物理、化学及び気象学的要因の解析による広島県における光化学大気汚染の予測及び制御

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Prediction and Control of Photochemical Air Pollution in Hiroshima Prefecture based on the Known Physical, Chemical and Meteorological Parameters

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Introduction

The atmospheric transport, dispersion, transformation, deposition and control of photochemical air pollutants were investigated using a 3-Dimensional Eulerian grid photochemical model. The air pollution substances included in this study are nitrogen oxides (NOx), sulfur dioxide (SO_2), volatile organic compounds (VOCs), ozone (O_3), nitric acid (HNO_3), sulfuric acid (H_2SO_4), etc. Many of these substances have detrimental effects on humans, animals and plants and thus, they contributed to the degradation of our natural environment[1].

In this study, the diurnal variations and spatial distributions of these pollutants in Hiroshima Prefecture are numerically simulated based on the emissions data from anthropogenic (industry and vehicles) and natural (vegetation) sources and the impact of controlling NOx and VOC emissions on surface O_3 concentration is also examined.

Methodology

The numerical simulations were done during the 2-4 August 1995 air pollution episode using the CALGRID[2] photochemical and transport model. The model is based on the diffusion equation for atmospheric pollutants,

$$\frac{\partial C}{\partial t} + \nabla\cdot(VC) - \nabla\cdot\left[\rho K \nabla(C/\rho)\right] = P - L,$$

where C is the pollutant concentration; V and K are the winds and diffusion coefficient, respectively, ρ is

広島大学総合科学部紀要IV理系編、第 28 巻 (2002)
*広島大学審査学位論文
口頭発表日：2002 年 2 月 22 日、学位取得日：2002 年 3 月 21 日
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the air density, P and L are the production and loss rates of the chemical transformation. The numerical solutions are determined by using the operator time-splitting and Galerkin techniques and by employing the Crank-Nicolson time integration scheme. The chemical scheme is based on SAPRC-90[3] mechanism which contains 54 chemical species and 129 reactions.

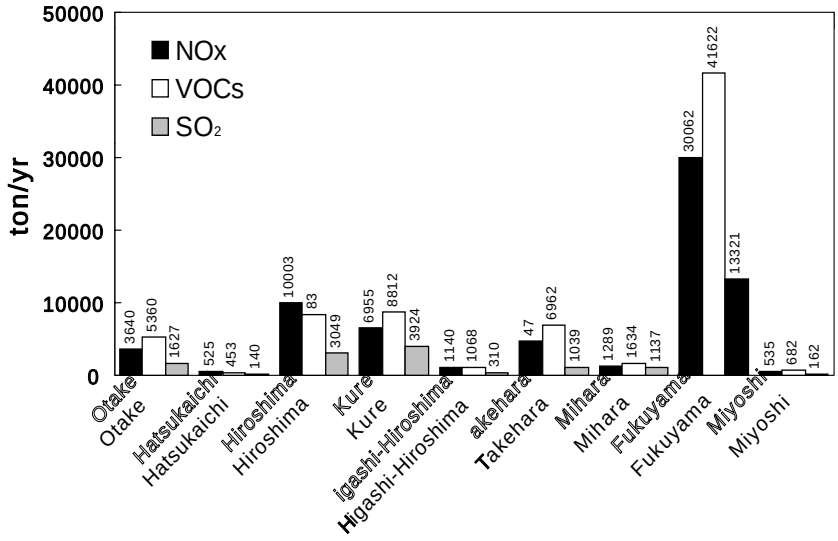

Figure 1. Annual emissions (tons/yr) from area and mobile sources of the major districts in Hiroshima Prefecture in 1995.

The emission rates from area and mobile sources are estimated based on energy consumption from various industries in Hiroshima and the number of vehicles together with the emission rate factors, respectively. The annual emissions rates of the major districts are given in Figure 1. The meteorological data were obtained from the AMeDAS network and the upper-air data were taken from the three upper-air stations located in Fukuoka, Yonago, and Shionomisaki.

Simulation Results

The photochemical oxidant simulation results show good agreement with field observation data as shown in Figure 2. Results also show that the emission of high VOCs with the combination of high NOx emissions from area and mobile sources located at the coastal areas produces high concentration of O_3 that is transported aloft towards inland area which can impact mountains of higher altitudes as shown in Figure 3. The results are in consistent with the modeling studies done by Kitada et al.[4] over central Japan. The impact of controlling the precursor emissions of NOx and VOCs in Hiroshima Prefecture is shown in Figure 4. The results show that the urban and industrialized coastal areas are NOx-sensitive so that future air pollution strategies should focus in controlling the NOx emissions.

Figure 2. Predicted and observed daily maximum 1-hr O_3 concentrations for 4 August 1995.

Figure 3. Predicted and observed daily maximum 1-hr O_3 concentrations for 4 August 1995 along 34.37° N and 34.79° N, respectively. The heights are in 102 m.

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