The authors have investigated aerosol-induced changes to cloud properties in shallow maritime tropical clouds. The modelling study demonstrates that increasing the aerosol loading enhances aerosol regeneration at the expense of rainout regardless of aerosol type. Such studies are very important for a process-based understanding of aerosol-cloud interactions. However, clarity and precision are lacking in the manuscript. However, clarity and precision are lacking in the manuscript.

The topic "Aerosol-cloud impacts on aerosol detrainment and rainout in shallow maritime tropical clouds" is of interest and fits the scope of EGUsphere. The paper can be accepted with major revisions. Please see the comments below.

We thank the reviewer for their very helpful comments, which have greatly improved the quality of our manuscripts. Responses are listed below in blue.

Major Comments:

1. In Figure 1, the schematic illustrates entrainment from the cloud base. Does it mean that there is no lateral and cloud-top entrainment? Then what contributes to the hydrometeor evaporation at the cloud top?

Thank you for raising this point. We initially chose to illustrate entrainment at the cloud base only in order to simplify the figure. However, the reviewer is correct that there is also lateral and cloud top entrainment, which we have now included in the revised Figure 1.

2. The authors clearly explain that at higher aerosol loading, rather than being removed to the surface via rainout, it enhances aerosol regeneration. It is then transported to the free troposphere, where they remain available for reactivation and further aerosol-cloud interactions, which is clearly illustrated in Figure 1, which is a single-layered cloud. Now the question is, how does this relation in a multilayered cloud? So is this finding only apply to single-layer clouds?

The cloud field we simulated in this study was composed only of single-layer cumulus and congestus clouds, the kind of which is illustrated in Figure 1. However, the reviewer raises an interesting point about multilayered clouds. We suspect that in such a scenario, there would be multiple detrained aerosol layers at different levels where clouds are detraining. We saw similar scenarios in the field during the CAMP^{2}Ex field campaign, where congestus and deep convective clouds were simultaneously detraining. However, we would need to run further simulations with multilayered cloud fields to confirm this. Furthermore, aerosol that are detrained from lower clouds then have implications for entrainment by clouds at upper levels, as we now discuss in lines 469-471: "Instead, the aerosol particles are regenerated aloft, where they form an aerosol detrainment layer (or potentially, in the case of multilayer clouds, detrainment layers) that can serve as an aerosol source for future midlevel and multilayer clouds (Leung and van den Heever, 2022)."

3. This study investigates the aerosol impacts on shallow maritime tropical clouds, specifically the influence of aerosol budget. Out of four aerosol types, Mineral dust and ammonium sulphate also can act as INP. From Figure 2, it is evident that the cloud's top height reached up to 7 Km. How does it influence the aerosol budget? Is this also considered by calculating the aerosol budget?

Because the focus of this study was on warm phase convection (shallow cumulus and congestus clouds), we did not specifically vary the INP between simulations. Instead, in all simulations, we prescribed a fixed concentration if INP starting at 0.01 # cm^{-3} at the surface and decaying exponentially in the vertical, with a scale height of 7km. We describe this in lines 99-100: " In all simulations, ice-nucleating particles (INP) were also initialized with concentrations starting at 0.01 # cm^{-3} at the surface and the same vertical structure as the aerosol field." Additionally, aerosol mass could be transferred when liquid water is transferred to ice species; any aerosol mass existing within the ice species was also included in the "in-hydrometeor" term of the aerosol budget, as specified in lines 108-109: "As water mass was transferred between hydrometeor species (i.e., cloud, drizzle, rain, ice, snow, aggregates, hail, graupel), a corresponding fraction of aerosol was also transferred."

4. Under increased aerosol loadings, the cloud droplets are smaller, and it enhances the cloud albedo. In addition, the regenerated aerosol particle interacts with the radiation. How does aerosol regeneration influences total and effective radiative forcing?
We were not entirely sure of what the reviewer is asking here.

If the question is whether the regenerated aerosol particles are accounted for in the total and effective radiative forcing, then the answer is yes. Regenerated aerosol particles are assigned the same radiative properties as the unprocessed aerosol, and thus still contribute to the overall radiative forcing.

If the question is requesting more detailed information about the role of these regenerated aerosol particles of different types on the radiative budget, then while we agree this is an important consideration, this is beyond the consideration of this paper. However, we do show and discuss the radiative heating rates and differences as a result of aerosol loading and type in Section 5.

5. It would be much appreciated if you could include the model domain details as well (for example, latitude and longitude) in the experimental setup.
We have now included information about the domain latitude and longitude in Table 1.

6. In section 2.3, it is mentioned that "..updrafts weaker than 1 ms-1 are necessarily excluded from the analysis". The model domain is over the ocean, and the model is initialised using CAMP2Ex observations. What was the observed range of updraft velocities in CAMP2Ex? I expect for the marine clouds, the updraft between 0.01 to 1 m s−1 would be quite strong. Is this a simulated case with a high vertical velocity?
Thank you for raising this point. The simulated cloud field produced tens of thousands of updrafts with maximum vertical velocities above 1 m s^{-1} (see Supplementary Figure 1e-h, which shows the maximum updraft is 10-30 m s^{-1} for most of the simulation period). Although complete measurements of the updraft velocity PDFs during CAMP^{2}Ex are unfortunately not as yet available, our simulations are consistent with observations of numerous individual updrafts over 1 m s^{-1} were observed (Reid et al. 2023). The PDF of vertical velocity here is also in keeping with past modelling studies of the same region (e.g., Leung and van den Heever 2022, Sokolowsky et al. 2022).

As the reviewer says, there are indeed numerous updrafts between 0.01 to 1 m s^{-1}. However, these weak updrafts do not significantly impact the domain-wide precipitation or aerosol budget. The table below shows the percent of precipitation and aerosol rainout attributed to all updrafts above 1 m s^{-1} and to features which pass all our QC thresholds. Weak updrafts below 1 m s^{-1} contribute less than 1% of all precipitation and less than 2% of all aerosol rainout, and thus are not important for the results we present.

		All Updrafts > 1 m s^{-1}		**Features passing QC**	
		Precipitation	**Aerosol Rainout**	**Precipitation**	**Aerosol Rainout**
Ammonium Sulphate	100 cm^{-1}	99.2	98.9	81.7	83.0
	500 cm^{-1}	99.1	98.9	77.3	78.5
	1000 cm^{-1}	99.0	98.8	78.6	77.2
	1500 cm^{-1}	98.9	98.9	74.8	74.0
Sea Salt	100 cm^{-1}	99.2	98.9	82.3	85.7
	500 cm^{-1}	99.1	99.0	91.1	81.6
	1000 cm^{-1}	99.0	98.8	78.4	77.2
	1500 cm^{-1}	99.1	99.1	76.3	76.3
Absorbing Carbon	100 cm^{-1}	99.1	98.0	79.2	82.2
	500 cm^{-1}	99.0	98.3	80.0	80.4
	1000 cm^{-1}	99.2	99.0	79.6	78.6
	1500 cm^{-1}	99.1	98.9	75.4	74.4
Mineral Dust	100 cm^{-1}	99.1	97.9	81.2	82.3
	500 cm^{-1}	99.1	98.4	79.3	81.3
	1000 cm^{-1}	99.1	98.6	78.2	78.4
	1500 cm^{-1}	99.2	98.9	76.0	75.4

We have added a statement on this in lines 170-174: "Although there are numerous updrafts with maximum vertical velocities below 1 m s^{-1} present in the simulation, we found that such weak updrafts do not contribute significantly to the precipitation or aerosol budget, accounting for less than 2% of precipitation and aerosol rainout. Furthermore, after applying all our QC thresholds, we found that a vast majority of the falling rain and rained out aerosol (75-80%) could be attributed to the remaining features, and that this was consistent across all these simulations."

Minor Comments:

1. Page 2, l34; please correct heterogenous to heterogeneous.

We have changed this.

2. Page 2, l36; Please change cloud top to cloud tops

We have changed this.

3. Table 1; Please expand ERA-5

We have now defined ERA-5 on page 4, line 81.

4. Table 1; Please expand AGL

We have now defined AGL

5. Table 1; Please mention LEAF-3
We have now defined LEAF-3.

6. Page 5, l94; “Aerosol particles were initialized in the unactivated aerosol category.” Cloud, please elaborate on it; what are these unactivated aerosol categories? It would be easier for the readers to understand.
We have updated this sentence (lines 104-106) to better explain this: “Upon initialization, all aerosol particles are initially categorized as unactivated aerosol, i.e., aerosol particles which have not yet been activated in cloud droplets.”

7. Section 2.3: A very brief explanation of the Tracking and Object-Based Analysis of Clouds (tobac) would be helpful for the readers.
The first paragraph in this section does provide a description of how *tobac* works (feature identification, tracking, and segmentation).

8. Page 8, l146: Is QC means quality control? Then please abbreviate it before (P7, l132).
We have now defined QC on line 155.

9. Figure 2: It would be better to have alternative altitude levels (0,2,6,..) for better understanding. Also, please move a bit down the x and y-axis texts.
Thank you for this suggestion. We have changed the tick marks for the altitude labels and moved down the x- and y-axis labels.

10. Figure 2 Caption: Please change g kg-1 to g kg^{-1}
We have now changed this.

11. Figure 2 Caption: Please add unit to potential temperature (K).
We have now added this.

12. Figure 3: In Figure 3b, At lower initial surface concentration, except ammonium sulfate, all other aerosols increase with initial aerosol mass. An explanation would be useful for the readers.
The trend that the reviewer is pointing to between the 100 and 500 # cm^{-3} simulations is actually not consistent in time (see Supplementary Figure 2e-h). Given that any apparent trends in the percent of aerosol in the in-hydrometeor category are small in magnitude, not stable in time, not consistent between aerosol types, and not monotonic with concentration, the evidence does not appear to support a physically driven trend in this aerosol category. We have therefore chosen not to focus our discussion on this.

13. Figure 4: Please add units to the parameters in the figure caption.
We have added the units in the figure caption.

14. Figure 5: Please add units to the parameters in the figure caption and to the Figure titles.
We have added in the figure caption that all process efficiencies are in % of condensed vapor. This is already indicated on each panel of the figure.

15. Saturation effect for the rainout: Would it be possible to show this, perhaps an additional figure?

We were not entirely sure of what the reviewer is asking here. Figure 7c does show the drop-off of the aerosol rainout rate with increasing aerosol loading, which demonstrates the saturation effect we describe. It is possible that with further simulations at increased aerosol loadings, the graph could be extended to extend this trend further; however, this is beyond the scope of this current paper.