We thank Ben Kravitz for suggestions and comments. Comments helped to clarify several parts of the text. Our point by point answers to the comments are presented below. Referee comments are in bold and our replies in body text.

This is a great study, and important. This has needed attention for some time. I am recommending minor revisions. I'd like to see the conclusions fleshed out a bit more. What have we learned about best practices for simulation? When is it okay to use a modal model versus a sectional one? I'd like to see some insight that people in the field can use.

Thank you for this comment. We added some discussion on best practices in the text. However we also want to emphasize that we purposely avoided making too strong suggestions to use either one of the models used here or sectional or model models generally. The model capability to simulate stratospheric aerosols depends on several different factors e.g how individual microphysical processes are represented in the model in addition to how aerosol size distribution is represented. Even though we strove to analyze those comprehensively, there is the need for more extensive research for this topic which covers multiple models. In any case we now focus more on practices and issues which should be considered when analyzing results of modal/sectional models or when choosing between those (includes suggestions from the other reviewer).

We changed the last line of section 2.1: "*However when using M7, this requires changes in the configuration of the modes and having a narrower width of the largest mode to improve the representation of the stratospheric aerosols (Kokkola et al., 2009). Thus one downside of using a modal scheme is that tropospheric and stratospheric aerosols are not well described with the same mode configuration*"

We also added the following paragraph to Conclusions:
"*There are several factors which support a sectional model over a modal model for stratospheric aerosol simulations, despite the fact that the modal scheme is significantly computational faster than sectional (simulations with M7 were 60% faster than SALSA). First of all, tropospheric and stratospheric aerosols require different configurations for modes and thus studying both in the same simulations is not recommended. In addition, even though only stratospheric aerosols are studied, the tropospheric aerosols, which were not well represented by configuration designed for stratospheric aerosols, can affect indirectly to stratospheric aerosols. In SAI simulations, and especially in the case of continuous injections, the size distribution inside the injection region does not have a clear multimodal structure in the sectional model simulations except for the lowest injection rates (1-2 Tg(S)yr-1) (Fig 5 and Fig A3) (English et al, 2012, Kleinschmitt et al., 2018). This is probably because there is available H2SO4 gas for particles to grow by condensation, and particles are not accumulating to certain size classes by coagulation. This kind of size distribution cannot be represented by 4 modes and in this study the problem culminates in that there is a persistent gap between the two largest modes. One option could be to use more modes, but then the computational benefits compared to sectional schemes would become smaller. In the standard setup of M7 (the largest) coarse mode width is 2.0 instead of 1.2 which is used here. This would make the gap between the two largest modes smaller. However in the case of stratospheric sulfur injections or a large volcanic eruption, a wider coarse mode width leads to a tail of large particles. This causes an overestimation of the*

effective radius of the coarse mode and increased the sedimentation velocity and reduced residence time of aerosols in the stratosphere which is the reason why the different setup is used for stratospheric aerosols. One option could be to increase mode widths of the Aitken and accumulation modes. However, number concentrations of these modes are typically higher and thus widening of the modes can lead to a situation, where widened mode would cover the adjacent larger mode. It is also good to keep in mind that the partitioning of sulfuric acid to particle phase due to nucleation over condensation was suspiciously large in SALSA and the model produced significantly larger net total radiative forcing than in e.g. Kleinschmitt et, al. (2018), where simulations were done with the sectional model. Thus, even though there was not as clear a shortcoming as the gap between modes in M7, there is a need to analyze the individual microphysical processes and to understand the differences between the results of different sectional models."

I found numerous typos, LaTeX issues, and other errors at the word and sentence level, both in the text and figures. Another round of proofreading (or having ACP do copyediting) would be useful.
We did a round of proofreading and tried to fix issues.

I found the description on lines 241-248 confusing. You first attribute the difference between the studies to different LW treatments, then the optical properties, and then the different size distributions. Which is it and how do you know?
We added the word "probably" to line 243, which now reads:
"*This indicates that differences in radiative forcings between the studies are probably caused by differences in the LW radiation transfer, i.e in using a different radiative transfer scheme, or differences in the aerosol optical properties in LW radiation calculations.*"
We just wanted to bring up possible explanations for different results between our study and Kleinschmitt et al. (2018). To say which one is causing the differences, or if there is some other explanation, we would need to have more information about Kleinschmitt et al. (2018) results and about the model used in their study.

Line 267: I see four modes in Figure 2, so it's not obvious to me which one you're calling the accumulation mode. I'm guessing the second-largest one, since that would fit with small changes in number concentration?
The reviewer is correct. It is the second largest mode. We added the name of the modes in the caption of Figure 2, which now reads:
"Figure 2. Aerosol number size distribution at the Equator and at 20-22 km altitude in scenarios with different injection rates simulated with M7 (names of the four modes from the left: Nucleation, Aitken, Accumulation, Coarse) and SALSA (10 size bins, there is no significant number of aerosols in largest bin, and thus it is not shown in the figure.). Dots on ..."

Note that we also changed Figure 2 based on comments from the other reviewer.

First line in section now reads (2.1.2): "*In M7, aerosols are represented using a superposition of seven log-normal modes, 4 for soluble (nucleation, Aitken, accumulation and coarse) and 3 (Aitken, accumulation and coarse) for insoluble material.*"

Line 268: How does the coarse mode change in size? That capability/feature seems like it should be mentioned in Section 2 in your description of M7.

We modified section 2.1.2 which now reads:

"Similarly to Niemeier and Timmreck (2015), we modify the setup of the modes so that the coarse mode is made narrower than in the standard setup (using standard deviation σ_{CS} = 1.2 instead of 2.0). In the case of high sulfur concentrations, a coarse mode with 2.0 standard deviation has been shown to lead to a tail of large particles (Kokkola et al., 2009). Based on Kokkola et al. (2009) this caused an overestimation of the effective radius of the coarse mode, when compared to the highly resolved particle spectrum reference model, and thus increased the sedimentation velocity and reduced the residence time of aerosols. In M7 the median size of the mode can change, but only between mode specific maximum and minimum threshold radii. For the nucleation mode there is no lower threshold radius and for coarse mode there is no higher threshold radius. This threshold radius also defines when aerosols are transferred from one mode to another. As in Niemeier and Timmreck (2015) we changed this threshold radius between accumulation and coarse mode (the two largest modes) from 0.5 µm to 0.2 µm."

Line 270: You could quantify "considerably different" by integrating the area under the pink curve that falls within the coarse mode.

Unfortunately, this line was written confusingly. Line 270 was not meant to refer to the previous line. Here we wanted to say that generally speaking, the size distributions between our study and Niemeier and Timmreck 2015 are considerably different.

Line 270 now starts the new paragraph and now reads: "*Compared to the aerosol size distribution in Niemeier and Timmreck (2015), the size distribution based on M7 simulations in our study was considerably different.*"

Lines 275-276: As written, this is kind of a throwaway claim. You have to show that this matters if you're going to claim it. Same comment for lines 467-468 and line 500.

Lines 275-276 is rewritten as following: *"In addition, the difference between our study and Niemeier and Timmreck (2015) is a different version of the GCM and different resolution used in the model. Niemeier and Schmidt (2017) have shown that low and high vertical resolutions led to different stratospheric dynamics which further caused differences in aerosol sizes in SAI simulations"*.

We are now citing Niemeier and Schmidt (2017) on lines 467-468.

We added *"Our results indicate that "* to Line 500 as this claim is discussed in the text and is based on the results: *"Our results indicate that the impact of atmosphere dynamics on aerosol microphysics had a clearly larger role when injecting.. "*.

Lines 291-297 (and also section 3.2): So which one is right? My guess would be that SALSA is closer to the truth (although certainly not perfect), and I acknowledge that this is hard to verify based only on Pinatubo, but I'd like to see you talk more about this.

We do not want to make any strong statements which one is right. As you mention, it is really difficult to verify. Obviously there are some numerical issues especially in M7 and the gap between the modes which we wanted to bring up. Our main message in this study is that there are a lot of uncertainties when modelling SAI and there is a certain need to decrease these uncertainties and improve our aerosol models. Anyway now we discuss this more in conclusions (see our reply for first comment).

Lines 618ff: True, for equatorial injection (as you say later).
This is now rewritten as: "*One consequence of the warming of the tropical stratosphere in case of equatorial injection is the slowing down of the quasi-biennial oscillation.*."

Other corrections:
1) "and forcing efficiency" is removed from Figure A1 panel titles
2) Caption of Fig A3 is fixed, colors are changed and number distribution of M7 simulations is now shown as sum of the modes (thus not showing individual modes separately).
3) We added a comment to Section 2.2 that concentration of injected sulfur varies in the seasonal scenario during the year: *"Note that as injection band is always 20° latitudes wide and a same mass in injected in every month, the concentration of injected sulfur is smaller during the times when the injection area is located over the Equator compared to times, when it is over midlatitudes"*