Improve of Speciated Anthropogenic VOC Emissions using KORUS-AQ/MAPS-Seoul Aircraft Field Campaign Data

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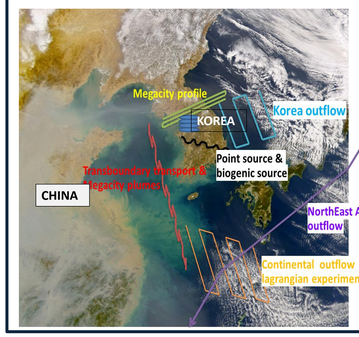
Background & Objectives



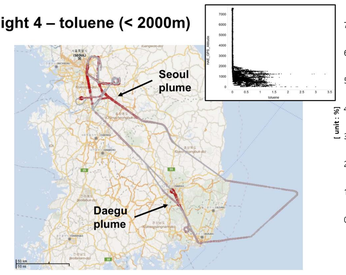
Background

- KORUS-AQ and MAPS-Seoul aircraft field campaigns have been deployed to study the air quality of the regions, the campaigns were comprised o comprehensive on-site measurements including chemical evolution emission inventory, transboundary pollutant contributions, and satelite imag
- The CREATE(Comprehensive Regional Emissions inventory for Atmospheric Environment) emissions inventory and SMOKE-Asia(Woo et al., 2012) emission processing system were used to support KORUS-AQ/MAPS-Seoul chemical transport forecasting and to serve as a priori for evaluation.
- Initial results of inter-comparison analysis show large discrepancies in VOC species over South Korea-especially over urban regions.
- The ambient concentration of Benzene among cities are generally similar but of Toluene in Seoul and Shanghai

Objectives

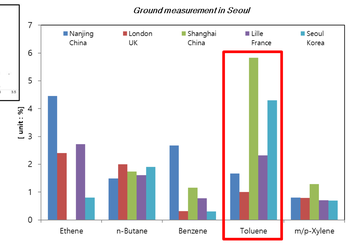
- To achieve a better understanding of particulate matter pollution through improvements in estimation of VOC and potential SOA productions
- The goal is to improve the chemical speciation profiles of speciated NMVOC through comparison with KORUS-AQ/MAPS-Seoul field campaign data

Flight 4 – toluene (< 2000m)



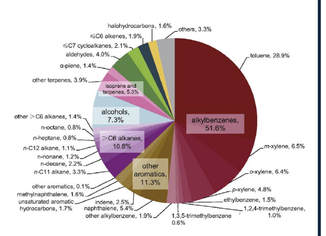
Source: Tomas Mikoviny, University of Oslo, May 9, 2016

Ground measurement in Seoul



Ground concentration in multiple megacities

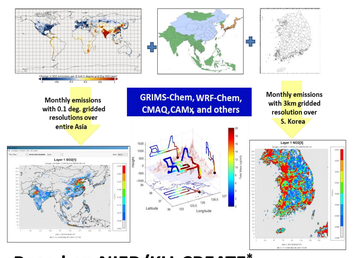
Source : Jang et al., 2016



SOA formation of major VOCs groups and individual VOCs species in China in 2010

Source: Wenjing Wu et al., 2016

Inventory Analysis

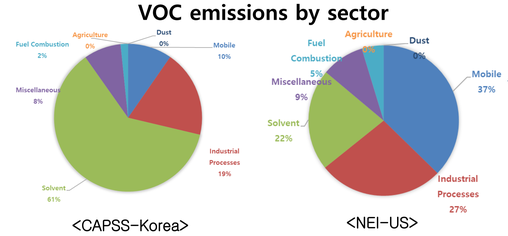


Based on NIER/KU-CREATE*

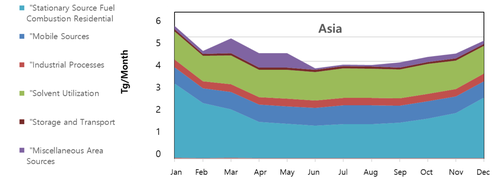
* Comprehensive Regional Emissions for Atmospheric Transport Experiments

- **Anthropogenic Emissions Inventory**
  - GAINS-Korea/Asia with national activities/policies
- **Year 2010, Asia regions, ~300 SCCs**
- **Pols.: CO_2, NO_x, PM_{10}, $PM_{2.5}$, SO_2, VOC, NH_3, CO**
- **Biogenic(MEGAN), Biomass burning(BlueSky)**

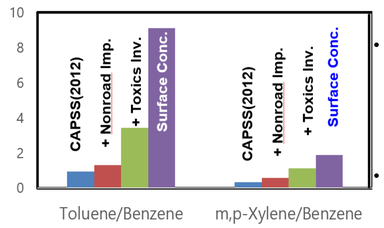
VOC emissions by sector



(Source: CAPSS inventory, NIER/ NEI inventory, EPA)



Improvement of Emissions Inventory to meet Surface Measurements



Source: Jang et al.

- CREATE, an anthropogenic emissions inventory for Asia, was developed with a reference year of 2010. The KORUS Ver. 1.0 inventory is primarily based on CREATE, but projected to year 2015
- The primary contributing sources of VOCs in Korea are solvent consumption and industrial processes, whereas in the United States automobiles, along with solvent consumption and industrial processes. For the whole Asian continent, residential combustions are key sources in VOC emission due to inefficient combustors
- In Korea, when the nonroad engines inventory was improvement and toxics inventory was included, toluene/benzene ratio of the inventory is getting closer to the surface concentration

Overall Workflow

Total **NMVOC** emissions by individual source categories → **Emissions Inventory**

Speciation X-ref file
Speciation profiles assignments → **NMVOC speciation**

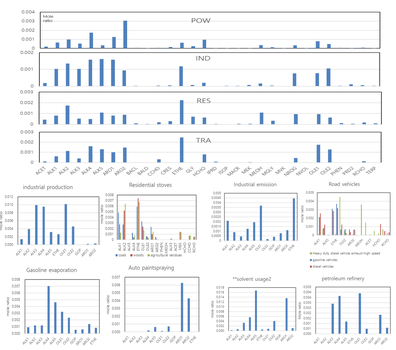
Emissions by Chemical mechanism species

Effect on Secondary pollutant → **Effect**

- For NMVOCs, output VOC chemical species depend on emission source characteristics.
- Therefore, in order to improve the chemical speciation mechanism, it is necessary to accurately analyze the source categories of NMVOC emission.
- In addition, the characteristics of each source should be analyzed to improve the Chemical speciation profile and Cross-reference file.
- After the aforementioned steps were performed, effects of VOCs on secondary pollutants were analyzed.

Chemical Speciation

Improve chemical speciation profiles



Power
Industry
Residential
Transportation

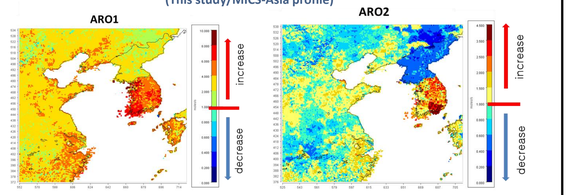
Gasoline emission
Diesel emission
Coating
Graphic art
diesel vehicles
gasoline vehicles
motor cycles
Auto paintspraying
petroleum refinery

industrial production
Industrial emission
crude oil refinery
Print
Combustion
residential stoves : coals
residential stoves : woods
Gasoline evaporation
solvent usage2
Heavy duty diesel

- Simple Asia VOC speciation profiles for four sectors were used to perform speciation for KORUS-AQ model predictions The profiles in the SMOKE-Asia emission processing system were used during the KORUS/MAPS-Seoul field campaigns period and more detailed profiles, from more updated and local researches, were compiled from this study.
- In addition to the four profiles, 19 profiles were added and a total of 23 profiles were applied

Ratio of VOC emissions in the Gridded Map

(This study/MICS-Asia profile)



Inter-comparison of speciated VOC emissions (This study vs. KORUS ver 1.0)

China, North East	Beijing, Hebei, Tianjin
China, Central East	Shangdong
China, South East	Anhui, Jiangsu, Shanghai, Zhejiang

- With the updated profiles, ARO1 increased by a factor of 3.5~7 with a strong increase over the E. China and South Korea region.
- ARO2 in general showed decreased levels over China and North Korea
- Increased ARO1 emissions show similar emissions strength and spatial distributions to the KORUS-AQ DC-8 observation

SOA formation and CTM Performance Improvement

SOA formation

- Secondary organic material produced by the oxidation of VOCs is a major global contributor to the mass concentration of organic particles

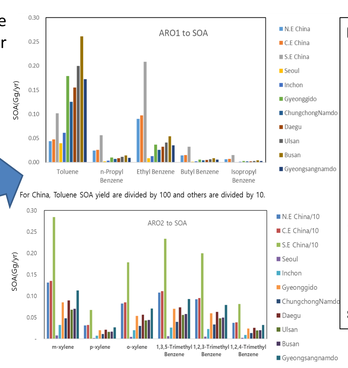
SOA formation estimation(FAC)

FAC = [SOA]/([VOC]*fraction of VOC reacted)
***[SOA]:Amount of aerosol produced(kg/day)**
***[VOC]:Amount of VOC emitted(kg/day)**

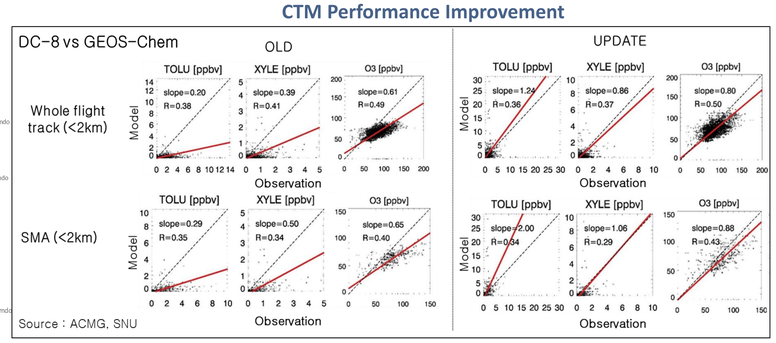
- The FAC method allows SOA yield to be estimated directly from emission inventory data.

Source : Wipawee Dechapanya et al., 2004; Daniel Grosjean et al., 1992

- Amounts of SOA from FAC method show the highest in the southeastern part of China where Shanghai is located, and the Gyeonggi province is the highest emitter in Korea



CTM Performance Improvement



- A comparison of KORUS-AQ observation and GEOS-CHEM model results revealed an increase in model prediction accuracy in Toluene, Xylene, and Ozone, when the new speciation was applied

Conclusion

- The KORUS-AQ / MAPS-Seoul field campaign observation and CTM modeling intercomparison showed, VOC emissions of KORUS Ver 1.0 inventory were underestimated, especially for aromatic species
- Emission inventory showed improved match with surface concentration when the new nonroad and PRTR inventory were included
- The more updated local chemical speciation profiles help improving speciated AVOC emissions inventory
- As a result of FAC method, toluene and xylene have the largest distribution in SOA production
- The updated speciated AVOC inventory were tested with GEOS-Chem, which show better agreements with KORUS-AQ DC-8 measurements over Korea

Reference

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