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> This paper estimates the radiative fluxes and heating rates of absorbing aerosols, scattering aerosols, and cloud ice particles in tropical stratosphere using the newly developed radiative kernels. A notable merit of this study is the construction of aerosol kernels, and the application of them has the potential to better understand the radiative effects of aerosols in the upper troposphere and stratosphere.

## Major comments:

> 1. Line 221. It seems that the kernels are calculated by perturbing aerosols at each level simultaneously. To my knowledge, previous studies all established kernels (e.g., water vapor, cloud) by perturbing the variable at each level at one time. It is necessary to clarify and justify the choice.

Thanks for your comments, I didn't give a clear explaination. I just use kernels perturbing at each level simutaneously when testing kernel method, while the aerosol kernel at each level seperately in application part. To clearify my method, the modifications are: Line 221 "For convenience, aerosols are perturbed by increasing concentrations by 10% at each level simultaneously only when testing the accuracy of various kernel method."

Line 366 "We then use the results of these simulations to construct aerosol and cloud kernels at each level for UTS region." Line 397-Line 400 "$R=\sum(\Delta\tau l \times kl)+Rref$ (6), where l is the atmospheric level. A vertical one-dimensional kernel is calculated for the disturbance of aerosol at each layer, and the total aerosol radiative effect is the sum of that at each layer."

> 2. Line 285. The authors select four reference state boundary conditions for the kernel calculations. It is not clear why these four points are selected and why these points can represent clear-sky, low cloud, middle cloud, and high cloud conditions.

Those four represent points are chosen because of their relatively high frequency in the distribution of 200 hPa shortwave and longwave radiative flux. Due to the significant difference in corresponding albedo (or emission temperature), it could be assume that they represent four different scenarios, and we name these four sceranios as clear sky, low cloud, middle cloud and high cloud.

We modify the pharagraph in Line 283 - Line 288: By analysing joint plots of shortwave and longwave radiative flux at 200 hPa within 30°S – 30°N (only Fig. S3 shown here as 30°S example), we identify four representative points with relatively high frequency between 30°S – 30°N (four red stars in Fig. S3). The albedo and emission temperature calculated from 200 hPa radiative flux are listed in Table 3, which can be regarded as four reference state boundary conditions. Four different albedos could broadly represent four different cloud cover in the underlying troposphere, name as clear-sky, low cloud, middle cloud, and high cloud. The upper troposphere lower stratosphere aerosol kernels are based on these four scenarios, with the frequency decreases sequentially.

> 3. Line 298. It seems that the changes of water vapor and ozone in the upper troposphere and stratosphere are ignored in the simulations. Any estimate of its impact?

We think the change of ozone and water vapor won't influence aerosol radiative effect. To test that, we run the rrtm model with different times of ozone and water vapor, even 1.5 times of them only cause about 0.001

W/m2 difference of aerosol radiative effect for both longwave and shortwave, which can be regarded as systematic error. We can emphasize this in the paper.

Modification in Line 298: Due to the changes of radiatively active components like water vapor and ozone do not significantly affect aerosol radiative effects, they are assumed have no large variations in UTS.

> 4. Line 299. The new kernels are constructed based on several linearity assumptions. However, it is not clear whether the cloud radiative effect varies linearly within a range of COD and whether the total radiative effects of aerosols and cloud ice can be represented as a linear sum of radiative effects associated with AOD and COD. It is necessary to validate these assumptions.

To improve our ability to represent the radiative effects of aerosol-cloud interactions through the kernels, we describe cirrus cloud ice using an aerosol-type input file, in other word, using the same module to calculate aerosol and cloud radiative effect in RRTMG, which is explained in Line 151-154 and shortly mentioned again in Line 301. So the variation of COD has the same pattern as AOD and can be linearly summed. Figure 5, 6 and 7 represent the all-sky radiative flux, which include both aerosol and cloud radiative effects.

To strength this, a sentence is added in Line 220: Since cirrus clouds are regarded as aerosols in model calculation, the radiative effects of cirrus clouds also conform to this conclusion.

> 5. Figures 2, 3, 5-7, S3. The authors select several months (i.e., January, May, July) to validate the assumptions of kernel calculations. Are these months representative? Are the test results in other months consistent with the results in these months?

We have plotted the aerosol and cloud distribution zonally averaged between 30°S – 30°N at each month, the variations across each month are not large, so it doesn't make much difference which month to choose.

I would show the distribution of AAOD, SAOD and COD in supplementary file as Figure S2 - S4, and give an explaination in Line 212: the radiation effects in July is chosen here. Due to the variations in AAOD, SAOD and COD are small in each month (Fig. S2 - S4), consistent conclusions were drawn for the remaining months.

## Other comments:

> 1. Line 200. Please correct the time range of reference state.

The modification is in Line 200: The atmospheric reference state is taken as the July 2019 average from MERRA-2 and the target state as July 2020.

> 2. Line 314. “Figure 5 and Fig. 6”. Please use the uniform expression.

The template of this journal said: "The abbreviation 'Fig.' should be used when it appears in running text and should be followed by a number unless it comes at the beginning of a sentence, e.g.: 'The results are depicted in Fig. 5. Figure 9 reveals that.'". In Line 314, the sentence "Figure 5 and Fig. 6 show comparisons of ..." meets the formatting requirement.

> 3. Lines 413, 420, 478, 496. Please correct the superscript and subscript.

Modification has been done.

> 4. Table 2. Please add RMSE for the kernel calculation.

Modification has been done in Table 2, and some misuse of slope and correlation coefficient in Table 2 have been corrected in this revision.