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Fine-scale CMAQ model application to Houston

Golam Sarwar[1], Daiwen Kang[2], Rob Gilliam[1], George Pouliot[1], James Godowitch[1], David Wong[1], Jonathon Pleim[1], Rohit Mathur[1], Shawn Roselle[1], and S.T. Rao[1]

[1]National Exposure Research Laboratory, USEPA, RTP, NC 27711, USA, [2]Computer Science Corporation, RTP, NC 27709, USA

1. Introduction

In this study, the Community Multiscale Air Quality (CMAQ) model is applied to simulate air quality in Houston during the 2006 Texas Air Quality Study (TexAQS) period (August 1 – October 15). Here, we compare CMAQ predictions with observed data from the Air Quality System.

2. Methodology

Air quality simulations were performed using CMAQv4.7.1 (Foley et al., 2010) and the new CMAQv5.0. Nested model simulations were conducted with a 4-km domain embedded within a 12-km eastern US domain. The 4-km domain covered central and eastern Texas.

Meteorological fields were developed from the WRF (version 3.3) model (Skamarock et al., 2008).

Anthropogenic emissions were obtained from the National Emissions Inventory (NEI 2005). However, all point source emissions in the NEI for Texas were replaced by the specialized emissions inventory prepared for the TexAQS study. Biogenic emissions were estimated using the Biogenic Emission Inventory System version 3.14 (Schwede et al., 2005).

3. Results

The predicted and observed mean daily maximum 8-hr O_3 over the monitoring network in Houston are presented in Figure 1. It is evident that the model predicts higher O_3 when observed data levels are low and lower O_3 when observed levels are high.

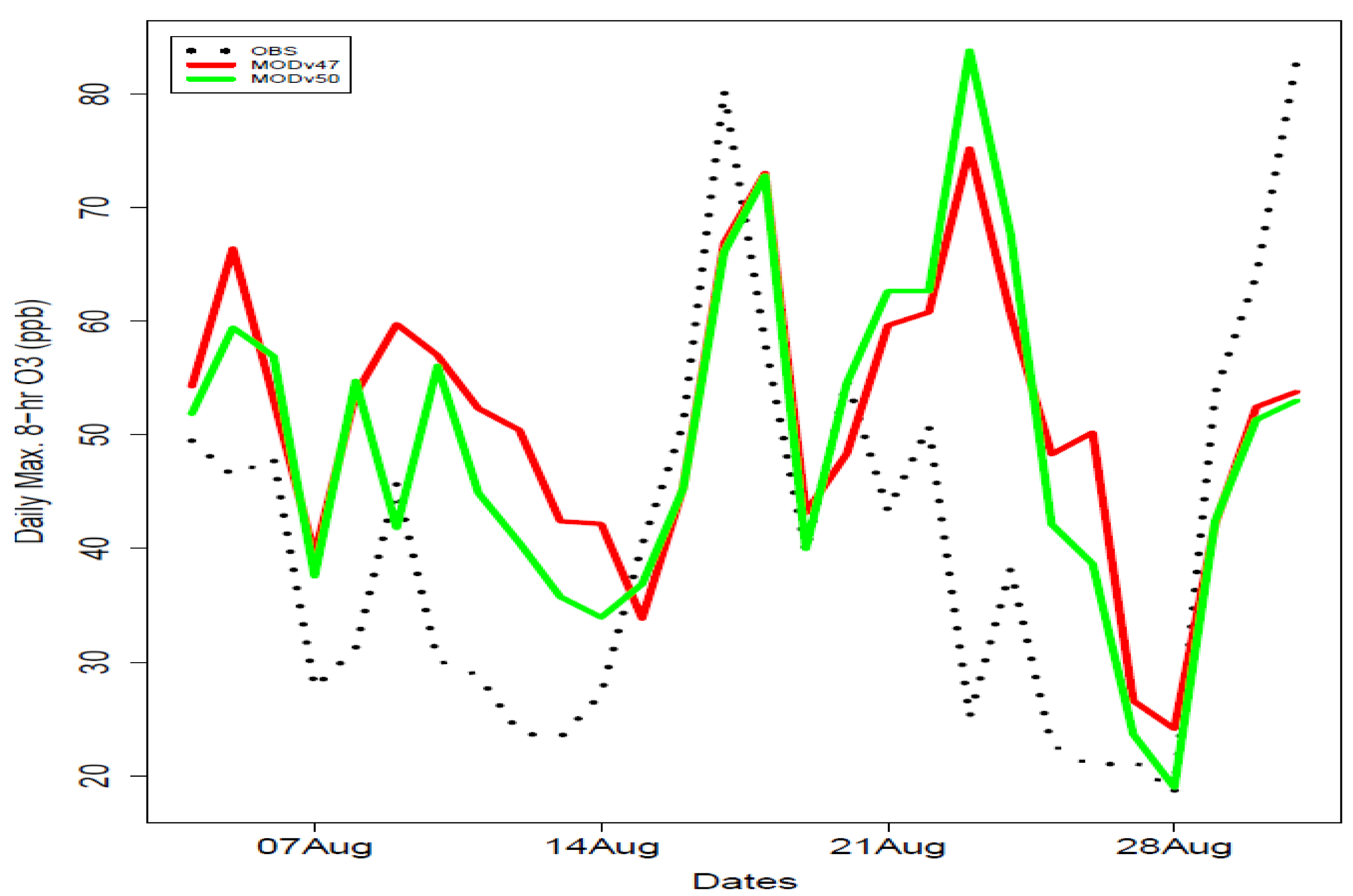

Figure 1: A comparison of predicted and observed mean daily maximum 8-hr O_3 in Houston

Model predicted mean diurnal NO_x and CO levels over the monitoring network in Houston are compared with observed data in Figure 2. Predicted NO_x and CO levels are much greater than the observed data.

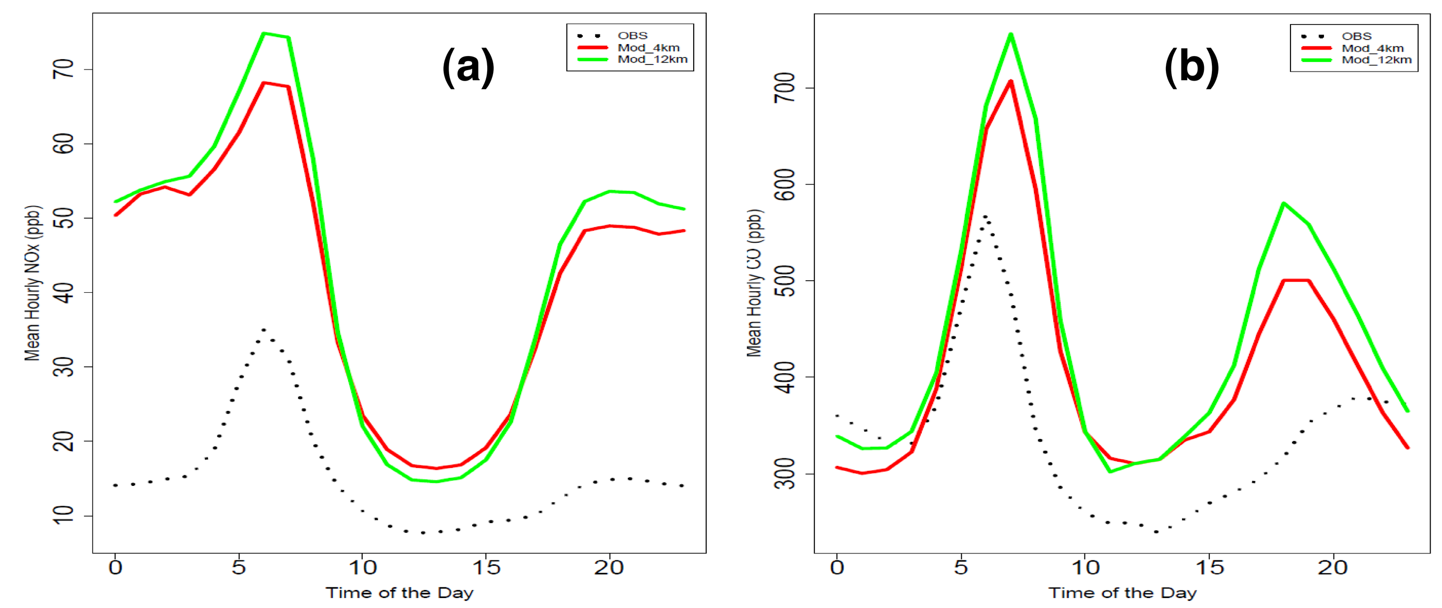

Figure 2: (a) A comparison of predicted and observed mean diurnal NO_x levels in Houston (b) A comparison of predicted and observed mean diurnal CO levels in Houston

Predicted ethane and ethylene levels are compared with observed data in Figure 3. While predicted ethylene levels are in reasonable agreement with observed data, predicted ethane levels are much lower than observed data. Peak VOC levels present in the observations are missing in the predicted values.

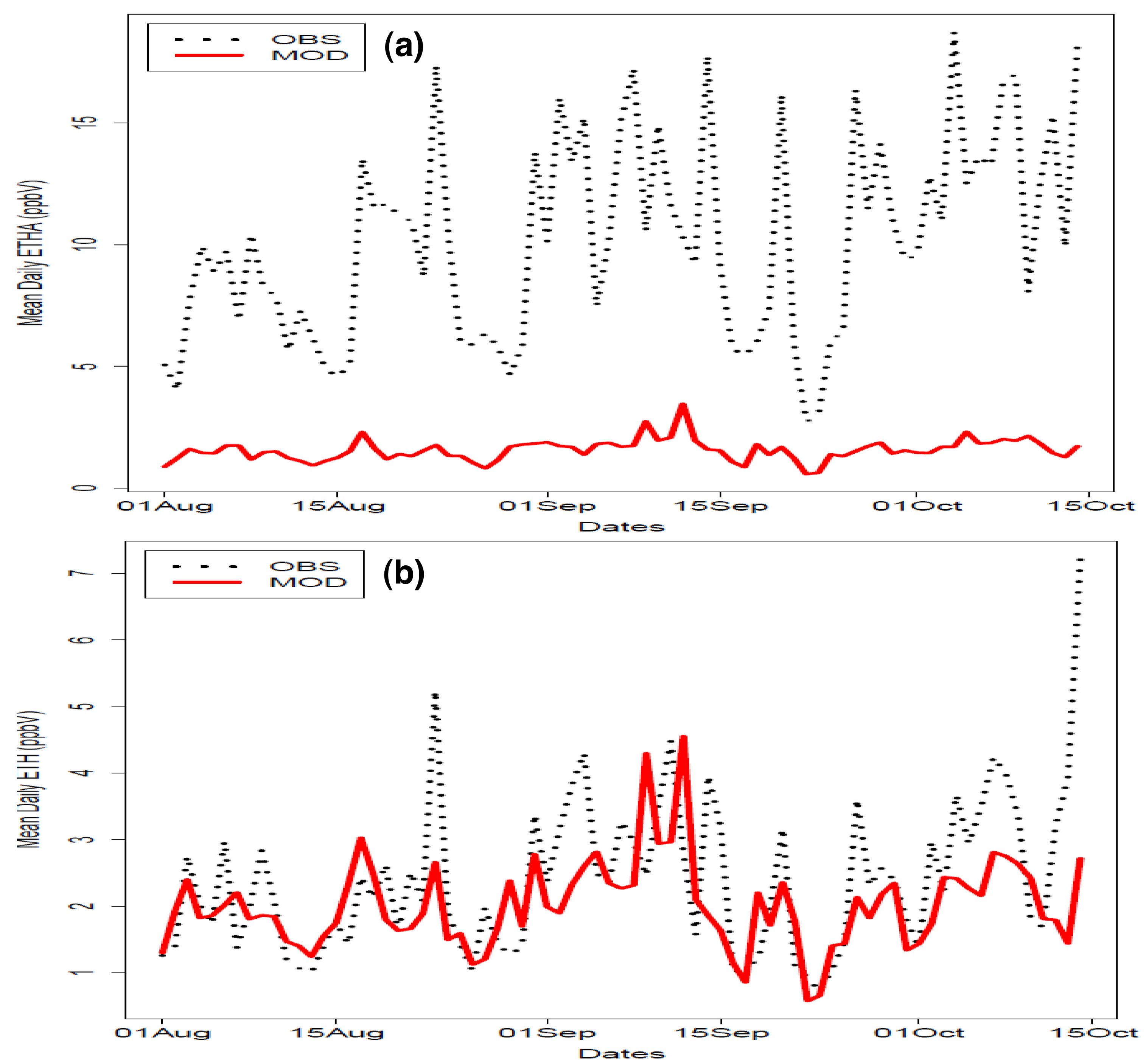

Figure 3: A comparison of predicted and observed mean (a) ethane (b) ethylene in Houston

Three other simulations were performed: (1) different meteorological fields, (2) 50% reduction in NO_x emissions, and (3) 35% reduction in the boundary concentrations for O_3. Model predicted diurnal variations in hourly O_3 averaged over the monitoring stations in Houston are shown in Figure 4. Predicted O_3 obtained with lower boundary values are much lower than those with lower NO_x emissions. Thus, boundary values play a dominant role on the predicted O_3 for the inner domain pointing to the need to properly representing interactions of the Houston air-shed with regional scale O_3 transport.

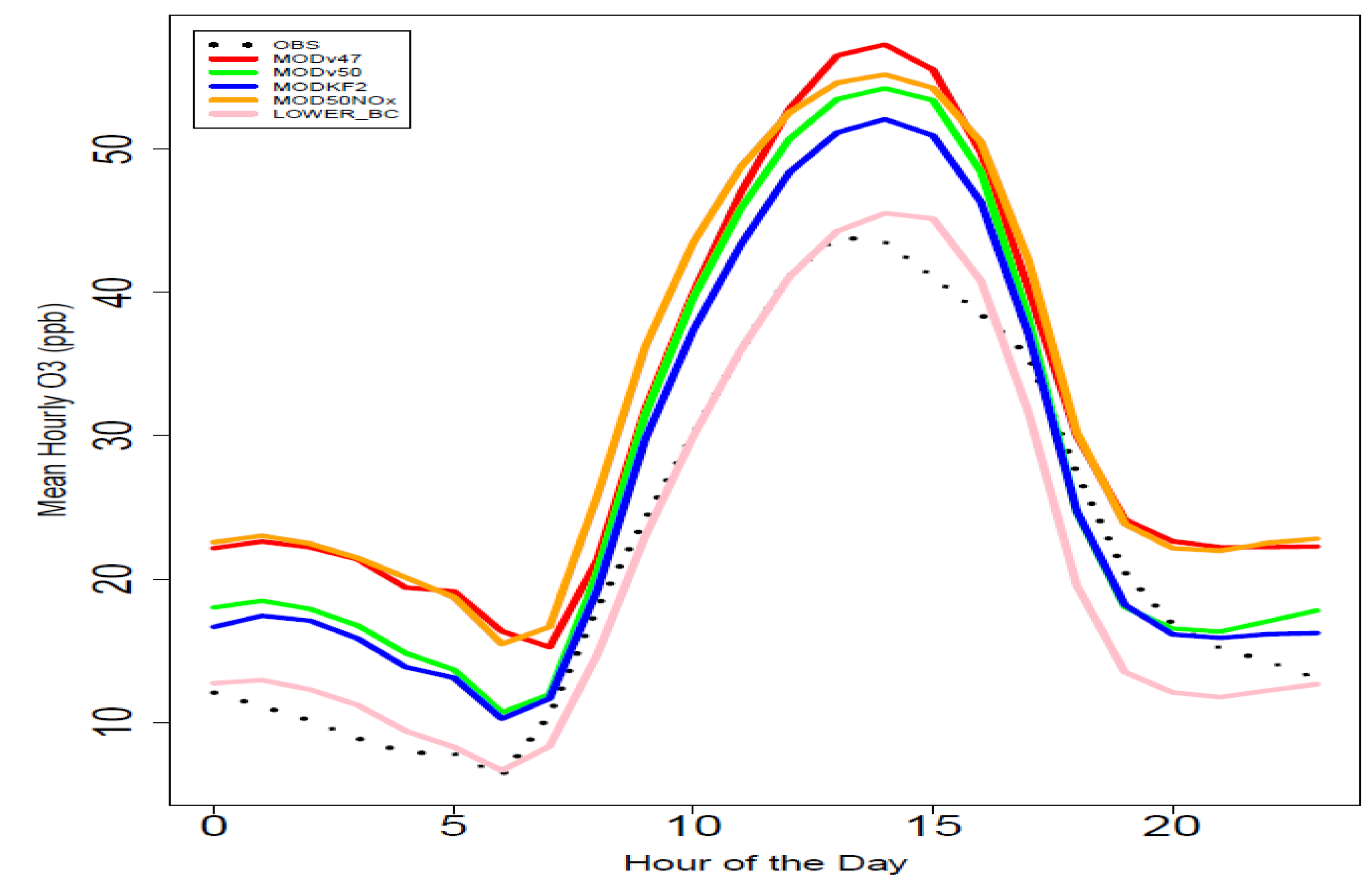

Figure 4: Impact of lower NO_x emissions and lower boundary values on predicted O_3 in Houston

4. Summary

- CMAQ model with the current estimates of NO_x and CO emissions simulates levels that are much greater than observed data.
- Model employing the current estimates of VOC emissions produce ethane levels that are much lower than observed data. Peak VOC levels present in the observations are missing in the predicted values.
- Boundary concentrations play an important role on the predicted O_3 levels in the small domain.

5. References

Foley, K. M., et al., 2010. Incremental testing of the Community Multiscale Air Quality (CMAQ) modeling system version 4.7, Geosci. Model Dev., 3, 205–226, 2010.

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Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M. Barker, M. G. Duda, X-Y Huang, W. Wang, and J. G. Powers, 2008: A description of the advanced research WRF version 3. NCAR Tech Note NCAR/TN 475 STR, 125 pp. [Available from UCAR Communications, P.O. Box 3000, Boulder, CO 80307.]