

Supplementary Materials

Model performance evaluation metrics

We used three statistical metrics suggested by Emery et al (2017): correlation coefficient (R), normalized mean bias (NMB), and normalized mean error (NME) for the evaluation of the CMAQ. The statistical metrics are defined as follows:

$$R = \frac{\sum_{i=1}^{i=N} (O_i - \bar{O})(M_i - \bar{M})}{\sqrt{\sum_{i=1}^{i=N} (O_i - \bar{O})^2} \sqrt{\sum_{i=1}^{i=N} (M_i - \bar{M})^2}} \quad (\text{Eq. 1})$$

$$\text{NMB (\%)} = \frac{\bar{M} - \bar{O}}{\bar{O}} \times 100 \quad (\text{Eq. 2})$$

$$\text{NME (\%)} = \frac{\sum_{i=1}^{i=N} |M_i - O_i|}{N \bar{O}} \times 100 \quad (\text{Eq. 3})$$

For the WRF, we used metrics based on absolute values, mean bias (MB), and root mean square error (RMSE), rather than metrics based on relative values such as NMB and NME following Emery et al. (2001)'s work. The definitions for these metrics are

$$\text{Bias} = \bar{M} - \bar{O} \quad (\text{Eq. 4})$$

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{i=N} (M_i - O_i)^2}{N}} \quad (\text{Eq. 5})$$

Emery et al. (2001; 2017) proposed guidelines for the statistical metrics to comply with, which were utilized in sections 3.2 to evaluate the performance of the CMAQ and the WRF. The guidelines are shown in Tables S1.

Table S1. The evaluation guidelines for predicting wind speed, PM_{2.5}, and nitrate by model recommended by Emery et al. (2001; 2017).

For wind speed					
R		MB		RMSE	
Benchmark		Benchmark		Benchmark	
None		$\leq \pm 0.5$ m/sec		≤ 2 m/sec	
For PM _{2.5}					
R		NMB		NME	
Goal	Criteria	Goal	Criteria	Goal	Criteria
>0.70	>0.40	< $\pm 10\%$	< $\pm 30\%$	<35%	<50%
For nitrate					
R		NMB		NME	
Goal	Criteria	Goal	Criteria	Goal	Criteria
None	None	< $\pm 15\%$	< $\pm 65\%$	<65%	<115%
For O ₃					
R		NMB		NME	
Goal	Criteria	Goal	Criteria	Goal	Criteria
>0.75	>0.50	< $\pm 5\%$	< $\pm 15\%$	<15%	<25%

Reference

Emery, C., Liu, Z., Russell, A.G., Odman, M.T., Yarwood, G., Kumar, N., 2017. Recommendations on statistics and benchmarks to assess photochemical model performance. *Journal of the Air & Waste Management Association* 67, 582-598.

Emery, C., Tai, E., Yarwood, G., 2001. Enhanced meteorological modeling and performance evaluation for two Texas ozone episodes. Prepared for the Texas natural resource conservation commission, by ENVIRON International Corporation.