Response to Editor:

We would like to thank the editor for the time, and useful comments. The comments are repeated below, followed by our response.

General comments:

1. Abstract: I agree with Reviewer 2 that the abstract is highly technical. There need to be stronger links to big picture questions. For example, the first sentence goes straight into what was done in the study, without mentioning any motivation or identifying any research gaps. It is not clear how the manuscript was revised in response to Reviewer 2's major comment 6.

Response: The abstract has been revised in the manuscript as below:

"**Abstract.** Heterogeneous chemistry of oxidized carbons in aerosol phase is known to significantly contribute to secondary organic aerosol (SOA) burdens. The UNIfied Partitioning Aerosol phase Reaction (UNIPAR) model was developed to process the multiphase chemistry of various oxygenated organics into SOA mass predictions in the presence of salted aqueous phase. In this study, the UNIPAR model simulated the SOA formation from gasoline fuel, which is a major contributor to the observed concentration of SOA in urban areas. The oxygenated products, predicted by the explicit mechanism, were lumped according to their volatility and reactivity and linked to stoichiometric coefficients which were dynamically constructed by predetermined mathematical equations at different NO_x levels and degrees of gas aging. To improve the model feasibility in regional scales, the UNIPAR model was coupled with the Carbon Bond 6 (CB6r3) mechanism. CB6r3 estimated the hydrocarbon consumption and the concentration of radicals (i.e., RO_2 and HO_2) to process atmospheric aging of gas products. The organic species concentrations, estimated by stoichiometric coefficient array and the consumption of hydrocarbons, were applied to form gasoline SOA *via* multiphase partitioning and aerosol–phase reactions. To improve the gasoline SOA potential in ambient air, model parameters were also corrected for gas–wall partitioning (GWP). The simulated gasoline SOA mass was evaluated against observed data obtained in the UF-APHOR chamber under varying sunlight, NO_x levels, aerosol acidity, humidity, temperature, and concentrations of aqueous salts and gasoline vapor. Overall, gasoline SOA was dominantly produced via aerosol–phase reaction, regardless of the seed conditions owing to heterogeneous reactions of reactive multifunctional organic products. Both the measured and simulated gasoline SOA was sensitive to seed conditions showing a significant increase in SOA mass with increasing aerosol acidity and water content. A considerable difference in SOA mass appeared between two inorganic aerosol states (dry aerosol vs. wet aerosol) suggesting a large difference in SOA formation potential between arid (Western United States) and humid regions (Eastern United States). Additionally, aqueous reactions of organic products increased the sensitivity of gasoline SOA formation to NO_x levels as well as temperature. The impact of the chamber wall on SOA formation was generally significant, and it appeared to be higher in the absence of wet salts. Based on the evaluation of UNIPAR against chamber data from 10 aromatic hydrocarbons and gasoline fuel, we conclude that the UNIPAR model with both heterogeneous reactions and the model parameters corrected for GWP can improve the ability to accurately estimate SOA mass in regional scales."

2. Response to Reviewer 1 Specific Comment 1 seem cursory and may not be clearly addressing the comment. The response seems to provide more explanation into model details, rather than provide the big picture impacts of GWP as predicted by the model. It would be useful to expand the discussion of GWP and broader impacts, at least within the context of these experimental results. For example, why does GWP vary between aromatic hydrocarbons? Why is the factor ~1 for benzene and so much higher for other aromatic hydrocarbons?

Response: The section4.1 has been revised with additional discussion in the manuscript as below:

"Impact of GWP on SOA formation differs with oxidation product distributions according to volatility and reactivity. The estimated $kon_{w,i}$ of i to the chamber wall was ~5×10^{-4} s^{-1} for UF-APHOR chamber. Similar to OM_P, the impact of GWP on SOA formation is significant in the HCs with low volatile products. The HC with the higher impact of OM_{AR} on OM_T is less influenced by GWP. The characteristic time of aerosol–phase reactions that lead OM_{AR} is generally shorter than that of GWP (Han and Jang, 2020). In the UNIPAR model, the formation of OM_{AR} is irreversible to form nonvolatile oligomer products. Benzene SOA, which is mainly attributed to OM_{AR}, was little influenced by GWP. The oxygenated products from benzene are highly reactive in aerosol phase leading a high contribution of OM_{AR} to OM_T, but they are volatile lowering OM_P as well as the impact of GWP."

Technical comments:

Line 18: aerosol-phase reactions

Response: It has been updated in the revised manuscript

Line 23: United States
Response: It has been updated in the revised manuscript

Line 26: not sure what "in the corpus" means
Response: The abstract has been updated in the revised manuscript.

Line 38: "budget" is the wrong word. You do not predict a budget. The budget is the prediction itself.
Response: It has been updated in the revised manuscript

Line 190: "it" is incorrect, if referring to "SOA models"
Response: It has been updated in the revised manuscript

Line 264: peroxyacetyl nitrate is formed from RO2+NO2, not RO2+NO
Response: It has been updated in the revised manuscript

Line 273: overestimation of SOA mass
Response: It has been updated in the revised manuscript

Line 349: "in an urban atmosphere" instead of "in an urban ambient"
Response: It has been updated in the revised manuscript