4.2

APPLICATION OF MODELS-3/CMAQ TO PHOENIX AIRSHED

[1]Sang-Mi Lee, and [2]Harindra. J. S. Fernando

[1]Environmental Fluid Dynamics Program, Department of Civil and Environmental Engineering
P.O.Box 879809, Arizona State University, Tempe, AZ 85287-9809, USA
Email: smlee@asu.edu
Web address: http://www.eas.asu.edu/~pefdhome/
Voice: 480-727-6660, Fax: 480-965-8746

[2]Environmental Fluid Dynamics Program, Department of Mechanical and Aerospace Engineering
P.O.Box 879809, Arizona State University, Tempe, AZ 85287-9809, USA
Email: j.Fernando@asu.edu, Voice: 480-965-2807, Fax: 480-965-8746

1. INTRODUCTION

World's population centers are often located along transportation corridors build upon waterways, and the topography of such locales is characterized by complex terrain. Complex topography has a profound influence on local microclimate as well as on air quality. Phoenix is one of the large and growing cities in the U.S., which has been classified as "serious" by the US Environmental Protection Agency for non-attainment of the National Ambient Air Quality Standards for ozone, fine particulate matter (PM) and CO. One of the major factors contributing to this phenomenon is the complex-terrain induced thermal circulation.

The synoptically influenced microscale meteorological fields in Phoenix valley were simulated *post-eventum* using the mesoscale meteorological model MM5 (Penn State/NCAR Mesoscale Model version 5). In addition, Models-3/CMAQ (Community Multi-scale Air Quality) model was employed to simulate the air quality in order to understand dynamical and chemical characteristic of air pollution episode in the Phoenix basin

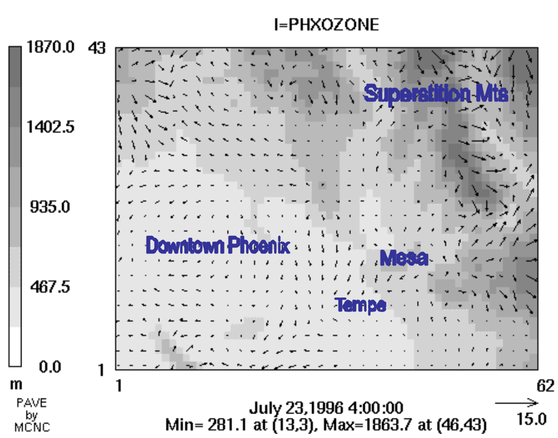
2. DESIGN OF NUMERICAL EXPERIMENTS

The "design days" of Models-3/CMAQ simulation was the period of July 22nd – 23rd, 1996, since it was a period of a high ozone episode that violated NAAQS. Three nested grids were used for the MM5 simulation, using horizontal grid resolutions of 16 km, 4 km, and 2 km for the three domains used. The inner most domain of the MM5 spanned the Phoenix valley with 76 X 58 computational grids in E-W and N-S direction, respectively. The number of vertical layers of all three MM5 domains was 28, and enhanced vertical resolution near the ground was adapted to resolve the detailed structure of the boundary layer. The analysis output of the NCEP (National Center for Environmental Prediction) Eta model was used as initial and boundary values of the outer domain. The simulation in point was begun at 0000 UTC July 22, 1996 and ended at 1200 UTC July 24, 1998. The computational domain of CMAQ was equal to the inner most domain of MM5 expect 7 cells at each lateral boundaries. Averaged ground measurements and aircraft measurement were used as initial and lateral boundary values.

3. RESULTS AND DISCUSSION

The MM5 simulation results showed that the diurnal variation of mountain-valley breeze accounted for the dominant flow in Phoenix basin. The effect of every mountain and valley was well resolved, and was found to be contributing to the local thermal circulation (Fig. 1). High pressure, low synoptic winds, and, consequently, dominant local mountain/valley circulation pattern are typical climatology of the Phoenix valley. MM5 has been tested and turned out to be a suitable mesoscale model for generating synoptically influenced local circulation pattern over Phoenix valley (Lee *et al*. 2002).

(a) 0400 MST July 23rd, 1996



* Corresponding author address: Dr. Sang-Mi Lee
Arizona State University, Environmental Fluid Dynamic Program/Civil & Environmental Eng, P.O.Box 879809, Tempe, AZ 85287-9809
e-mail: smlee@asu.edu

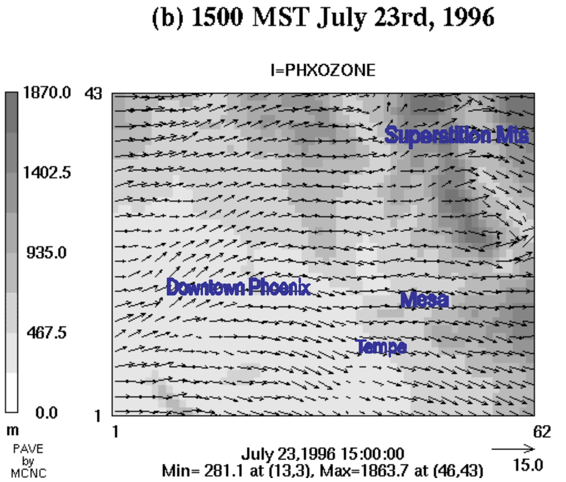


Figure 1. The distribution of horizontal wind at approximately 10m above ground level. (a) 0400LST July 22, 1996 and (b) 1500LST July 23, 1988. The Shading represents terrain heights.

Figure 2 shows the horizontal distribution of the simulated ozone concentration. Due to horizontal advection by the dominant westerly surface wind, the ozone plume is transported to the east, with the maximum concentration occurring at high elevations of the eastern Phoenix valley. Interesting enough, the NO_x concentration in the central Phoenix causes its O_3 concentration to be lower than in surrounding areas, though the traffic-induced contaminants in the proximity of central Phoenix appears to be the root cause of ozone problems in surrounding areas. As evident from Figure 3, the simulated and measured ozone concentrations show a reasonable agreement, at least qualitatively. One of the main reasons for the difference between the predicted and observed peak concentration in the afternoon of the second day is due to the stronger near surface winds predicted by MM5 than observed. The implementation of surface wind nudging in MM5 may improve the prediction of ozone concentration (Fernando *et al*., 2001).

In general, the predicted concentration of air pollutants showed a reasonable agreement with observations. It is found that high concentration of ozone occurred in the eastern part of the valley, which is relatively low-populated area compared to the downtown of Phoenix. This is because of the transport of ozone precursors by the westerly valley wind during daytime. At the same time, abundant NO_x emissions in the downtown of Phoenix titrated the ozone, reducing the level of ozone in that area.

Reference:

Fernando, H. J. S., S. M., Lee, J. Anderson, M. Princevac, E. Pardyjak, and S. Grossman-Clarke, 2000: Urban fluid mechanics: Air circulation and contaminant dispersion in cities. *Environmental Fluid* Mechanics, **1**, 107-164.

Lee, S. M., J. A. Zehnder, and H. J. S. Fernando, 2002: Evaluation of mesoscale meteorological models, MM5 and HOTMAC, using PAFEX-I data, *Journal of Applied Meteorology* (in revision).

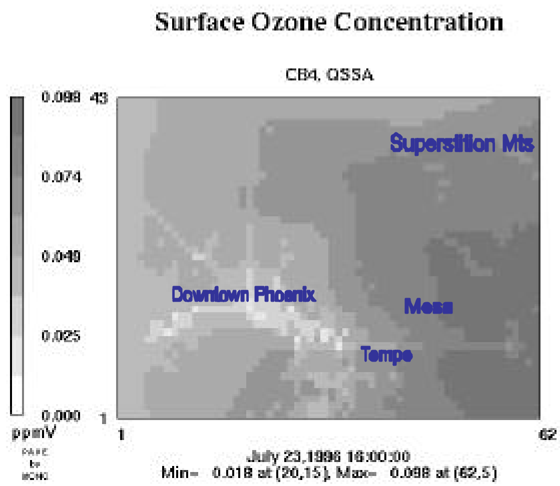


Figure 2. The horizontal distribution of simulated ozone concentration in the Phoenix valley at 1500LST on July 22, 1996.

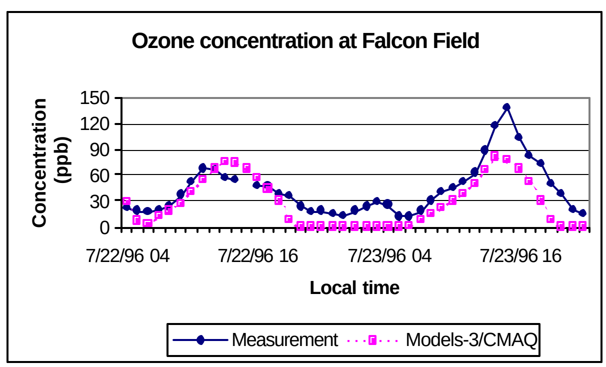


Figure 3. A comparison of simulated and measured at the Falcon Field Airport by the Arizona Department of Environmental Quality) surface-level ozone concentration for several days in 1996.