

Task assigned in the meeting

Source-Receptor Relationships (urban-regional)

- Follow up on 3 studies we heard at this meeting. What additional work is of interest that would allow comparison of results?

- Franks TM5 perturbations – test the Rn - PM2.5 assumption?

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Introduction

In the early to mid-1990s, a number of regional models for acid deposition were just beginning to be applied in Asia and early results indicated significant differences in calculated source-receptor (S/R) relationships for sulfur deposition between different groups (cf. Carmichael et al., 2002 and references therein). In the recent decade, regional chemical transport models (CTMs) have undergone important improvements on the parameterizations of atmospheric processes affecting transport, chemistry, and removal of such pollutants as ozone, aerosols, and nitrogen compounds. **Can the state-of-the-art CTMs provide more reasonable S/R relationships for sulfur and nitrogen deposition in East Asia?** Impact of global emissions on regional air quality in Asia has been addressed by several studies (e.g. Holloway et al 2007). **The urban-to-regional S/R relationships in Asia need to be redistributed to include the global inflow.**

Consistency issues for comparison of results

It should be noted that there are considerable differences in emission inventory, the driving meteorology, and the model configurations. Firstly, efforts should be made to have a consistent definition of sources and receptor areas:

1. SO₂ emissions from Miyakejima volcano in 2001 are included or not? (See

Figure 1 and Figure 2)

2. SO₂ emissions from other volcanoes except Miyakejima are included or not? (See Figure 1 and Figure 2)
3. Global inflow by using boundary conditions from MOZART-CCM, MOZART NCEP or HTAP BC?
4. Definition of receptor areas, Japan, Taiwan, or an EANET site?

Secondly, emission reduction scenarios are different among three studies. Lin et al (2007b) proposed to use 25% reduction of SO₂ and NO_x in combination, and non-linear effects are estimated to be <2% for annual sulfur deposition, and <5% for NO_y deposition. Reduction of ammonia emissions is found to have significant non-linear effects to NO_y deposition. HTAP use 20% reduction of NO_x and VOCs. Hayami et al (MICS 2008) use 20% reduction of all emissions.

Questions to be addressed for comparison of results:

1. Use emissions-normalized S/R relationships?
2. Scale up the emissions perturbation results to obtain a 100% incremental source contribution to receptor areas?
3. How the non-linear effects can be transferred to the uncertainties or errors in predicted S/R relationships?

Preliminary analysis and major findings

Lin et al (2007a,b) have estimated regional source-receptor relationships for sulfur and reactive nitrogen deposition in East Asia, using the CMAQ model with emission and meteorological data for 2001. Results are compared with previous studies using the simple Lagrangian models (Table 1-3). The preliminary analysis by Lin et al (2007b) suggests two major findings:

(1) The results calculated by the CMAQ Eulerian model show higher long-range transport effects from foreign sources than those calculated by the early simple Lagrangian models. This is probably related to the Eulerian model's ability to describe vertical pollution transport in the free troposphere, whereas the Lagrangian model can not manage to trace the fate of pollution above the atmospheric boundary layer with the same accuracy. **Is it possible to validate this finding by comparison with other Eulerian model studies?**

(2) Regional modeling studies show that impact of global emissions on sulfur deposition in East Asia is significant. By using boundary conditions from MOZART NCEP, CMAQ estimated 9% of total sulfur deposition in Japan in 2001 is due to emissions outside the study domain (Table 1, also see Figure 6 in Lin et al. 2007b). **Is it possible to validate the impact of global inflow to acid deposition from the results of global CTMs, such as the HTAP models and MOZART analysis by Holloway et al (2007)?**

References:

Carmichael, G. R., Calori, G., Hayami, H., Uno, I., Cho, S. Y., Engardt, M., Kim, S. B., Ichikawa, Y., Ikeda, Y., Woo, J. H., Ueda, H., Amann, M., 2002. The MICS-Asia study: model intercomparison of long-range transport and sulfur deposition in East Asia. *Atmospheric Environment* 36 (2), 175–199.

Lin, M., Oki, T., Holloway, T., Streets, D. G., Bengtsson, M., Kanae, S., 2007a. Long-range transport of acidifying substances in East Asia - Part I: Model Evaluation and sensitivity studies. *Atmospheric Environment* (in review).

Lin, M., Oki, D. G., Bengtsson, M., Kanae, S. T., Holloway, T., Streets, 2007b. Long-range transport of acidifying substances in East Asia - Part II: Model Evaluation and sensitivity studies. *Atmospheric Environment* (in review).

Holloway, T. et al. 2007. MICS-Asia II: Impacts of global emissions on regional air quality in Asia. *Atmospheric Environment*, in press.

(Figures and Tables attached)

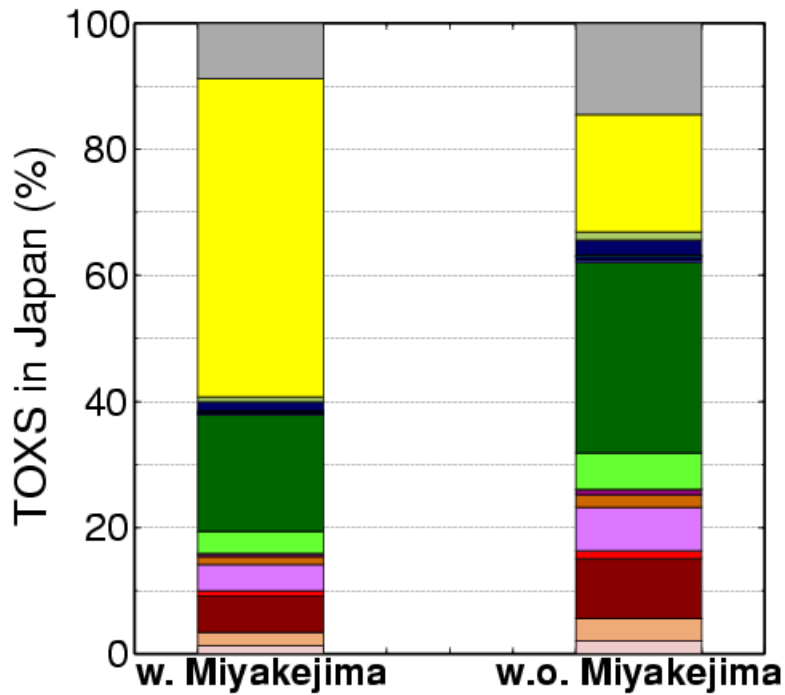


Figure 1 Percentage source contribution to total sulfur deposition over Japan, with and without SO₂ emissions from Miyakejima volcano

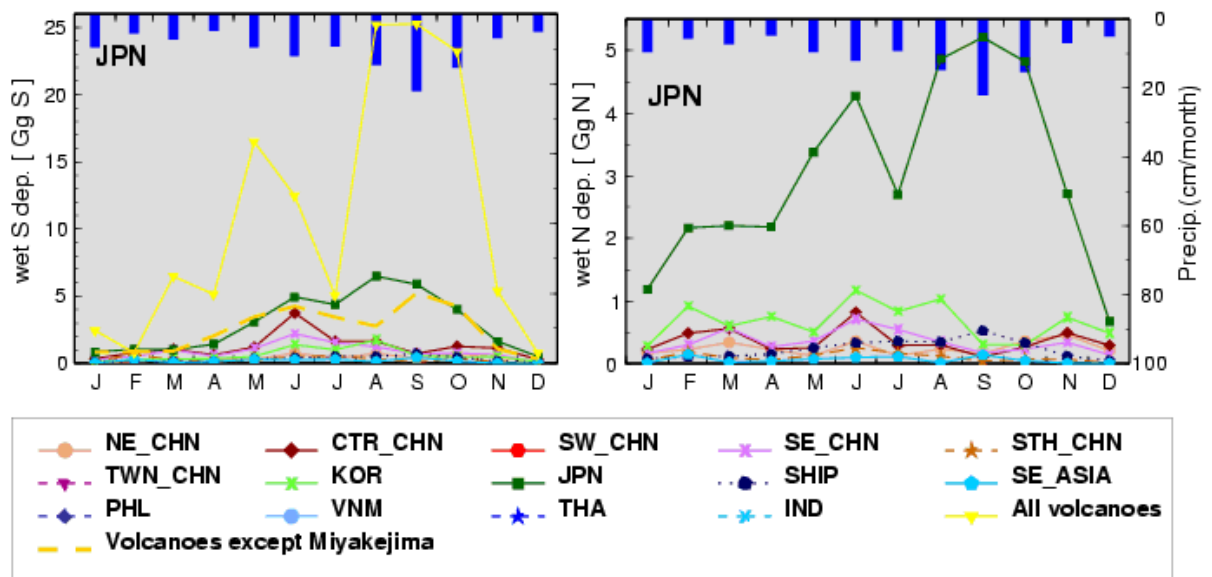


Figure 2 Seasonality of wet sulfur (left panels) and wet nitrogen (right panels) deposition in Vietnam, Taiwan, and Japan with contributions from major sources. The left/bottom axis refers to individual source contribution, whereas the right/top axis refers to monthly precipitation averaged over the receptor area. (Lin et al 2007b)

Table 1 from Lin et al 2007b,

*results from HTAP (for global inflow), Hayami et al (MICS 2008) and others can be added and compared

Comparison with previous studies: major sources contributing to total sulfur deposition in Japan (in percent). Note that the values in parentheses are the percentage contributions to anthropogenic sulfur deposition in Japan excluding the deposition originating from volcano sources.

References	Year	China	N-S Korea	Japan	Volcano
Huang et al.(1995)	1989	3.5	2 ^a	93 ^b	-
Ichikawa and Fujita (1995)	1990	(45)	(16)	(33)	20
Ichikawa et al.(1998)	1990	25.0	16	40	18
Ardnt et al.(1998)	1990	(17)	(14)	-	-
Calori et al.(2001)	1997	36.0	12	-	-
This study ^c	2001	15.4(31)	3.5(7)	18.4(37.2)	50.4

^a South Korea only

^b Combined contribution from anthropogenic and volcanic sources in Japan

^c Boundary contribution in this study is 8.9(17.8)%

Table 2 from Lin et al 2007b,

*results from HTAP (for global inflow), Hayami et al (MICS 2008) and others can be added.

Comparison with previous studies: major sources contributing to total sulfur deposition in Vietnam (in percent)

References	Year	China	Vietnam	Thailand	Boundary	Shipping
Ardnt et al.(1998)	1990	40	36	19	-	-
Engardt et al.(2005)	2000	38 ^a	41	7	9	1
This study ^b	2001	51.4	15.3	10.5	5.3	3.0

^a Parts of Southern China only

^b Other noticeable ($\geq 2.0\%$) contributors are IND (2.9%), PHL (3.3%), and volcano (2.5%)

Table 3 from Lin et al 2007b, *results from HTAP (for global inflow), Hayami et al (MICS 2008) and others can be added.

Comparison between CMAQ and ATMOS estimated source-receptor relationships for total nitrogen deposition (in percent)

Receptors →	Taiwan		N-S Korea		Japan		China	
	CMAQ	ATMOS	CMAQ	ATMOS	CMAQ	ATMOS	CMAQ	ATMOS
Taiwan	46.0	80	1.1	-	0.9	2	1.6	2
N-S Korea	4.2	-	46.9	61.5 ^a	14.9	15 ^a	2.6	1 ^a
Japan	1.8	1	4.6	2.5 ^b	55.7	65	0.5	-
China	34.1	18	39.1	36 ^b	20.6	18	79.7	90
SE Asia	6.6	-	0.6	-	0.6	-	4.0	-
Shipping	6.5	-	2.1	-	3.4	-	1.1	-
Boundary	0.6	-	4.3	-	2.7	-	8.1	-

a. Taken as combined contribution from emissions in South and North Korea

b. Taken as averaged contribution to deposition in South Korea and deposition in North Korea