Abstract

[Research Title]

Development and Application of a Standard Method to Predict Ozone Reduction Caused by Strategies

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The environmental quality standard for photochemical oxidants has not been attained at almost all monitoring stations. Ozone, which is a major component of photochemical oxidants, is formed from precursors including nitrogen oxides (NO_x) and volatile organic compounds (VOCs) via photochemical reactions in the atmosphere. Air quality simulations are useful to represent nonlinear relationships between ambient ozone and precursor emissions caused by the complex photochemical reaction cycle. This study aimed at developing a standard method based on air quality simulations to evaluate effectiveness of emission controls on ambient ozone and confirming that the method developed in this study can represent a long-term trend of ambient ozone caused by emission controls implemented in past years.

Long-term emission inventories were newly developed in this study. They represent long-term variations in precursor emissions from all sources in Japan and surrounding countries since 2000. They revealed that NO_x and VOC emissions in Japan have been reduced by various emission controls.

A ratio of formaldehyde (HCHO) and nitrogen dioxide (NO_2) is known as a useful indicator to evaluate sensitivities of ozone formation to NO_x and VOCs (=ozone formation regime). A long-term dataset of ambient HCHO, NO_2, and ozone concentrations was newly developed based on continuous observations with Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) at urban (Chiba) and suburb (Tsukuba) sites. In addition, satellite observation data was analyzed to derive long-term trends of ambient HCHO and NO_2 concentrations. Both datasets revealed that ozone formation is sensitive to VOCs and NO_x in urban and suburb regions, respectively, and regimes tend to be shifted from VOC-sensitive to NO_x-sensitive.

Long-term air quality simulations for years 2000-2020 using long-term emission inventories were performed. They reasonably reproduced long-term trends in meteorological fields and ambient concentrations of ozone and precursors. In particular, absolute values and variations of annual top 10-day ozone concentrations were reproduced quite well by simulations. Ozone formation regimes derived from simulations were consistent with those obtained by MAX-DOAS and satellite observations. Simulated results indicated that various emission controls implemented in past years have effectively suppressed higher ozone concentrations while influences of annual variations in meteorological fields are also large on them.

This study suggests that it is possible to evaluate effectiveness of future emission controls on ozone concentrations based on relative changes in annual top 10-day concentrations simulated by air quality simulations which are not affected by unusual meteorological fields and transboundary transport.

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