The Impact of Emissions Control Policies on Speciated NMVOC Emissions and Air Quality

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1. Background & Objectives

Background

- Asia, particularly **Northeast Asia, which includes countries such as South Korea, Japan, and China**, has experienced rapid population growth and industrialization in the last several decades, **leading to severe air pollution problems**.
- Northeast Asian countries are **establishing policies and technologies** to control air pollutant emissions to improve air quality.
- In many prior policy modeling studies, **changes in VOC emission composition due to control policy or technology** were not considered when assessing the effect of control policies.
- In this study, we analyzed how changes in VOC composition affect atmospheric **$PM_{2.5}$ and O_3 concentration**.

Objectives

- **Developing VOC speciation profile DB** for applying control policy/technology. This is achieved through comprehensive literature review focused on Northeast Asia domain targeting to **major VOC sectors, including solvents and transportation** (refer to Figure 1). The industrial sector is excluded because its policies have minimal impact on VOC compositions.
- Simulating $PM_{2.5}$ and O_3 concentration using CMAQ in two cases. **The first is the base case for year 2019, the second is maximum policy case (Test case) to sensitivity run.**

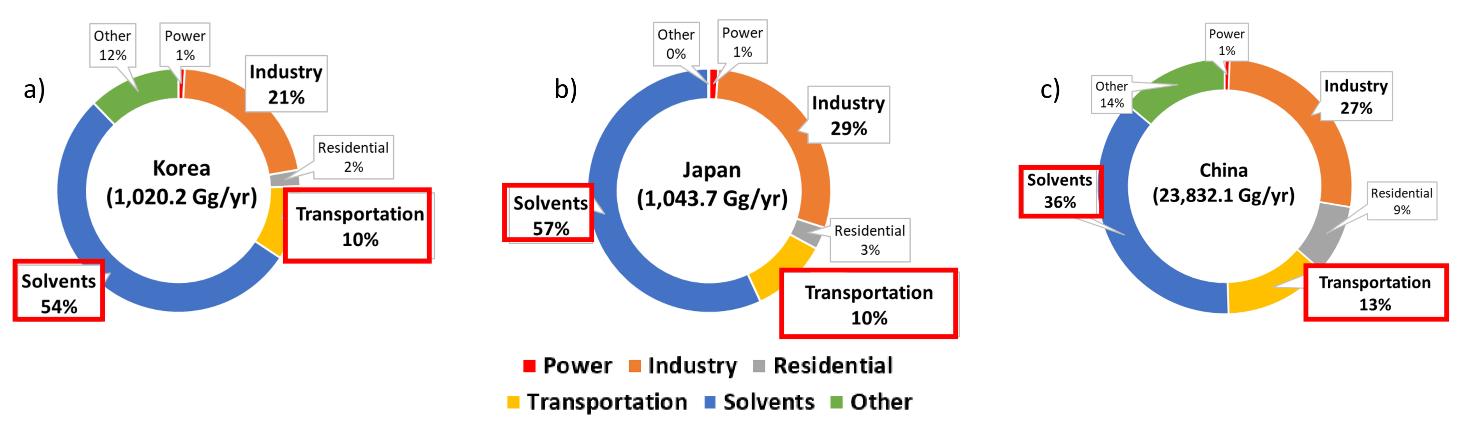

Figure 1. VOC emission sectors in the latest Northeast Asia emission inventory by country (AQNEA v1.0)

2. Research Framework

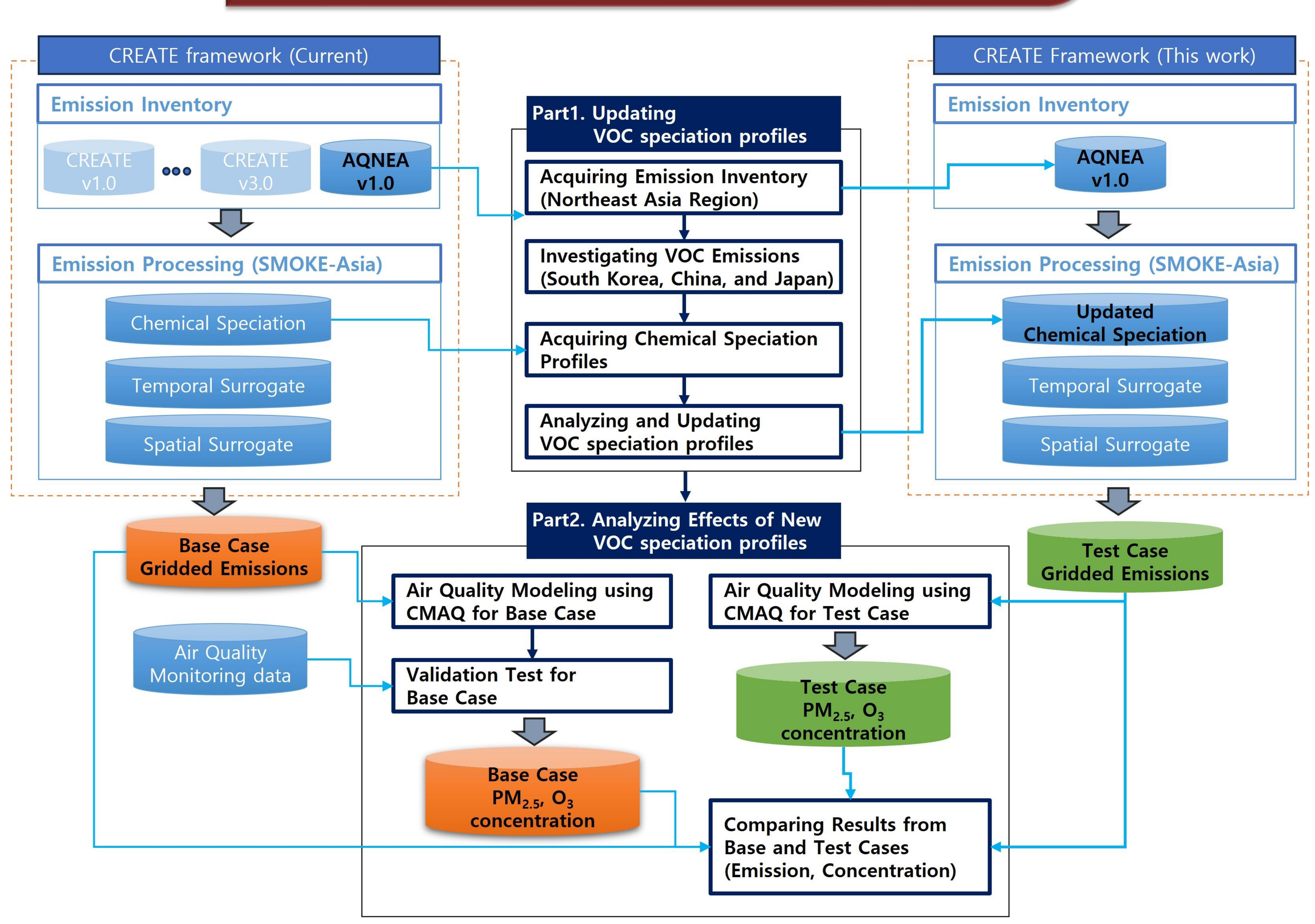

Figure 2. Research Framework

3-1. Results (VOC Profile)

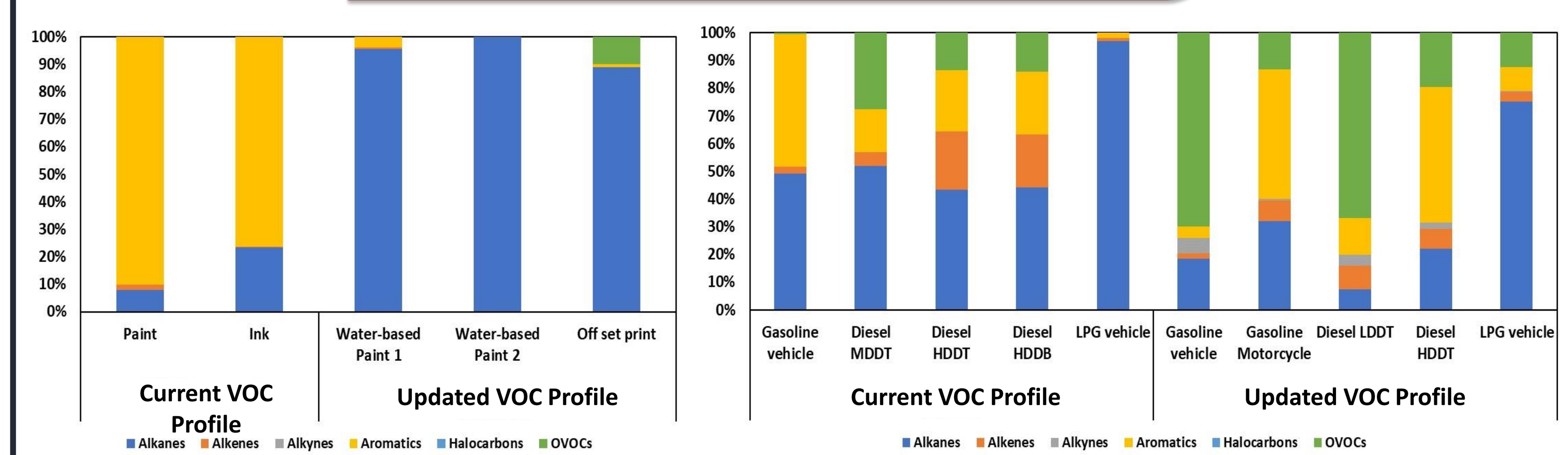

Figure 3. Changes in VOC speciation profiles for Solvent Use sector and Transportation sector (onroad)

Equation to calculate Formation Potential (FP) for Secondary Organic Aerosol (SOA) or Ozone

$$FP = \sum_i (e_i Y_i)$$

FP is total SOA Formation Potential value or Ozone Formation Potential value.
e_i is emissions of species i
Y_i is SOA yield value of each species i (refer to Derwent et al., 2007; Derwent et al., 2010; Wu et al., 2017) or Photochemical Ozone Creation Potential (POCP)

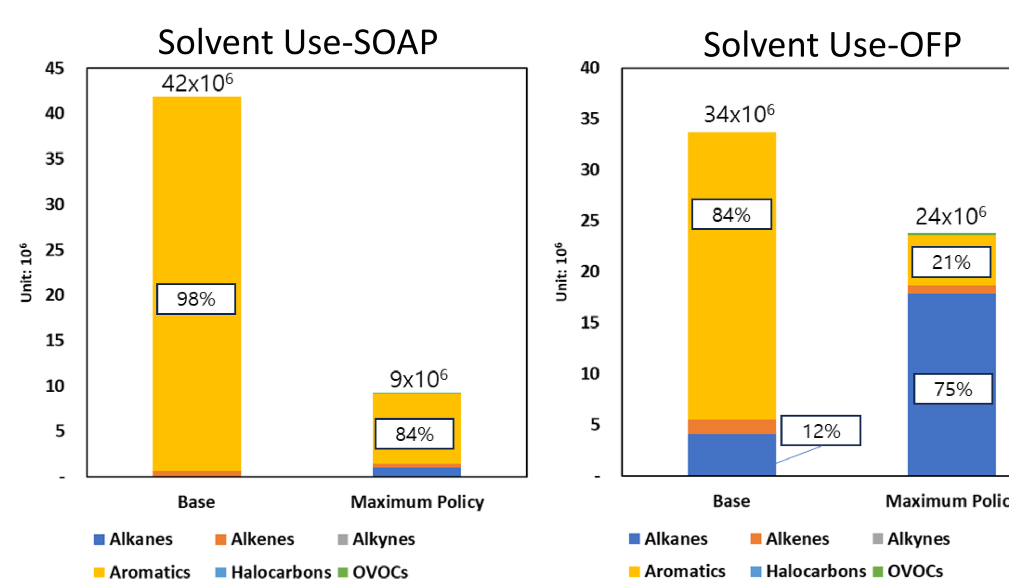

Figure 4. Calculated SOAP and OFP of Solvent use sector

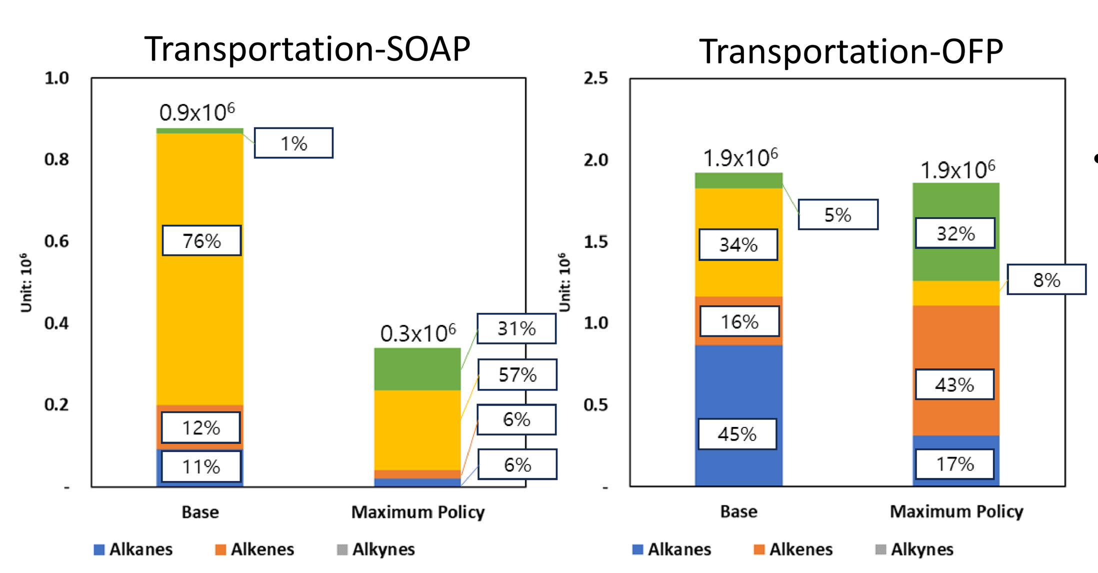

Figure 5. Calculated SOAP and OFP of Transportation sector

- Two types of FP (Secondary organic aerosol potential (SOAP) and Ozone formation potential (OFP)) were calculated for the both Base and Maximum Policy cases by grouping closely related species in the VOC profiles of solvent use and transportation sectors.
- The numbers above the bar-charts shows the calculated total FP values and the percentage in the box shows the contribution of each FP values by grouped species.
- Aromatics have the highest potential for SOAP and a significant potential for OFP. SOAP and OFP values decrease in the Test Case due to the decrease of aromatics.
- In the Test Case, the OFP value for the Transportation sector was not decreased significantly due to the increased composition of Organic VOCs (OVOCs) and Alkenes.
  - ✓ Strengthened policies have increased OVOC ratios for Gasoline Vehicles and LDDTs (see Figure 3), resulting in a substantial impact as they constitute half of the Korean vehicle fleet.
  - ✓ In areas with high vehicle traffic, OFP values may be higher in the Maximum Policy case.

3-2. Results (CTM)

Table 1. Chemical Transport Modeling Framework

Chemical Transport Model	CMAQv5.3.2
Anthropogenic Emission Processor	SMOKEv4.5 - Emission Inventory: AQNEA v1.0 (2019) - Chemical mechanism: VOC: SAPRC07 Aerosol: AERO6
Biogenic Emission Processor	MEGANv2.1
Meteorological Model	WRFv3.9.1 - Meteorology: FNL 0.25°
Modeling Domain	- Projection type: Lambert Conformal Conic - Grid resolution (Number of Grid): 27 km x 27 km (270 x 240) - Domain information (Below-Left): (-5,513,000, -2,324,500) - Reference Lon., Lat.: (126.0, 38.0) - Standard parallel: (30, 60) North
Modeling Period	2019 (Jan., Apr., Jul., Oct.)

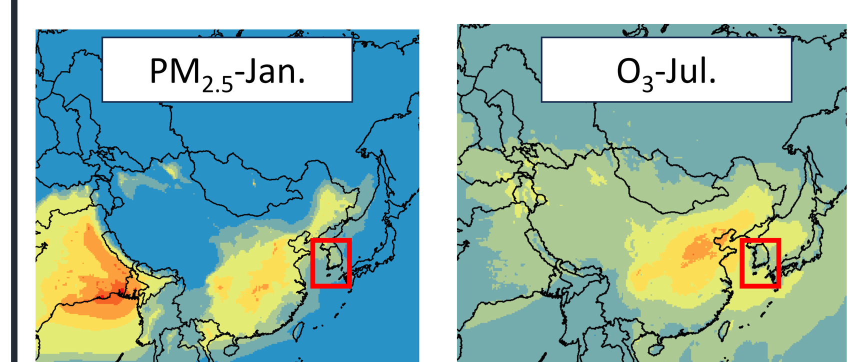

Figure 6. Base Case $PM_{2.5}$ and O_3 concentration map (Red box: South Korea)

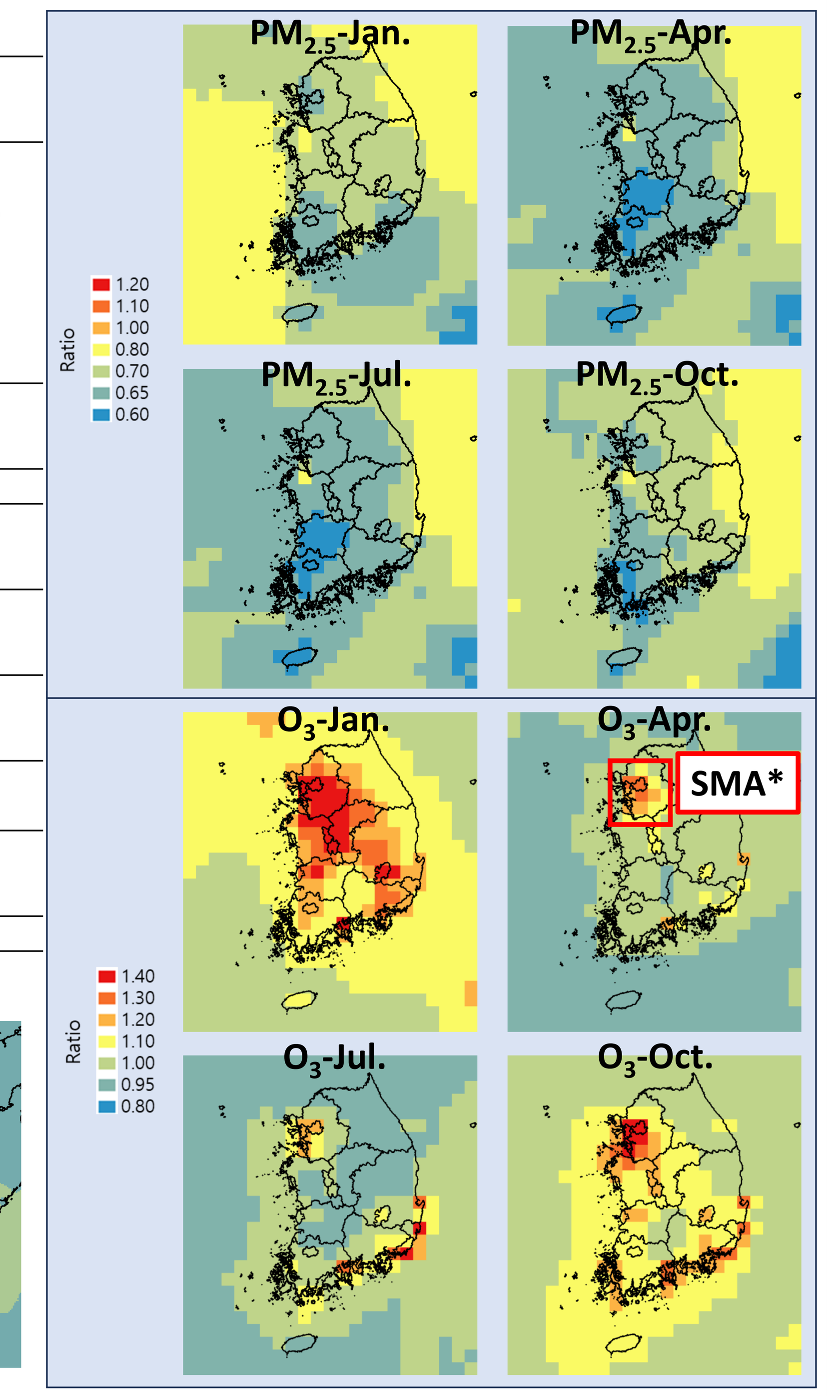

Figure 7. Ratio of $PM_{2.5}$ and O_3 concentrations from Test Case vs. Base Case in S. Korea (Ratio = Test Case concentration/Base Case concentration)

- The $PM_{2.5}$ concentrations in the Test Case (maximum policy case) are lower than those in the Base Case throughout the entire South Korea area.
- The O_3 concentration in the Test Case increased mainly in areas with large contribution on transportation sector, such as the Seoul Metropolitan Area (SMA*)

4. Summary & Conclusion

- In this study, applied control policies in the Solvent Use and Transportation sectors are not reduce the total VOC emissions but only a change the VOC composition.
- In the Test Case, less aromatics reduced SOAP, OFP, and $PM_{2.5}$ concentrations, while more OVOCs in transportation increased O_3 concentration in the atmosphere.
- Need to consider carefully when applying VOC control policy by regional characteristics.

5. Acknowledgement

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