Thank you for your review and valuable comments. Please see our response below (reviewer comments in italics, our response will follow, with text modifications in bold).

*Page 13, line 28: Whilst I agree that there should be a benefit in running more simulations, if one is to look at parametric uncertainty in a highly parametrised scheme, what will we really learn about the atmosphere? I agree that this would be valuable for "making the model better" but are there not risks associated with this? Risks that we would end up over-tuning models, which would inevitably result in false confidence in their predictions? I would appreciate some comment on exactly how you see the benefits to our understanding of the atmosphere using ensembles of simulations with chemistry schemes that lack the sensitivity of the real atmosphere (i.e. are simplified -- you may like to rebut my assumption that simplified schemes have the incorrect sensitivity).*

The ability for simplified/parameterized models to inform and constrain more complex, less parameterized models is well demonstrated in the Earth system Models of Intermediate Complexity (EMIC) field, and part of the motivation for this work was to see how simplified global 3D chemistry models could stand in between 2D EMICs and full 3D complex climate-chemistry models. While there are risks of over tuning models, the potential benefit in providing a much broader context of the larger parameter space we feel is quite large. As all mechanisms are simplifications of the real atmosphere, the issue of complexity is largely a matter of degree. We have mentioned in this manuscript the need for both simple and complex models to be used in parallel, and we feel that maintaining a connection between the characterizations in the simplified models and the complex models is of critical importance. To this point, we've added the following (red text) in the manuscript and trimmed the beginning of the following sentence to incorporate this addition.

**Page 13, Line 28: We feel that the capability to run three SF simulations for the price of one MO simulation under different sets of initial conditions, for example, can extend the quantification of parametric uncertainties which is largely unavailable to the most complex and most computationally demanding mechanisms. Of course, the SF mechanism may not be appropriate for every sensitivity study, but neither is the MO mechanism. The choice of mechanism really depends, then, on the science question. If the research objective is to predict complex chemistry-climate interactions and computational resources are available, then a more complex mechanism will have the most value. However, if the research objective is to better understand various parameterizations, then a more computationally efficient mechanism will have higher value, even if it might not be capable of accurately simulating all variables in detail (Hoffman et al., 1996). This is particularly the case when a baseline can be established between the simplified mechanism and the complex mechanism, as we have done here. We feel that this parallel approach, in which a set of mechanisms with varying levels of complexity are run concurrently with a consistent set of parameters, allows us to enhance our exploration of uncertainties and thus our ability to understand the atmospheric chemistry of the Earth system.**

**For instance, there are many research frameworks where the "three-for-one" advantage of the SF mechanism could be utilized with the MO mechanism in which one simulation…**

Hoffman, R., Minkin, V. I., and Carpenter, B. K.: Ockham's Razor and Chemistry, Bull. Soc. Chim. France, 133, 117-130, 1996.

*Page 15, line 31: "efficiency" should, I think, be "efficiently".*

Corrected.