Influence of Fossil-fuel Power Plant Emissions on the Surface PM2.5 in the Seoul Metropolitan Area, South Korea

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Introduction

- Many large fossil-fuel power plants are located near the Seoul Metropolitan Area (SMA), the highest population density and largest population area in South Korea.
- Since NOx and SOx emissions from fossil-fuel power plants have significant impacts on the regional PM2.5 air quality, the impact of emissions from additional fossil fuel based electricity generation on the air quality in the SMA needs to be understood and quantified.
- Therefore, we estimate the contribution of fossil-fuel power plants on PM2.5 concentration in SMA to support air quality planning with respect to future electricity demand changes.

Methodology

◆ Modeling Domains

◆ Modeling Period
January, April, July, and October 2010 to represent winter, spring, summer, and fall

◆ Model Configuration
We utilize the WRF - SMOKE - CMAQ framework.

◆ Analysis of Contributions
Contributions from power plant are estimated using the BFM (Brute Force Method).
1. SMA PM2.5 Concentration from base case run, C1
2. SMA PM2.5 Concentration from 20% reduction case, C2
3. Sensitivity of SMA PM2.5 concentration to 20% Emission Reduction of Power Plants
   \[ \Delta C = (C_1 - C_2) \]
4. Contribution of power plants
   \[ 5 \times \Delta C \]

Large Fossil–fuel Power Plant in South Korea

- NOx and SOx emissions from fossil-fuel power plants is 91,227 tons and 52,372 tons in 2010.
- These emissions account for 9% of the total NOx emissions and 13% of SOx emission in South Korea.

Daily Contribution of PM2.5 and its major constituents

- PM2.5 Conc. & Contribution
- PM2.5 Components Contribution

Results and Discussion

◆ Model Performance Evaluation
- The model showed the best performance in October (R^2=0.802) and the worst performance in January (R^2=0.515). However, there were many days with missing observations in January. Therefore, the estimated model performance statistics for January may not be used critically.

◆ Monthly Average PM2.5 Contribution

- Simulated monthly PM2.5 concentration in January was its highest among four months selected.
- On October 11, PM2.5 concentration was 63.3 µg/m³ which is over the Korean air quality standard for 24-hr PM2.5, 50µg/m³. For the day, Power plant contribution is 7.1 µg/m³ which is 14% of the standard.
- In summer, among the components of PM2.5, relative portion of sulfate and ammonium to the total PM2.5 is increased although the contribution of nitrate is the most significant in general.

Conclusion and Implication

- Contribution of domestic fossil fuel power plant emissions to the surface PM2.5 in SMA, South Korea where over 20 million people live was estimated.
- The average monthly PM2.5 contribution in the SMA was 0.29µg/m³ in January and 1.22µg/m³ in October. The estimated annual average PM2.5 contribution is 0.9 µg/m³.
- According to “2nd Metropolitan Air Quality Control Master Plan”, South Korean government plans to improve regional annual PM2.5 concentrations from 27µg/m³ in 2010 to 20µg/m³ in 2024.
- Air quality managers can utilize the results of this study to design anticipated power plant control requirements to keep up with additional energy supply plans such as ‘6th Electricity Supply Plan’.
- Seasonal variations of PM2.5 components may need to be accounted in the future air quality management.

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