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SIMULATION OF TEMPORAL AND SPATIAL DISTRIBUTIONS OF OZONE IN THE SEOUL METROPOLITAN AREA USING MODELS-3/CMAQ

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ABSTRACT

In order to simulate hourly ozone levels, the photochemical model, CMAQ is applied to Seoul and down wind area. Horizontal grid of 30km, 10km and 3.3km have been employed for this study. Ozone episode periods in June 2004 were simulated and the results have been compared to several Air-quality Monitoring stations. Input data of emissions have been used to CAPSS. The CB-IV chemical scheme has been used to simulate the atmospheric reaction for ozone. The model performance has been evaluated with measured data through a range of statistical measures.

Key Word: Photochemical Model, Ozone Modeling

1. INTRODUCTION

Recently, high ozone concentration phenomenon is embossed as one of the air pollution problem in downtown and downwind side of Seoul metropolitan area.

It is difficult to simulate the photochemical reaction of various air pollutants such as ozone because production process is complicated. In this research, the simulation of photochemical pollutant was carried out especially ozone was performed by using Models-3/CMAQ. Temporal and spatial patterns of ozone concentration obtained by Models-3/CMAQ under various weather conditions were examined. Also we analyzed the contribution of the emission source in Seoul metropolitan and downwind area.

Together with a user interface the MM5. CMAQ system is referred to as Models-3 (Byun et al., 1998). MM5 (Fifth-Generation Penn State/NCAR Mesoscale Model) was developed by Pennsylvania State University/National Centre for Atmospheric Research (PSU/NCAR) as a community mesoscale model. It is a limited-area, non-hydrostatic, terrain-following sigma coordinate model designed to simulate or predict mesoscale atmospheric circulation. The model is supported by several pre- and post-processing programs. CMAQ (Community Multiscale Air Quality Model) is a powerful third generation air quality modelling and assessment tool designed to support air quality modeling for various applications ranging from regulatory to research studies (Byun et al., 1998). The CMAQ system can simulate concentrations of tropospheric ozone, acid deposition, visibility, fine particulate and other air pollutants in the context of ‘‘one atmospheric’’ perspective involving complex atmospheric pollutant interactions on regional and urban scales.

2. METHODOLOGY

The nested grid system (grid sizes are 30km, 10km, 3.333km respectively) was used for CMAQ modeling (Fig.1). The domain for 30km grid covers important emission areas in the East Asia.

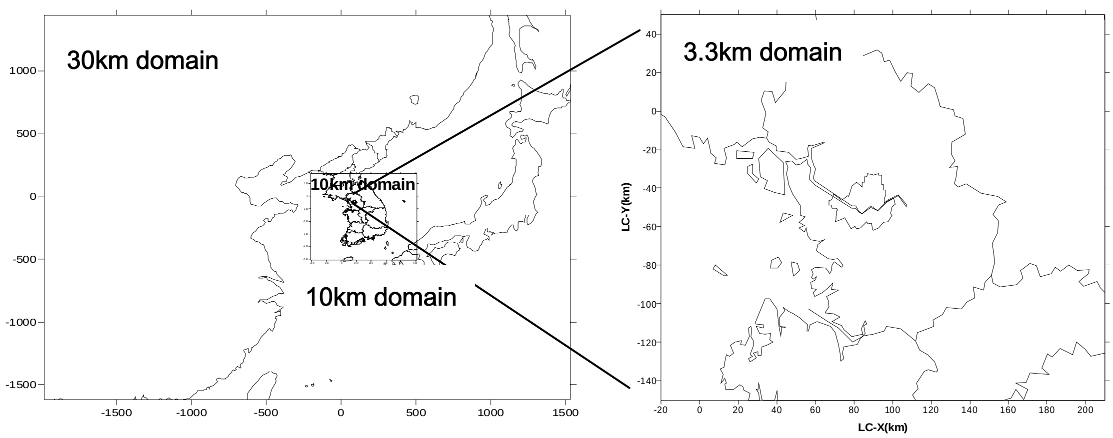

Figure 1. The 30km, 10km and the 3.3km domain in Korea.

The emission data prepared for ACE-ASIA project, which was conducted in North Pacific Ocean area and East Asia in 2000, were used as emission data for 30km grid simulation of CMAQ. The emission data of 2001 Clean Air Policy Support System(CPASS) is used for the modeling of 10km and 3.3km grid domain as emission data.

CAPSS is one of the most reliable and useful emission inventory in Korea. CAPSS has a resolution of 1km*1km covering all the southern part of the Korean Peninsula. It has been used for air quality model as emission inventory. CAPSS data changed to L-C(Lambert Conformal) coordinate system to used by input data of Models-3/CMAQ because it is TM(Transverse Mercator) coordinate system. Also, it equalized according to 10km, 3.3km grid modeling and considered time factor about each material.

Meteorological data were generated by using MM5 model. The simulation was performed for 14 days from May 30 to June 12 when various meteorological events occurred.

Because of spin up time, the results of CMAQ for May 30, 31 were excluded in analysis and CMAQ result of 12 days were divided into 3 period(June 1-4, June 5-8, June 9-12) based on weather condition. The modeling results were evaluated spatially and temporally. The process analysis, included in CMAQ modeling system as a tool, was used to analyze the contribution of chemical reaction, diffusion, advection and deposition process. Figure 2 shows process analysis area. Process analysis divides upwind area(west), urban(center) and down wind area(east).

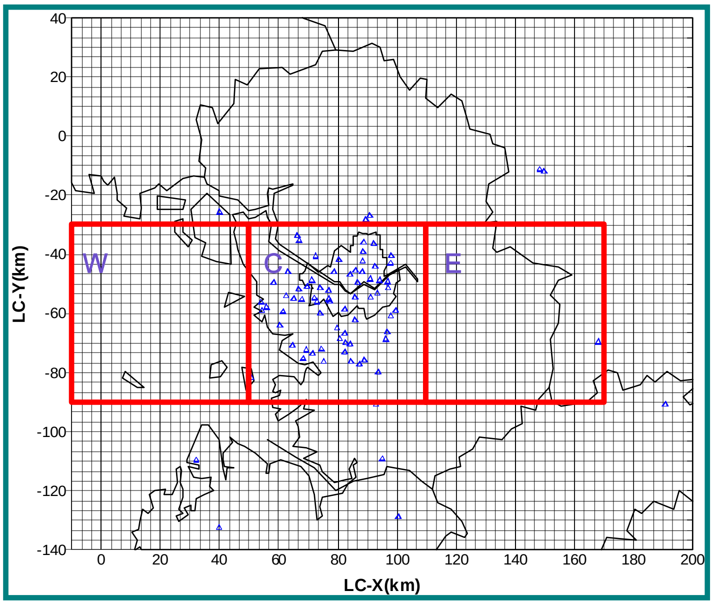

Figure 2. Process analysis area and Air-quality monitoring site in 3.3km modeling area.

3. RESULTS

Figure 3 shows MM5 results during the modeling period. Temperature and solar radiation are very high during the period from June 1 to 4. During the period from June 4 to 8, ‘cloudy’ and ‘temperature’ were low. After June 8, temperature rose again and solar radiation became strong.

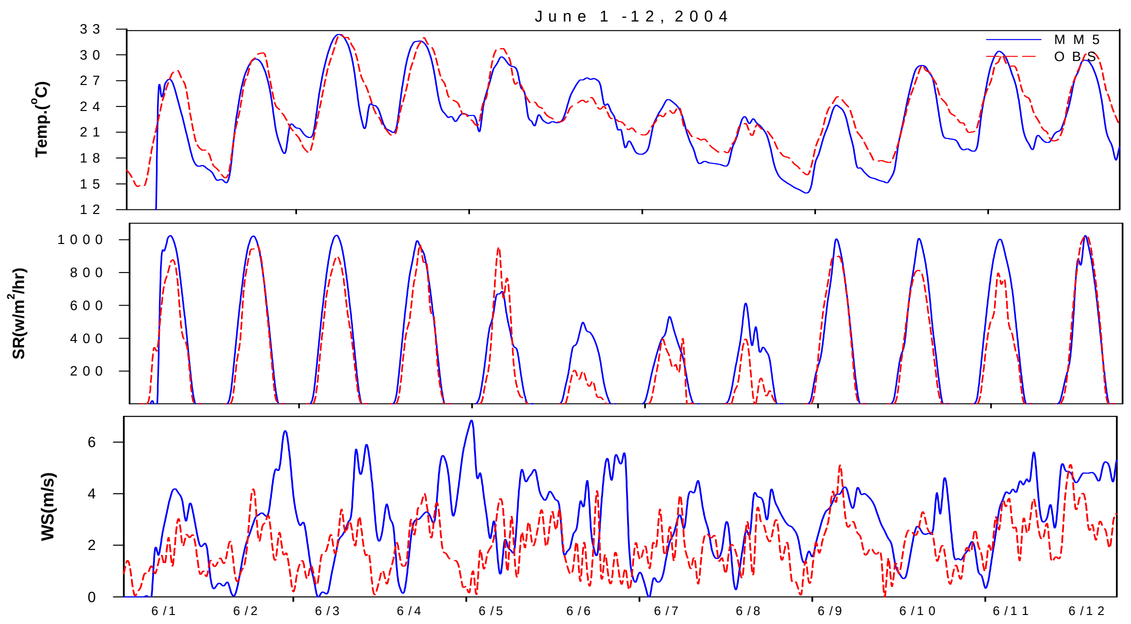

Figure 3. Comparison of observations and MM5 model results for 1-12 June 2004.

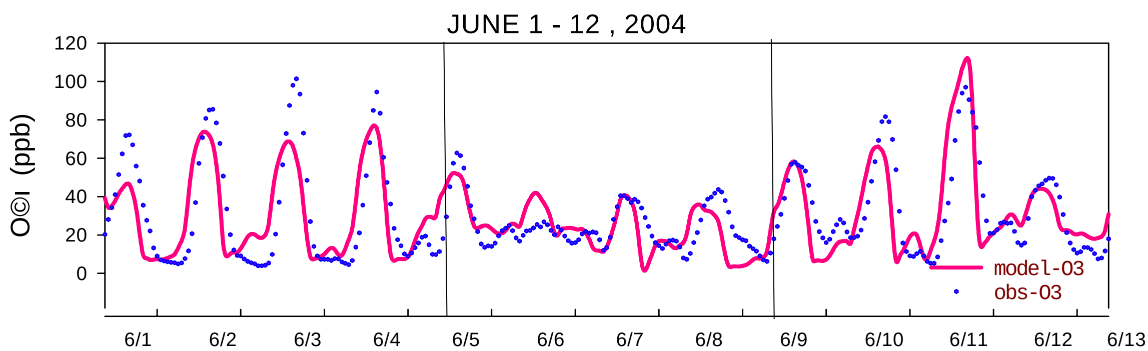

Figure 4. Ozone time series comparison between observed data form the Seoul monitoring station and CMAQ predictions for 1-12 June 2004.

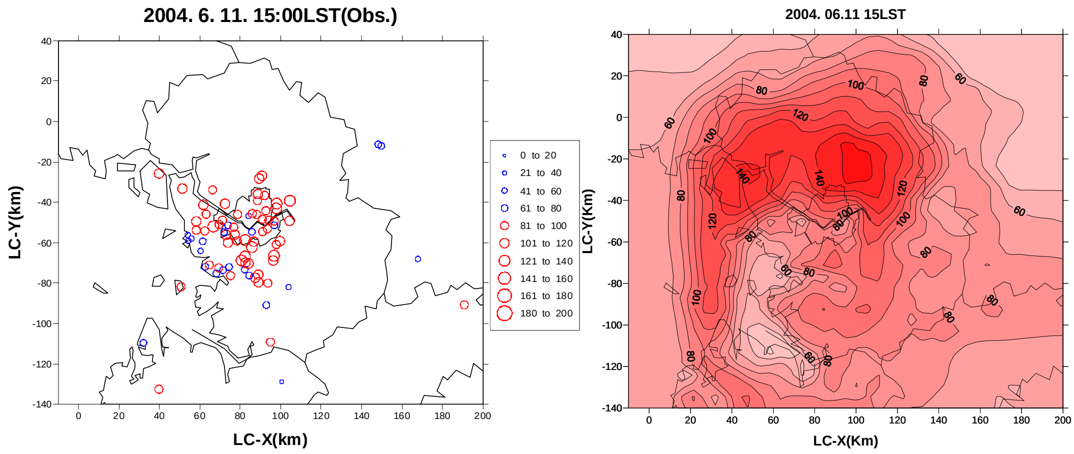

Figure 5. Ozone(ppb) distribution comparison between observed data(left) and CMAQ predictions(right) on June 11,2004, 15LST.

The model results were compared with the observational data during modeling periods (Fig.4). The high ozone concentration appeared on June 3 and 11 and modeling results were similar to observation.

Modeling result of horizontal distribution of ozone on June 11, 15LST shows the high concentration over 120ppb, in downtown of Seoul. As see in horizontal distribution of survey ozone concentration, showed high concentration more than 100ppb Seoul and its outskirts (Fig.5).

Figure 6 shows process analysis result of June 11 that showed the highest ozone concentration. Process analysis examined contribution of ozone creation from 09 LST to 15LST(left) and from 15LST to 18LST(right) about up wind area, urban and down wind area. As see result from 09LST to 15LST, it was chemical reaction that make the biggest contribution in ozone creation in up wind area, downtown area and down wind area. As see result from 15LST to 18LST, ozone concentration of upwind area and downtown area decreases by horizontal transport. But ozone concentration of down wind area increased by horizontal transport.

4. SUMMARY

The performance of CMAQ was evaluated using observed ozone concentration. The results show that the performance of CMAQ was quite good for simulation of ozone episode in the Seoul metropolitan area.

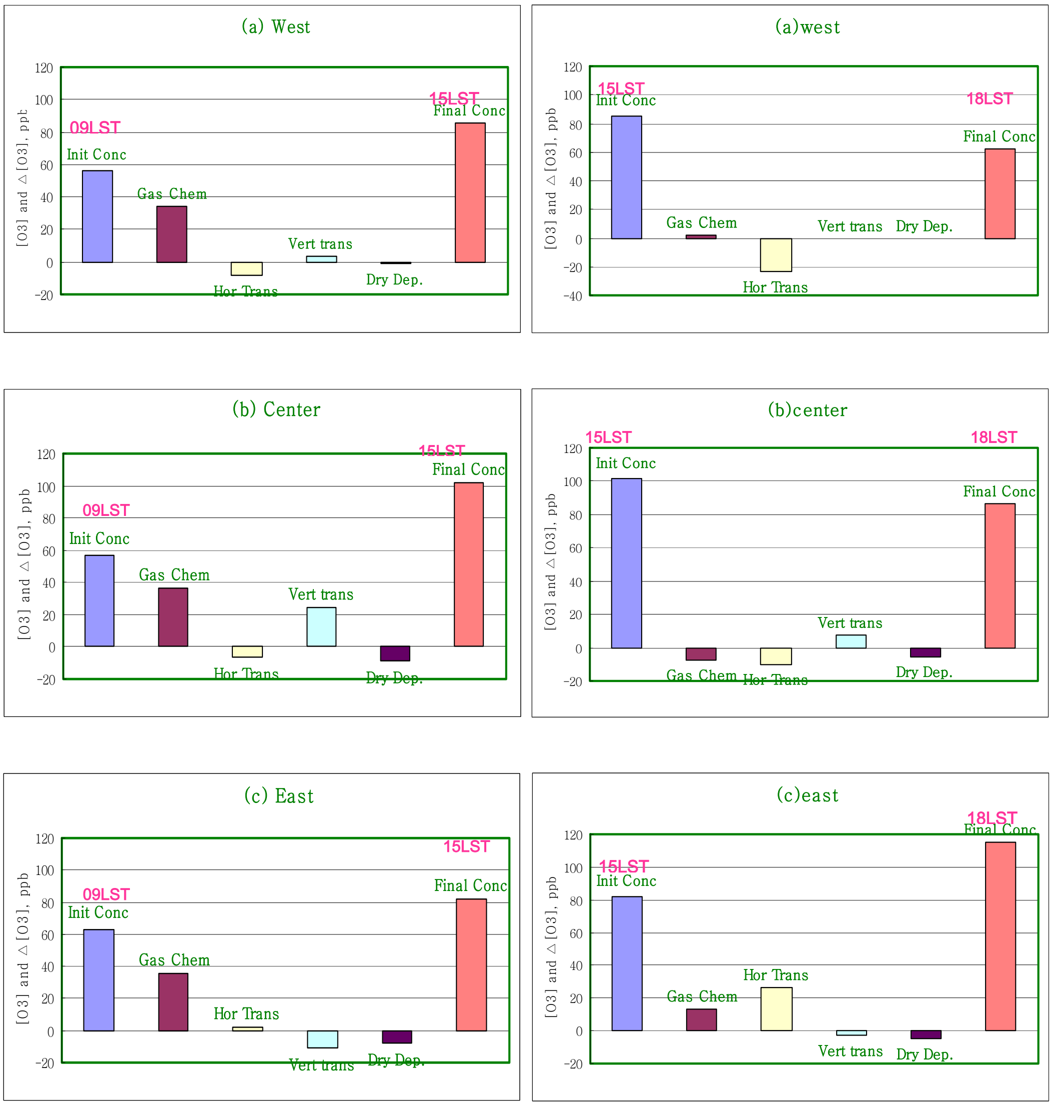

Figure 6. Mass balances of process contribution to O3 on June 11, 2004, 9LST-15LST(left) and 15LST-18LST(right).

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