Anonymous Referee

> During the Asian summer monsoon, strong deep convection helps lift aerosols from pollution into the tropical upper troposphere, lower stratosphere where it can impact radiation directly or by changing the thermodynamic and dynamic conditions of those layers. This paper introduces new radiative kernels designed specifically to quantify these components of radiation change in the tropical UTLS where this Asian Tropopause Aerosol Layer (ATAL) occurs. The paper shows these kernels are computationally efficient yet still able to properly represent the total aerosol radiative effects originally simulated directly by fully complex models. This manuscript is well written, and provides a nice approach to constructing aerosol kernels, which is a much needed tool. I provide some minor comments below.

Minor comments:

> 1. Line 48: Matus et al 2019 also developed aerosol kernels that the authors may consider citing and discussing in the into: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019GL083656

A brief discussion of this paper is in Line 48: Matus et al. (2019) used aerosol radiative kernels based on observations to estimate anthropogenic aerosol radiative forcing. Although their aerosol kernels are calculated by simply dividing changes of aerosols and radiations under linear assumption, the results are reasonable compared with CMIP5.

> 2. Line 98-100: I appreciate the need to use different data sources for different variables, but did the authors evalute these combinations for inconsistencies? For instance, are ERA5 temperatures sufficiently cold for instances where there is nonzero ice water content as reported by MLS? Or is the height reported by ERA5 a reasonable representation of where MERRA-2 thinks the aerosols are located? It would be useful to provide evidence of a sanity check to give the reader confidence that the dataset merging done here was appropriate.

The ERA5 temperatures in recent reanalyses near the tropopause are very similar to each other and in good agreement with radio occultation profiles (Tegtmeier et al., 2020). Heights based on ERA5 and MERRA-2 are somewhat different, mainly because MERRA-2 suffers from a warm bias in the upper troposphere. As a result, geopotential heights in MERRA-2 are somewhat larger than those in ERA5. But since MERRA-2 is just the basic state for the kernel form of Taylor series expansion, so we wouldn't expect this to matter much for the kernel computations. In the other word, we need an aerosol layer just for calculating kernel, but it doesn't need to be fully consistent with the actual situation.

The accuracy of ERA5 is supplemented in Line 100: The temperature from ERA5 is in good agreement with radio occultation profiles (Tegtmeier et al., 2020).

> 3. Line 184-186: What is the shading effect of aerosols? And why is it not impacting the linearity of aerosol radiation at the tropopause? The authors should provide more discussion here about why linearity holds so well at the tropopause calculations.

The discussion of "shading effect" is in Line 185: That is to say, most of the radiation that can be scattered and absorbed has already been interacted with by the existing aerosol particles, like shading the sunlight. The SW radiation that the newly added aerosol particles can interact with is markedly diminished. As a result, the influence of aerosols on radiation no longer follows a linear relationship.

> 4. Line 213-216: More explanation about why AAOD is so impactful on tropopause radiation and SAOD is not would be helpful here. It may not be intuitive to most readers, who are likely more experienced with TOA or Surface conditions.

The discussion is in Line 219: The significant difference in the impact of absorbing and scattering aerosols on radiative heating rate is that absorbing aerosols can directly absorb radiation and convert the absorbed radiation energy into thermal energy, thereby heating the surrounding atmosphere and significantly affecting the radiative heating rate. Scattering aerosols only change the direction of radiation propagation, but do not directly heat the atmosphere, and their contribution to the local radiative heating rate is relatively small.

> 5. Line 258: I can appreciate that aerosol effects have low sensitivity to the background thermodynamic or cloud state? But what about sensitivity to the background aerosol state? I would imagine a 10% aerosol perturbation in a high aerosol concentration condition vs a pristine condition would lead to a different radiative perturbation. And likewise, the heterogeneous spatial pattern of aerosol base state would matter. Is that the case? If so, does it mean the kernels are only relevant for simulations where the background aerosol fields are similar to those of MERRA2?

The state of the background aerosol is of great significance. However, when using the aerosol radiative kernel, it is not necessary to have the same background. Within the range of linear variation (not exceeding three times to radiative flux and no limitation for radiative heating rate), people can use kernels to calculate a new background radiation with different aerosol concentrations. And then calculate how the perturbation of aerosol could influence radiations with aerosol radiative kernels.

A supplement explanation is added in Line 399: A new reference state can also be defined with difference of aerosol concentrations.

> 6. Line 364: Mention of creating cloud kernels felt quite sudden as there was really no discussion of it in the intro. There are mentions of aerosol-cloud interaction but I thought that was in reference to setting the base state for the radiative transfer calculation. I recommend the authors spend a little more time in the intro or in this section explaining the motivation for making these cloud kernels and why its a natural fit to make these particular cloud ice kernels along with the aerosol kernels

The explaination about why cloud radiative kernel is included is in Line 151: Except aerosols, cloud also plays an important role to influence radiative effect. The cloud above upper troposphere is located at a height similar to aerosols and are mainly composed of ice particles. So the cirrus cloud radiative kernels in upper levels are calculated to compare with aerosols. The establishment of cloud radiative kernel also helps to better simulate radiation changes in the stratosphere. We describe cirrus cloud ice using an aerosol-type input file that specifies optical depth, single scattering albedo, and asymmetry factor.

> Conclusion: Especially since we are heading into CMIP7, I recommend a summary of the types of model various, levels and temporal resolutions one would need to apply these kernels to diagnose radiative effects. I suspect subdaily data is always needed given the preservation of diurnal information in the kernels, and often modeling centers do not provide more than monthly or daily mean data.

There is no limitation for model and temporal resolutions for these kernels, although they don't include hourly data, people can choose the time they want from kernel to calculate corresponding radiative effects. The recommendation of dataset has been added in Line 500: Dataset include 3-dimensional aerosol concentration or cloud optical depth data could use this radiative kernel, choose the corresponding month and local time to estimate stratospheric radiative effects.