Review of egusphere-2026-3428

Evaluating the EPICC-Model for Regional Air Quality Simulation: A Comparative Study with CAMx and CMAQ

General Comments

This paper intercompares ozone and $PM_{2.5}$ simulation results over China for the year 2021 between a new photochemical grid model developed for China (EPICC-Model) and two established models (CAMx and CMAQ). The analyses go deep into the performance comparisons spatially and temporally across many scales, yielding a broad assessment of the EPICC-Model relative to the other two models on a regional basis. Based on how the modeling study was conducted, the conclusions are generally sound. The paper is well-written with proper English grammar and syntax, with just a few exceptions as noted below.

Overall, the three models yield generally consistent model performance in replicating measured spatiotemporal patterns, which makes sense given many similarities among their formulations and the use of common emission and meteorological inputs. Divergences among the model results seem to be mostly driven by controllable model configuration differences. Ideally, the configurations of CMAQ and CAMx should have been made more consistent with the EPICC-Model to minimize these important and controllable factors.

Based on this overview and the key issues I note below, revisions are needed before publication.

Specific Comments

1. The paper stresses systematic consistency in the model comparison. But according to Table 1 that is not entirely accurate.

    a) The EPICC-Model uses 20 vertical layers, while CAMx and CMAQ use 14. The authors stress the better layer structure in EPICC as "demonstrating superior vertical resolution compared to the 14 layers coordinates used in other two models" especially "for near-surface turbulent mixing and nocturnal stable layer structures." The manuscript should state that the choice for 14 layers is a user configurable choice, not a fixed feature of CAMx and CMAQ. The rationale for this choice needs to be clearly stated. Ideally, all models should use the same 20 layer structure to improve model-to-model consistency and remove a key source of uncertainty in the comparison of model results.

    b) CAMx was run with the CB05 photochemistry mechanism, which is an odd choice given that it represents 20-year old science. CAMx v7.00 used in this study includes CB6r4, and CAMx v7.10 released just 6 months later in 2020 includes CB6r5 (the same CAMx mechanism that was adopted by EPICC, while CMAQ was run with CB6r3). This is a critical issue, and the manuscript should include a statement that CAMx includes CB6, and it should present a well-developed rationale for selecting CB05. Ideally, CAMx should be run with CB6 chemistry.

    c) The authors state that both CMAQ and CAMx use "default" boundary conditions to specify concentrations on the 45-km outer grid. They go further to state that CMAQ and CAMx rely on their respective default settings, which is not true. There are no preferred "default" or built-in profile boundary conditions implemented or recommended for these models. Both CMAQ and CAMx can utilize the same MOZART global model output data to derive boundary conditions, as was done for EPICC. While I understand that boundary conditions do not appear to have appreciable effects on model results overall, use of consistent boundary conditions is preferable.

The boundary conditions values and their sources should be stated in the paper with a rationale justifying their selection.

d) Some other simple descriptions for CAMx processes are inadequate or inaccurate. The PPM vertical advection solver was not available in CAMx v7.00 or v7.10, so that entry in Table 1 is either incorrect, or the authors used CAMx v7.20 or later. It is inaccurate to state that CAMx employs the YSU vertical diffusion scheme, rather it employs a first-order K-theory approach (apparently like EPICC-Model) where the vertical diffusivities are diagnostically derived from WRF meteorological fields based on the YSU approach. While Table 1 correctly indicates that TUV is used in 2 ways, the text insufficiently describes the process. Both EPICC and CAMx use the full-science TUV as a pre-processor to generate a photolysis rate input file, then internally apply a streamlined TUV version to adjust those for effects from clouds and aerosols. All of this should be stated in the manuscript.

2. Section 1, lines 64-68: Please include the latest literature citations for CMAQ, CAMx, WRF-Chem, GEOS-Chem.

3. Section 2.1, lines 125-127: Upon my code review, EPICC relies heavily on original codes from CAMx and CMAQ. A simple statement acknowledging and attributing the source code origins of major process-level routines to CAMx and CMAQ should be added here. I see also that previously published papers describing the development of EPICC do not acknowledge the 30-year developmental legacy of these schemes from CAMx and CMAQ. This is a critical omission.

4. Section 2.2, lines 199-200: "Therefore, the WRF model used in this study demonstrates high reliability in simulating temperature and humidity." I suggest replacing the subjective words "high reliability" with a more general word like "adequacy". Also, lines 216-217, "Overall, the WRF model provides reliable meteorological forcing fields for CTMs," I again suggest replacing with "adequate" or similar.

5. Section 2.2, lines 214-215: "While parts of Southwest and Central China exhibited slight underestimation (MB < 20 hPa)", I suggest adding a phrase for context such as error related to unresolved terrain altitudes at model resolution.

6. Section 3.1, Lines 316-326: "This discrepancy mainly stems from differences in chemical mechanisms design among the models" and "In addition, the EPICC-Model employed the CB6r5 chemical mechanism, which offered more comprehensive representation of BVOC oxidation (especially isoprene) compared to CB6r3 (used in CMAQ) and CB05 (used in CAMx), thereby increasing O3 formation potential." All certainly true – see my comments above about running CAMx with CB05 rather than CB6r5. CB05 is a choice, not the only option in CAMx.

7. Section 3.1, Lines 406-408: "CAMx generally underestimated O3 nationwide, which may be associated with the use of the CB05 chemical mechanism and the 14σ vertical configuration adopted in this study." See my comments above. Adding reasons for these selections in the model configuration section would help provide the reader valuable context, rather than seeming to be historical requirements or random choices.

8. Section 3.4, Lines 720-721: "For Wuhan and Guangzhou, where peak concentrations persisted, model predictions showed approximately one-day deviations." The observations do not indicate that peak concentrations persisted (not like Beijing), I suggest removing that phrase. Figure 12 does not show much difference between the models except in Guangzhou where CMAQ seemed to perform best and the other 2 models under predicted.

Technical Corrections

Be sure to define all acronyms at the time of their first occurrence.

Use consistent past or present verb tense. Many sentences within single paragraphs shift between past and present throughout the manuscript.

Throughout manuscript: Perhaps a better word for "identifying" pollution levels or events is "forecasting".

Section 3.2, Lines 524-525: "As shown in the stacked bar charts of $PM_{2.5}$ absolute concentrations in Figure 6e-7h", I think the authors mean Figures 6e-6h.

Section 3.3, Line 625: Use subscript for $PM_{2.5}$.

Section 3.1, Line 350: Replace "As shown in Figure 3" with "As shown in Table 3".

Section 3.2, Line 569-571: I suggest rewording to "While the EPICC Model demonstrates relatively lower consistency among species, it maintains better performance in terms of RMSE and NMB."