DEVELOPMENT OF AN EMISSIONS PROCESSING SYSTEM FOR RCP SCENARIO INVENTORIES IN SUPPORT OF GLOBAL AND ASIA AIR QUALITY MODELING STUDIES

Ki-Chul Choi[1], Jung-Hun Woo[1*], Jaebum Lee[2], Chang-Keun Song[2], Jinseok Han[2]

[1]Dept. of Advanced Technology Fusion, Konkuk University, Seoul, South Korea, [2]National Institute of Environmental Research, Incheon, South Korea

1. BACKGROUND

Climate change is one of the most important issues, and many researches have been examining not only future climate but interaction of climate and air quality. The new generation of scenarios for climate change, namely as Representative Concentration Pathways (RCPs), were developed in support of IPCC's Fifth Assessment Report (AR5). The RCPs have been selected from existing literature to span full range of possible trajectories for future greenhouse concentration through 2100. The National Institute of Environmental Research (NIER) of Korea has been conducting integrated modeling research for future climate and air quality under the scenarios of IPCC. In this study, a new version of the emissions processing software tool, named Konkuk University – Emissions Processing System version 2.0 (KU-EPS v2.0) is developed to support climate and atmospheric chemistry modeling studies using RCPs. The KU-EPS v2.0 is designed to cover global and regional scale modeling domains, which are corresponding to GEOS-Chem and CMAQ/CAMx models, respectively. The SMOKE-Asia emissions modeling system is linked to this tool to create model-ready emissions for regional scale air quality modeling. Due to its flexible software architecture, the KU-EPS v2.0 could be apply to any pre-gridded emissions as well as regional inventories.

2. METHODOLOGY

2.1 General overview

The key elements of RCPs inventory are listed in right table.

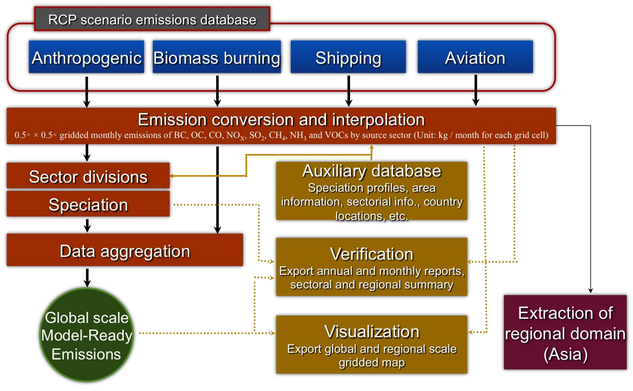
The RCPs emission processing system is an open source software created with ESRI ArcGIS and SMOKE-Asia (Woo et al., 2012) modeling system. We classify the main system under two major groups depending on the modeling scales.

Table. Summary of the RCPs emission inventory dataset

Item	Description
Domain	40 regions of the globe
Species	BC, OC, CO, NO_X, SO_2, CH_4, NH_3, VOCs
Spatial resolution	0.5 º × 0.5º grid resolution
Temporal resolution	Monthly
Sectors	*Anthropogenic: ENE, IND, SLV, DOM, TRA, WST, AGR, AWB Biomass burning: Forest fire, Glass fire International shipping and Aviation
Period	2000-2100, every 10 years
Data availability	RCPs database available online at http://tntcat.iiasa.ac.at:8787/RcpDb/dsd?Action=htmlpage&page=about

2.2 Global scale emissions processing

Detailed schema of global emissions processing



Emission conversion and interpolation:
This function allows calculating and converting the emission sources at each grid cell in the entire gridded inventory for the target years.

$$E_{Y_m,P,S,ij} = E_{Y0_m,P,S,ij} + \left(\frac{Y-Y0}{Y1-Y0}\right)\left(E_{Y1_m,P,S,ij} - E_{Y0_m,P,S,ij}\right)(TF \cdot AF)$$

Where $E_{YmP,S,ij}$ is the emission of source sector S in a pollutant P for target month of the year Y_m at each grid cell (i, j). The Y0 and Y1 are the representative years given by input RCPs inventory, which generally at 10 year intervals. TF and AF are the time and area unit conversion factor, respectively.

RCPs source sector mapping table

RCP sector	EDGAR sector	Sector description
ENE	B20	Power generation
	F20	Power generation
	B30	Charcoal production
	F30	OTS(ALL)- Other transformation sector
	F80	Oil production
	F90	Gas production
IND	B10	Industry
	F10	Industrial sector
	I10	IRO: Iron & steel
	I20	NFE: Non-ferro
	I30	CHE: Chemicals
	I40	Building materials
	I50	PAP: Pulp & paper
	I60	FOO: Food (Beer & Wine)
	I90	MIS: ind. Miscellaneous
SLV	I70	SOL: Solvent use/ Misc.
DOM	B40	RCO: Residential
	F40	RCO sector (RES+COM+OTH)
*TRA for Globe	B51	Road transport
	F51	Road transport (Incl. Evaporation)
	F54	Trans. Land Non-road
WST	W40	Waste incineration (non-energy)
	W50	Misc. waste handling
AGR		
AWB		
*TRA for Asia	Non-road	Non-road vehicle
	LDGV	Light duty gas vehicle
	LDDV	Light duty diesel vehicle
	HDGV	Heavy duty gas vehicle
	HDDV	Heavy duty diesel vehicle
	LDGT	Light duty gas truck
	LDDT	Light duty diesel truck
	MTCC	Motorcycle

Sector divisions:
Before chemical speciation process, RCPs simplified emission sectors for VOCs were extended to the detailed level ones. The detailed sectors were obtained from EDGAR 3.2 FT 2000 inventory (Olivier et al., 2005)

*Note that transportation sector emissions for Asia are independently mapped onto regionalized information to represent Asian activities.

Chemical speciations:
The chemical speciation function consist of two steps.

1. VOCs emissions for each detailed source sector divided by sector division process were speciated according to the SAPRC99 chemical mechanism. mapping method between EDGAR and US source sectors followed as in Woo et al. (2012).
2. VOCs species by SAPRC99 mechanism were reclassified to GEOS-Chem species. To link both of chemical species, related study (Moon et al., 2005) was used.

Table. Chemical species mapping table between SAPRC99 and GEOS-Chem model

SAPRC99	GEOS-Chem species	SAPRC99	GEOS-Chem species
NO2	NOx	OLE1	1/2×PRPE
O3	Ox-NOx	ALK2	C3H8
PAN	PAN	HCHO	CH2O
CO	CO	ALK1	C2H6
ALK3	1/3×ALK4	N2O5	N2O5
ALK4	1/3×ALK4	HNO4	HNO4
ALK5	1/3×ALK4	COOH	MP
ISOPRENE	ISOP	SO2	SO2
HNO3	HNO3	NH3	NH3
HO2H	H2O2	ASO4J	SO4
ACET	ACET	ANH4J	NH4
MEK	MEK	ANO3J	NO3
CCHO	CCHO	AORGPAJ	0.1×OCPI + 0.1×OCPO
RCHO	RCHO	AORGBJ	SOA1+SOA2 + SOA3
MVK	MVK	AECJ	BCPI + BCPO
METHACRO	MACR	ACORS	0.18×DST2 + 0.29×DST3 + 0.29×DST4
MA_PAN	PMN	ASEAS	0.621×SALA
PAN2	PPN	ASOIL	0.29×DST1 + 0.11×DST2
RNO3	R4N2		

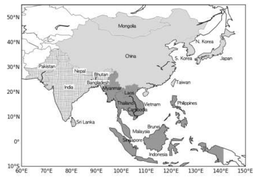
$$E_{Y_m,P,ij} = \sum_{S=1}^{n} E_{Y_m,P,S,ij}$$

Where $E_{YmP,ij}$ is the emission of given chemical species P for target month of the year Y_m at each grid cell (i, j). The S and n are stand for the source sectors and the total number of source categories in this inventory.

Visualizations:
The results of this system are in the form of ASCII text, and basically it could be visualized with any other possible programs. Nevertheless we have created a visualization module using intermediate data as well as final model-ready inventory for user convenience

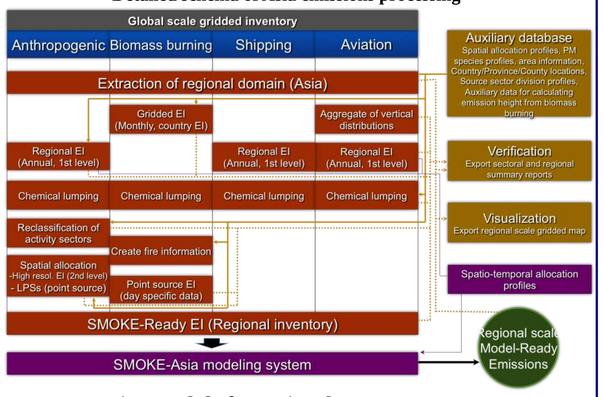
2.3 Emissions processing for Asia

Definition of the emissions domain for Asia



Extraction of regional domain:
extracting the selected range of regional domain, e.g., Asia.

Detailed schema of Asia emissions processing



$$E_{C_k,Y,P,S} = \sum_{ij \subset C_k} \sum_{m=1}^{12} E_{ij,Y_m,P,S}$$

Where $E_{CKY,P,S}$ is the emission of given source sector S and pollutant P relative to year Y in countries C_K, Y_m stands for the target month of the year Y, ij is the grid cell

Summation module for regional EI:
It allows aggregating emissions from gridded data to regional one, which required for creating input inventory of SMOKE-Asia modeling system. Spatial reference table that links the each grid cell and lst level administrative regions was created by ESRI ArcGIS

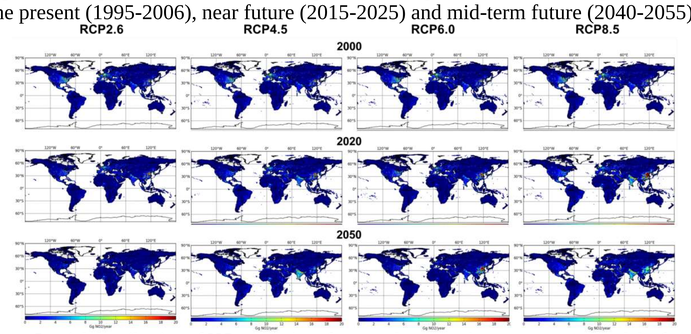
Chemical lumping:
The RCPs emissions inventory provides speciated cabonaceous emissions, nevertheless it should be generate a set of pollutnat, such as $PM_{2.5}$, because SMOKE system is generally reading the pollutants inventory and outputing speciated compounds as referred to model chemistry.

Reclassification of activity sectors:
For the emissions processing, detailed emission activities in inventory are required. The reclassification of activity sectors module provides RCPs simplified emission sectors for whole of pollutants were extended to the detailed level ones. The detailed sectors were obtained from EDGAR 3.2 FT 2000 inventory (Olivier et al., 2005)

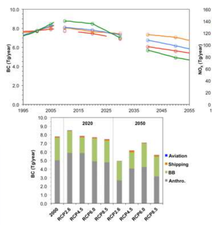
Applying the SMOKE-Asia modeling system:
The SMOKE-Asia (Woo et al., 2012) as an external software was selected to create model-ready emissions of regional scale domain for Asia. For this process, the regional scale processing group in main system basically calculates to not only a set of regional inventory compatible with SMOKE-Asia but auxiliary data such as spatio-temporal allocation profiles.

3. APPLICATION TO GLOBE AND EAST ASIA

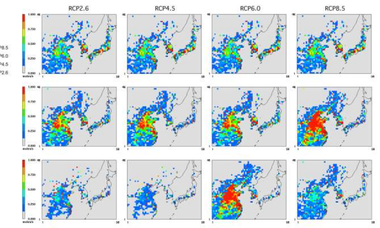
To support modeling experiments and illustrate the performance of this system, we chose a particular application that combines global and regional scale modeling domain during the present (1995-2006), near future (2015-2025) and mid-term future (2040-2055).



Spatial distribution of NO_X emissions from anthropogenic sources over the globe for the different RCPs at each representative year

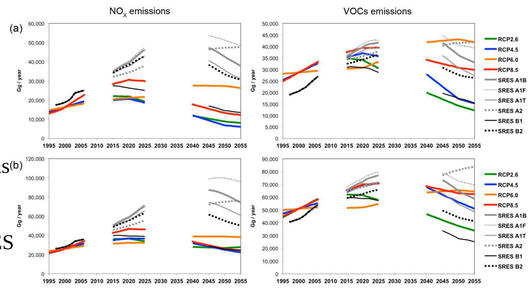


Comparison of global BC and NO_X emissions trend from all source categories with reference data (circle marker)



Spatial distribution of NO_X emissions from anthropogenic sources over Asia for the different RCPs at each representative year

The NO_X and VOCs trends generally show that the highest RCP emission scenario is RCP8.5 for year 2020s but RCP6.0 for year 2050s due to rapidly decreasing RCP8.5 emissions after 2020s, which present different trends than global total emissions. The six SRES scenario emissions from a previous study generally show higher range of emissions than RCPs especially NO_X emissions over the East Asia and whole of Asia



Emissions of NO_X and VOC trend during the modeling period over the (a) East Asia and (b) whole of Asia region. For a comparison the trends of RCPs emissions from this study described with a previous study for SRES scenario emissions (NIER, 2010) in Asia region

4. REFERENCE

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*** Corresponding author : jwoo@konkuk.ac.kr**