DEVELOPMENT OF A GLOBAL EMISSIONS INVENTORY IN SUPPORT OF A GLOBAL ATMOSPHERIC CHEMISTRY MODELING STUDY

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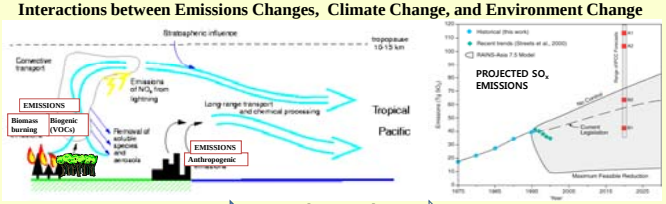
1. BACKGROUND AND OBJECTIVES

Climate change has been affecting human health, ecosystem, and human economic system. Assessing such impacts is frequently done using global climate and chemistry models which rely on emission inventories (EIs) of the relevant precursor emissions. In 2008, the Korean Ministry of Environment(KMOE) ambitiously launched several multi-year research projects that analyze the impacts of climate change on regional air quality. For our study, NCAR CCSM, Harvard GEOS-Chem, and EPA CMAQ are the models of choice for the global climate, global atmospheric chemistry, and regional atmospheric chemistry, respectively. A Global and a regional scale emissions inventory, therefore, need to be developed in support of global and regional climate and atmospheric chemistry modeling study.

Interactions between Emissions Changes, Climate Change, and Environment Change



NCAR CCSM (Global Climate) → Harvard GEOS-Chem (Global Atm. Chemistry) → EPA CMAQ (Regional Atm. Chemistry)

KORDI&CBNU (CCSM modeling) SNU (GEOS-Chem modeling) HYU (Parallel Code Development) KU (Global & Regional Emissions Inventory)

2. SELECTION OF EMISSION INVENTORIES

In this study, we have extensively reviewed and analyzed a number of existing global and regional scale emission inventories, then developed a most up-to-date emission inventory using that information. Evaluation is based on data availability and accessibility, spatial-temporal coverage, resolution, and etc. As a first year product of the five-year research project, we are trying to develop 11-years (1997-2007) transient emissions inventory, for the use of initial near-term atmospheric chemistry modeling, using RIVM IMAGE model (IPCC A1B scenario), Ohara et al.(2007) and other research efforts.

• The Characteristics of Global Emission Inventories

Inventory		spatial resolution	temporal resolution	period	Chemical	sector
Historical (Hindcasting)	EDGAR -HYDE	1x1	annual (10 year)	1890 - 1990 (100 year)	[1.3] CO, NO_x, CO_2, CH_4, N_2O, NH_3, SO_2, NMVOC [1 #] (H_2, CH, N_2)	10
	RETRO	0.5x0.5	Monthly (1 year)	1960 ~ 2000 (40 year)	CO, NO_x, CO_2, CH_4, C_2H_6, C_3H_8, C_4H_{10}, Butane and higher Toluene, C_5H_8H, $C_{10}H_{16}$, CH_3Cl, CH_2Cl_2, $CHCl_3$, $C_2H_3Cl_3$, CH_3CCl_3, Monoterpenes, H_2, N_2O, NH_3, OC, BC, TC, SO_2, CH_3CHO, CH_3COCH_3, C_2H_5OH, CH_3OH, TPM, VOC	2
Present (Base year)	EDGAR 3.2 FT2000	1x1	annual	2000	CO, CH_4, NH_3, SO_2, BHC, PAC, CO, NO_x, NMVOC, NH_3, SO_2	10 +
	GEIA v.1	1x1	annual monthly	discrete on the compound	CO, NO_x, CO_2, CH_4, N_2O, NH_3, OC, BC, SO_2, CFC (sfc-11 & sfc-12), Pb, Hg, Ketone chlorine, Particulate, VOC	10
	POET	1x1	annual	1990 ~ 2000	CO, NO_x, CH_4, CH_4, C_2H_6, C_3H_8, Butane and higher, Butane and higher, Toluene, C_5H_8H, $C_{10}H_{16}$, CH_3Cl, CH_2Cl_2, $CHCl_3$, CH_3CCl_3, CH_3COCH_3, CH_3, Monoterpenes	4 ~
	GFEDv2	1x1	monthly or 8-day	1997 - 2005	NO_x, CH_4, H_2, N_2O, OC, BC, TC, $PM_{2.5}$, TPM, NMHC	4 ~

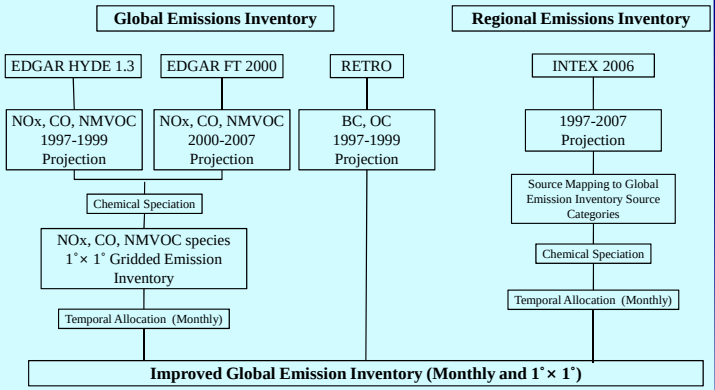
• The Characteristics of Regional Emission Inventories

Inventory	Inventory Domain	Spatial resolution	Temporal resolution	years	Sector / chemical
TRACE-P 2000	Latitude : -10 ~ 50 Longitude : 60 ~ 150	1x1	annual	2000	Anthropogenic : SO2, NOx, CO, NMVOC, NH3, OC, BC CO2, CH4 Biomass burning : SO2, NOx, CO, NMVOC, NH3, OC, BC CO2, CH4
REAS	Latitude : -10 ~ 50 Longitude : 60 ~ 150	0.5x0.5	annual	Historical : 1980-2003 Base :2000 Prediction : 2004-2009 Project : 2010, 2020	Anthropogenic : SO2, NOx, CO, NMVOC, NH3, OC, BC, CO2, CH4, N2O
INTEX 2006	Latitude : -10 ~ 50 Longitude : 60 ~ 150	0.5x0.5	annual	2006	Anthropogenic : SO2, NOx, CO, NMVOC, OC, BC, PM10, PM2.5
ABBI	Latitude : -10 ~ 60 Longitude : 59 ~ 150	1x1	Monthly and daily	Mar-May, 2000 Mar-May, 2001	Biomass burning only. (chemical species 37)

*TRACE-P2000 and INTEX2006 inventory prepared by Streets et al.(2003), and Streets &Zhang, respectively. REAS – Ohara et al.(2007), ABBI (Asian Biomass Burning Inventory)

3. EMISSIONS PROCESSING

3.1 Overall process



3.2 Chemical Speciation

• SAPRC-99 chemical species profiles w.r.t SCCs in SMOKE were lumped w.r.t. global emission inventory source categories. Chemical species mapping based on N.K. Moon, et al. (2005)

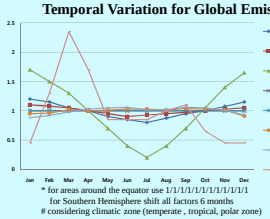
Table 1. Chemical species mapping table for SAPRC-99 to GEOS-CHEM

SAPRC99 Chemical ID	GEOS-CHEM Chemical ID
OLE1	½*PRPE
ALK2	C3H8
ALK3+ALK4+ALK5	ALK4
ALK1	C2H6
ACET	ACET
MEK	MEK
CCHO	ALD2
HCHO	CH2O

3.3 Temporal Allocation

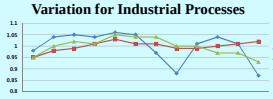
• EDGAR monthly allocation factors were mostly used for allocation
•Monthly variation of residential combustion (Kim, 1998) and monthly allocation factors for mobile sources in SMOKE were used to allocate residential and mobile emissions in Korea, Japan, and Taiwan

Temporal Variation for Global Emissions



* for areas around the equator use 1/1/1/1/1/1/1/1/1/1/1/1
for Southern Hemisphere shift all factors 6 months
considering climatic zone (temperate , tropical, polar zone)

Variation for Industrial Processes

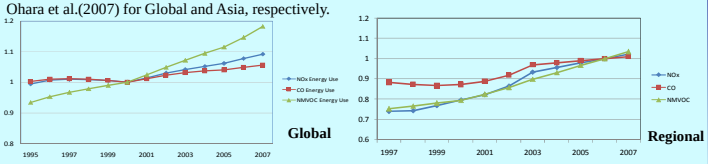


References for Temporal Allocation

Region3	Sector	Reference
Korea, Japan, Taiwan	Power plants	EDGAR temporal variation
	Industrial comb.	EDGAR temporal variation
	Industrial process	EDGAR temporal variation
	Solvent use	EDGAR temporal variation
	Residential	D. Y. Kim(1998), Ph. D. thesis
	Transportation	SMOKE temporal allocation factor
China	Power	Wang et al.(2005)
	Industry	Streets et al.(2003), Wang et al.(2005)
	Transportation	Streets et al.(2003), Wang et al.(2005)
	Residential (F+B)	Streets et al.(2003)
Southeast Asia	Power plants	EDGAR temporal variation
	Industrial comb.	EDGAR temporal variation
	Industrial process	EDGAR temporal variation
	Solvent use	EDGAR temporal variation
	Residential	Streets et al.(2003) using South China average value
	Transportation	EDGAR temporal variation
India	Power plants	EDGAR temporal variation
	Industrial comb.	EDGAR temporal variation
	Industrial process	EDGAR temporal variation
	Solvent use	EDGAR temporal variation
	Residential	Streets et al.(2003) using South China average value
	Transportation	EDGAR temporal variation
Other Asia Country	Power plants	EDGAR temporal variation
	Industrial comb.	EDGAR temporal variation
	Industrial process	EDGAR temporal variation
	Solvent use	EDGAR temporal variation
	Residential	EDGAR temporal variation
	Transportation	EDGAR temporal variation

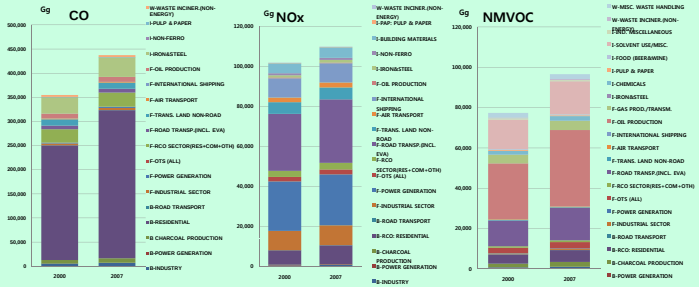
3.4 Inventory Projection

• 1997 ~ 2007 yearly emissions were projected from the base-year inventories (2000 for global and 2006 for Asian, respectively). Projection parameters were estimated using the RIVM IMAGE model(IPCC A1B) and Ohara et al.(2007) for Global and Asia, respectively.



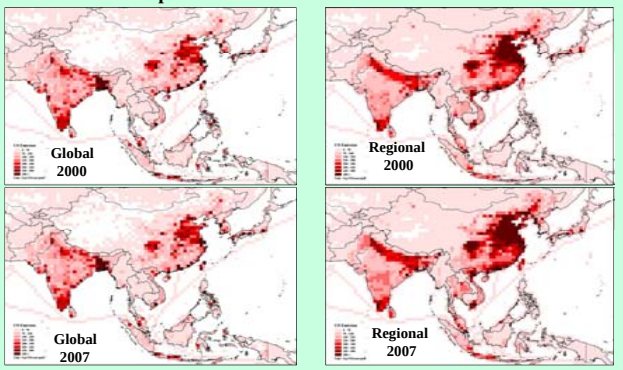
4. EMISSIONS INVENTORY RESULTS

4.1 Emission by source sectors and countries for year 2000 and 2007



Total emissions for CO, NOx, and NMVOCs show moderate increase from year 2000 to 2007 period. These emissions projection were conducted using RIVM IMAGE model (A1B, global) and Ohara et al.(2007) projection parameters.

4.2 Difference of spatial distribution between two inventories



Gridded(1deg. * 1deg.) CO emissions in Asia for year 2000 and 2007

Gridded CO emissions from original EDGAR(left) and INTEX2006 (right) inventories. Regional and 2007 inventories show higher emissions compare to global and 2000 inventories. Global emissions were projected using RIVM IMAGE model (A1B, global) and regional emissions were projected by Ohara et al.(2007) projection parameters.

5. ON-GOING WORK

The GEOS-Chem air chemistry modeling using CCSM3 meteorological field and 1997~2007 transient emissions data is being conducted to understand impact of emissions change on global and regional air quality. Top-down emissions will be estimated using airborne and satellite measurement data and air chemistry model. The more comprehensive and optimized bottom-up emissions inventory would be developed using more updated activity information and top-down emissions estimation.

6. REFERENCE

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• TRACE-P2000 and INTEX2006 inventory prepared by Streets et al.(2003), and Streets &Zhang, respectively http://www.cgrer.uiowa.edu/EMISSION_DATA_new/index_16.html
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•ACKNOWLEDGEMENT

This research was performed under the support of "National Comprehensive Measures against Climate Change" Program by Ministry of Environment, Korea (Grant No. 1700-1737-322-210-13)