PRELIMINARY MODELING APPLICATION OF COMMUNITY MODEL CMAQ TO CENTRAL REGION OF THAILAND

Kasemsan Manomaiphiboon*
School of Civil and Environmental Engineering, Georgia Institute of Technology, USA

Pruek Pongprueksa
Department of Civil Engineering, Lamar University, USA

1. INTRODUCTION

Air quality modeling (AQM) is a useful tool for studying air pollution problems. In Thailand, air quality has been an important issue, particularly for her rapidly developed and populated cities where anthropogenic emissions can be large and dominant due to various urban activities. In this study, we are interested to examine the potential of applying the US EPA's community model CMAQ (CMAS, 2005) to AQM for Thailand through a case study, which is the sole objective of the study. In doing so, a simplified modeling framework was set up for ozone (O3) (one of the national criteria air pollutants) simulation during a short summer period over the central region of Thailand. The scope of implementation covers the three essential parts of modeling: 1) Meteorological modeling, 2) Emissions work, and 3) Photochemical-transport modeling. Meteorological modeling was implemented through the MM5 model (MM5, 2005) with global analysis data. Emissions work includes collecting and preparing emissions data, based on considering the recent literature and available databases, spatial and temporal allocations of anthropogenic and biogenic emissions, and emissions processing. Photochemical-transport modeling was implemented using CMAQ. Example results from the study and recommendations for improvement are given. Limitations in the study are also addressed.

2. IMPLEMENTATION

The initial step was to select the spatial modeling domains of current interest (i.e. covering the central region of Thailand and parts of its neighboring regions) and their grid configurations. Here, MM5 modeling was carried out for a spatial domain of ~700 x 700 km to produce all required meteorological fields. A set of archived global analysis data (NCEP, 2005) was used to suggest the initial and boundary conditions for the modeling. A short simulation period of 7 days during Mar. 08-14, 2004 was chosen, corresponding to the early summer season of the region. Assimilation of observed meteorological data was not performed. The meteorology from MM5 was further processed and converted to the IOAPI/ MODELS3 format by the Meteorology-Chemistry Interface Processor or MCIP (CMAS, 2005) for a smaller domain of 360 x 390 km with a grid size of 6 km. Fig. 1 shows a Thailand map (with province boundaries) and the AQM domain chosen for CMAQ simulation.

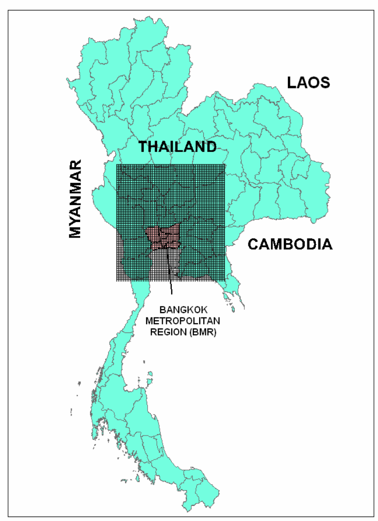

Fig. 1. Thailand map and CMAQ domain

For emissions work, anthropogenic and biogenic emissions inventories as well as emissions-related information were based mainly on consulting the recent literature and databases

**Corresponding author:* Kasemsan Manomaiphiboon, School of Civil and Environmental Engineering, Georgia Institute of Technology, 311 Ferst Drive, Atlanta, GA, 30332.
e-mail: km110@mail.gatech.edu

available to the authors during the study, which includes PCD (2000), Pongprueksa (2001), Streets et al. (2003), Oanh and Zhang (2004), MEGAN database (Guenther and Wiedinmyer, 2005), NSO (2005), and etc. For anthropogenic emissions, only NOx, VOC, and CO were considered. Their chemical speciation and temporal allocations were assigned as generic (i.e. non-source-specific). The chemical speciation followed the generic profiles suggested by the SMOKE model (CMAS, 2005) with the SAPRC-99 chemical mechanism. The spatial allocation of each speciated pollutant was done using the concept of linear area-weight contribution to distribute its mass into the modeling grids properly. Province codes for Thailand were specifically designed such that matching emissions data and geographical information was facilitated. Most of emissions work was implemented using a set of computer codes written for the study, together with use of spreadsheet & GIS-related software. For biogenic emissions, only isoprene and terpenes were included, whose annual flux rates and monthly weight factors were drawn from the MEGAN database (currently available for year 2000). Their hourly factors were calculated with adjustment to local temperature and radiation fields generated by MM5.

3. EXAMPLE RESULTS

CMAQ (with SAPRC-99) simulation was performed in a limited fashion for O3. Example results are given in Figs. 2-4. Fig. 2 shows the spatial distribution of normalized O3 (here, the ratio of O3 to O3max) at UTC Hr. 800 (i.e. local Hr. 1500) of Day 5 (i.e. Mar. 12). As seen in the figure, relatively high ozone levels develop in and around the northern part of BMR. Fig. 3 also presents normalized O3 but during the evening at UTC Hr. 1400 (i.e. local Hr. 2100) of the same day, showing a significant decrease of O3 for most part of the domain. Fig. 4 displays the time series of domain-wide average O3 level (in ppmV) for the final three simulation days, showing the diurnal fluctuation of O3.

4. LIMITATIONS & RECOMMENDATIONS

Many non-technical and technical constraints had arisen during the study due mainly to highly limited resources, inevitably leading to a number of simplifications in implementation. Along the course of the work, the authors have seen a need of preparing and using more detailed emissions-related data as the key priority for improvement. Some emissions were of very coarse resolutions. Using fine (or less coarse) resolutions will give more representative results. Domain selection should also be adjusted or modified to account for the impacts of emissions from other regions surrounding the current AQM domain. Incorporation of observed data into meteorological modeling through assimilation could be helpful as a way to reduce biases in modeled results. It should be

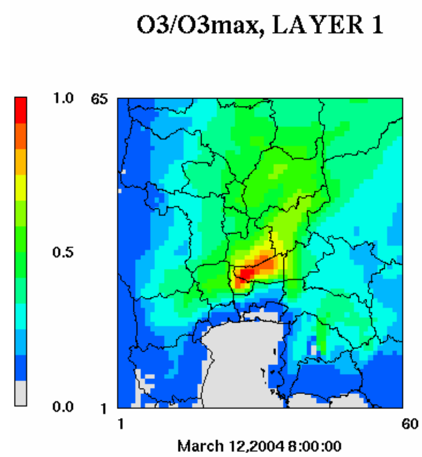

Fig. 2. Distribution of O3 at UTC Hr. 800, Day 5

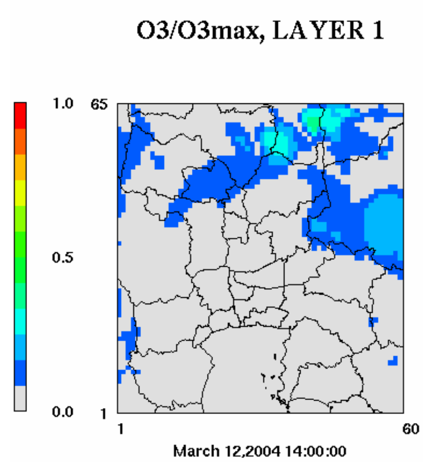

Fig. 3. Distribution of O3 at UTC Hr. 1400, Day 5

noted that this work lacks a model evaluation process. Thus, the example results should not be viewed as the approximate or representative of what took place. From air quality management's viewpoint, the model evaluation process is indeed crucial and indispensable, and it must be emphasized so that air quality modeling brings out reliable findings and practical implications. Through this work, the authors have realized the strong potential of applying the CMAQ model as one of technical tools to regional air quality study for Thailand. Three reasons are: 1) Open-source model and its ready access without cost, 2) Large community of users and continued interaction among users, and 3) Continued development of the model and its associated tools with technical support. The authors have also found that it is possible to utilize information available from the recent literature and databases in AQM for Thailand.

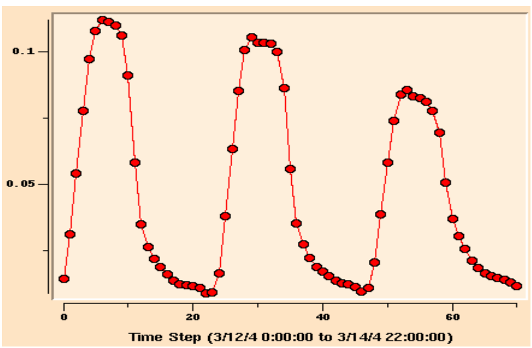

Fig. 4. Time series of domain-wide average O3 level (in ppmV) for the final three simulation days

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6. ADDITIONAL INFORMATION

Additional information related to this work can be found at http://www.prism.gatech.edu/~km110 (Accessible through Oct., 2005).

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