Regional air quality simulation framework to evaluate effectiveness of emission controls

*Satoru Chatani[1]

1. National Institute for Environmental Studies

Ambient concentrations of photochemical oxidants still exceed the Environmental Quality Standard in Japan. A regional air quality simulation framework is a useful tool to consider effective emission controls on ozone and $PM_{2.5}$, which forms in the atmosphere via complex photochemical reactions. It consists of emission inventories, a regional meteorological model, and a regional chemical transport model. We are working on establishing a reliable framework and removing difficulties in performing simulations for any model users.

There are large uncertainties in the existing emission inventories. We have developed a fine-scale gridded emission inventory of precursors emitted from all stationary sources in Japan. One of recent issues related to emission inventories is condensable particulate matter (CPM). Emissions from combustion sources are usually measured in hot exhaust gas. While semi-volatile components are condensed after emitted to the cooler atmosphere, they have been ignored in the existing emission inventories. We newly incorporated estimation of CPM emissions. They serve as critical inputs to recent regional chemical transport models, which can simulate dynamic behavior of semi-volatile components in the atmosphere.

Data processing procedures are required to input data of multiple emission inventories to regional chemical transport models. They include horizontal allocation, vertical allocation, speciation, and various data manipulation for sensitivity simulations. These complex procedures are likely to discourage model users to perform simulations. We have developed data processing tools and database required to convert data of multiple emission inventories, which reduce burden of model users.

It is desirable that simulations performed by different models and users give consistent results. Intercomparisons were conducted in Japan’s study for reference air quality modeling (J-STREAM) to investigate differences in results obtained by simulations using the same inputs. More than 30 models with different configurations participated in the intercomparisons. While ambient ozone concentrations simulated by them were consistently overestimated, halogen chemistry and deposition, dry deposition velocity, precursor emissions in other countries, and vertical transport were identified as the key factors influencing model performance on ozone. Reference model configurations were derived based on the results of the intercomparisons.

Simulations can provide various information useful to consider effective emission controls. Source sensitivities correspond to changes of pollutant concentrations induced by changes of precursor emissions. We evaluated source sensitivities of ozone concentrations over Japan. Sensitivities to transboundary transport were dominant for annual and monthly mean ozone concentrations. Sensitivities to domestic NO_X sources are mainly negative due to titration. In contrast, sensitivities to domestic sources could become positive and dominant for peak ozone concentrations occurring at limited locations and timings. Spatial and temporal heterogeneity of source sensitivities is important in considering effective emission controls on ozone concentrations.

Not only emission controls but also meteorological conditions and social factors including COVID-19

©2022. Japan Geoscience Union. All Right Reserved.

could affect trends of ambient pollutant concentrations. We are developing long-term emission inventories in which impacts of various emission controls are consistently reflected, and performing long-term simulations for decades. They will contribute to clarifying key factors causing changes in pollutant concentrations, and determining a standard protocol to evaluate effectiveness of future emission controls using simulations.

Acknowledgements
This research was performed by the Environment Research and Technology Development Fund (JPMEERF20165001, JPMEERF20185002, JPMEERF20195003, and JPMEERF20215005) of the Environmental Restoration and Conservation Agency of Japan.

Keywords: Air quality simulation, Emission inventory, Ozone, PM2.5

©2022. Japan Geoscience Union. All Right Reserved.