Response to Referees
gmd-2020-33
Reviewer comments in normal type face. **Response in bold.**

Ben Kravitz (Referee #1)

The authors present a really interesting approach to simple climate modeling that I hadn't considered before. I think this is a smart idea. The authors have done a thorough job with their analysis. My only comments are related to phrasing and context of the results. I am recommending minor revisions.

Thank you for taking the time to review this manuscript. We believe that our changes address the issues raised in your review.

Lines 12-14: This sentence caught my attention as needing more caveating. In linear time-invariant systems the impulse response fully characterizes system dynamics. In nonlinear systems it doesn't. So as written, this sentence is coming across as though your fundamental methodology is flawed (which I'm sure it's not – based on my reading of lines 51-52, you do understand the distinction). I do agree that your approach captures _some_ of the dynamics, perhaps even the most important parts of it, depending on what dynamics your model is designed to represent. Some rephrasing is needed.

We have revised this sentence to read:
This structure allows it to capture the most crucial nonlinear dynamics encountered in going from greenhouse gas emissions to atmospheric concentration to radiative forcing.

Lines 32-34: That's one way to do it. There are others, for example:
https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2011GL048623

Thank you for bringing this publication to our attention. This is an interesting analysis in frequency space, but we're not sure how this would be translated into the applications to which SCMs are commonly applied, such as scenario analysis. We changed the text to clarify there are multiple ways to approach idealized simple climate modeling, see paragraph starting at line 33.

Line 39: I'd be careful with the word "nonlinearities". You can have linear feedbacks that still result in interesting dynamical behavior. I agree that chemistry can result in substantial nonlinearities (I think Kate Marvel had a paper on this looking at single forcings), and some GHGs are known to have a nonlinear relationship between concentration and forcing, but talking about the entire suite of carbon cycle feedbacks as nonlinear is perhaps too much.

Agreed, we adjusted the text in lines 47-51 to improve our discussion about how process based models incorporate complex climate interactions and nonlinear climate dynamics.

Lines 44-45: Again, they _can_ be. They don't have to be.

Good point. We borrow this terminology from Millar et al. 2017 and have adjusted the text starting in line 33 to better reflect this and caveat that there are multiple ways to use IRFs in simple climate modeling.

Lines 68-72: Clever. And an excellent description of where the potential problems lie. And I appreciate the validation of your assumptions later.

Thank you!

Lines 89-90: This assumption is known to be incorrect (i.e., efficacy; Hansen et al., 2005). That's not a problem for your analysis, but you'll need a caveat on your interpretation of your results.

Good point, this was not properly conveyed in the previous draft of the manuscript. We've added text in lines 86-88, and 106-109 to more clearly communicate this point.

Lines 96-97: This strikes me as appropriate. It's always tricky to delineate temperature from response because they coevolve, but your choice here makes sense.
Thank you.

Line 110: How do you impose the RF pulse in the model? (Or if this is described later, say so.)

The RF pulse is equal to the difference between the radiative forcing between the reference and the BC emission perturbation run. Text in lines 132 and 139 was modified to clarify this point.

Section 2.3 is a bit odd. I expected to actually see the results of the validation here. Perhaps move these short descriptions to more relevant points of the manuscript?

Section 2 and 3 were combined/reorganized so that the results of the validation tests were paired with the description of the test setup.

Lines 132-133: I'm having trouble understanding this sentence.

The sentence now reads "In this experiment HIRM was set up with the Hector derived IRF and a RF input from an abrupt four times CO2 concentration step".

Section 4.1: I'm having a bit of trouble understanding exactly what you did. If I understand it correctly, you (1) come up with ranges of uncertainties for each of those aerosol forcing terms, (2) sample those spaces to come up with 29,000 sets of parameters that you call uncertainty scalers, and (3) simulate those combinations in HIRM, throwing out results that don't match historical radiative forcing and temperature?

Yes, that is what we did. The wording in this section was changed to more clearly explain this case study, please see lines 192-227.

Line 214: Typo
Corrected.

Line 297: Typo in your acronym
Corrected.

Figure 2: Can you choose different colors? Orange and gray are difficult on the eyes.
We've selected another grey-color combination from a color-blind friendly color palette.