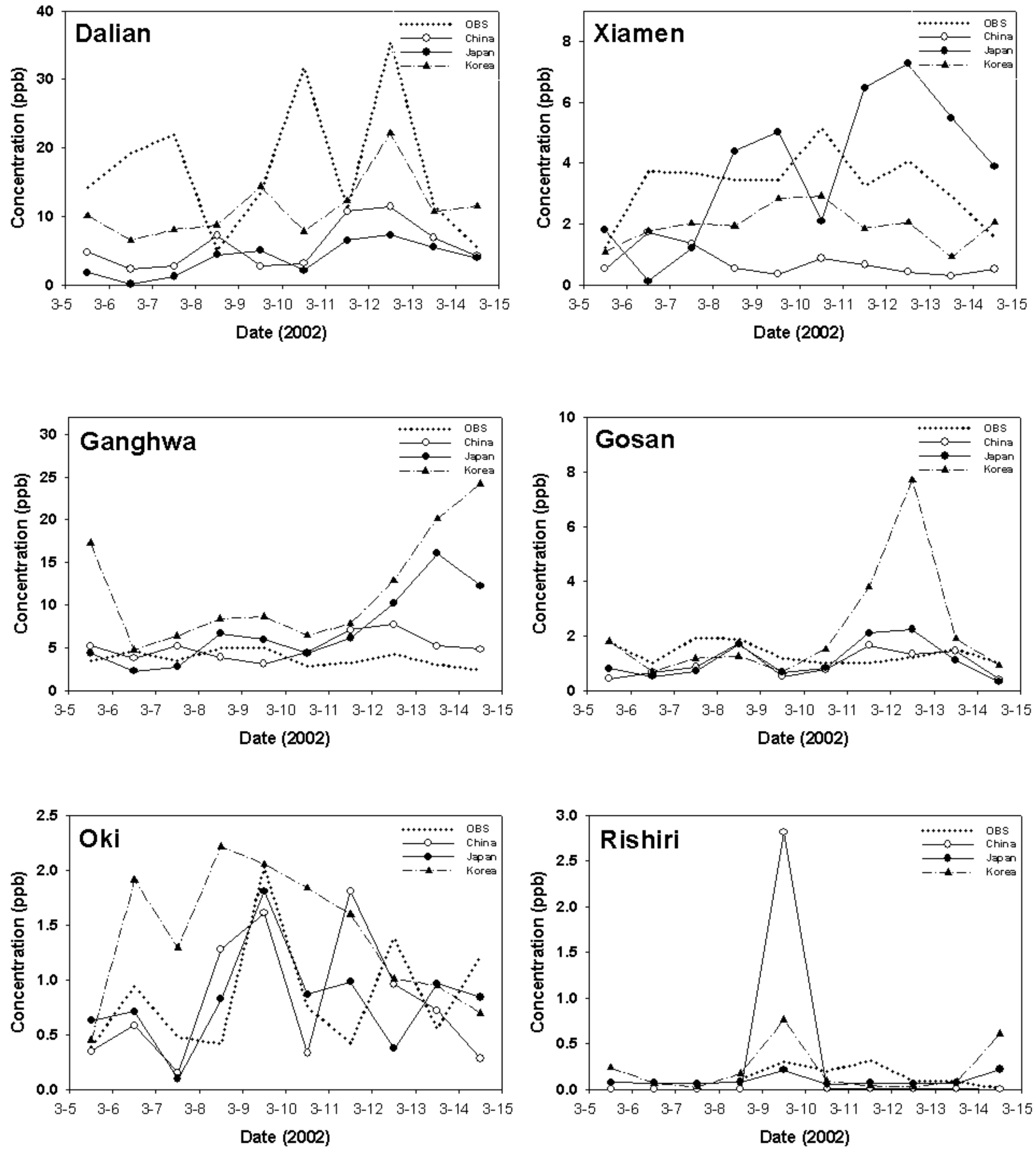
Summary of model performance (SO2)

	Obs	China	Japan	Korea
Sample size	57	57	57	57
Range(ppb)	0.0042-35.43	0.0-11.387	0.05-16.07	0.025-24.22
Mean(ppb)	4.59	2.35	2.91	5.01
Standard deviation (ppb)	7.13	2.66	3.26	5.81
Mean of ratio model/obs (S/O)		0.91	1.99	4.25
Standard deviation of ratio model/obs (S/O)		1.37	6.81	19
Absolute gross error		3.11	3.61	3.44
Correlation coefficient		0.54	0.19	0.53
Mean difference		2.24	1.68	-0.42
Difference standard deviation		6.13	7.24	6.42
Root-mean square error		6.48	7.37	6.38
Mean square error. MSEN		5.06	10.21	24.56
Mean square error. MSES		37.54	45.05	16.86
Index of agreement		0.53	0.37	0.69
Mean fractional error		0.59	0.22	-0.12

Model performance comparison



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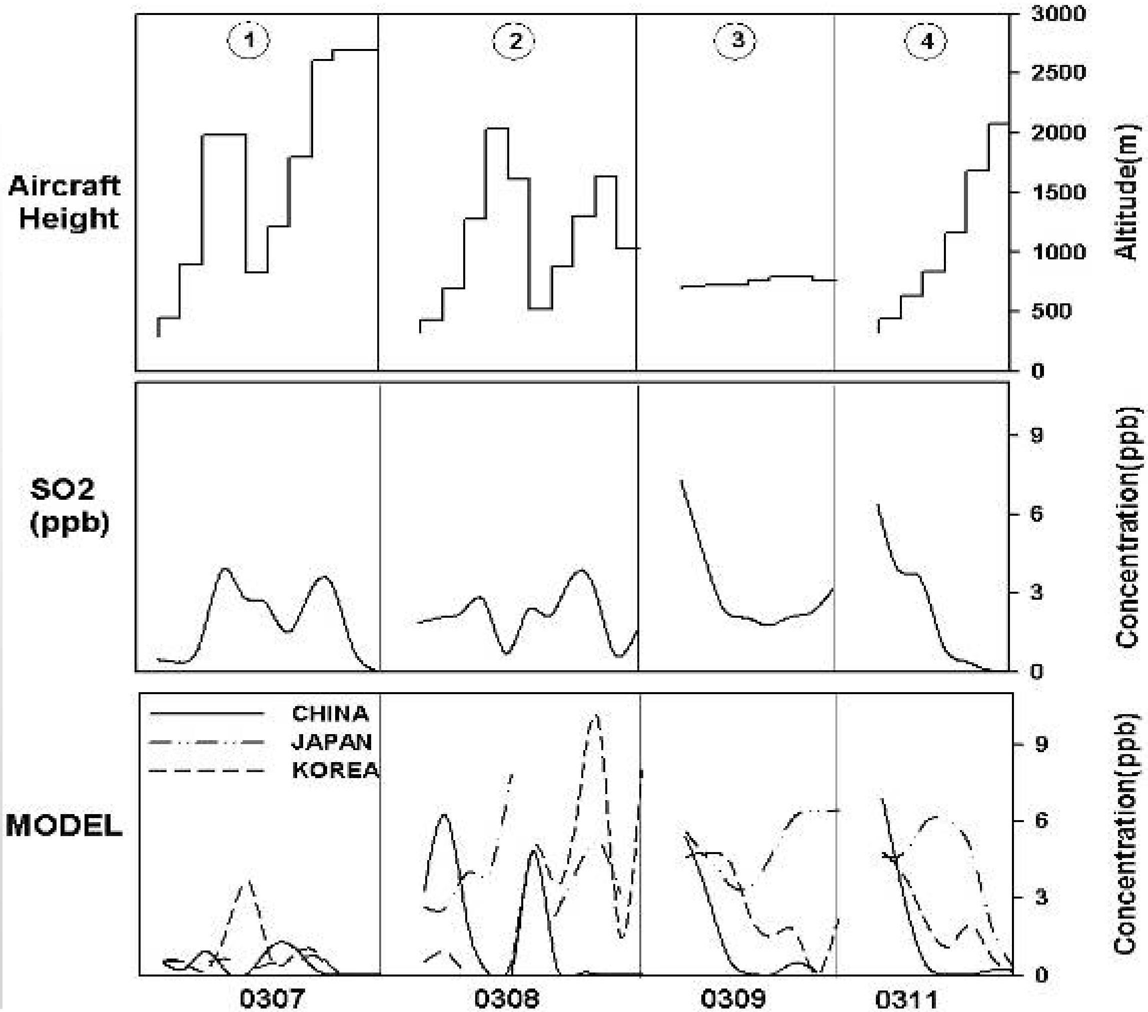
Model performance comparison



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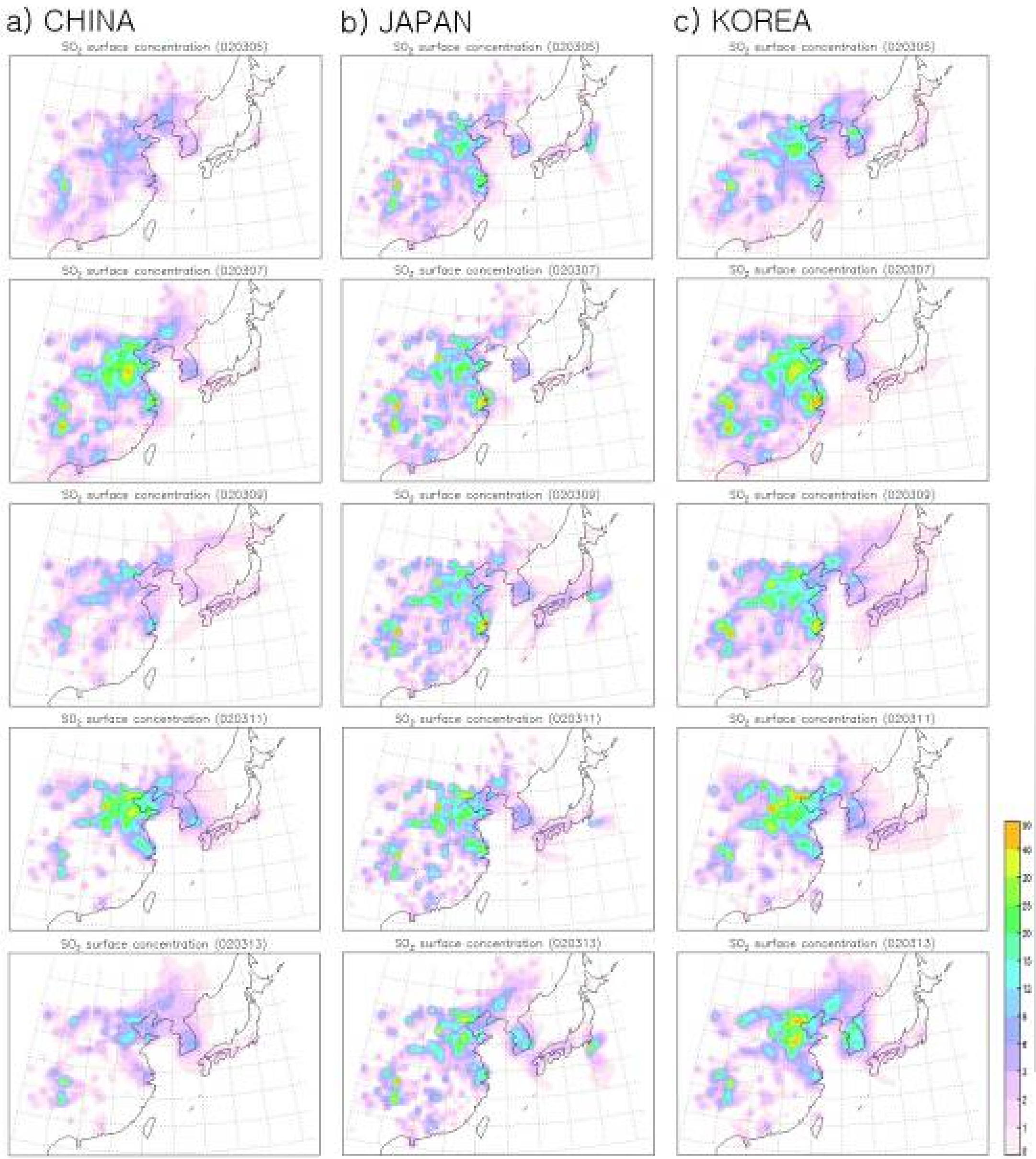
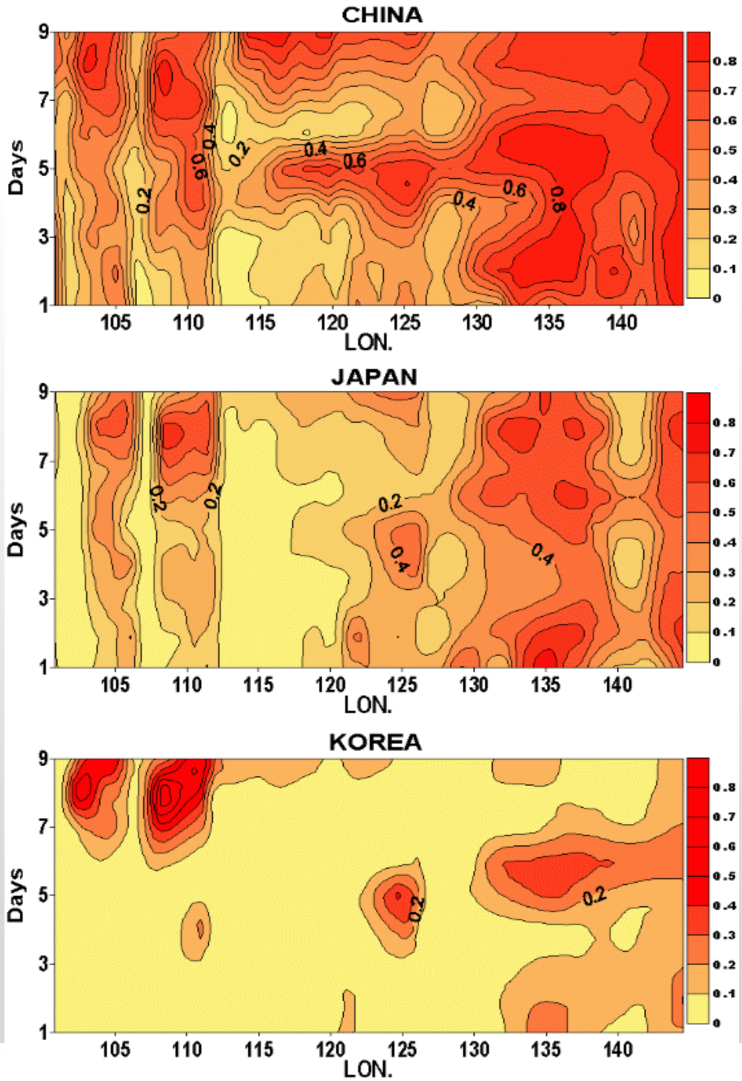
Spatial distribution of the simulated [SO2]



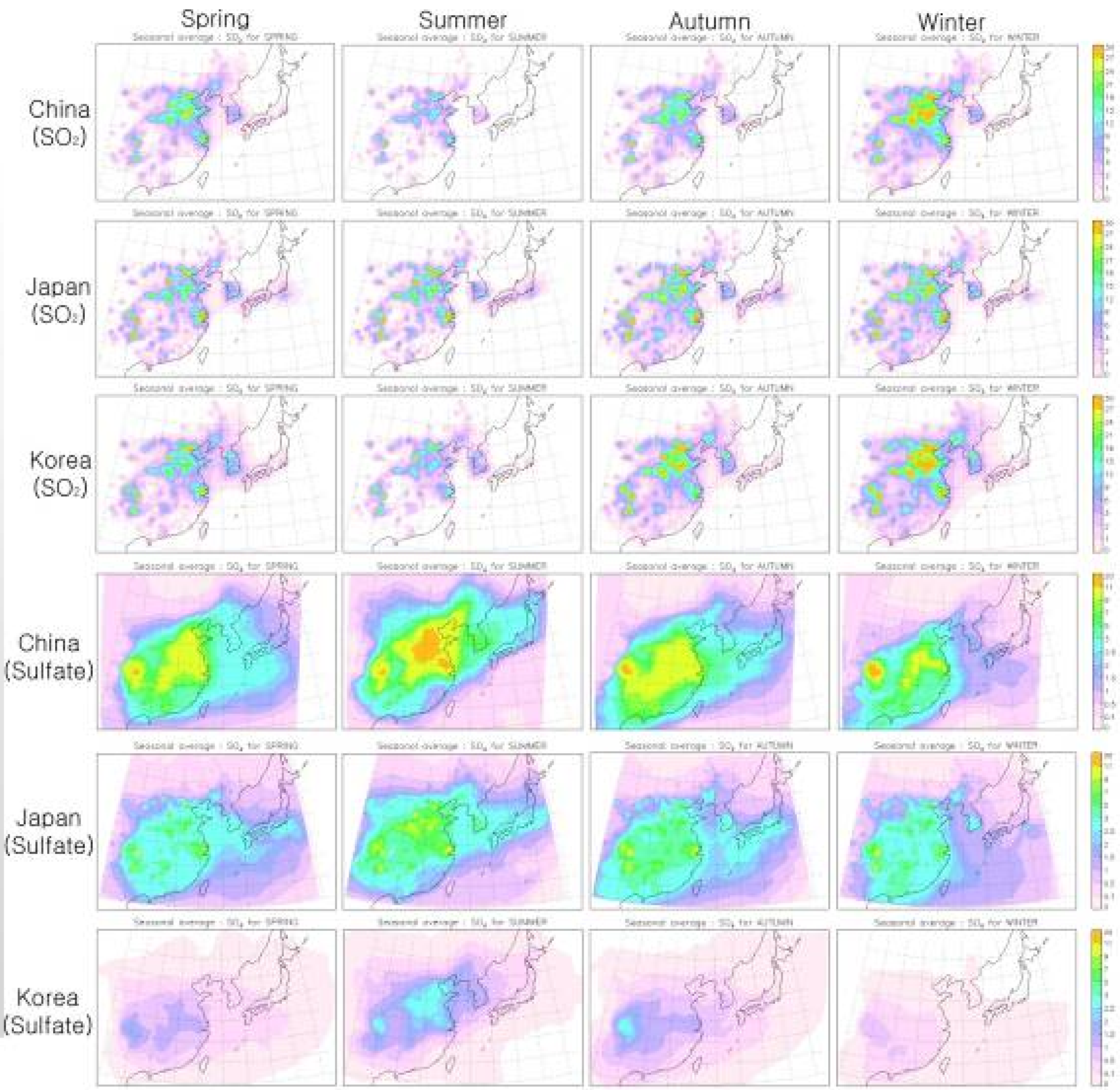
Simulated surface SO_2 concentrations from (a) China, (b) Japan, and (c) Korea on 5-13, March.

Conversion ratio of SO2 to sulfate



Time variations of longitudinal cross-section of simulated conversion ratio of sulfur (Fs = SO_4^{2-}/(SO_2 + SO_4^{2-}) from (a) China, (b) Japan, and (c) Korea on 5-13, March.

Spatial distribution of the simulated [SO2]



Seasonally averaged surface SO_2 and SO_4^{2-} concentrations simulated by (a) China, (b) Japan, and (c) Korea for the year of 2002.

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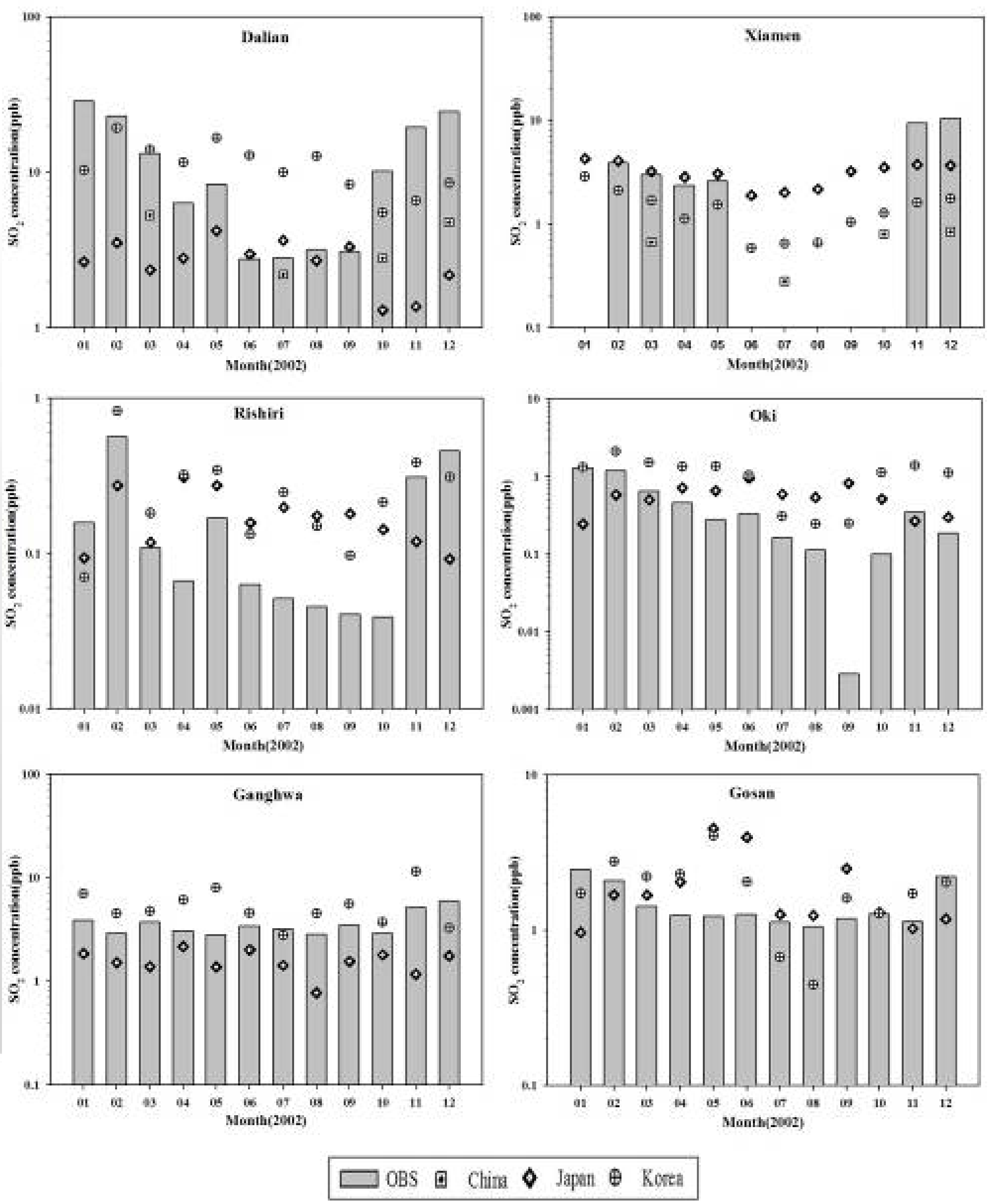
Model validation by observations



Comparison between monthly variation of simulated versus observed SO_2 concentrations at 6 LTP sites in 2002

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New Challenges

- The LTP research framework has been working out, 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

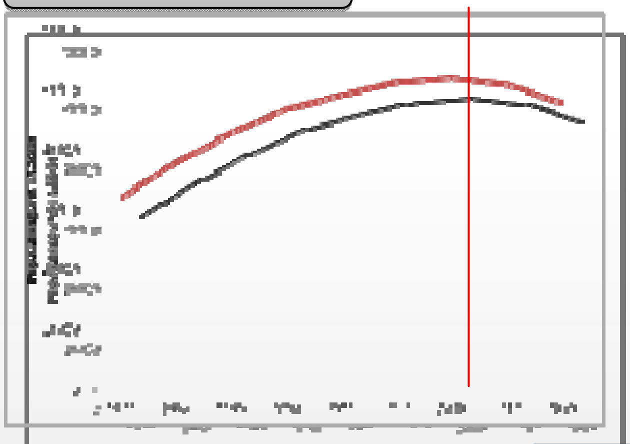
Trend

Night light during last 10 years

Rapid economic growth ➡ Transboundary Air Pollution Problem
➡ Collbotrationn among stakeholders

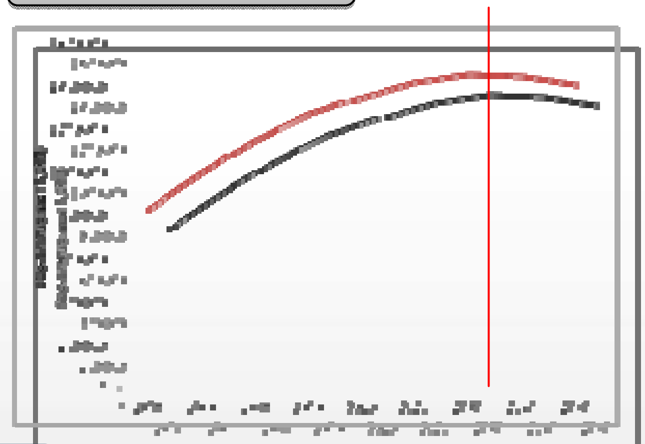
Population and Urbanization

ROK



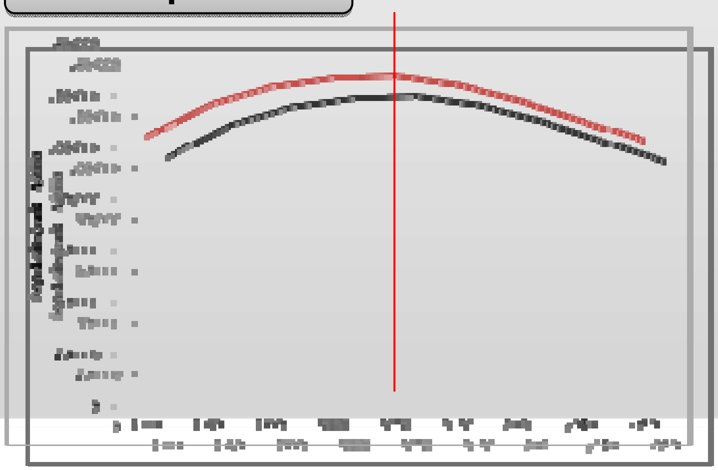
DPRK

China

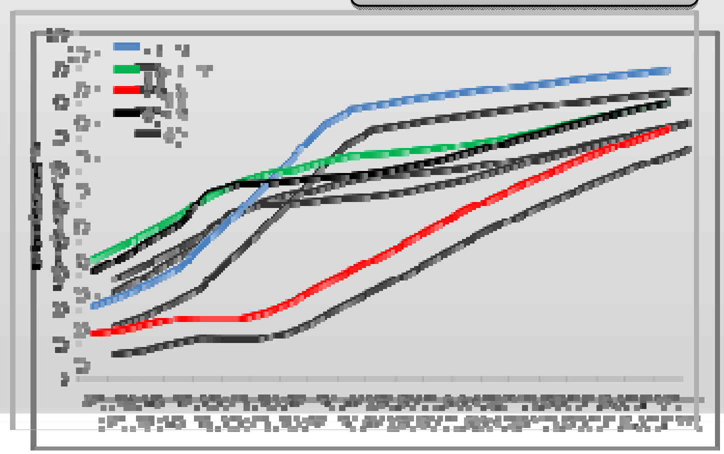


Target year?

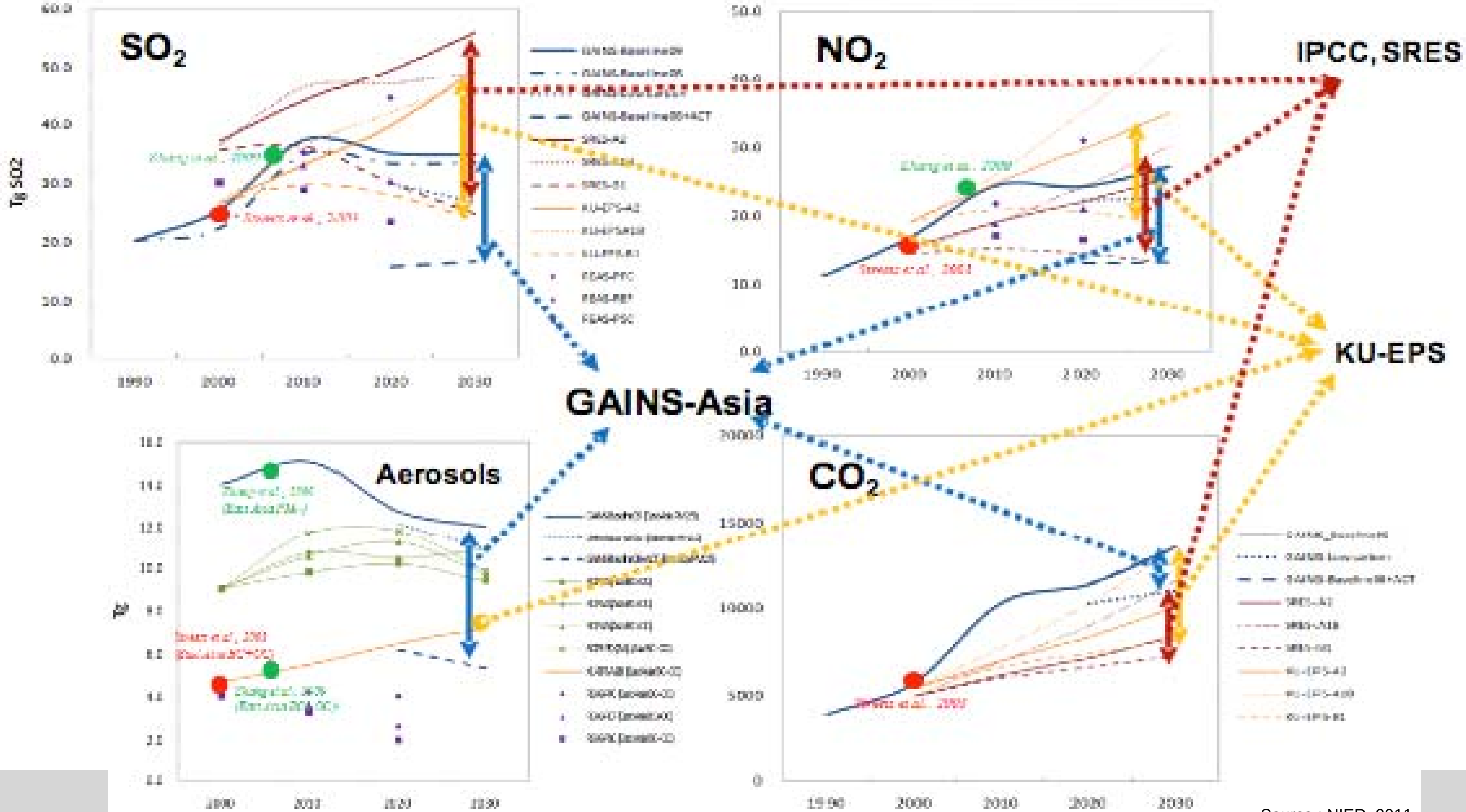
Japan



Urbanization



Time and Emissions



Source : NIER, 2011

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

- Air Quality Forecast for Northeast Asia
- Implementation of Advanced S-R Methodologies
- Assessment of O_3 and PM
- Scenario-based Collaboration Simulation Approach

2.1 Chemical Air Quality Forecast for Northeast Asia

Air Quality Forecast - Existing Efforts (examples)

- **Modeling Frameworks**

- Meteorological Models : MM5, RAMS, WRF

- Chemical Models : CMAQ, CFORS, CAMx

- Domian, Grid, and Emissions

✓China

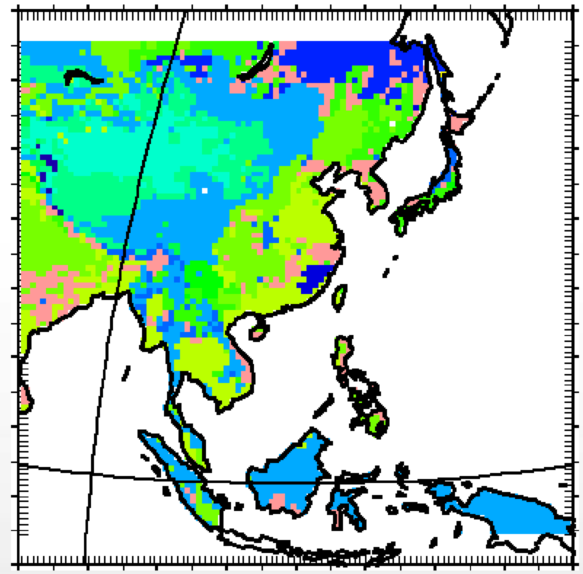
- Horizontal Grid Spacing:
  Asia: 36km, China and Korea:
  12km, Beijing Metropolitan Area: 4km
- Vertical Layer : 14 layers
- Emissions : Trace-P 2000 + Statistical Books

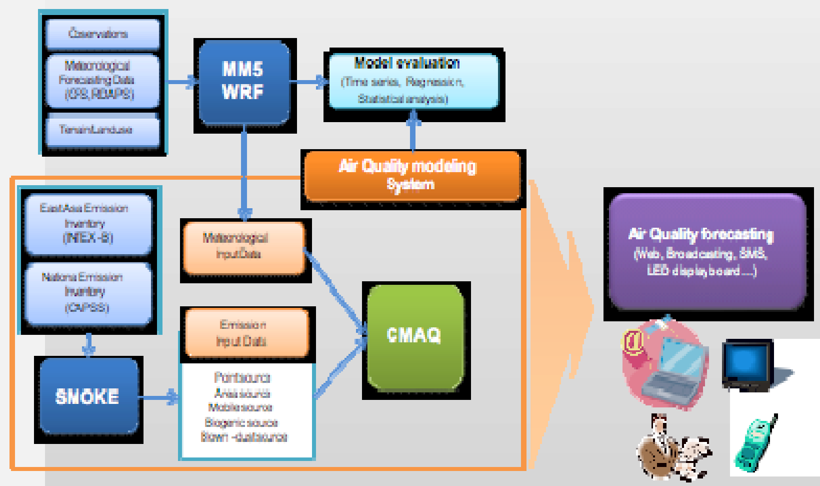
✓Japan

- 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





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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.

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

Advanced S-R Methods - Background

Why Do We Need Advanced S-R Methodologies?

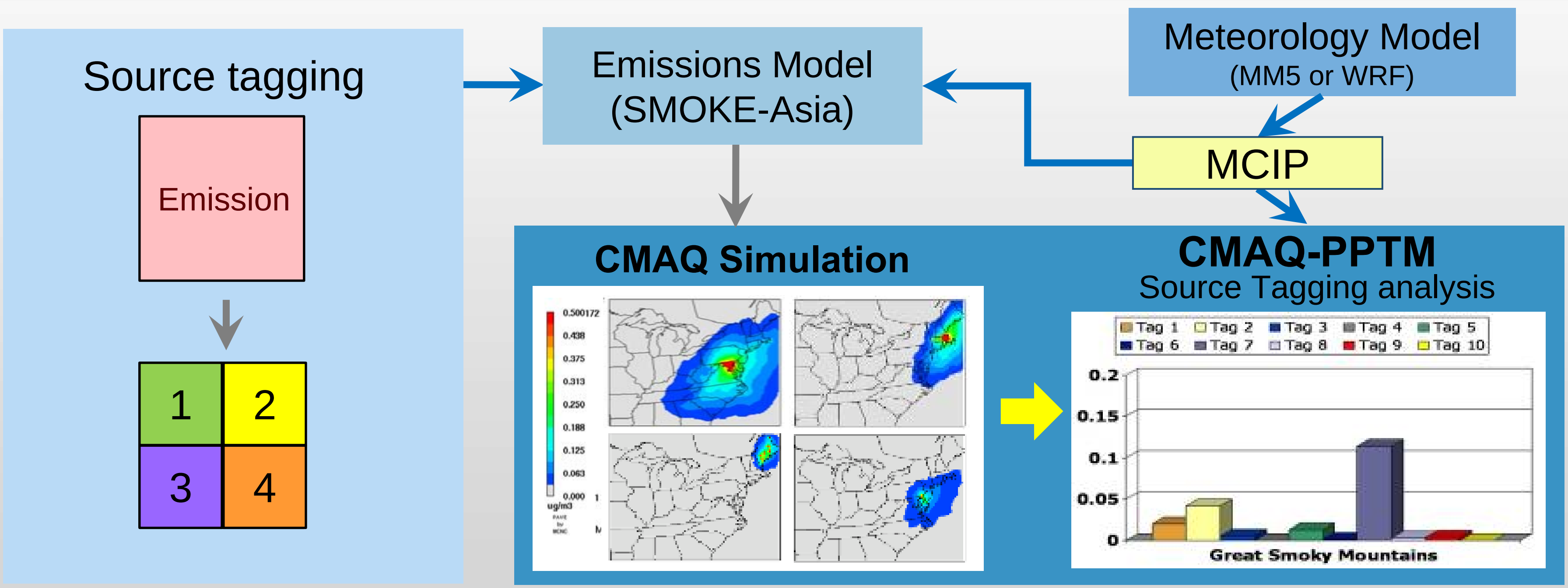
- **To conduct more sophisticate S-R research**
  - Simultaneous analysis for regions-sectors, ICs, BCs
  - Finer S-R(e.g. megacity impact study)
  - Control measure testing …
- **To understand various sensitivities**
  - Precursor to product sensitivity
  - Region to region sensitivities…
- **Benefits**
  - 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



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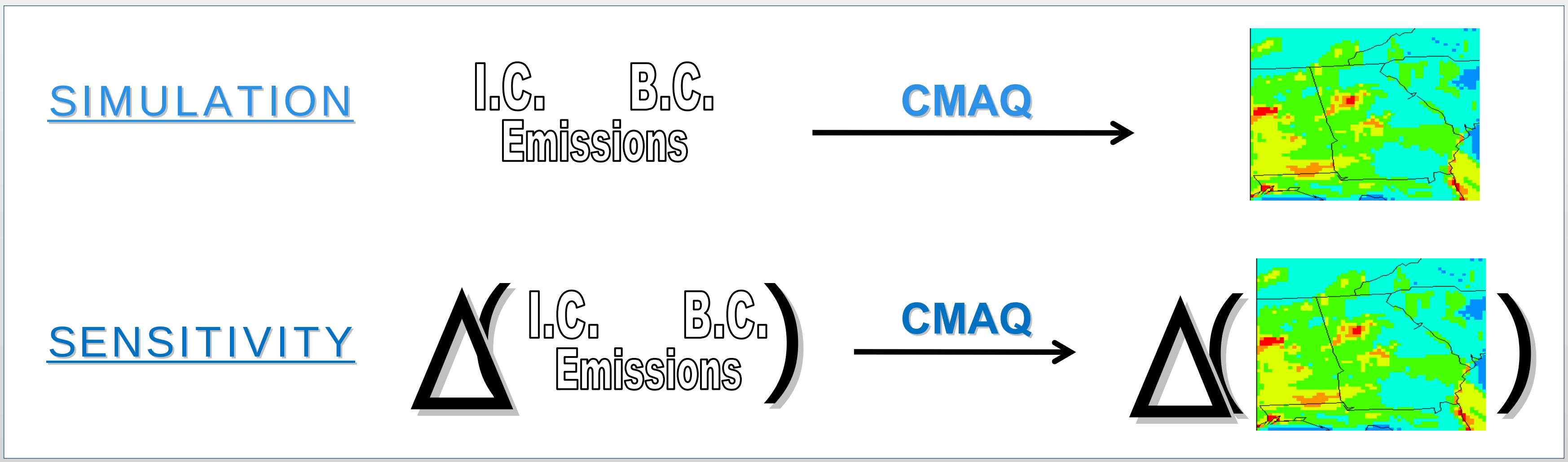
Forward Sensitivity(CMAQ-DDM)

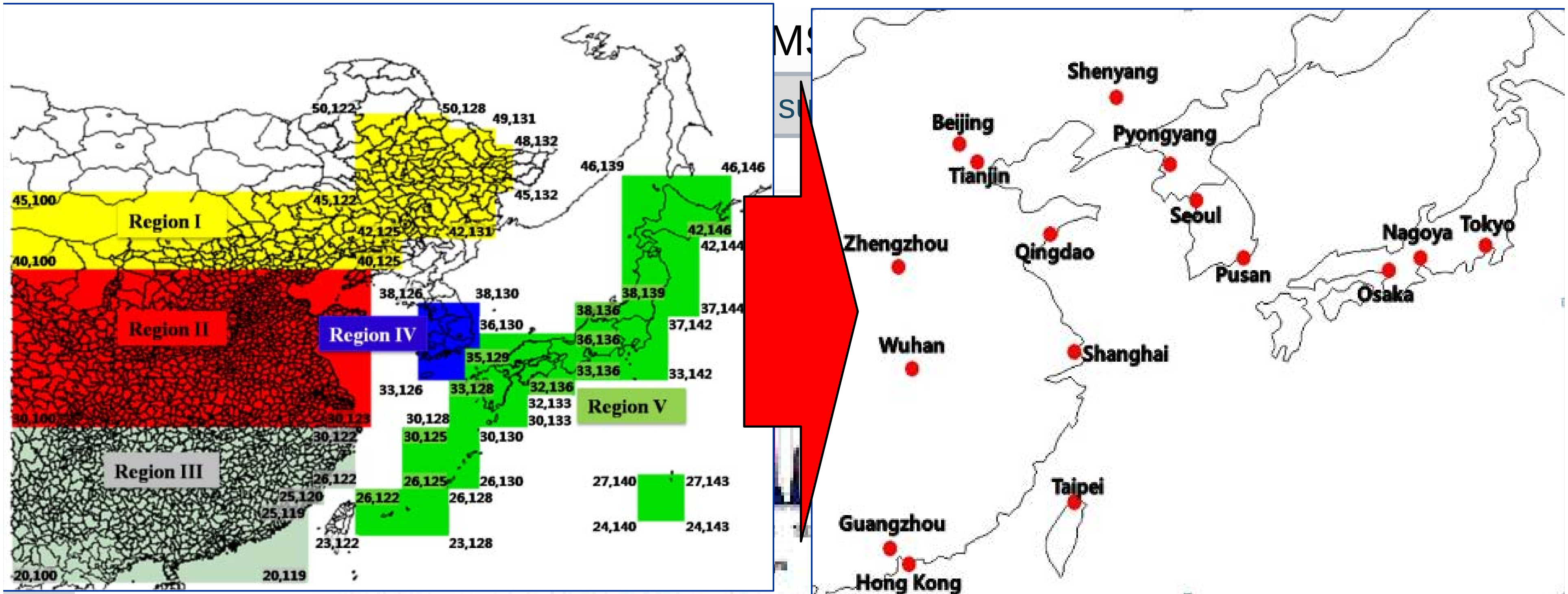
- Calculates sensitivity of concentrations to input parameters along with the concentrations themselves
- Can provide sensitivity to:
  - species
  - regions or individual sources
  - other model parameters (e.g. reaction rates)



Advanced S-R Methods - Source Tagging

Source Tagging(REMSAD-tagging)

Woo et al.(2006)



Assessment of megacity impacts

2.3 Assessment of O_3 and PM for the future LTP Project

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 O_3 resulting from emissions from foreign regions contributes 20% to >50% of O_3 mortalities, subject to large uncertainty
- Three studies estimate that reductions in O_3 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

Hundreds of annual avoided mortalities, threshold=5.8 μg/m³ in *italics*

Source Region	Receptor Region				
	NA	EA	SA	EU	World
NA	502 *125*	20 *19*	9 *8*	49 *38*	590 *190*
EA	10 *5*	4348 *3330*	25 *23*	18 *14*	4433 *3376*
SA	2 *1*	42 *39*	2105 *1099*	5 *3*	2168 *1142*
EU	8 *4*	82 *78*	70 *57*	1769 *573*	2010 *71600*

Impact on foreign receptor regions:

← 14.9%

← 1.9%

← 2.9%

← 12.0%

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

(unit: mW m^{-2}, mean ± std. dev)

Source Region	Sulfate	POM	BC	Sulfate+POM+BC
NA	16.1 ±5.6	1.6 ±1.0	-4.5 ±1.9	13.2 ±5.2
EU	26.7 ±9.5	1.9 ±1.2	-7.4 ±2.3	21.2 ±9.5
EA	19.6 ±7.2	3.2 ±1.8	-14.5 ±8.0	8.4 ±10.2
SA	6.1 ±1.9	2.5 ±1.3	-5.5 ±2.4	3.1 ±3.2
NA+EU+EA+SA	68.4 ±22.9	9.1 ±5.0	-31.9 ±13.7	45.9 ±24.6

2.4 Scenario-based Collaboration Simulation Approach

Scenario-based Collaboration Simulation - Background

Roadblocks for international environmental cooperation

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

Collaboration Simulation - Methods

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

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

Collaboration Simulation – Benefits and Pre-requisite

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

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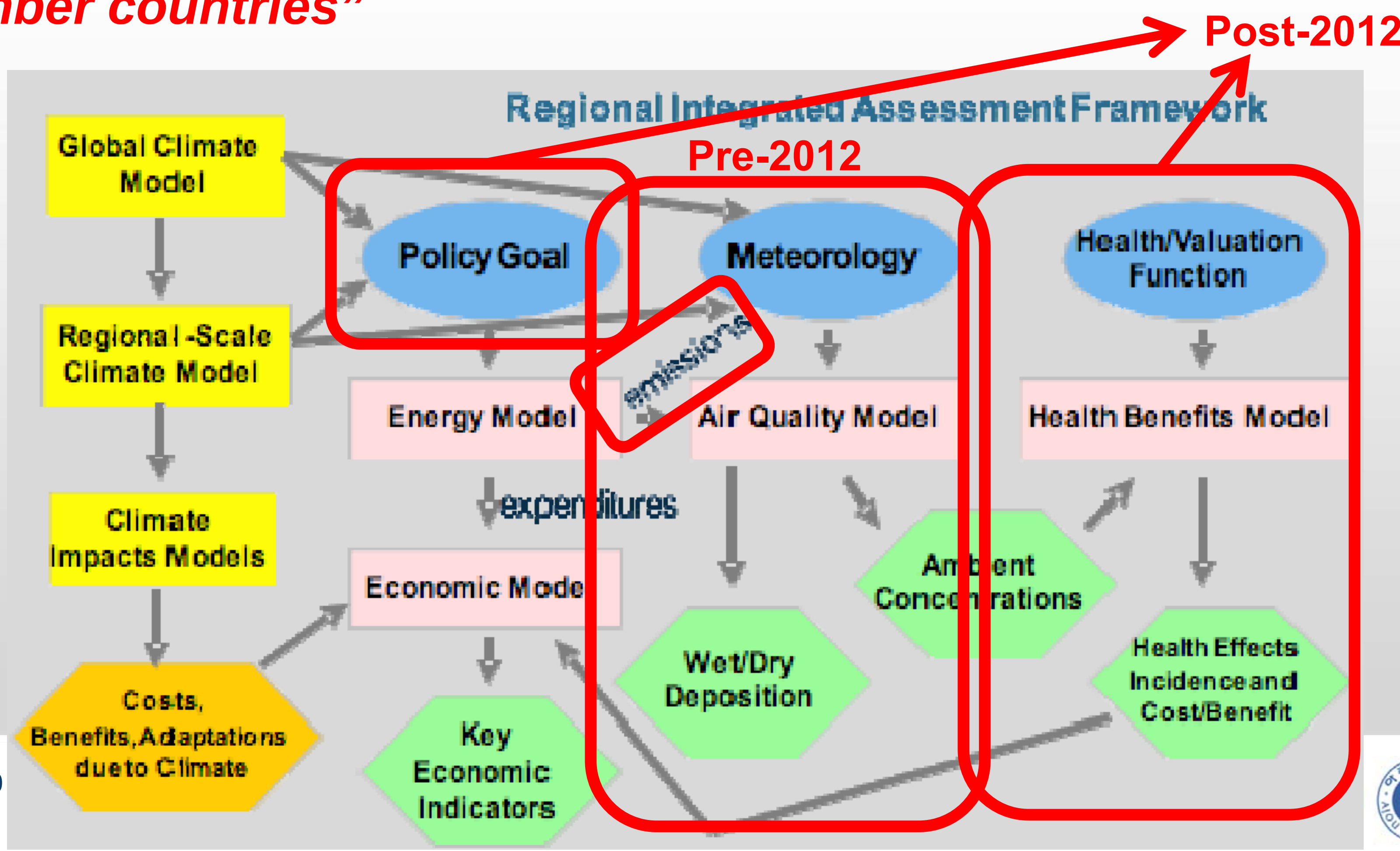
Ultimate Goal of for future

"Building an integrated and comprehensive regional air quality research collaboration framework that can produce state-of-art science results(papers) and useful policy supporting information, under the consensus of members from all three member countries"



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