Modeling results from LTP project

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Contents

I Tripartite LTP project

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 Northeast Asia(Three countries)**
- **- Long lasting geo-scientific collaboration in Northeast Asia**

Concept of LTP

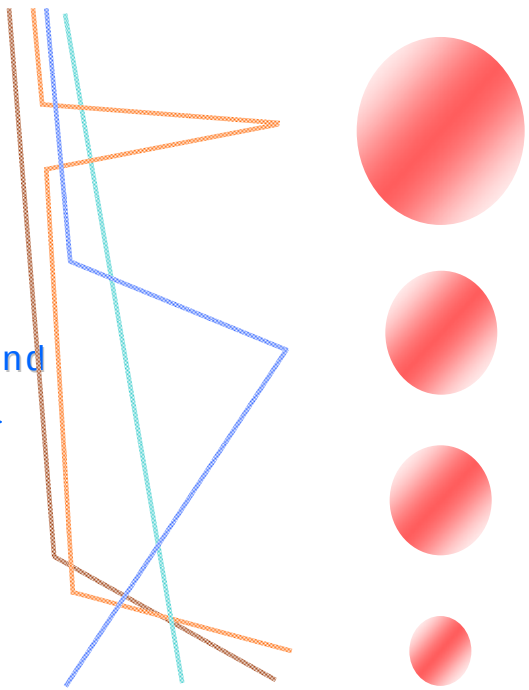
Movement and diffusion

Anthropogenic emissions

Transport patterns?

How much?

How ?



Synoptic wind

Only SO_2

SO_2+Sulfate?

SO_2→Sulfate?

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

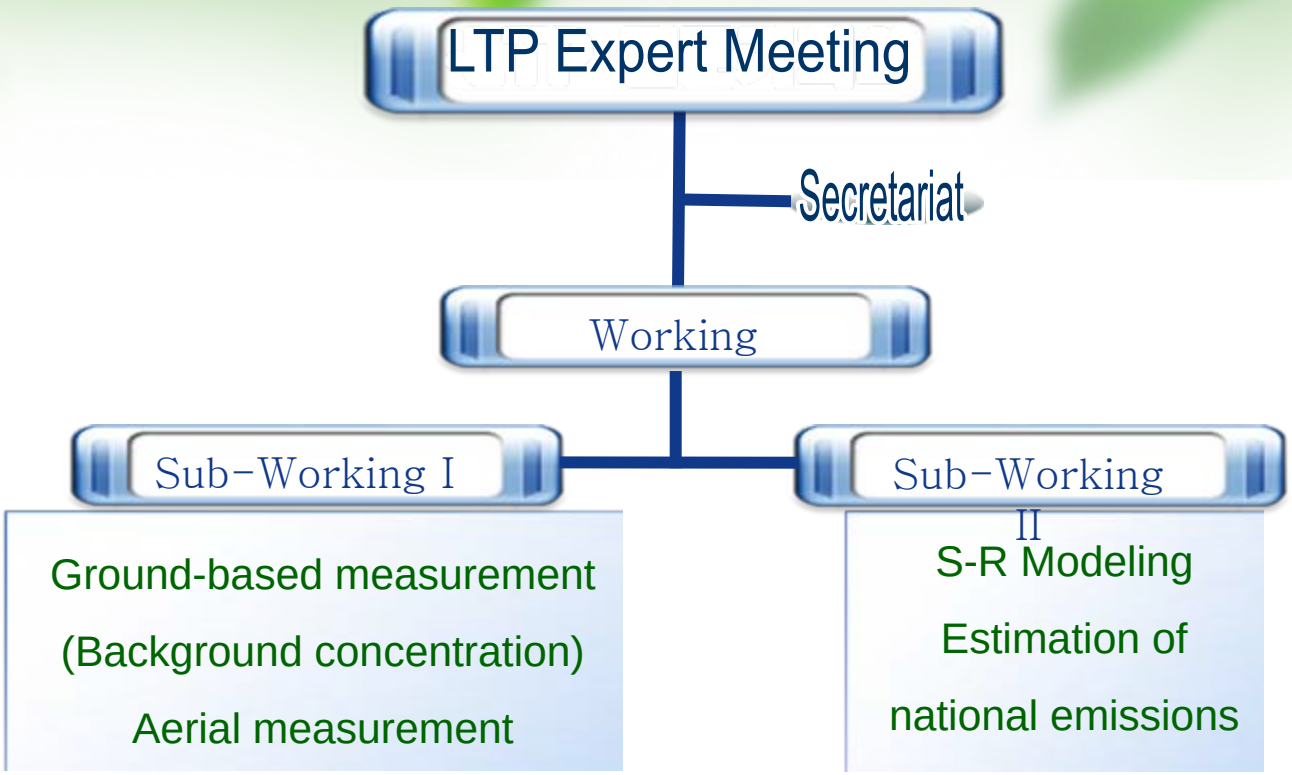
- **The 2nd LTP Expert Meeting**

Launch sub-working groups for modeling and monitoring

2000 ~ 2004
2005 ~ 2007
2008 ~ present

- The 1st stage joint study: frame construction
- The 2nd stage joint study: sulfur study
- The 3rd stage joint study: nitrogen study

LTP Organization



- 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.

Outline of LTP Project

International cooperation for improving air quality in Northeast Asia

1st stage ('00~'04)

Establish a foundation for joint research

- ✓**Establish database on the concentration and emissions of air pollutants**
- ✓**Establish a modeling system**

2nd stage ('05~'07)

- Estimate emissions among three countries
- Research on monitoring and modeling
- Produce S-R relationships 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

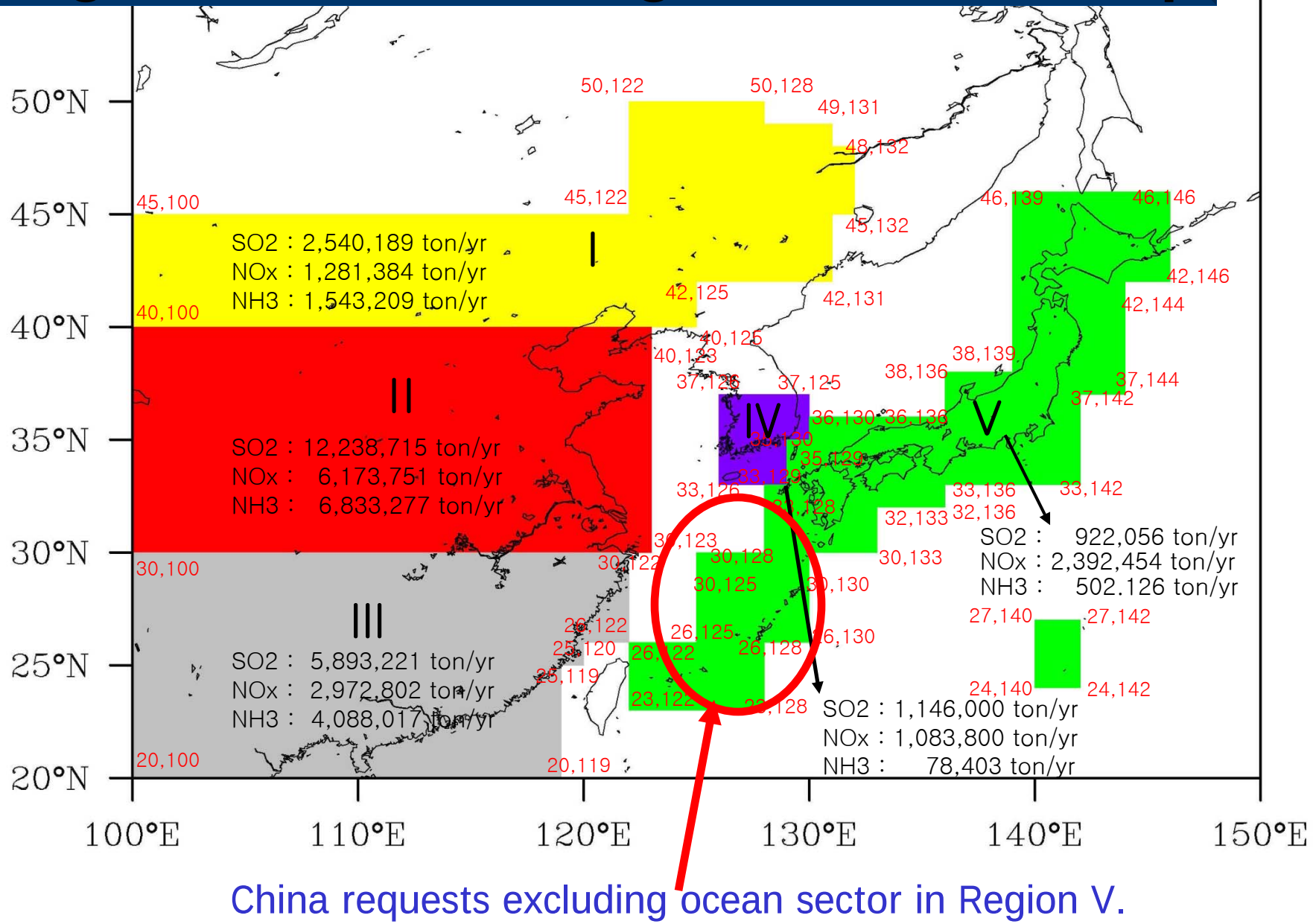
Make an emission reduction scenario in Northeast Asia

Ⅱ Modeling design

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	Diagnostic cloud model in RADM	Cloud model in MM5	Cloud model in CSU-RAMS
Physical option	Simple explicit moisture scheme Grell cumulus schemes, MRF	Betts-Miller cumulus scheme, MRF RRTM	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)

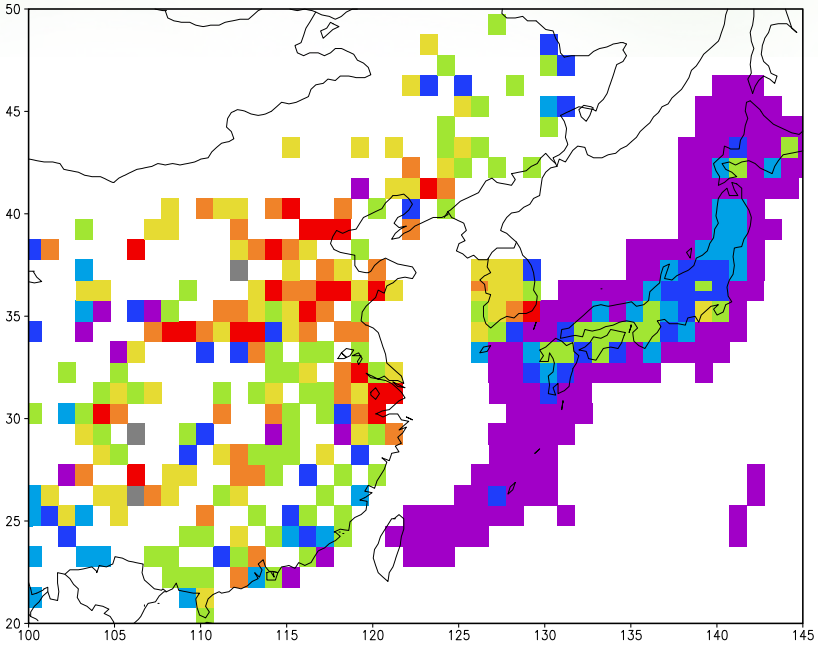
Regions for estimating S-R Relationship



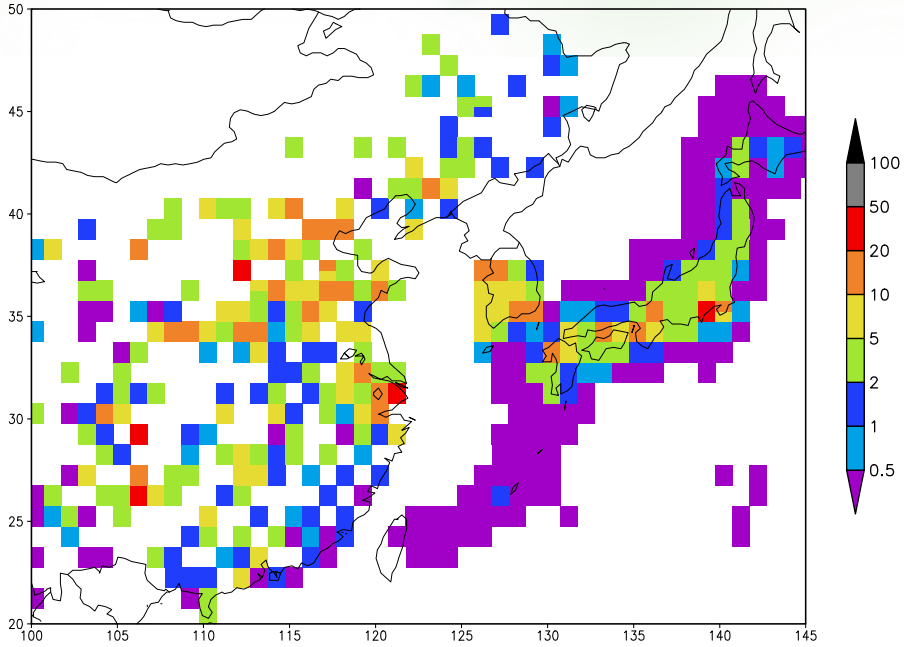
China requests excluding ocean sector in Region V.

LTP standard emission for SO2 and NOx

SO_2 Emission (ton/year)



NOx Emission (ton/year)



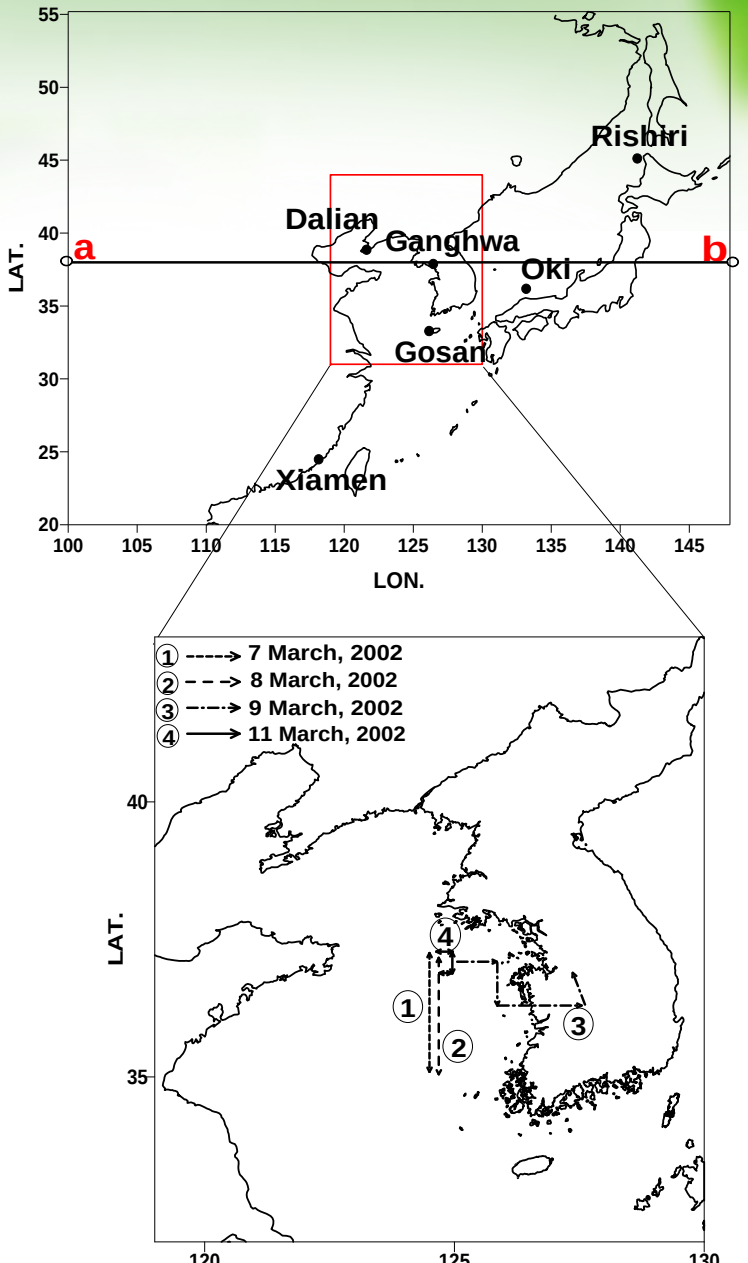
•(unit: ton $year^{-1}$ $grid^{-1}$).

E(SO2) : 20,672,125 ton/yr > 1,146,000 ton/yr > 922,056 ton/yr

Emission rate in China is greater than those in Korea and Japan by 22 times

Ⅲ Modeling results

Model domain and locations of measurement



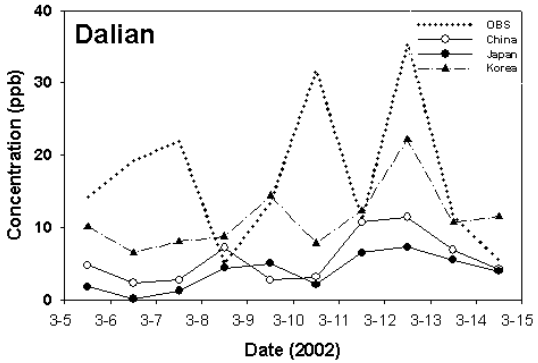
LTP project includes two monitoring sites in each participating country

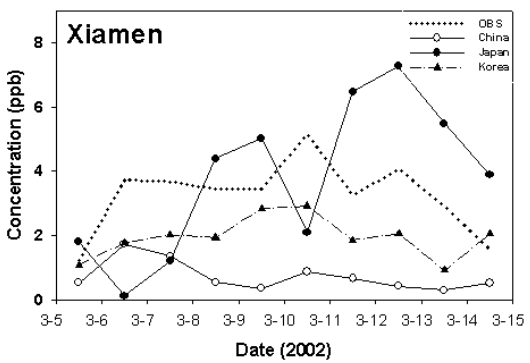
Korean research group conducts aircraft measurement over Western sea

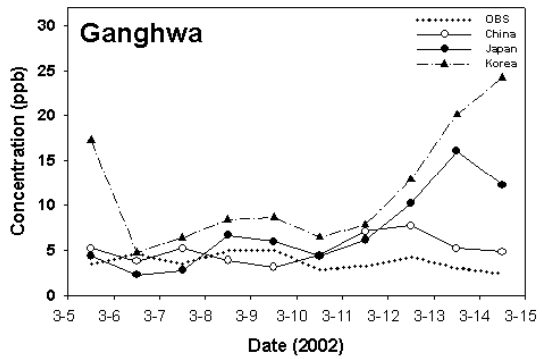
Summary of model performance

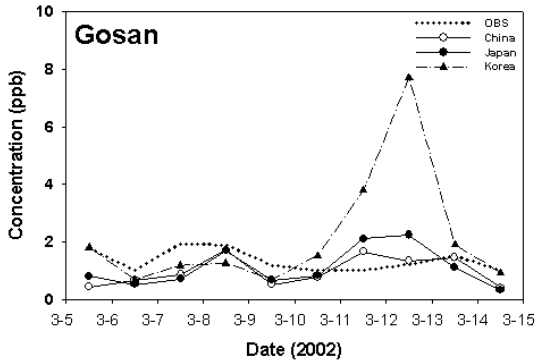
	Obs	China	Japan	Korea
Sample size	57	57	57	57
Range(ppb)	0.0042-35.43	0.0-11.387	0.05-16.07	0.025-24.22
Mean(ppb)	4.59	2.35	2.91	5.01
Standard deviation (ppb)	7.13	2.66	3.26	5.81
Mean of ratio model/obs (S/O)		0.91	1.99	4.25
Standard deviation of ratio model/obs (S/O)		1.37	6.81	19
Absolute gross error		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

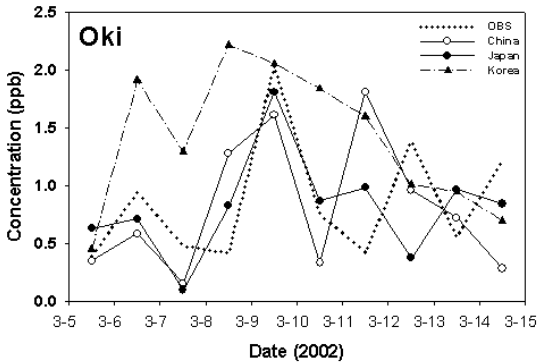
Model performance comparison

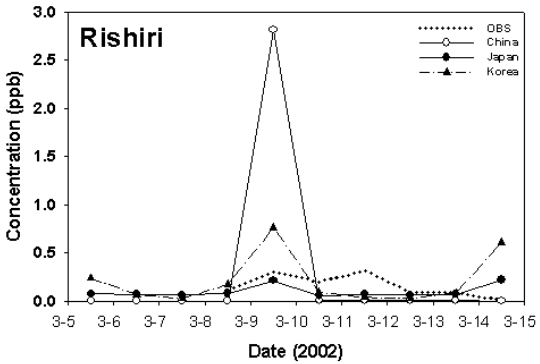




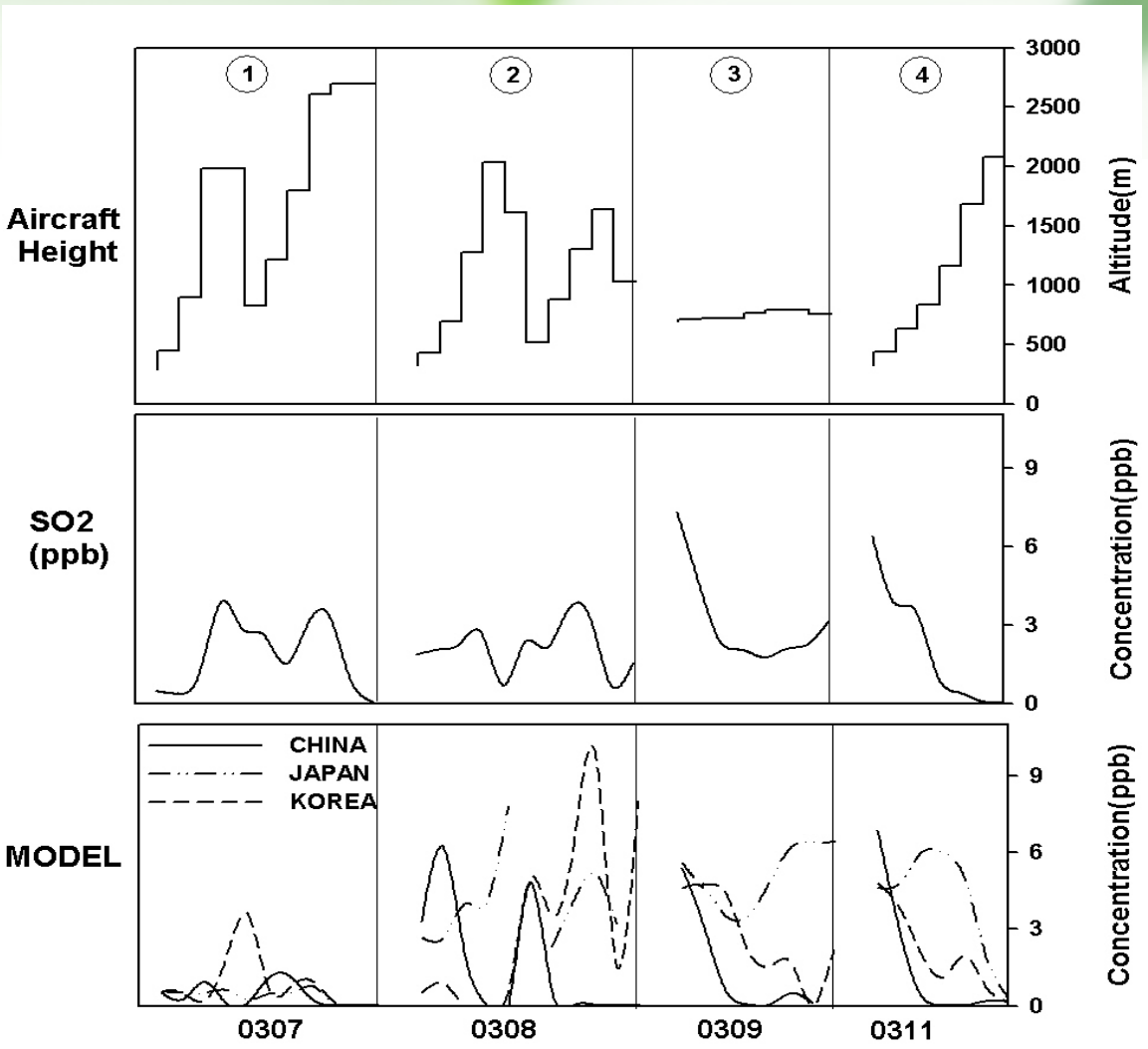




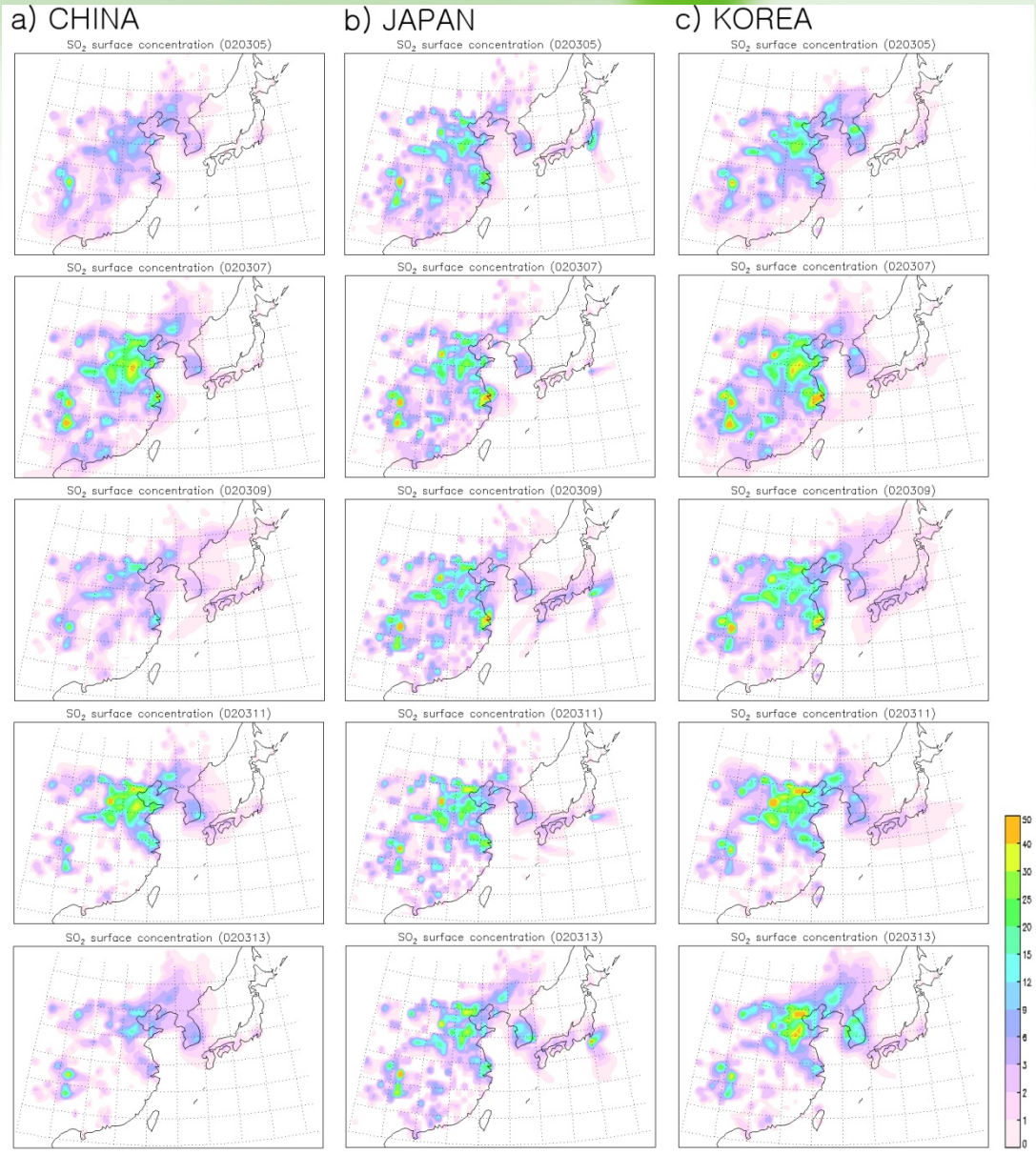




Model performance comparison

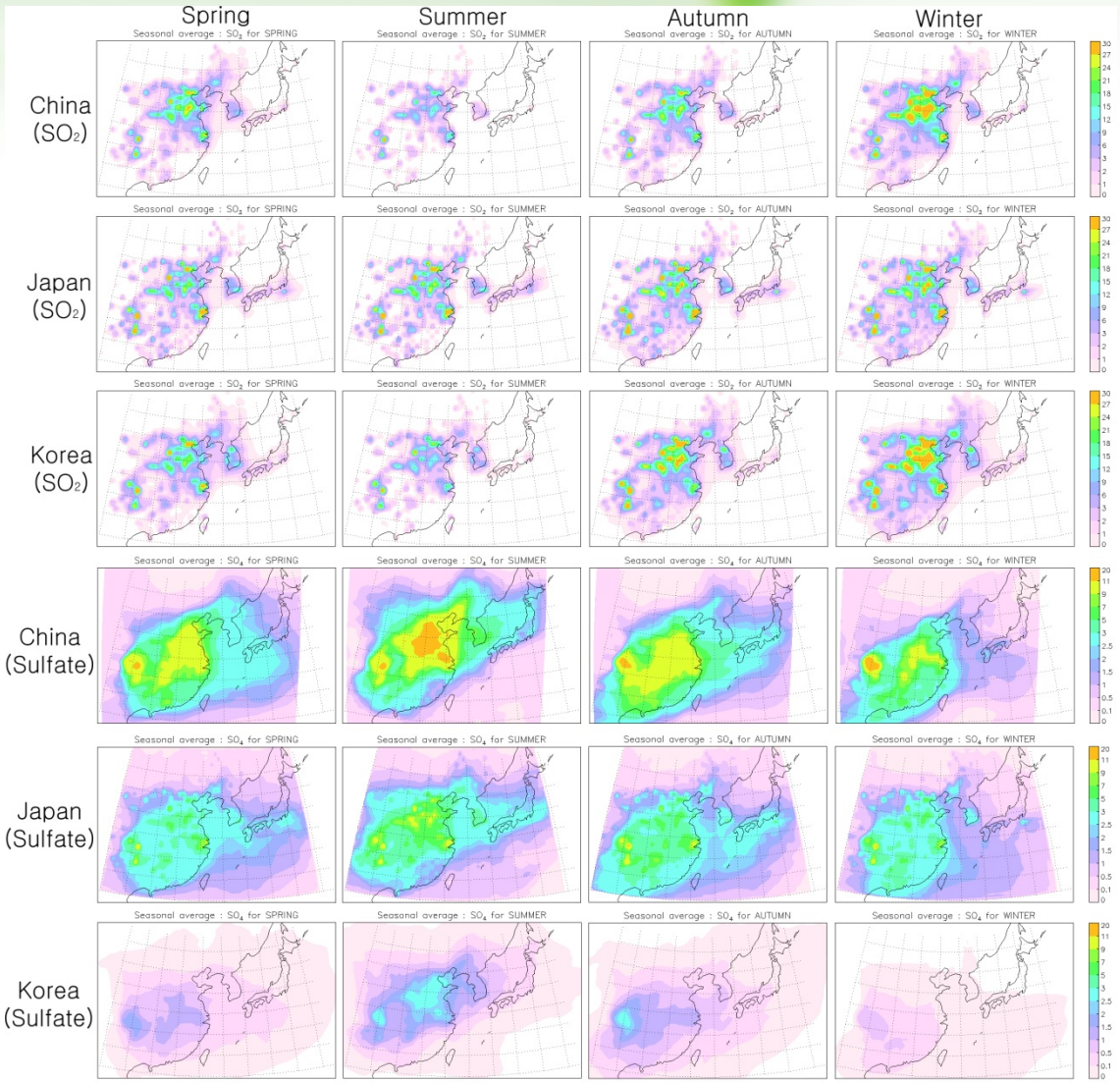


Spatial distribution of the simulated [SO2]



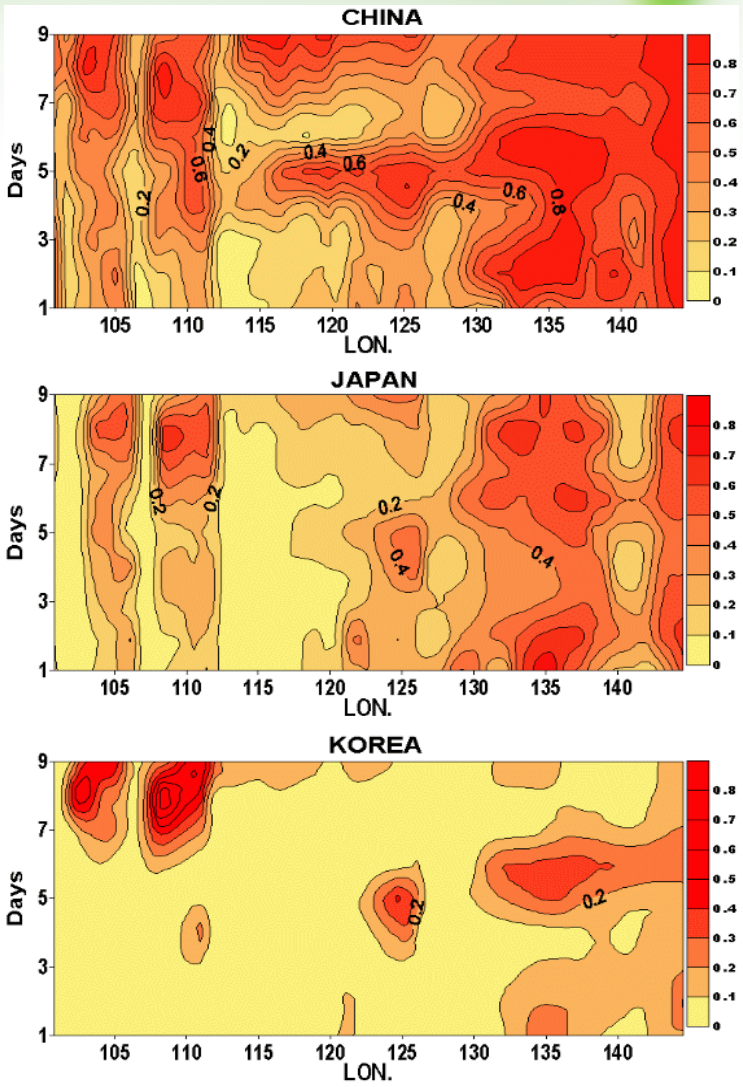
Simulated surface SO_2 concentrations from (a) China, (b) Japan, and (c) Korea on 5-13, March.

Spatial distribution of the simulated [SO2]



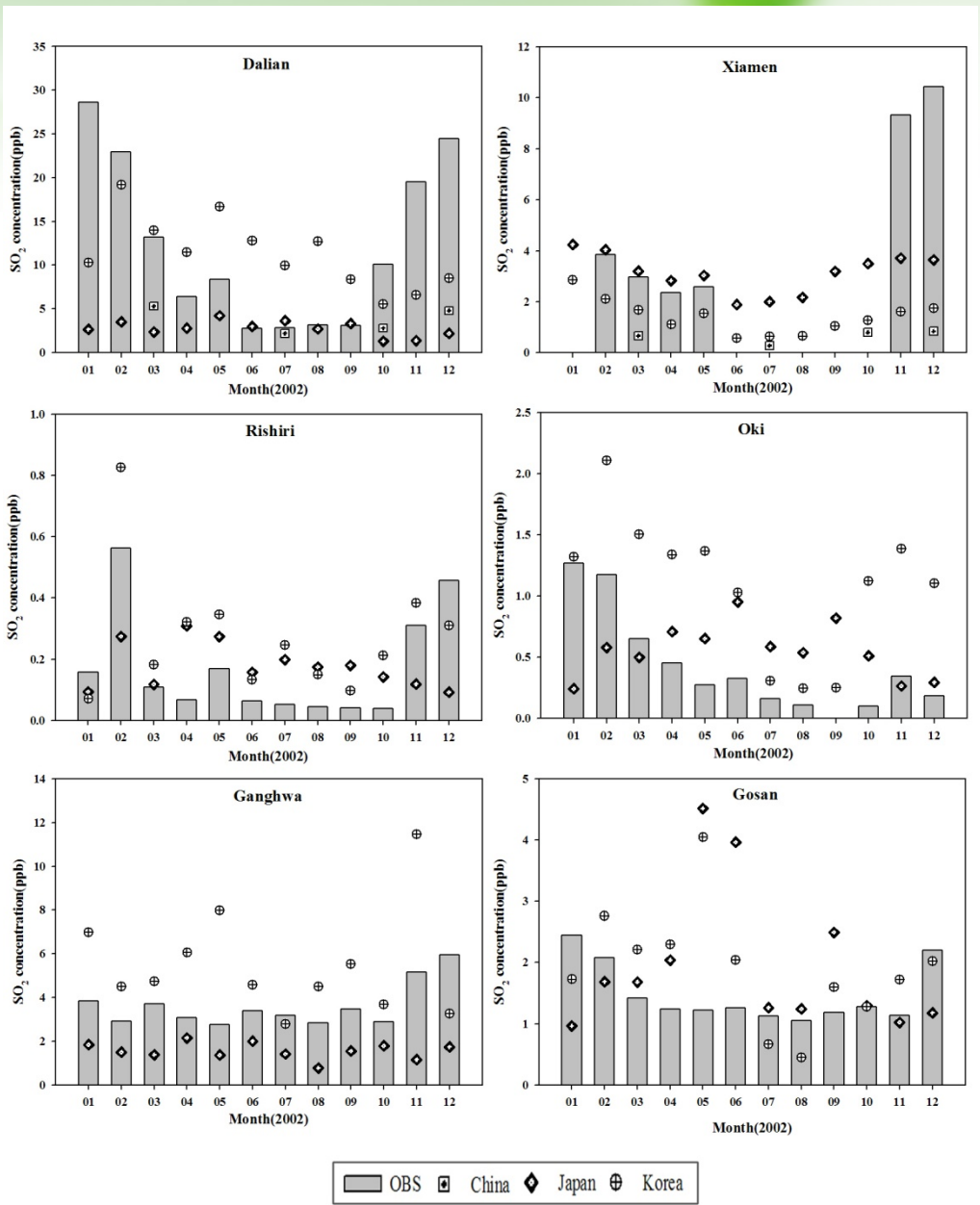
Seasonally averaged surface SO_2 and SO_4^{2-} concentrations simulated by (a) China, (b) Japan, and (c) Korea for the year of 2002.

Conversion ratio of SO2 to sulfate



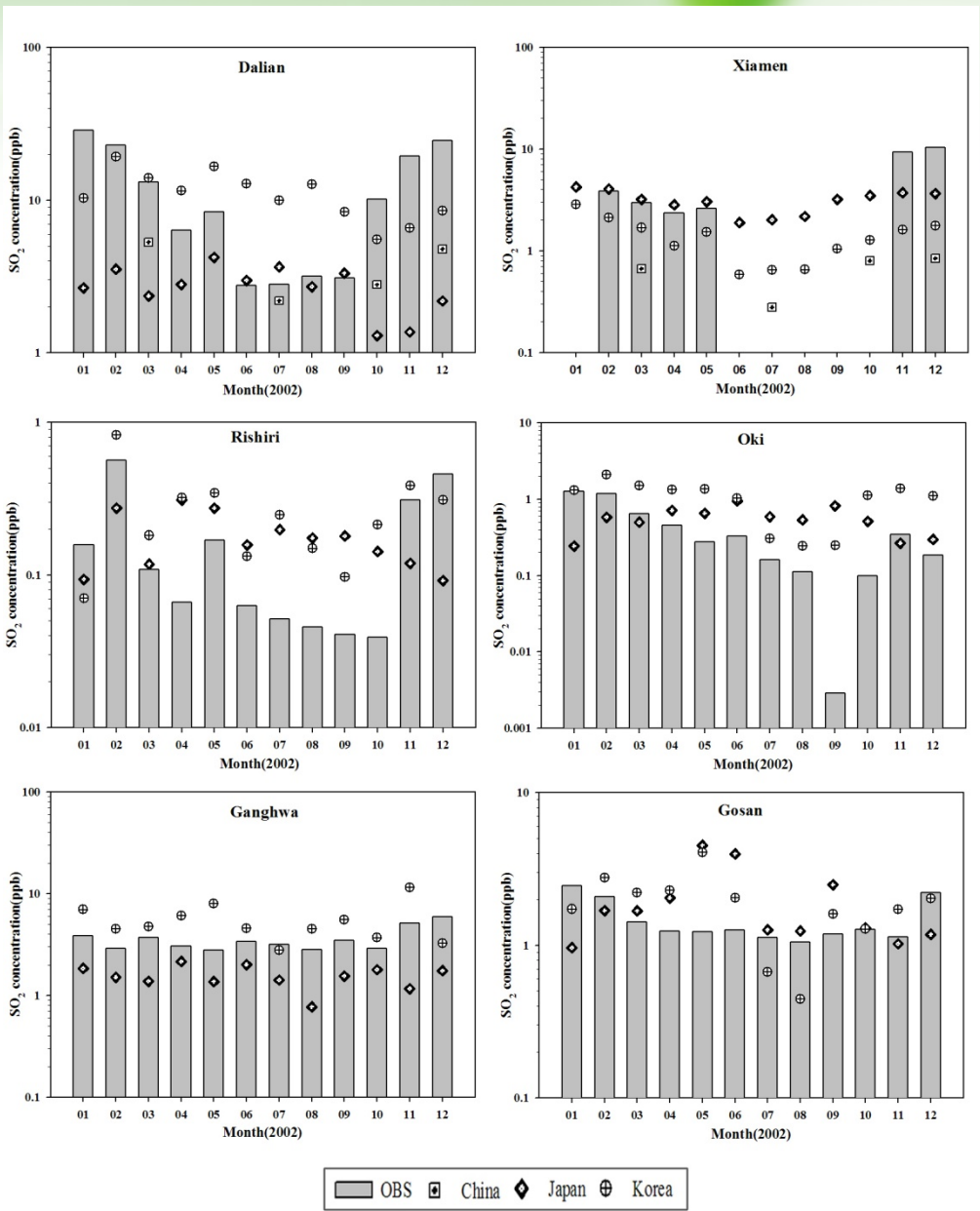
Time variations of longitudinal cross-section of simulated conversion ratio of sulfur (Fs = SO_4^{2-} /(SO_2 + SO_4^{2-}) from (a) China, (b) Japan, and (c) Korea on 5-13, March.

Model validation by observations



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

Model validation by observations



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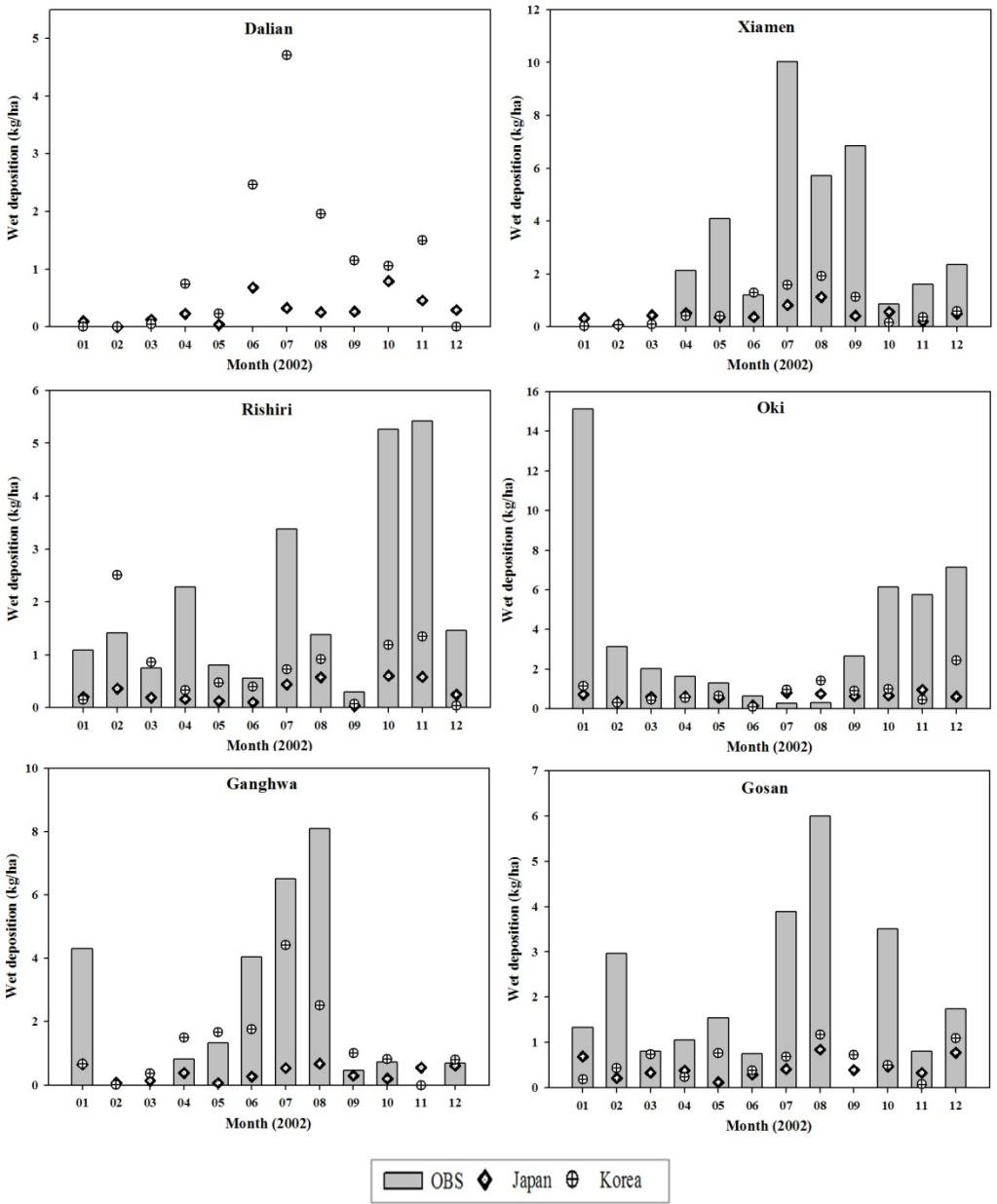
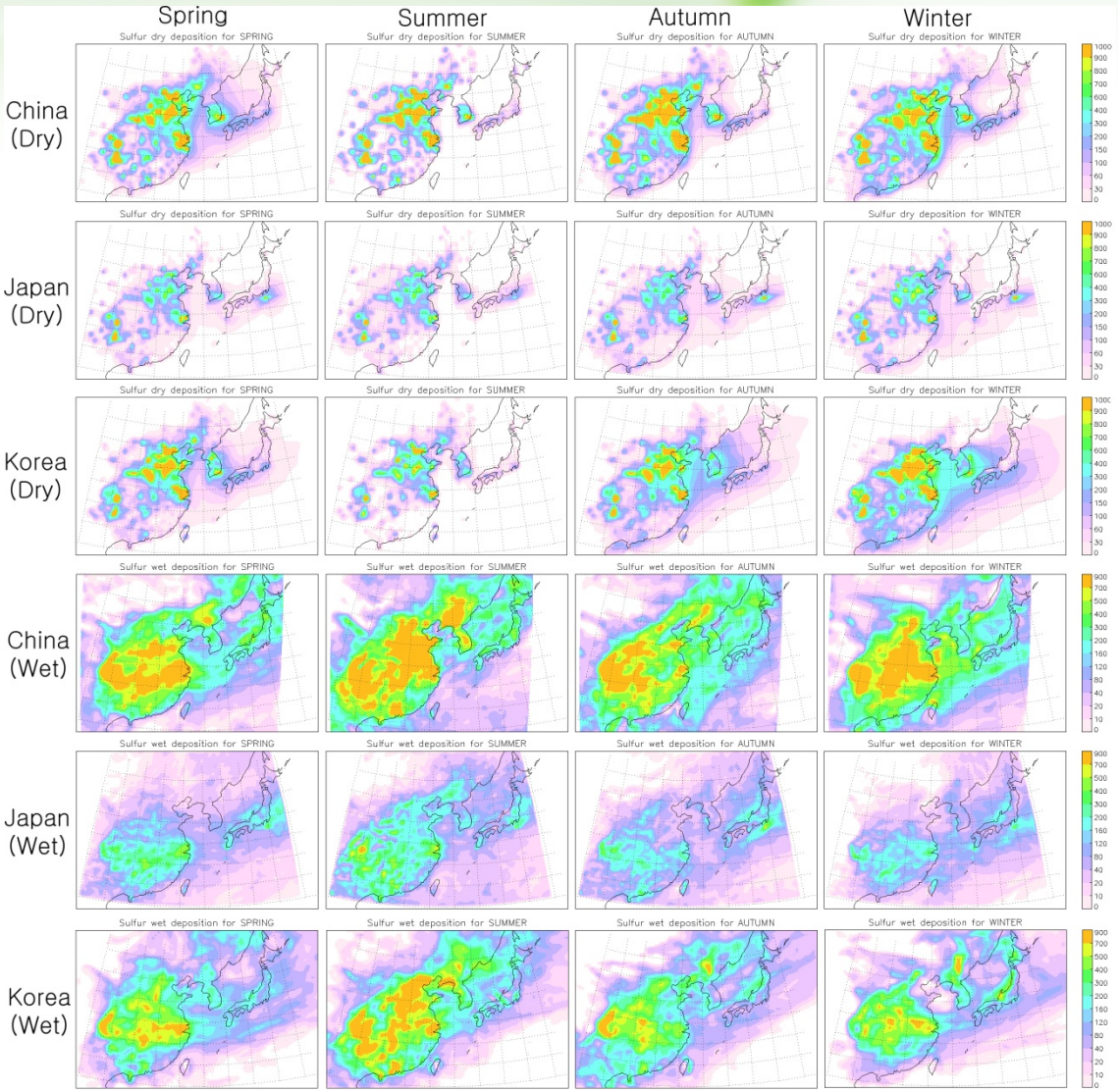


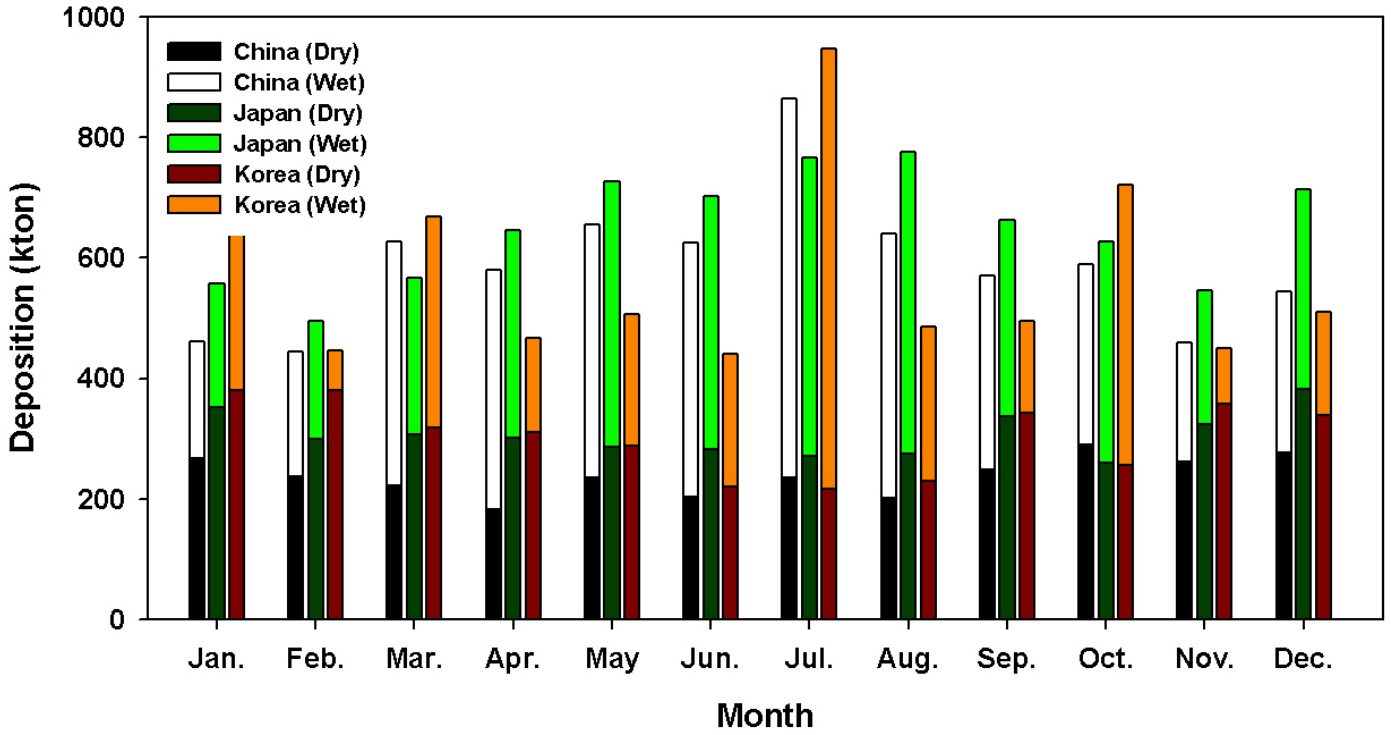
Comparison between observed simulated sulfur deposition at EANET sites in 2002

Sulfur deposition distribution



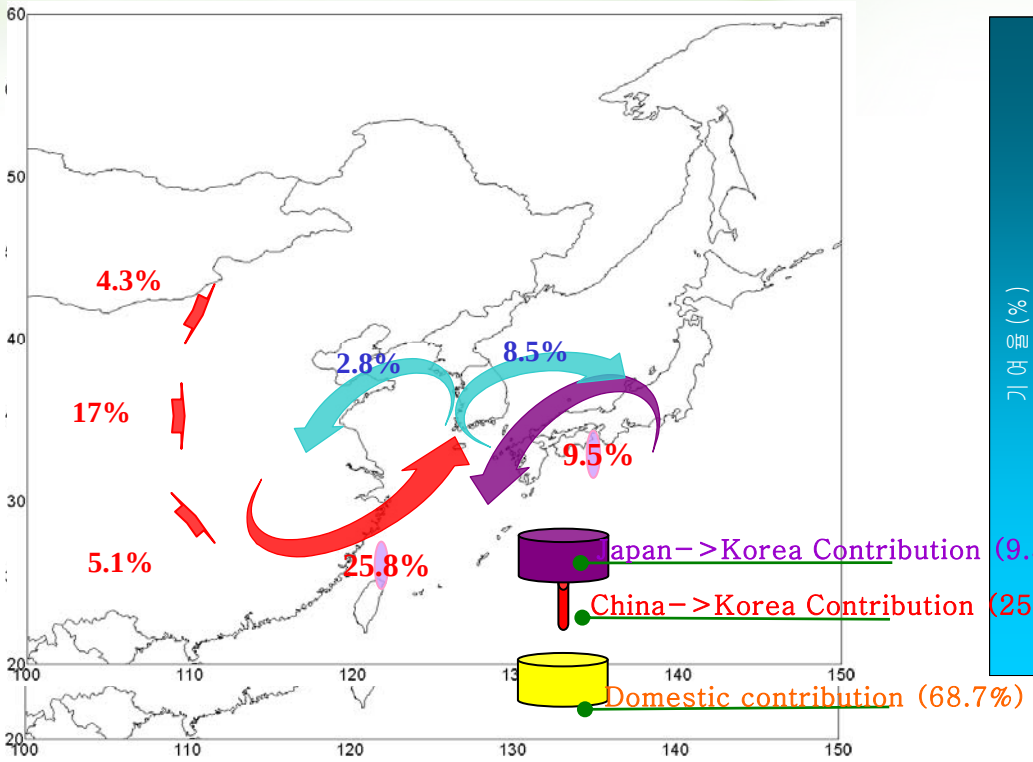
Simulated sulfur deposition patterns from (a) China, (b) Japan, and (c) Korea on 5-13, March.

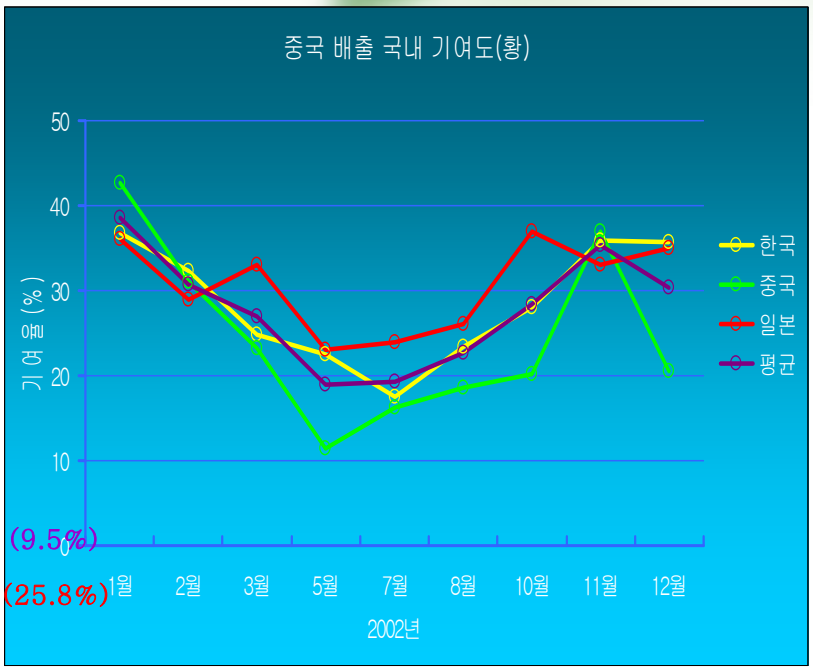
Monthly variation of sulfur deposition



Monthly variations of total, wet, and dry depositions of sulfur simulated from China, Japan, and Korea for the entire year of 2002.

Result of estimating S-R Relationship for Sulfur among three countries

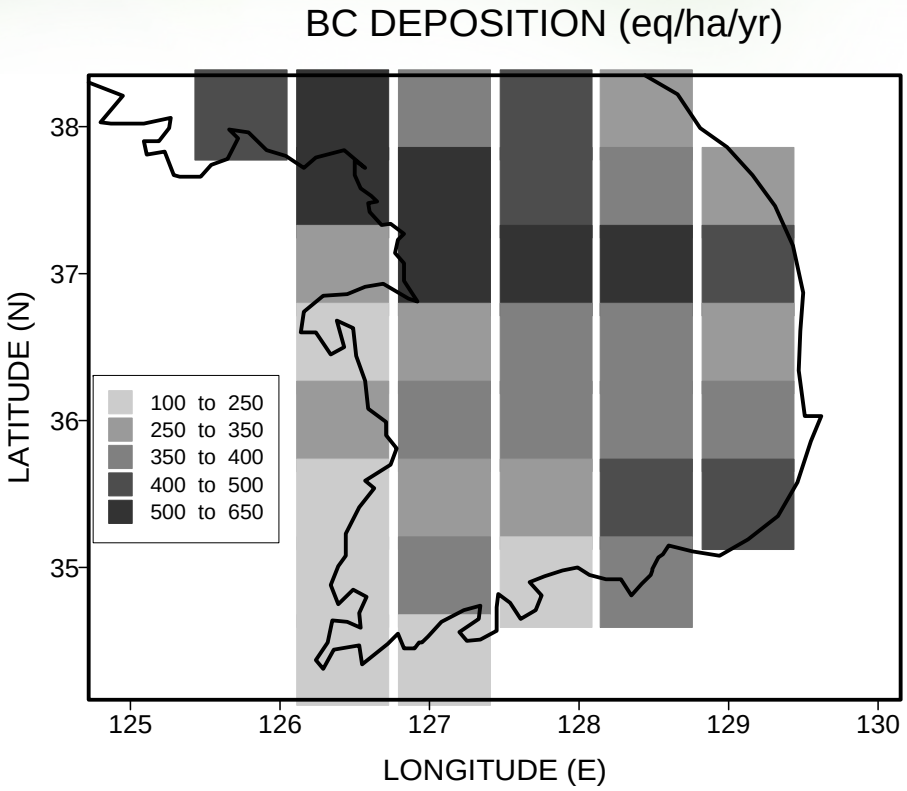


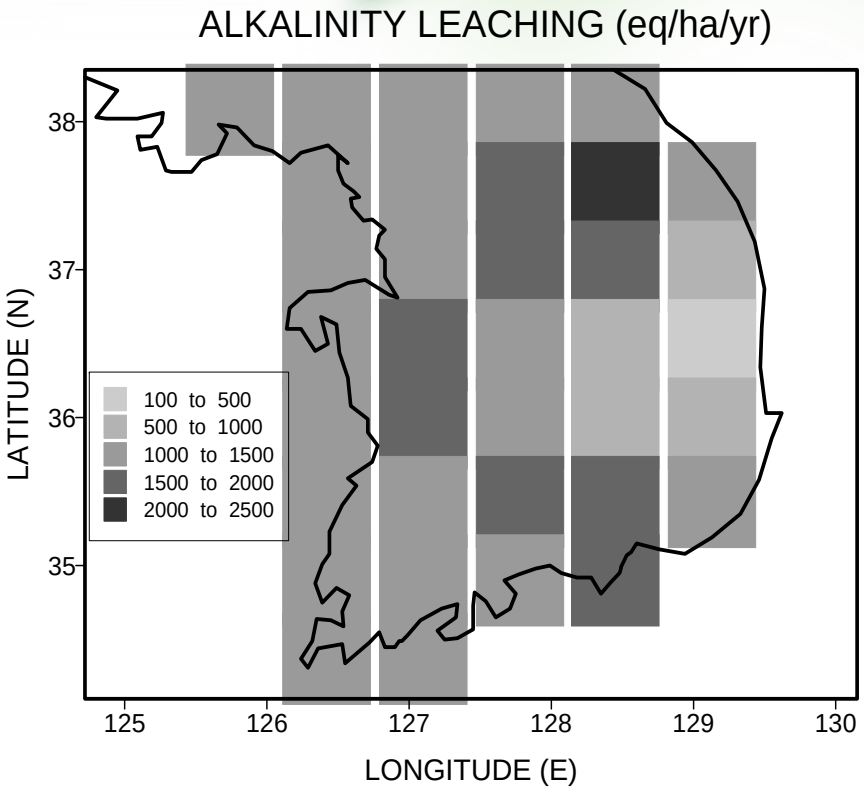


30% of the domestic sulfur depositions are originated from China and Japan

- As a result of joint research among three countries for the year 2002, 20~40% of sulfur depositions in Korea originated from China, and the concentration was the highest in the winter season.

Impacts of LTP on Forest Ecosystem





- Alkalinity of soil in Korea slows down its acidification

Ⅳ Future plan

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?

Thank you

for your attention.