MICS-Asia

: Collaborative Emissions and Modeling Research Frameworks in Asia and Beyond

Jung-Hun Woo

Konkuk University, Seoul, Korea

UN ESCAP Consultation Meeting on the North-East Asia Clean Air Partnership (NEACAP)

13 October 2017, Haeundae Grand Hotel, Busan, Republic of Korea

MICS-Asia
Model InterComparison Study for Asia

International Institute for Applied Systems Analysis

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08 March 2017 - 10 March 2017
IIASA, Laxenburg

International Workshop on Atmospheric Modeling Research in East Asia (MICS-Asia III)

More than 40 scientists will participate in the 2017 MICS-Asia III workshop to report on and discuss progress with the analysis of model intercomparisons for the three topics of MICS-Asia III.

The MICS-Asia III project has its focus on the evaluation of the strengths and weaknesses of current multi-scale air quality models, and aims to provide techniques to reduce uncertainty in Asia, to develop reliable anthropogenic emission inventories for Asia, and to research the interaction between air quality and climate change. At the workshop, the participants will report on and discuss the progress made with the analysis of model intercomparisons for the three topics of MICS-Asia III, which are: the comparison of modeling systems, the comparison of emission source inventories, and changes in the atmospheric environment and climate.

This workshop is co-hosted by the Asia Center for Air Pollution Research (ACAP) of Japan, the Institute of Atmospheric Physics (IAP) affiliated to the Chinese Academy of Science (CAS) and IIASA and will bring together more than 40 scientists from 24 different research institutions in 12 countries.

The first 11 meetings of the MICS-Asia project were hosted at IIASA. After that the meetings were moved to China, as more and more of the modeling community came from Asia. To acknowledge the importance of IIASA as a breeding place for scientific cooperation, even in

CONTACT DETAILS

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PUBLICATIONS

Akimoto H, Kurokawa J, Sudo K, Nagashima T, Takemura T, Klimont Z, Amann M, & Suzuki K (2015). SLCP co-control approach in East Asia: Tropospheric ozone reduction strategy by simultaneous reduction of NOx/NMVOC and methane.

Chen F, Yamashita K, Kurokawa J, & Klimont Z (2015). Cost-benefit analysis of reducing premature mortality caused by exposure to ozone and PM2.5 in East Asia in 2020.

Wang SX, Zhao B, Cai SY, Klimont Z, Nielsen CP, Morikawa

http://www.iiasa.ac.at/

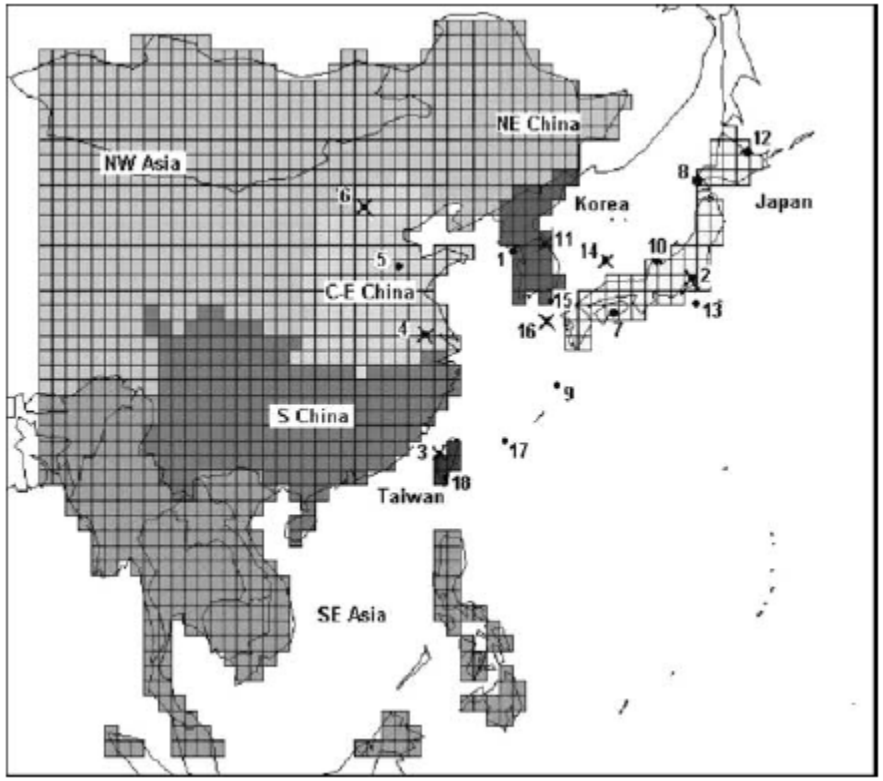
MICS-Asia Phase I (1998-2003)
: Long-range transport and deposition of sulfur

- After the acidification debate in Europe, projections of economic growth in Asia raised concerns about future SO_2 emissions in Asia
- However, transboundary aspects were controversial
- IIASA offered neutral, scientific meeting place (5 workshops at IIASA)

- Modeling Domain and S/R regions
  - obs.: CRIEPI gas/particle/wet dep. network
  - met.: RAMS outputs by Uno@KyushuU
  - emis.: RAINS-Asia

- Model settings
  - zero boundary conc.
  - V_d prescribed

- 5 Eulerian and 3 Lagrangian Models were participated



Source : M. Amann(2017) and H. Hayami (2017)

3rd MICS-Asia Workshop, IIASA, Sep 19, 2000

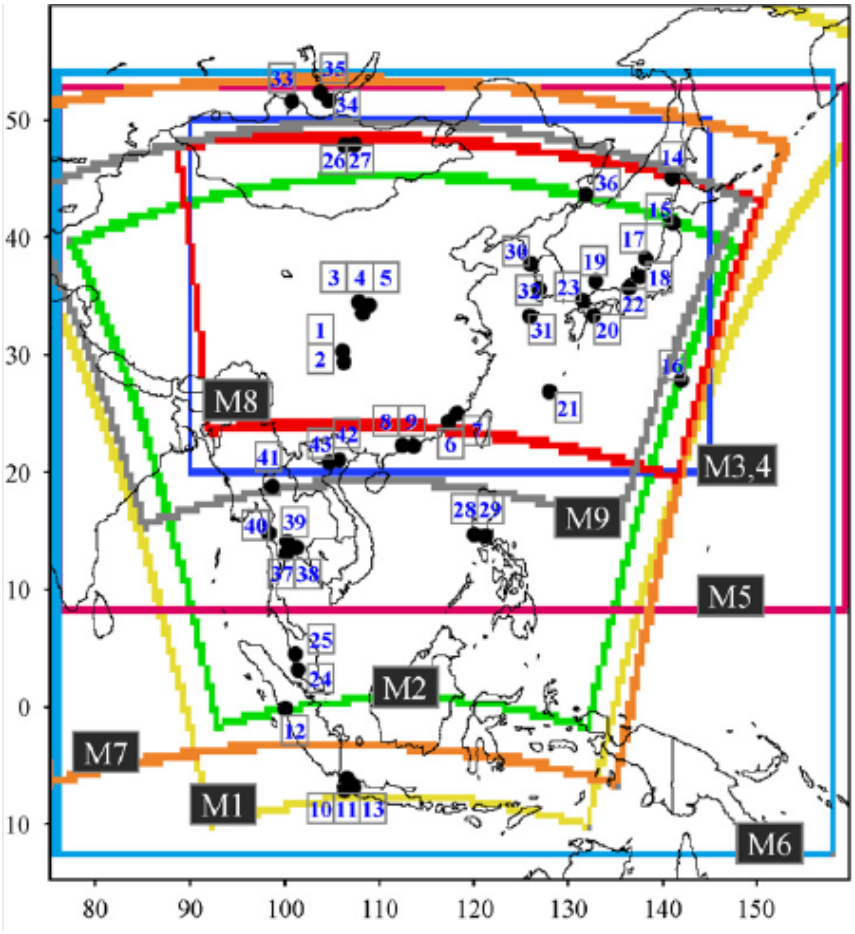
MICS-Asia Phase II (2004-2009)
: Understanding the multi-pollutant nature of pollution

- Unexpected acceleration of economic development and emissions growth
- A wider multi-pollutant/multi-effect perspective on air quality management, learning from European experience
- Extension to nitrogen, ozone and aerosols
- Six workshops at IIASA

9 Eulerian Models(3D) : 0.5 deg grid

Organization	Model name
Seoul Nat'l U	SNU model
Hong Kong EPD	PATH
ADORC (Japan)	RAQM
Kyoto U (Japan)	MSSP
CRIEPI (Japan)	CMAQ
SMHI (Sweden)	MATCH
CEREA (France)	ATMOS-2
U. Tenn. (USA)	CMAQ
U. Iowa (USA)	STEM III

Source : M. Amann(2017) and H. Hayami (2017)



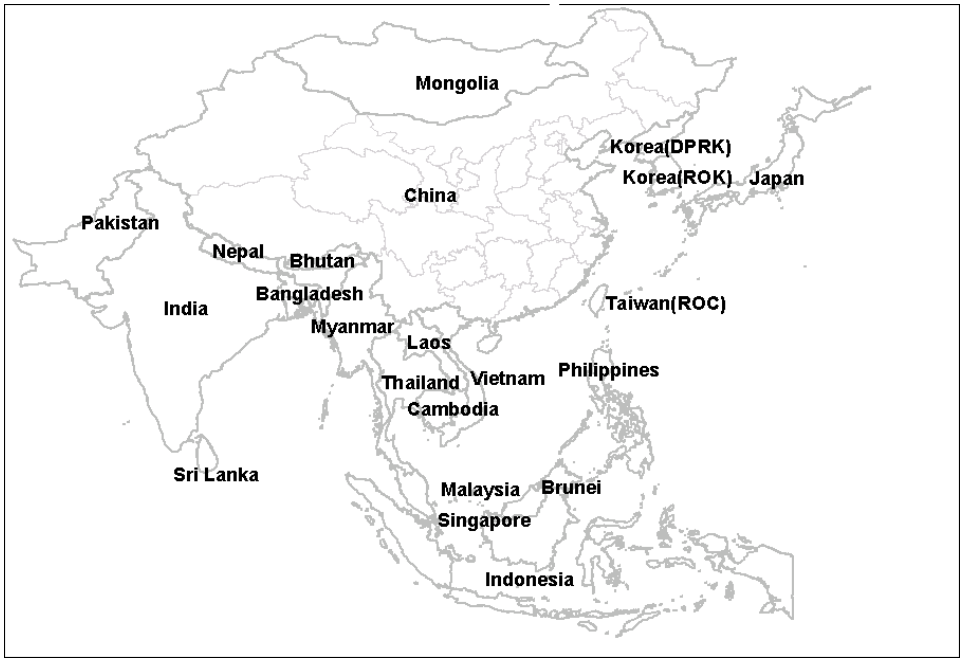
MICS-Asia Phase I vs. Phase II

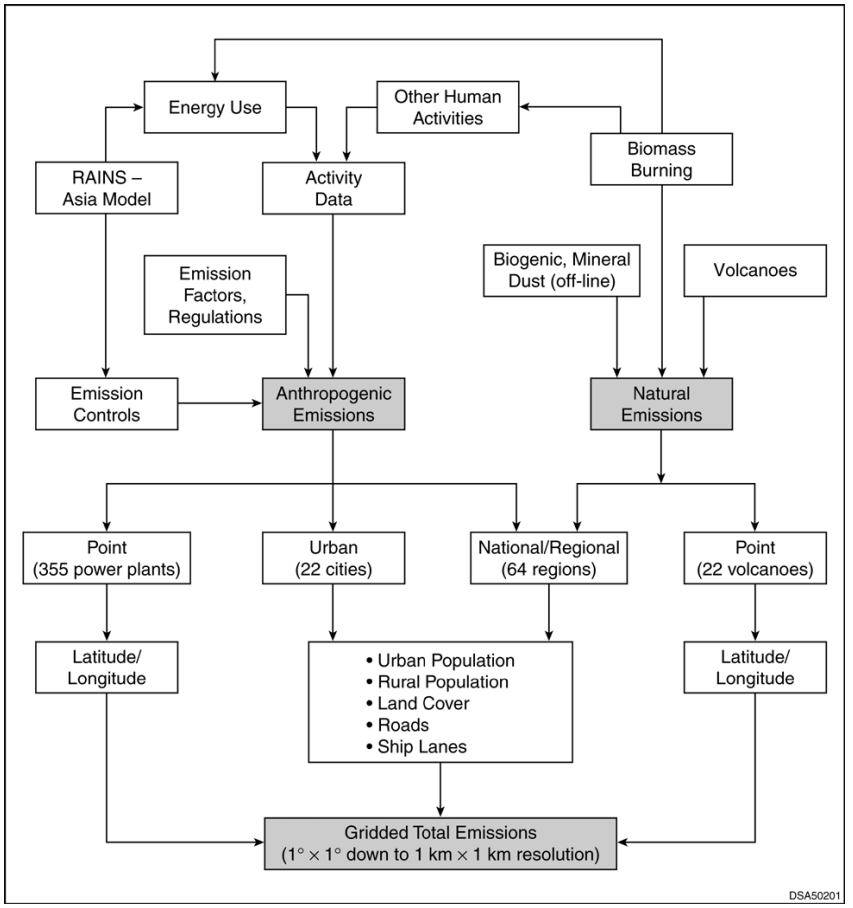
	Phase I	Phase II
Chemical species	SO_2, sulfate	O_3, PM, S/N dep.
Domain	5-50°N, 5-150°E	15°S-60°N, 15-160°E
Period	Jan & May, 1993	Mar, Jul, Dec, 2001 Mar, 2002
Standard met. field	RAMS	MM5
Base emissions	RAINS-Asia II	TRACE-P
Standard boundary	zero	MOZART
Observations	CRIEPI	EANET
Models	8 (3 Lagrangian, 5 Eulerian)	9 (all Eulerian)
Tasks	1 must-do + 3 optional	1 + intra-comparison
Publication	1 + ex. sum. and conf. rep.	7 + ex. sum.
Web site	U. Iowa	ADORC (ACAP)
Organizer	CRIEPI/IIASA	ADORC (ACAP)/IIASA

Asia Emissions Inventory : TRACE-P/Ace-Asia

TRACE-P (Transport and Chemical Evolution over the Pacific)
ACE-Asia (Asian Pacific Regional Aerosol Characterization Experiment)

Streets et al., 2003
: cited 1812 times!





CAE = (EF)(Act) [(1- (CE)]

CAE = Controlled emissions
EF = Uncontrolled emission factor
Act = Category activity
CE = % Control efficiency/100

Schematic methodology for the development of Asian emission estimates

MICS-Asia Phase III (2010-)
: Health, climate and development co-benefits

- Limited effectiveness of initial pollution control strategies
- Air quality–climate interactions and co-benefits

Objectives

Topic 1: To evaluate strengths and weaknesses of current multi-scale air quality models and provide techniques to reduce uncertainty in Asia

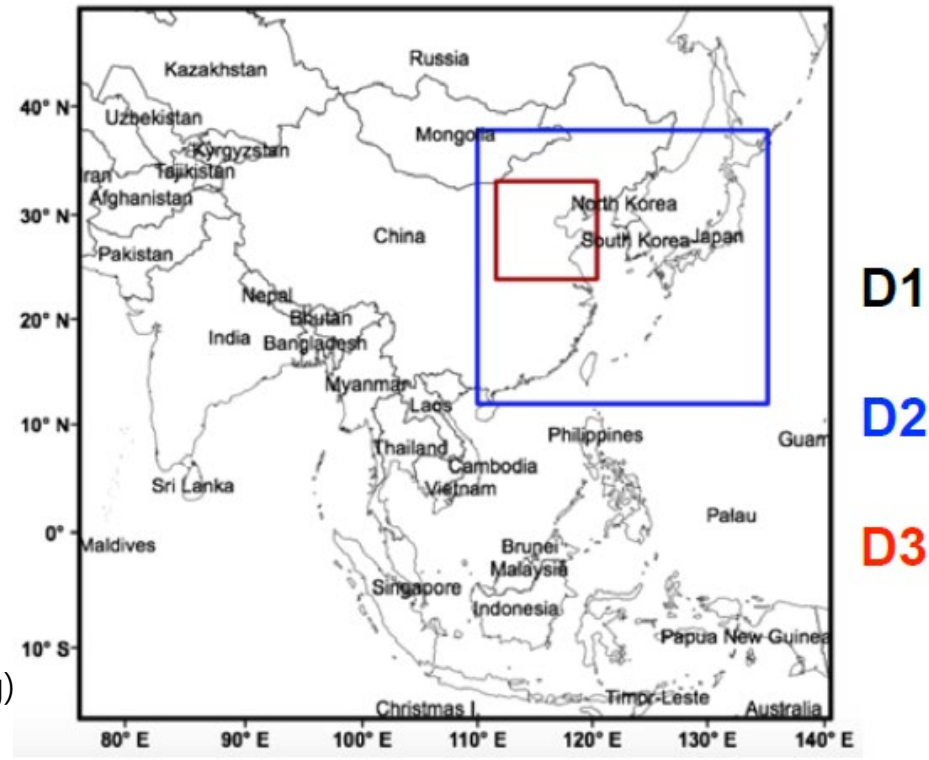
(Leaders: Z. Wang, K. Yamaji and J. Fu)

Topic 2: To develop a reliable anthropogenic emission inventories in Asia and understand uncertainty of bottom-up emission inventories in Asia

(Leaders: J. Woo, J. Kurokawa, and Q. Zhang)

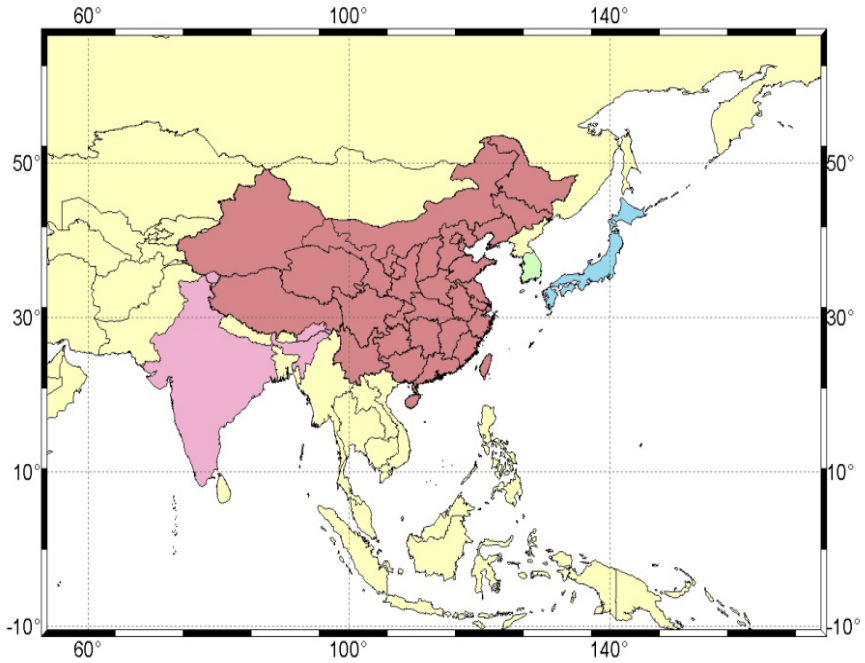
Topic 3: To provide multi-model estimates of radiative forcing and sensitivity analysis of short-lived climate pollutants

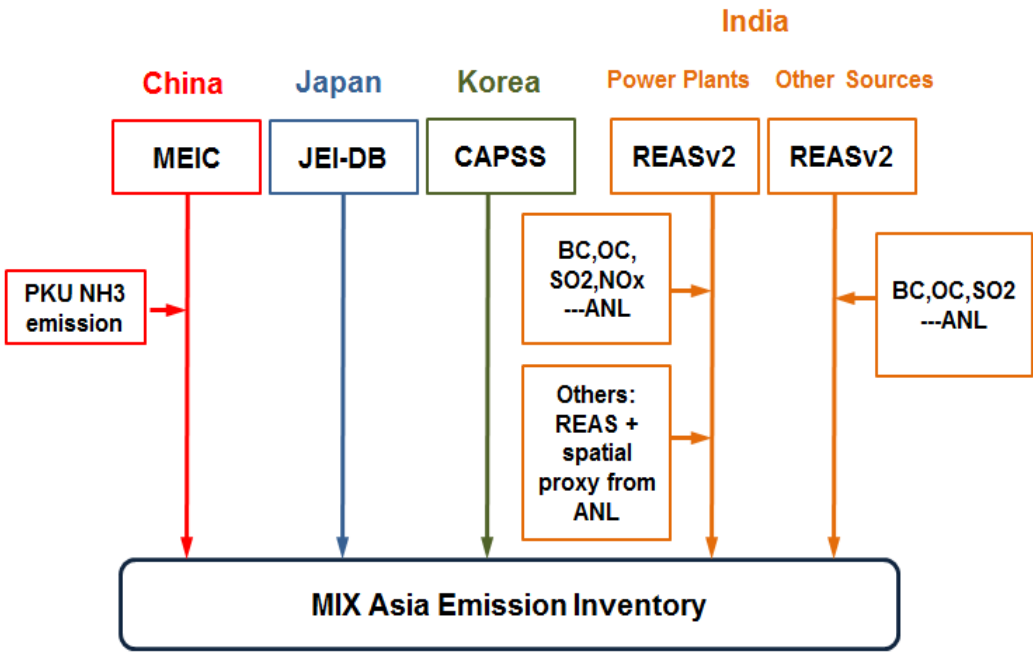
(Leaders: Greg Carmichael, ZW Han, Yafang Cheng)



MICS-Asia Phase III (2010-)
: Health, climate and development co-benefits

MICS-Asia III Emissions Inventory





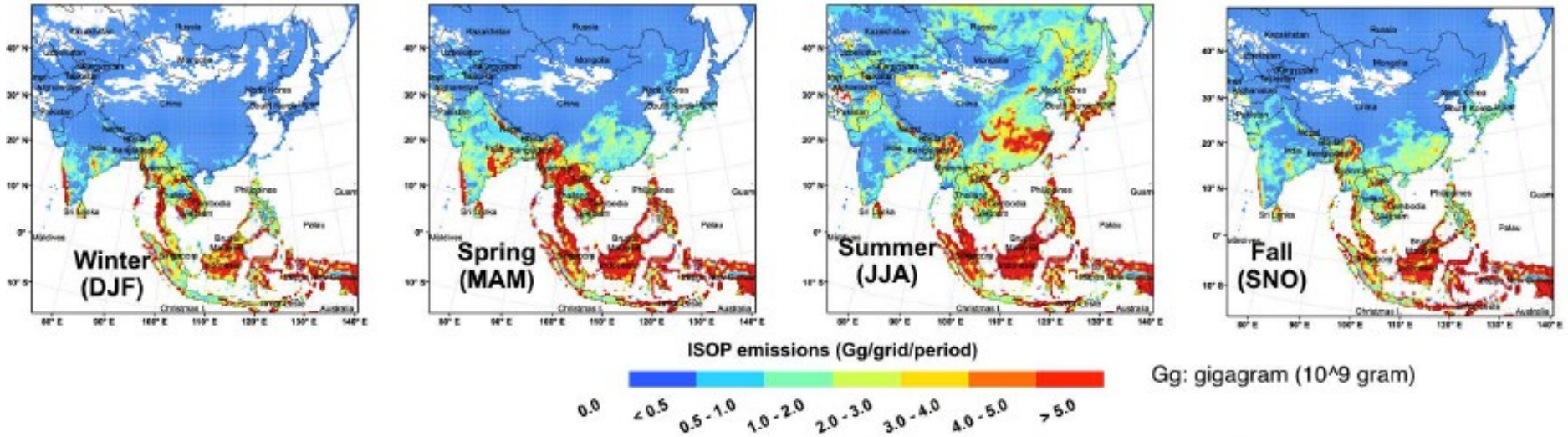
Unit: Gg Year: 2010	SO_2	NO_x	CO	NMVOC	NH_3	PM_{10}	$PM_{2.5}$	BC	OC	CO_2
China	28493	28597	170114	22989	10714	16536	12151	1755	3379	9852209
Other East Asia	1571	3750	11017	2828	786	692	378	69	42	2022586
South East Asia	4449	5120	50925	16640	4592	3051	2278	378	1452	1526602
South Asia	10963	11271	83617	20802	13306	8383	6298	1219	3229	2697876
Central Asia	1648	971	5227	1162	133	963	458	21	46	386695
Russia Asia	4164	2405	15605	2597	105	2103	1188	87	172	830408
Total	**51288**	**52113**	**336506**	**67017**	**29636**	**31728**	**22750**	**3529**	**8321**	**17316376**

Zhang, 2013

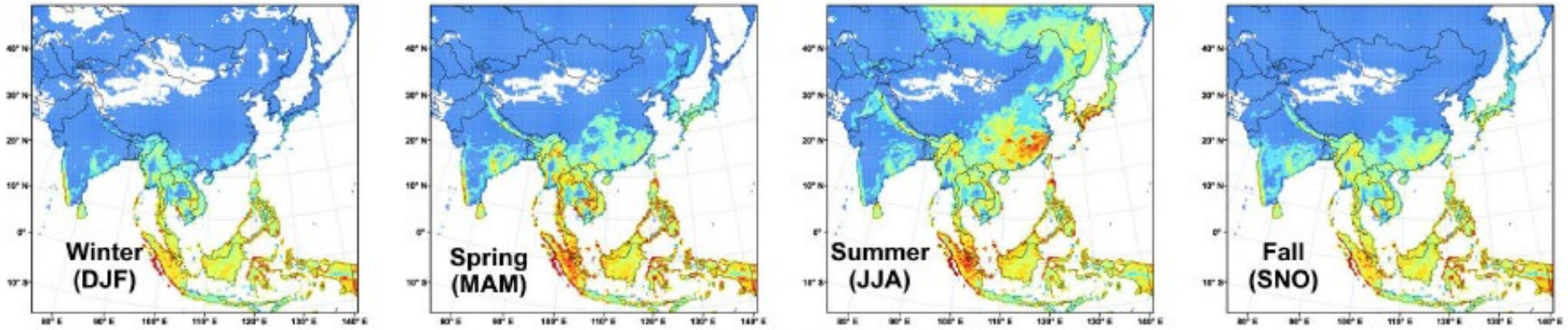
Part of The Task Force on Hemispheric Transport of Air Pollution (TF HTAP) EI

MICS-Asia III Emissions Inventory

Biogenic Emissions



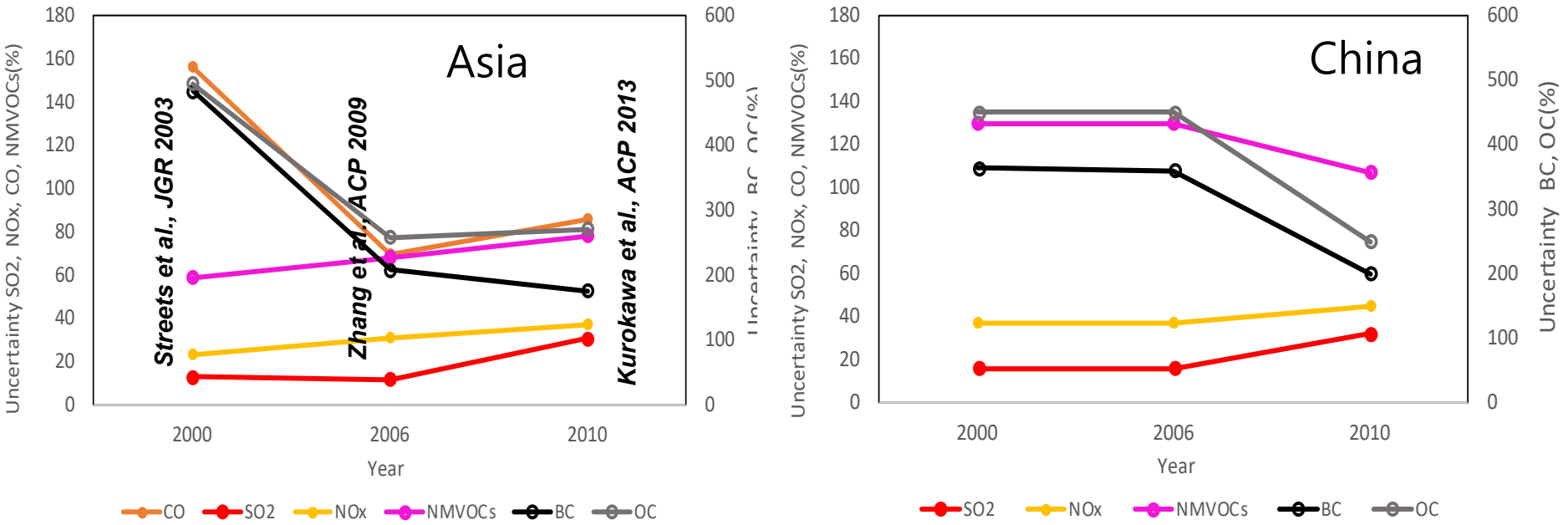
Gg: gigagram (10^9 gram)



<Note>
ISOP: isoprene
MTP: monoterpene
Tg: teragram (10^12 gram)

Asia Emissions Inventory

Evolution of Bottom-up Emissions Inventory Uncertainties



Overall Uncertainty in Anthropogenic Emission Estimates (±95% Confidence Intervals, Unit: %).

Uncertainties of CREATE emissions in China:

±28% (SO_2), ±39% (NOx), ±68 (NMVOC), ±60% (CO),

±101% (NH_3), ±50% (PM_{10}), ±54% ($PM_{2.5}$)

Woo, 2013

Asia Emissions

as an Interface for Air Quality Science and Policy

ΔEnergy

ΔPopulation

ΔGDP

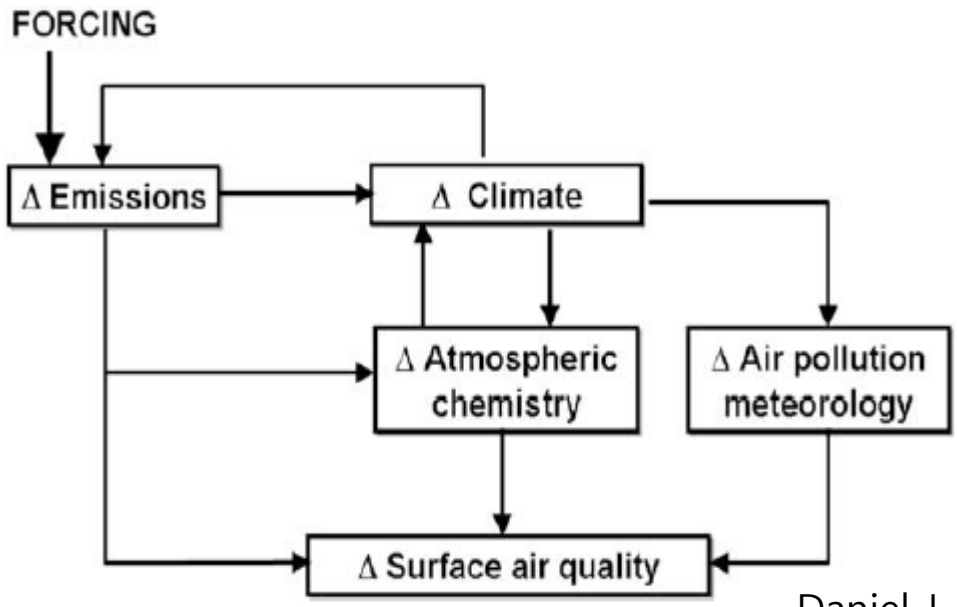
ΔPolicy

Δfuel-act

Δnon-fuel activity

ΔEm. Fac.

ΔTech



Daniel J. 2009

Socio-Economic Scenarios

Emissions Inventory

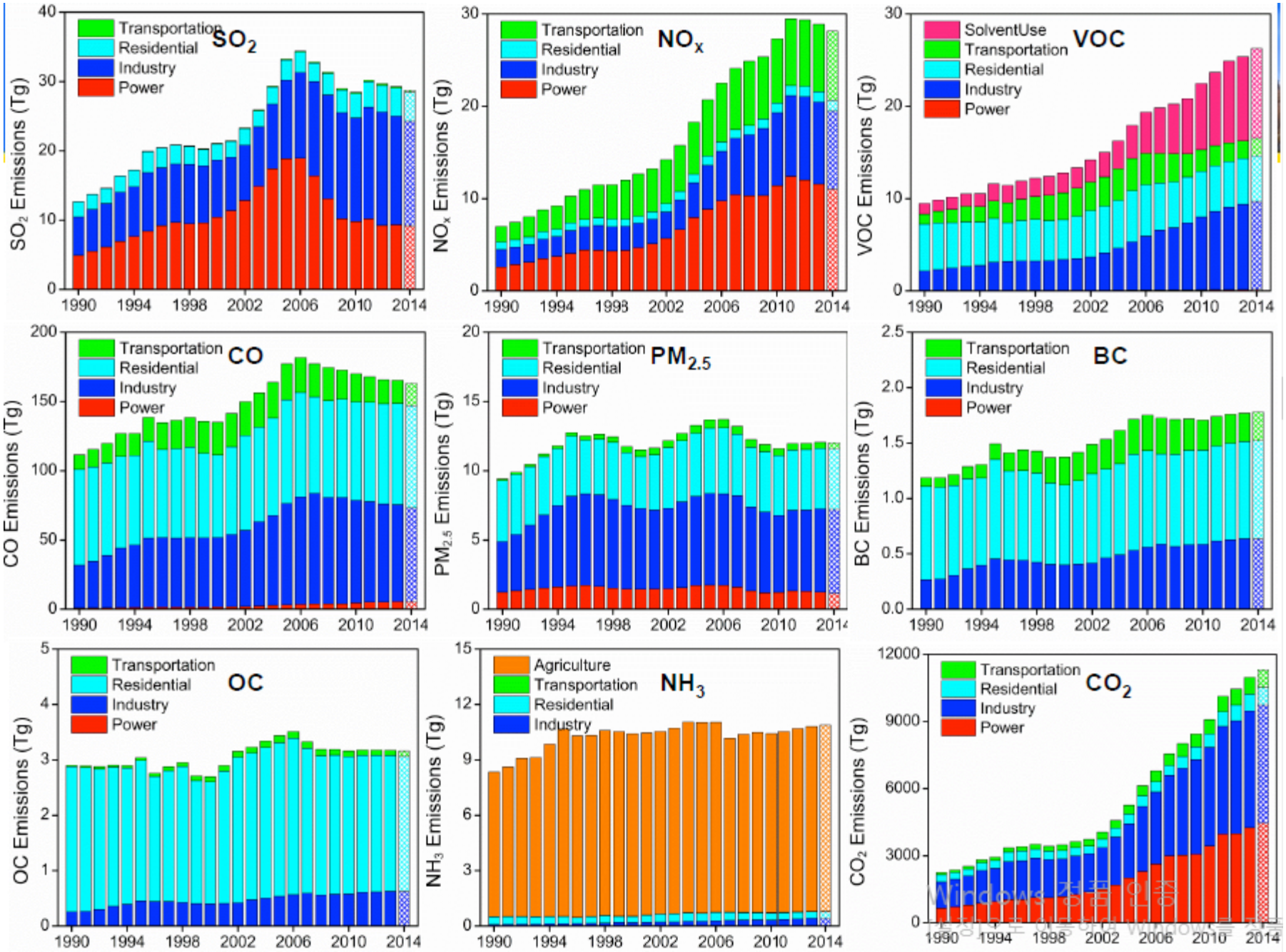
Modeling Emissions

$$Em_A = (EF_A)(Act)\ [(1-(CE)(RP)(RE)]$$

Em_A = Controlled point/area source emissions of pollutant A
EF_A = Uncontrolled emission factor for pollutant A
Act = Category activity
CE = % Control efficiency/100
RE = % Rule effectiveness
RP = % Rule penetration/100

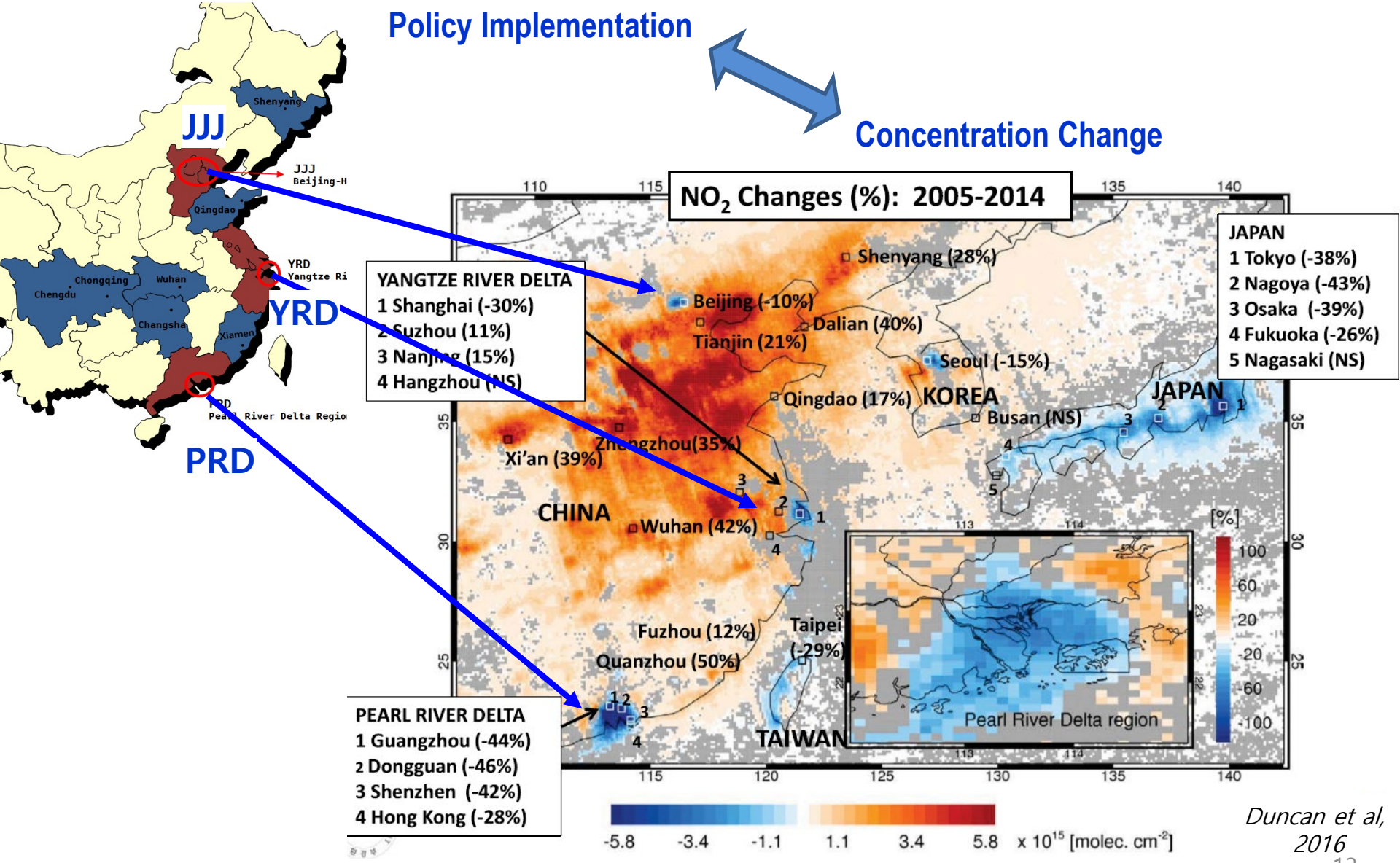
- **Spatial allocation**
  : region to grid, 2D to 3D
- **Temporal allocation**
  : annual to hourly
- **Chemical speciation**
  : NMVOCs to VOC species, PM to PA, SA

Emissions Trend (MICS-Asia)



Limitation of Emissions only Inventory

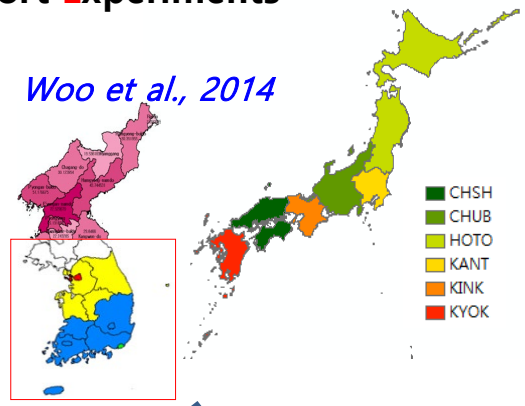
Inter-annual Variability of NO2 Concentration over Northeast Asia



Duncan et al, 2016

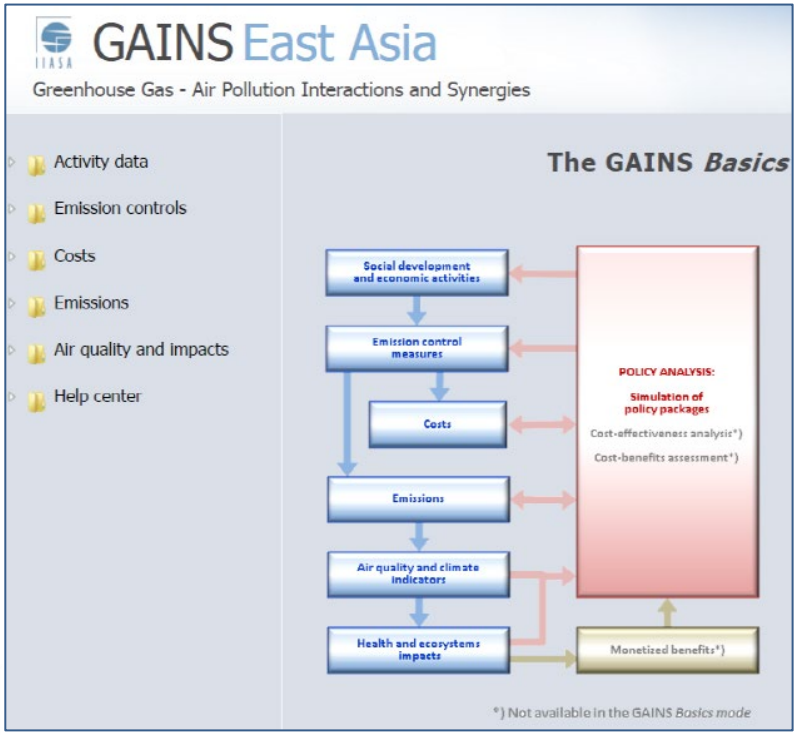
Emissions Inventory for LTP
: NIER/KU-CREATE*

* Comprehensive Regional Emissions for Atmospheric Transport Experiments

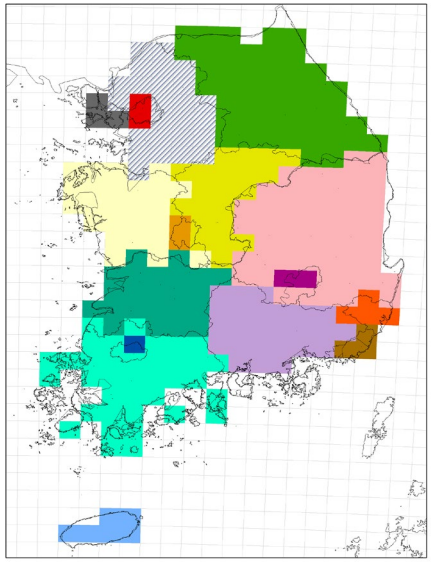


GAINS-Asia
:4 regions

GAINS-Korea
17regions



GAINS Korea
Greenhouse Gas - Air Pollution Interactions and Synergies

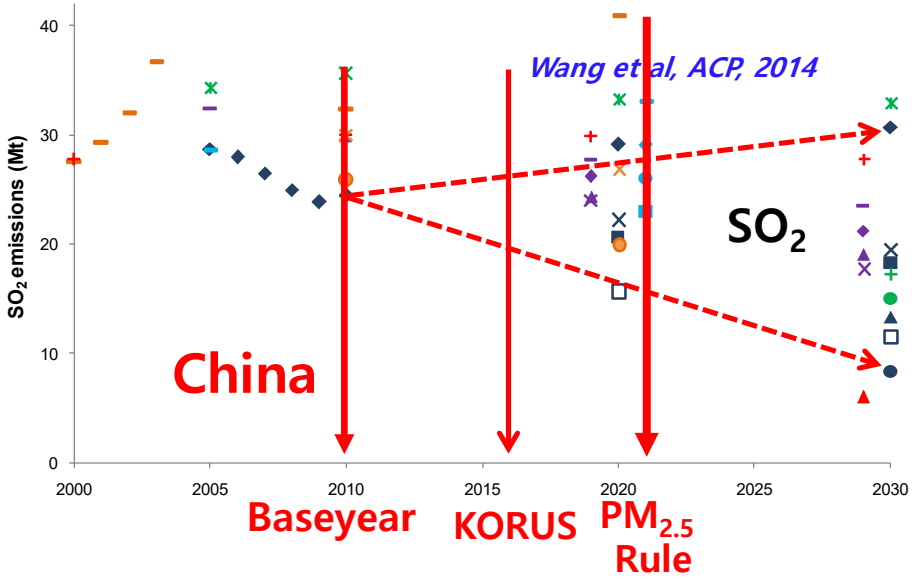


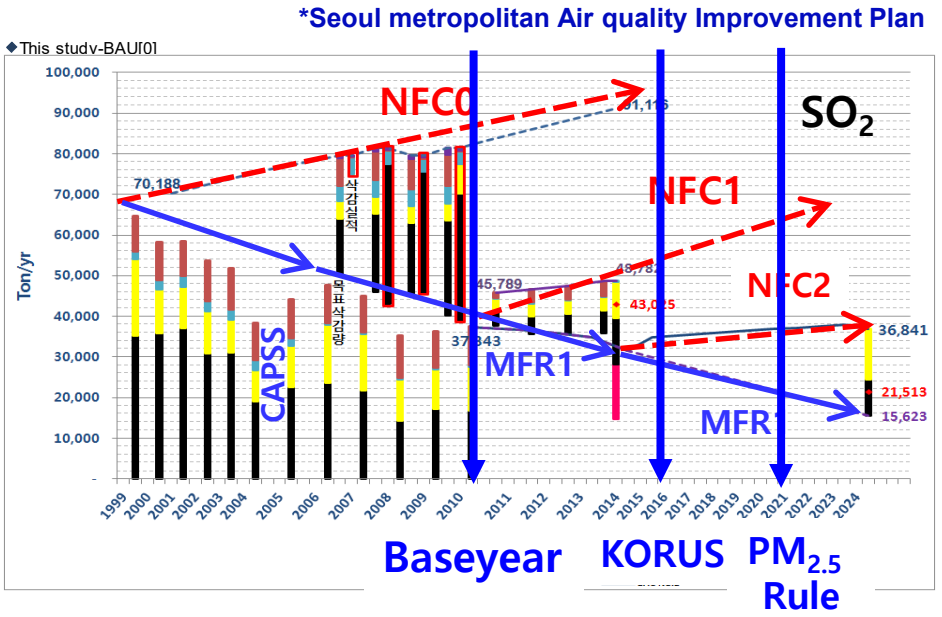
- 17 regions, Y 2010~2050
- Pollutants: CO2, CO, NOx, SO2, VOC, NH3, PM10, PM2.5, BC, OC
- Sectors: Energy, Mobile, Industrial Process, VOCs, Agriculture
- Transfer : CAMx & SMOKE

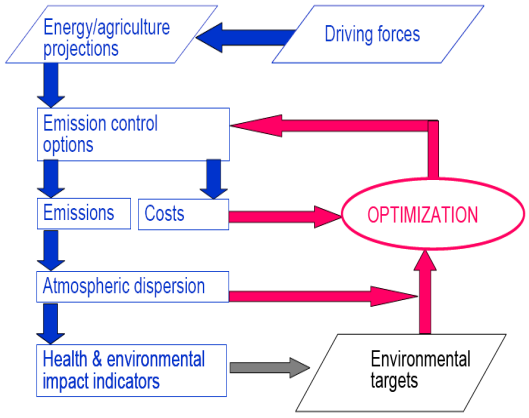
1. Anthropogenic Emissions Inventory : Improved GAINS-Asia and GAINS-Korea emissions using national info.
2. Year 2010, Asia regions, ~300 SCCs
3. Pols.: CO_2, NO_x, PM_{10}, $PM_{2.5}$, SO_2, VOC, NH_3, CO
4. Biogenic(MEGAN), Biomass burning(BlueSky)
5. Emissions projection and processing friendly

Linking Air Quality Policies Using CREATE/GAINS

China and Korea







$$Em_A = (EF_A)(Act)\ [(1- CE)(RP)(RE)]$$

GAINS

China

Korea

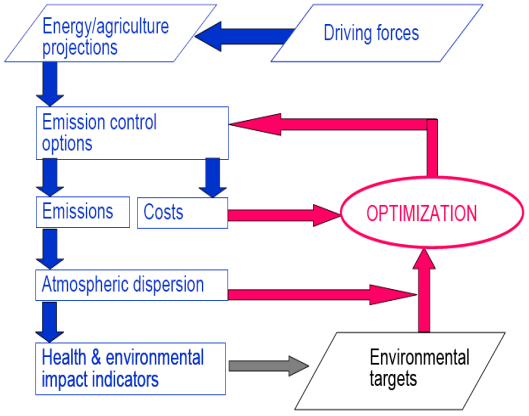
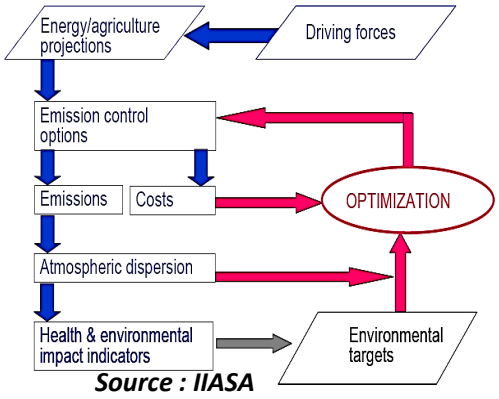


Figure 2.2: The iterative concept of the GAINS optimisation.

Figure 2.2: The iterative concept of the GAINS optimisation.

Linking Air Quality Policies Using CREATE/GAINS

➢ Assessment Framework : GAINS Framework



Source : IIASA

: Integrated Assessment Model for Climate Change and Air Pollution

Procedure

1. Implemented national activity statistics/policies
2. Add new experimental scenarios (Climate and NH_3)
3. Link the additional scenarios from GAINS-Asia into GAINS-Korea
   => analysis of transboundary impacts from outside (China, N.Korea)

➢ Implement control policies for Korea & China into the GAINS model

Control Scenario Definition

	Korea	China
BASE	• BAU Scenario	• BAU Scenario
OTB	• 「Seoul metropolitan Air Quality Improvement Plan」, • 「10-Year Plan to Improve the Air Quality」	• 「12th Five Years Plan」 • 「National emission standards」
OTW	• OTB + 「6.3 Particulate Matter Special Action」	• OTB + Regional Action Plan (JJJ, PRD, YRD)
BOTW _GHGs	• OTW + INDC GHGs reduction targets in Korea	• OTW + INDC GHGs reduction targets in China
BOTW _NH_3	• BOTW_GHGs + NH_3 reduction pathway	• BOTW_GHGs + NH_3 reduction pathway

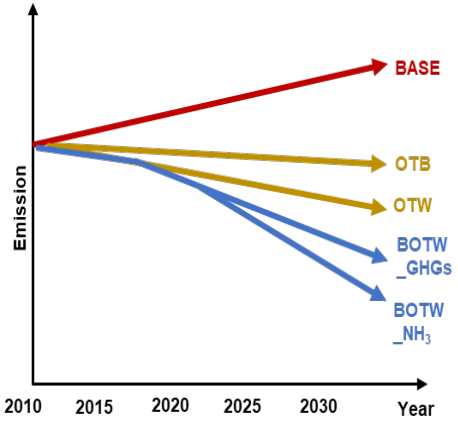
BAU

Existing / reserved AQ Policies

New: CC-AQ Co-control / NH_3 control

Linked scenario matrix

	Scenario Pathway	
	KOREA	CHINA
S1	BASE_k	BASE_c
S2		OTB_c
S3		BOTW_NH_3_c
S4	OTB_k	BASE_c
S5		OTB_c
S6		BOTW_NH_3_c
S7	OTW_k	BASE_c
S8		OTB_c
S9		BOTW_NH_3_c
S10	BOTW_GHGs_k	BASE_c
S11		OTB_c
S12		BOTW_NH_3_c
S13	BOTW_NH_3_k	BASE_c
S14		OTB_c
S15		BOTW_NH_3_c

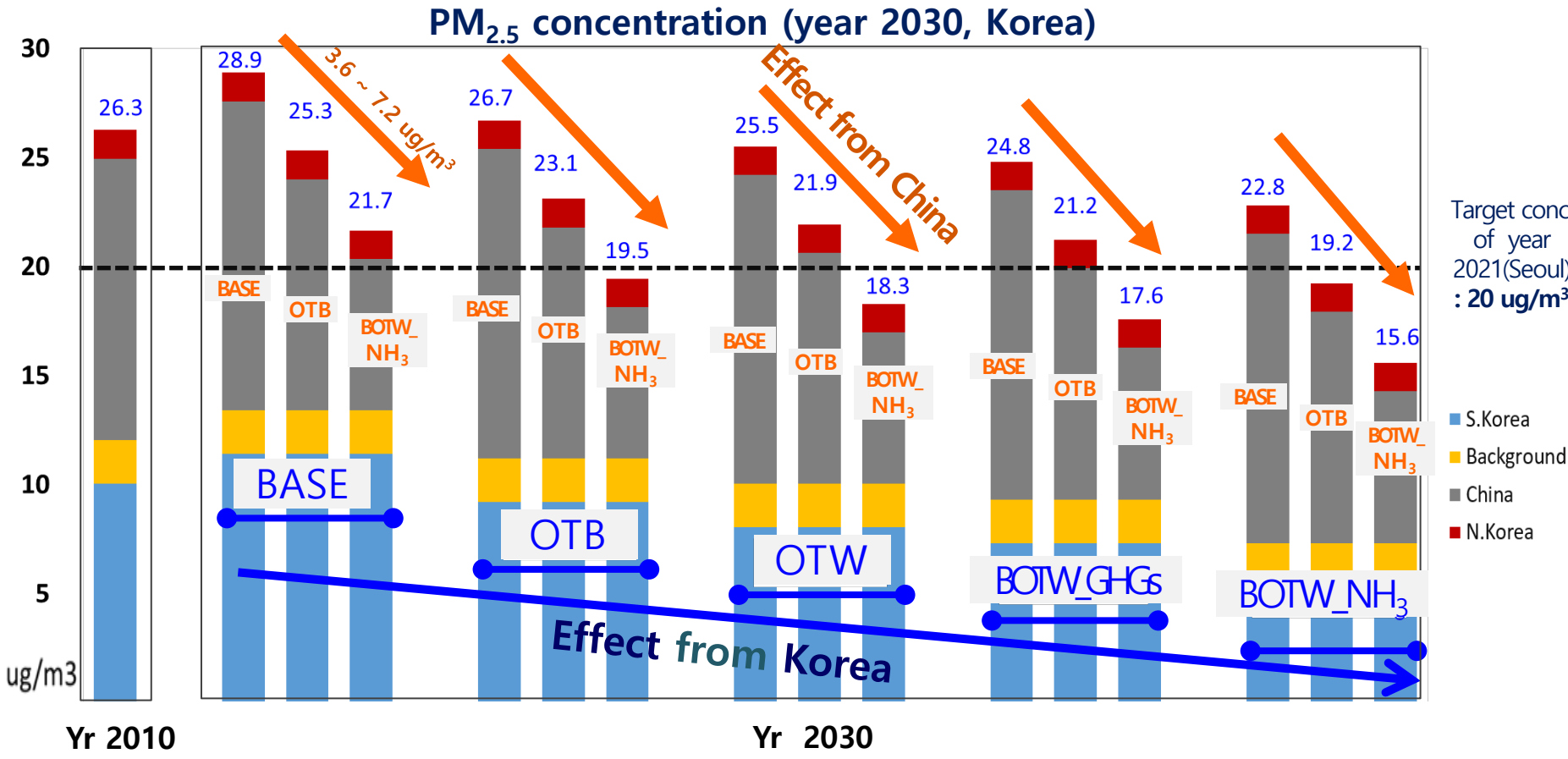


=> 15 cases of reduction pathways were linked to assess the possibilities and its impact of air quality improvement.

- ***Y.H. Kim et al, manuscript in preparation (Do no cite or quote).***

Linking Air Quality Policies Using CREATE/GAINS

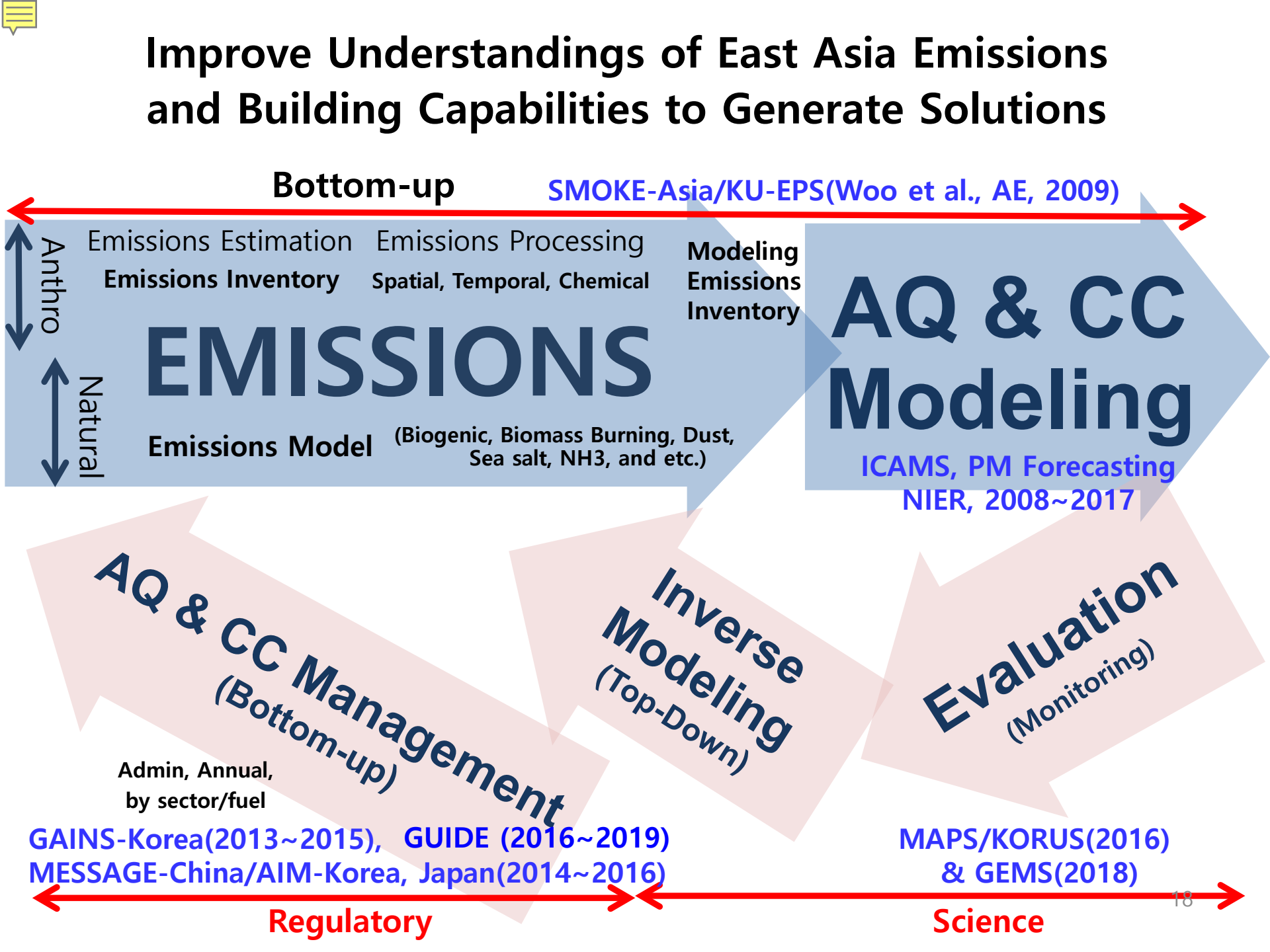
➢ Assessment of Control Policy Impacts by China-Korea linked scenario



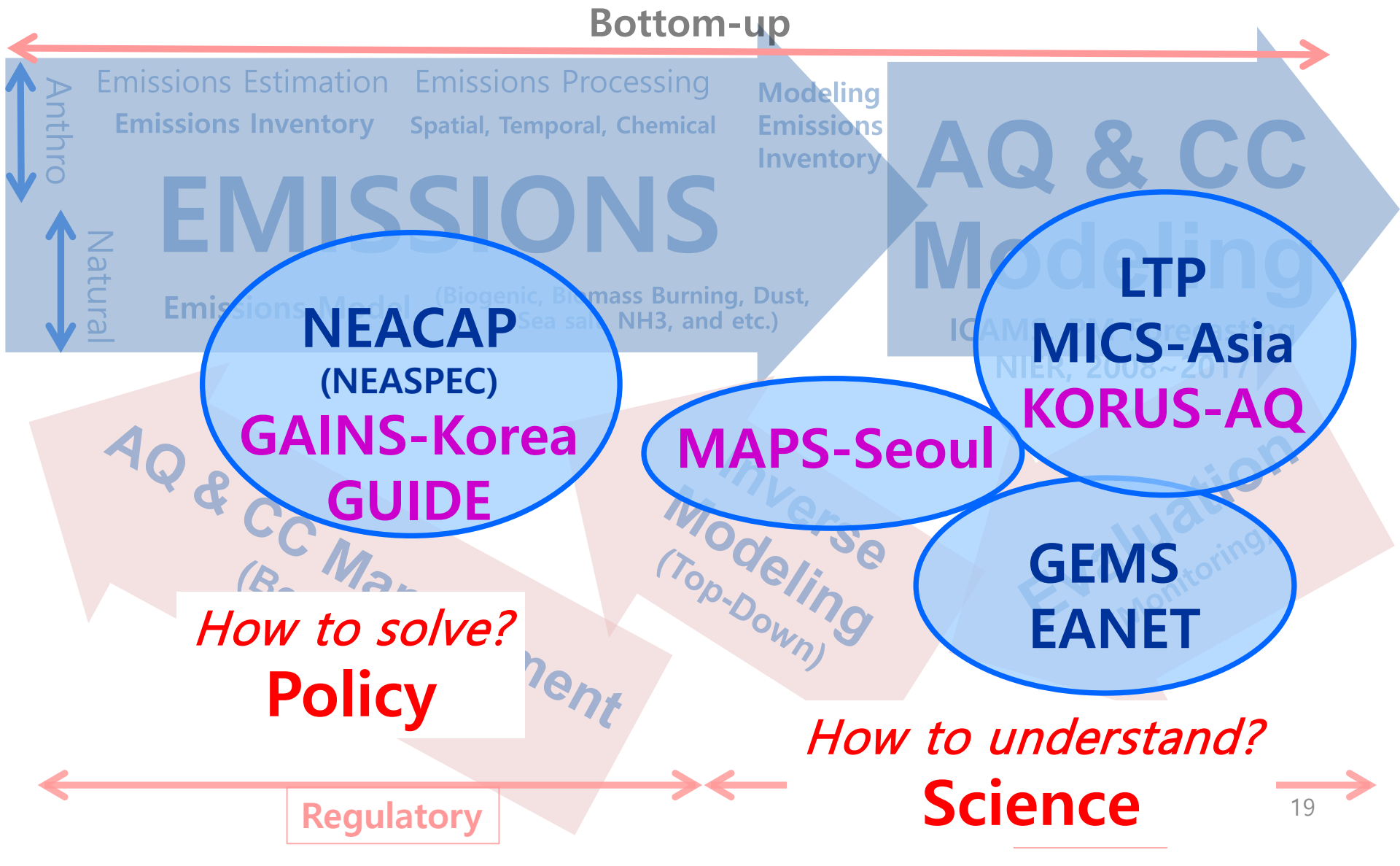
- 3.6~7.2ug/m^3 of additional $PM_{2.5}$ concentration improvement could be achieved due to China's reduction
- Korea could get the transboundary benefits from the China's control policies.

- *Y.H. Kim et al, manuscript in preparation (Do no cite or quote).*

Improve Understandings of East Asia Emissions and Building Capabilities to Generate Solutions



Improve Understandings of East Asia Emissions and Building Capabilities to Generate Solutions



Thank You!!!


3rd MICS-Asia
Workshop,
Sep 19, 2000


10th MICS-Asia
Workshop 2008


19th MICS-Asia
Workshop 2017