

Impact of Foreign Emissions on Simulated Ozone in South Korea

Seunghee You • Byeong-Uk Kim ¹⁾ • Hyuncheol Kim ²⁾ • Jung-Hun Woo ³⁾ • Soontae Kim *

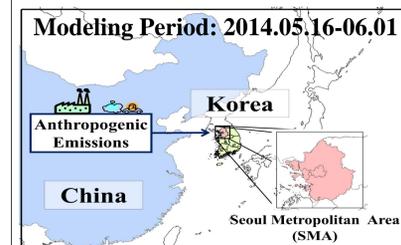
Ajou University, Dept. of Environmental Engineering, Suwon, Korea, ¹⁾Georgia Environmental Protection Division, Atlanta, GA, ²⁾NOAA/Air Resources Laboratory, College Park, MD, ²⁾UMD/Cooperative Institute for Climate and Satellites, College Park, MD, ³⁾Dept. of Advanced Technology Fusion, Konkuk University, Seoul, Korea

Introduction

- Nitrogen oxides (NOx) and volatile organic compounds (VOCs) emissions from foreign countries have potentially significant influence on surface ozone concentrations in South Korea (Bae et al., 2014).
- South Korean air quality managers need to consider the influence of foreign emissions on South Korea ozone when they develop a domestic air quality management plan.
- Instead of common modeling practice using a single inventory, we used three foreign emission inventories to assess confidently the impact of foreign emissions on ozone concentrations in Seoul Metropolitan Area(SMA), South Korea.

Methodology

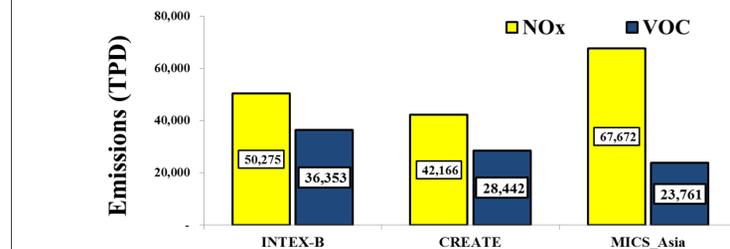
Modeling Setup and Emission Inventories



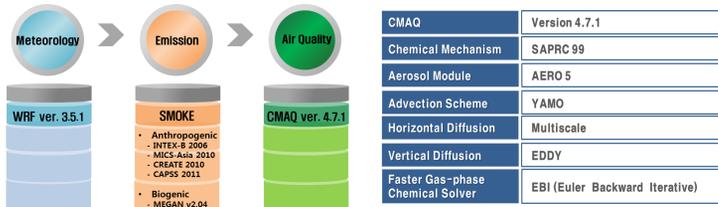
Anthropogenic Emissions

| Foreign | Korean |
|---------------------------------|---------------------------|
| INTEX-B 2006 ^(A) | CAPSS 2011 ^(D) |
| CREATE 2010 ^(B) | |
| MICS - Asia 2010 ^(C) | |

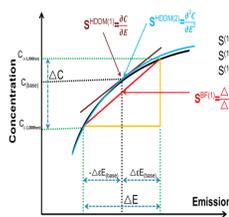
- Note : (A) Intercontinental Chemical Transport Experiment - Phase B
 *INTEX-B is the most commonly used foreign emission inventory in South Korea.
 (B) Comprehensive Regional Emissions inventory for Atmospheric Transport Experiment
 (C) Model Inter-Comparison Study
 (D) Clean Air Policy Support System (by National Institute of Environmental Research)



Modeling System & CMAQ Configurations

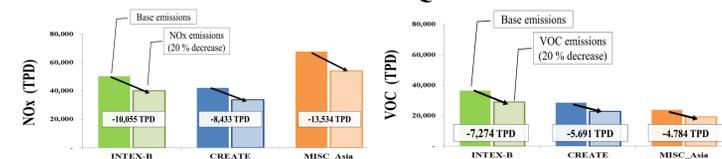


CMAQ - HDDM



- CMAQ-HDDM (High-order Decoupled Direct Method) was used to efficiently quantify ozone concentration changes due to foreign emission changes.
- To validate CMAQ-HDDM results based runs with 20 % Chinese anthropogenic NOx and VOC emission reduction were performed respectively.

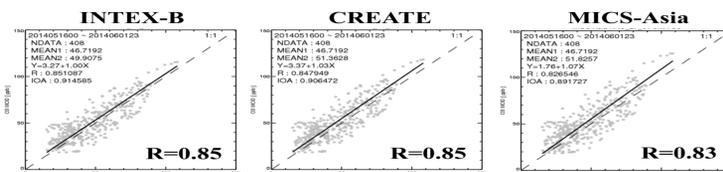
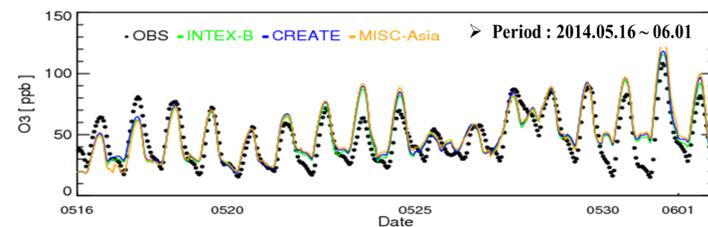
Emissions Reduction in CMAQ-HDDM run



- Uniform 20 % Chinese emission reduction runs using different emission inventories result in different amounts of reduced emissions. For NOx, the range of reduced emissions spans from 8,433 TPD to 13,534 TPD.

Result

Model Performance Evaluation



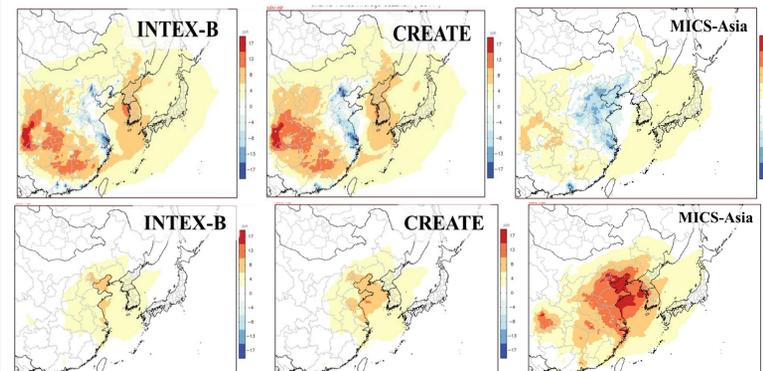
- Simulated ozone concentration with different foreign emission inventories showed comparable model performance in SMA.

Spatial Distribution of Modeled Ozone Concentration

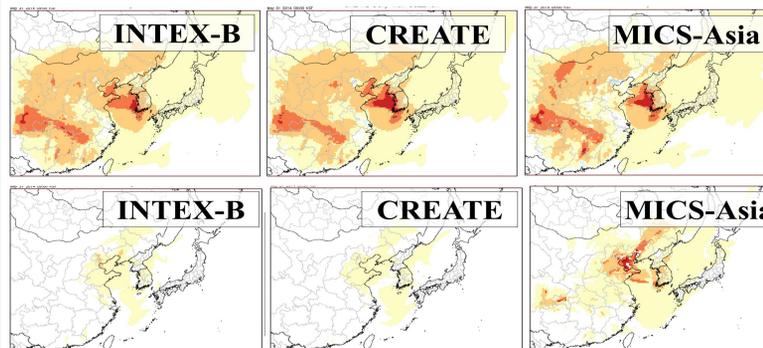


| Foreign Emission Inventory | Base Run O ₃ Concentration | 20 % NO _x Reduction O ₃ Concentration | O ₃ Concentration Difference |
|----------------------------|---------------------------------------|---|---|
| INTEX-B | 51.20 | 48.27 | 2.93 |
| CREATE | 53.06 | 49.91 | 3.15 |
| MICS-Asia | 53.24 | 50.30 | 2.94 |

Episode mean of sensitivity of SMA ozone to Chinese anthropogenic NOx and VOC

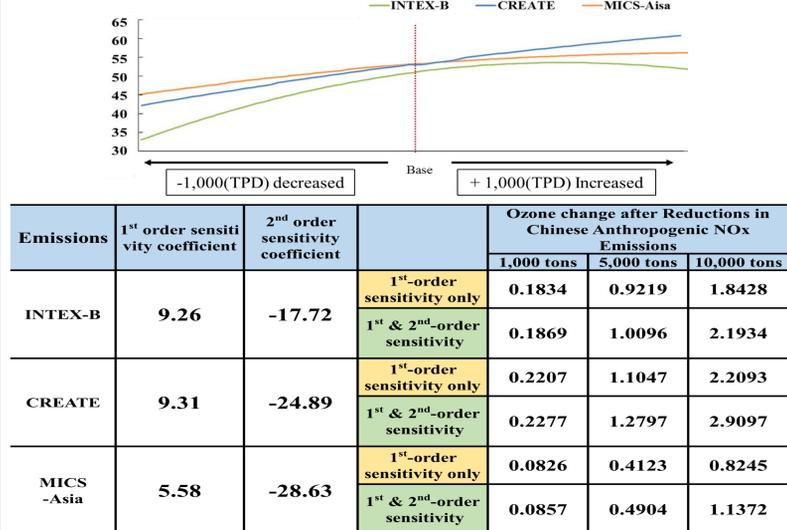


Episode mean of sensitivity Daily Maximum of SMA ozone to Chinese anthropogenic NOx and VOC



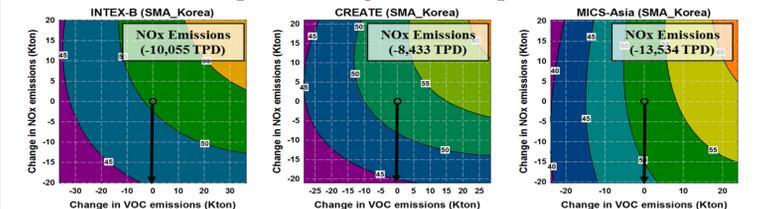
- Overall, SMA ozone showed positive sensitivity to Chinese anthropogenic emission reductions regardless of emission inventory choice.
- The range of episode mean sensitivity of Chinese anthropogenic NOx emission on the SMA 1-hr ozone is from 6 to 9 ppb and Daily Max ozone is from 20 to 30 ppb.

SMA Ozone Sensitivity to the Amount of Chinese Anthropogenic NOx Emission Reductions

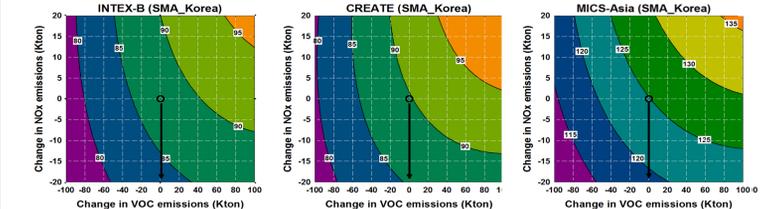


Ozone Response to Reduced Emissions

1-hr Ozone Response averaged for the Episode



Daily Maximum 1-hr Ozone Response averaged for the Episode



- We could derive SMA ozone changes due to incremental Chinese NOx emission reductions utilizing regular CMAQ-HDDM outputs.
- The estimated ozone change by 1,000 TPD NOx reduction was 0.1 ~ 0.2 ppb.

Conclusions

- We examined multiple inventory modeling approach to see whether we can assess the impact of foreign emissions on ozone concentrations in SMA with more confidently than single-inventory modeling.
- Episode mean ozone concentrations are 51.20 ppb with INTEX-B, 53.06 ppb with CREATE, and 53.24 with MICS-Asia, respectively. Ozone simulations with three different foreign emissions resulted in very comparable model performance.
- The range of episode mean 1st order sensitivity of Ozone to Chinese NOx reduction is from 6 to 9 ppb. The range of sensitivity to 1,000 TPD Chinese NOx reduction is from 0.1 to 0.2 ppb.
- We concluded that the choice of foreign emission inventories may not increase uncertainties in modeled SMA ozone concentrations because modeled response to fixed amounts of China anthropogenic NOx emission reductions resulted in very comparable model sensitivities regardless of foreign emission inventory selection.

Acknowledgement

- This study was supported by the Korean National Institute of Environmental Research (NIER).