Response to Reviewers Comments.

Reviewer 1: General Comment

Authors have revised the manuscript based on the first round of reviews, and the concerns raised in the reviews have nearly all been addressed.

Response:

We appreciate the reviewer's general positive comments on our revisions.

Reviewer 1: Main Comment

I have only one major concern remaining, related to the authors' interpretation of the tagged Mexico anthropogenic contribution when discussing Figure 9. In Figure 9, I've assumed that the date tick marks correspond with 00:01 local time, thus, when the authors discuss June 15 and 17 in the text, they are referring to the particular area after (to the right) of the 0615 and 0617 ticks. As such, it appears incorrect to say that on June 15th the Mexican Anthro contribution (red) exceeded the Arizona Anthro contribution (green), since this is only true in the first half (midnight to ~8am) of June 15th. The big peak when the exceedance (>70 ppb) occurred, has a large red area, indicating that the local anthropogenic contribution from Arizona is greater than that of Mexico, for a significant time period over this day, particularly during the exceedance time. While the authors have revised the text in this discussion based on the first review, the new text is quite contradictory, e.g; "exceedances of the NAAQS 70 ppb O_3 standard in Yuma are often significantly influenced by emissions from Mexico" yet "these contributions are modest in absolute terms". And:
"While not dominant overall…" yet "these transboundary emissions play a substantial role in elevating O_3 above background levels and contribute to exceedances"…It's as though by including the Mexican (green) portion at the top of the other contributions in the time series (Figure 9), they have perceived that the Mexican contribution caused the exceedances in Arizona. Whereas, if the Arizona (red) portion were placed at the top, one would perceive that that contribution caused the exceedance. Therefore, I highly recommend that the text discussing Figure 9 be changed further to something like this before publishing:

"Figure 9 shows that O_3 levels in Yuma are largely dominated by the background level, primarily from long-range transport and natural sources. The exceedances of the NAAQS 70 ppb O_3 standard in Yuma were significantly influenced by a peak in this background contribution on June 15 and 17th when the background made up X% and Y%, respectively of the total daytime O3. On June 15 and 17th, the anthropogenic contributions from Arizona were W% and Z%, respectively, and the anthropogenic contributions from Mexico were U% and V% respectively." (filling in the percents from your tagged simulation data). This new suggested text would rephrase the discussion of these results in a quantitative way and remove any perception bias from the interpretation of Fig 9. The authors can also add a brief sentence related to the fact that these are modelled results, and the modelled peaks on June 15th and 17th are +/-X% different from the measurement peaks.

Response:

We appreciate the reviewer's keen observation and thoughtful suggestions for rewording the interpretation of Figure 9. We have carefully revised the paragraph accordingly. It now reads:

"The exceedances of the NAAQS 70 ppb O_3 standard in Yuma were significantly influenced by a peak in this background contribution on June 15th and 17th when the background made up ~65% and ~70%, respectively, of the total daytime O_3. On June 15th and 17th, the anthropogenic contributions from Arizona were 20% and 10%, respectively, and the anthropogenic contributions from Mexico were 8% and 13% respectively. We note, however, that these are modeled results, and the modeled peaks on June 15th and 17th are 16 to 30% different from the measurement peaks, overestimating on June 15th and underestimating on June 17th."

Reviewer 1: Minor Comment

Figures 11(c and d) and 13 (c and d): When showing differences ("Diff"), please change to a divergent colour scale (e.g. blue to red with white at zero) instead rainbow, which makes it difficult to understand the results.

Response:

We thank the reviewer for this comment. We have revised Figure 11c-d and 13 c-d to have a divergent color scale.

Reviewer 2: General Comments

Although the author make significant revisions about this manuscript. The conclusion is still well-known based on previous studies. The authors cannot treat a typical region as the novelty of this study. Arizona did not show unique characteristic as Tibetan Plateau or Antarctic. Furthermore, it is also necessary to obtain new findings even if the study domain is located on special regions. The authors should summarize more novel findings compared with previous studies. Moreover, the authors did not examine the accuracy of H2O2 and HNO3 simulations. Therefore, I cannot recommend the manuscript for publication on ACP.

Response:

We sincerely appreciate the reviewer's thoughtful feedback on our revisions, as well as the recognition of the lack of novelty of this study and the accuracy of H_2O_2 and HNO_3 simulations. In response, we have made substantial revisions across multiple sections (incl. title) to better highlight the scientific contributions and unique aspects of our work, ensuring that these key elements are clearly conveyed to the readers.

We have revamped our Abstract, Introduction, Main Sections, and Conclusions. We added a good number of references to provide context to some of our findings. Specifically, we have made the following key improvements:

1. **Enhanced focus on source attribution using advanced modeling:**

We have clarified our goal to quantify fire contributions to O_3 levels using a high-resolution, coupled weather-air quality model with tagging capabilities. To our knowledge, this is the first study to apply such a framework at this resolution, as most previous tagged O_3 studies relied on global models (CTMs, not ESMs) or coarser-resolution regional/offline models that lack chemistry-meteorology feedbacks. This is particularly important for our case study on a compound event in a complex terrain environment, where coarser models may underestimate source attribution accuracy and fail to capture feedback mechanisms. We have emphasized this in the revised manuscript.

2. **Refined background O_3 estimates for Arizona and the Southwest U.S.:**

Our study presents an alternative estimate of background O_3 in Arizona, which can be extrapolated to the broader Southwest U.S. While our results are consistent with recent observational studies (notably Parrish et al., 2025), our model's finer resolution allows us to capture spatial variations in background O_3—an essential factor in accurate source attribution. We have expanded the discussion on this topic and included an additional figure to illustrate these variations.

3. **Fire-induced wind modifications and their role in source attribution:**

Our analysis reveals that wildfires altered local wind patterns, an essential finding that must be considered in source attribution for compound events. We have expanded this discussion with additional figures illustrating the impact of fires on wind.

4. **Comprehensive analysis of smoke plume chemistry:**

We provide a detailed illustration of the spatial distribution and cross-section of O_3 precursors and chemical regimes within the smoke plume. This is a direct advantage of our coupled modeling framework, which we argue is more realistic than photochemical box models, as it accounts for environmental variations and chemistry-meteorology feedbacks—a capability missing in models like HYSPLIT. We have further strengthened this section by comparing our results with available observations and discussing agreements with plume-based (box model) studies.

5. **Model comparison with ground and satellite observations:**

We have compared our model results with as many available ground-based and satellite-based measurements as possible. In combination with the improvements above, we argue that this study is one of the few that integrates multiple strengths to enhance the accuracy and robustness of wildfire-related O_3 assessments.

6. **Expanded chemical regime analysis and refinement of comparison metrics:**

We have expanded the chemical regime analysis by incorporating a comparison with TROPOMI FNR. Additionally, we have removed the discussion on H_2O_2/HNO_2, given the lack of available observations for validation. Instead, we replaced it with O_3/NO_x comparisons and introduced a new figure comparing TROPOMI-derived columnar FNR with WRF-Chem simulations (with and without fire emissions).

7. **Broader applicability to arid regions with persistent O_3 pollution:**

While our focus is on Phoenix, Arizona, we strongly believe that the insights gained from this study are applicable to other arid environments, particularly those struggling with persistent O_3 pollution. The O_3 dynamics in such regions—especially those with large urban centers—remain poorly studied and insufficiently observed. We have highlighted these broader implications in our revised manuscript.

These revisions strengthen the clarity, impact, and scientific contributions of our study, reinforcing its novelty and relevance in wildfire-driven O_3 research and highlighting the utility of this approach in future studies.