Case Study on the High Ozone Phenomena in Seoul Metropolitan Area Using CMAQ Model

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1. Introduction

The diurnal variation of ozone in urban area shows generally high concentration in daytime and low concentration in nighttime. Ozone in Seoul Metropolitan area occurs frequently days to maintain somewhat high level of ozone during nighttime period. The purpose of this study is to understand the mechanism of ozone episodes occurred in daytime and the phenomena of high level ozone in nighttime using Model3/CMAQ. To evaluate the results of CMAQ modeling, ozone concentration calculated from CMAQ modeling were compared with ozone measured in air pollution monitoring sites of the surface level. The effects of each of mechanism attributed to the variation of ozone concentration were analysed through the process Analysis method in CMAQ on Seoul Metropolitan area.

2. Methodology

The domain of CMAQ in this study consists of 132 grid cells in east-west direction and 114 grid cells in south-north direction, with 30km x 30km horizontal resolution covering the China, Korea and Japan as shown in Fig. 1. Number of vertical layer is 15 layers and the height of lowest layer is about 80m. The meteorological data for CMAQ simulation were obtained using the MM5. The emission inventory made for ACE-ASIA project(2001) were used. The CMAQ simulation was performed during 2 months period from 1 May to 30 June, 2007.

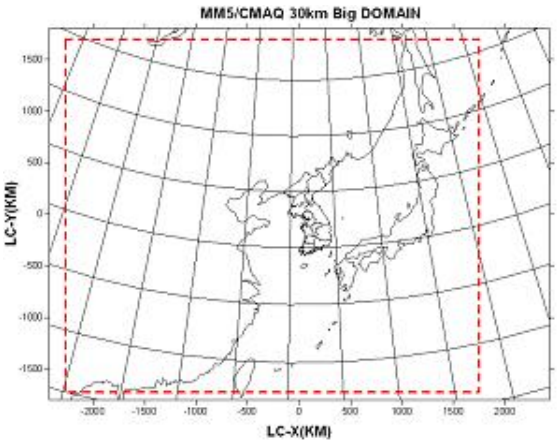

Fig. 1. Modeling domain of MM5(outer box) and CMAQ(inner dotted box). Grid size is 30km x 30km.

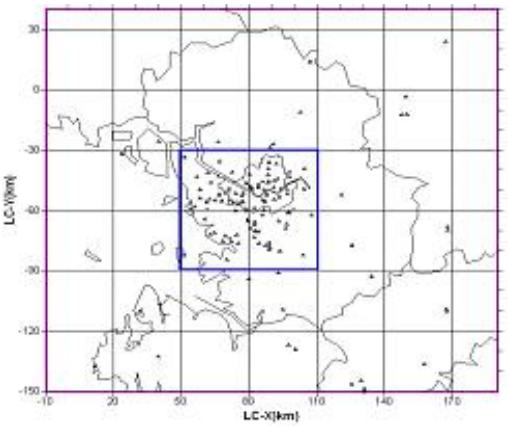

Fig. 2. 4 grid cells surrounded with thick line in 30km grid of CMAQ model domain is the target area for Process Analysis on Seoul Metropolitan area . The symbol of triangle denotes air pollution monitoring sites.

3. Results and Discussion

3.1. Evaluation of model

The comparison of observed and calculated ozone concentration during the modeling periods is presented in fig. 3. The time variation of ozone follows the trend of measured ozone very well. Table 2 shows the error measure of ozone concentration calculated by CMAQ using the algorithms in Table 1.

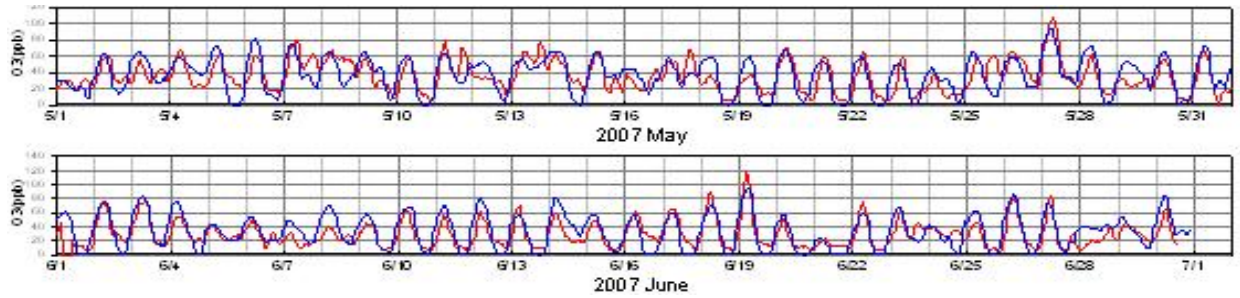

Fig. 3. Comparison of observed(thin line) and calculated(thick line) O3 concentration on May 1-June 30, 2007 in metropolitan area

Table 1. The statistics used for CAMQ evaluation

Root Mean Square Error (RMSE)	$RMSE=\sqrt{\frac{1}{N}\sum_{1}^{N}(C_p-C_O)^2}$ $RMSEs=\sqrt{\frac{1}{N}\sum_{1}^{N}(C^*-C_O)^2}$ $RMSEu=\sqrt{\frac{1}{N}\sum_{1}^{N}(C^*-C_p)^2}$ $C^*=a+bC_O$
Fractional Bias (FB)	$FB=\frac{\overline{C_p}-\overline{C_o}}{0.5(\overline{C_p}+\overline{C_o})}$
Mean Bias (MB)	$MB=\frac{1}{N}\sum_{i=1}^{N}(C_p-C_o)$

The evaluation results are provided in Table 2 and the correlation coefficient(r) between ozone observed and those calculated by CMAQ is 0.757.

Table 2. Model evaluation statistics for hourly ozone concentrations over Seoul Metropolitan area for the period of May 1-June 30, 2007.

	NO. of data	avr. obs.	avr. model	r
	1440	32.57	35.19	0.7570
RMSE	RMSEs	RMSEu	MB	FB
15.009	3.6469	14.559	2.8112	0.0826

3.2. Case studies

3.2.1 Case A

The simulated ozone concentrations and horizontal wind on fields on 13 May 2007 is showed in Fig. 4. The wind fields would be expected to affect the horizontal transport of air pollutants and their products from the Shanghai to the Seoul Metropolitan areas.

Fig. 5. shows the result of Process Analysis (PA) on 13 May 2007. We noticed that nighttime ozone was increased up to 10ppb in due to the horizontal transport (Hor. Trans).

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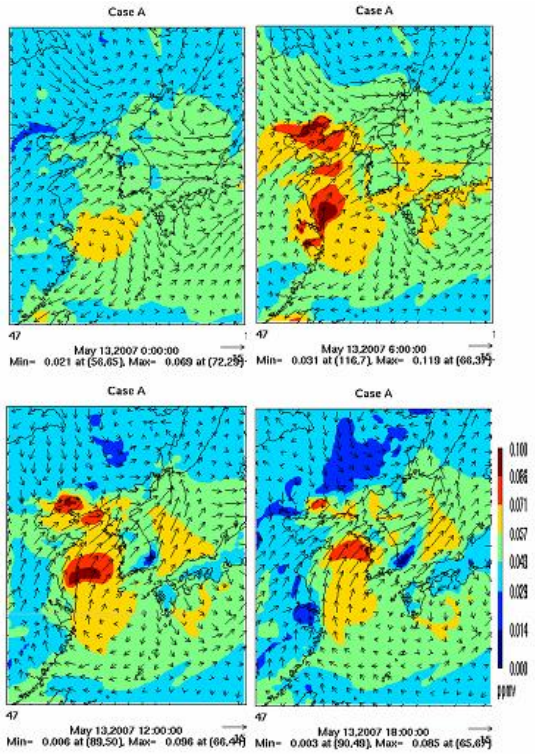
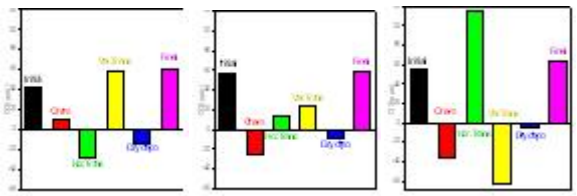


Fig. 4. Difference maps of ozone concentrations calculated by CMAQ model on May 13, 2007

3.2.2 Case B

Ozone in Seoul Metropolitan area is affected by ozone and precursor transported during 26 May, 2007. ozone production by chemical mechanism attributed to be increased more about 40ppb for 00-06 GMT on next day. Winds



13, May 00-06GMT 13, May 06-12GMT 13, May 12-18GMT

Fig 5. Mass balance of process contribution to ozone concentration on May 13, 2007.

converge to Metropolitan area during daytime and continued to 12 GMT on 27 May 2007. As a result of Process Analysis, ozone is increased as much as 95 ppb by horizontal transport and decreased as much as 110 ppb by vertical convection.

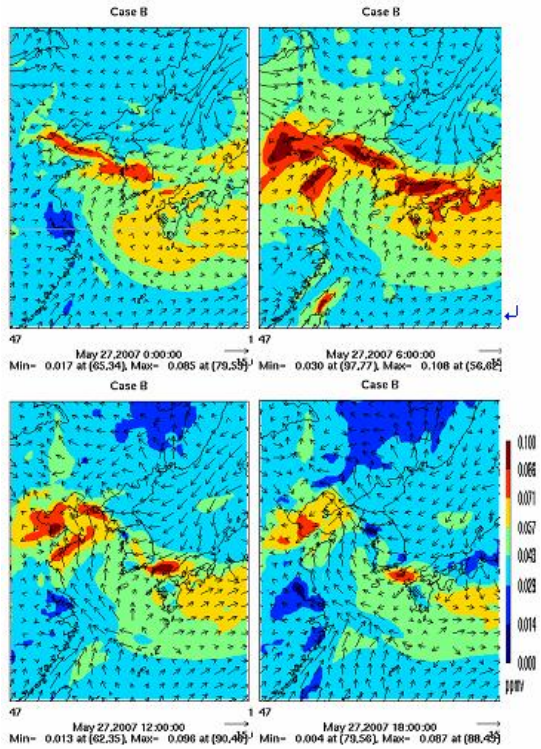
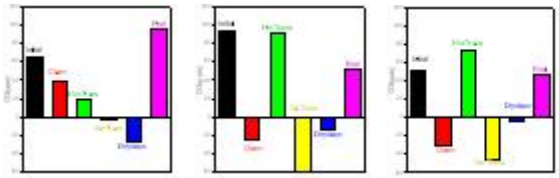


Fig. 6. Difference maps of ozone concentrations calculated by CMAQ model on May 27, 2007.



27, May 00-06GMT 27, May 06-12GMT 27, May 12-18GMT

Fig 7. Mass balance of process contribution to ozone concentration on May 27 2007.

3.2.3 Case C

On August 19 2007, ozone episode occurred in the Seoul metropolitan area. At that time, ozone over east sea area was near 60ppb and ozone in Seoul Metropolitan area was affected by the flowing of ozone converged into the Seoul metropolitan by the easterly wind from the east sea. Also, ozone was produced by local source in this period. We can notice that production of ozone by chemical reaction was 50ppb during 00~06 GMT through Process Analysis. At 06 GMT, production of ozone by chemical reaction was 100ppb. In nighttime, ozone concentrations decreased because of non-effect from China.

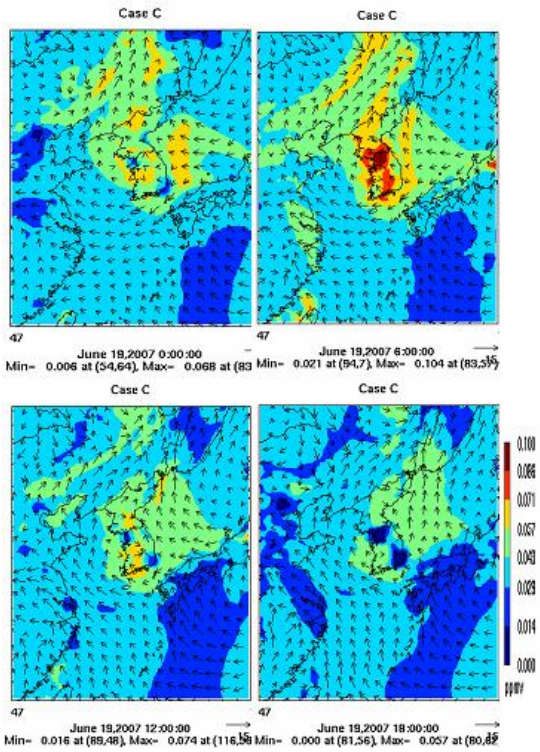
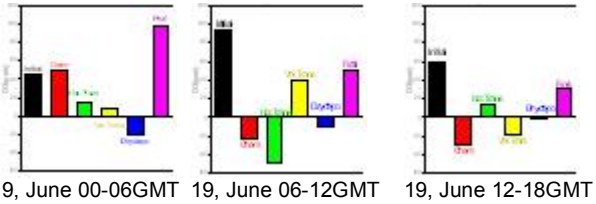


Fig. 8. Difference maps of ozone concentrations calculated by CMAQ model on June 19, 2007.



19, June 00-06GMT 19, June 06-12GMT 19, June 12-18GMT

Fig. 9. Mass balance of process contribution to ozone concentration on June 19, 2007.

4. REFERENCES

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