Reviewer Comments:

Thanks to the authors for thoughtfully addressing the reviewer comments. I still have two fairly important concerns with this version, but minor revisions should be sufficient to get it in publishable shape. -MD

Aerosol number sink: I'm not sure why the authors say "possible" coagulation, and have decided not to check aerosol mass (which is almost certainly an available output) in addition to number. Dilution and turbulent mixing cannot reduce aerosol domain-wide, by definition, unless those processes also enhance the rate of cloud processing, coagulation, or dry deposition. Cloud processing and impaction are both related to precipitation, which the authors also establish is small in their simulations. If number is lower but mass is similar between the simulations, you can conclude coagulation is the dominant number sink even without process-based outputs. Since this is a critical component of the main finding of the paper, I can't recommend publication until the authors investigate this in sufficient depth (which, again, likely only requires a brief look at aerosol mass).

We thank the reviewer for this important comment.

We agree that comparing aerosol number with aerosol mass would provide a valuable constraint on the role of coagulation, and we have therefore undertaken additional diagnostics to investigate the aerosol sink in greater depth.

Unfortunately, the standard Thompson aerosol-aware scheme used in our simulations prognoses aerosol number concentrations but does not provide a directly comparable prognostic aerosol-mass concentration. Although aerosol mass information is involved in the aerosol representation, aerosol mass cannot be uniquely reconstructed from the available aerosol-number fields without additional assumptions about particle size distribution, density, and composition. We therefore cannot perform the proposed direct comparison between aerosol mass and number in our simulations. We now explicitly acknowledge this limitation in the revised manuscript.

Nevertheless, we have conducted two additional diagnostics based on the available aerosol number fields. Specifically, we examined: (1) the aerosol number profiles for columns with high, moderate, and low aerosol concentration (Figure R1), (2) vertical profiles of aerosol number concentration separately for cloudy and clear-sky columns (Figure R2).

These diagnostics provide additional lines of evidence concerning the likely aerosol-number sinks. Firstly, looking at very high local aerosol number concentration point close to the source station in these experiments, EXP100 shows the strongest reduction in aerosol number (~92% loss) below approximately 0.75–1.0 km, whereas the reduction is weakest (~74% loss) in EXP20. In contrast, the aerosol number loss becomes much less pronounced at locations farther from the sources, where aerosol number concentrations are only low to moderate (Figure R1). This concentration-

dependent aerosol number loss is consistent with an important role of coagulation, because the efficiency of coagulation increases with particle number concentration. Dry deposition may also contribute, particularly in the near-surface layer. However, without process-specific tendency diagnostics, we cannot quantitatively distinguish the relative contributions of coagulation and dry deposition.

Comparison of the cloudy and clear-sky profiles (Figure R2) shows an additional reduction in aerosol number in cloudy columns around approximately 0.75–1.0 km, close to the cloud-base height in these simulations. This behaviour is consistent with an additional cloud-related aerosol sink once aerosols enter the cloud layer.

We have therefore revised the manuscript to avoid attributing the number reduction uniquely to coagulation as below. Instead, we now state that the diagnosed behaviour is consistent with concentration-dependent coagulation, potentially combined with dry deposition, with an additional contribution from cloud-related processing near cloud base. We explicitly acknowledge that the absence of aerosol mass output prevents a definitive separation of these mechanisms.

We believe these additional analyses address the reviewer's concern by providing independent spatial and vertical evidence for the processes contributing to the aerosol-number sink, while avoiding a stronger process attribution than can be supported by the available model diagnostics.

"In the sparse-source configuration (EXP100), aerosol emissions are concentrated at fewer locations, producing much higher local aerosol number concentrations near the source regions. Multiple processes may contribute to this behaviour, including cloud processing, dilution, possible coagulation, and deposition. However, it should be noted that aerosol mass and process-specific tendency diagnostics were not archived in these simulations, so the relative contributions of coagulation, dry deposition, cloud processing, and transport cannot be quantitatively separated. Therefore, to investigate the aerosol number sink further despite the lack of aerosol mass output, additional diagnostics have been analysed (Figure S3 and S4). These show that aerosol number reduction is strongest at locations with high aerosol concentration and becomes much less pronounced farther from the sources, where aerosol number concentrations are lower (Figure S3). This concentration-dependent behaviour is consistent with an important role for coagulation, which becomes increasingly efficient as particle number concentration increases. Dry deposition may also contribute, particularly within the near-surface layer.

The additional cloudy–clear-sky analysis (Figure S4) further shows an enhanced reduction around approximately 0.75–1.0 km in cloudy columns, close to the simulated cloud-base height. This suggests that cloud-related processing provides an additional aerosol number sink once the aerosols reach the cloud layer. Although dilution, turbulent mixing, and transport can modify the local aerosol distribution, these processes redistribute aerosol and cannot, by themselves, account for a net domain-wide reduction in aerosol number. Overall, the diagnostics are consistent with concentration-dependent coagulation, potentially combined with dry deposition and cloud-related processing, while the available model output does not allow their relative contributions to be quantitatively separated."

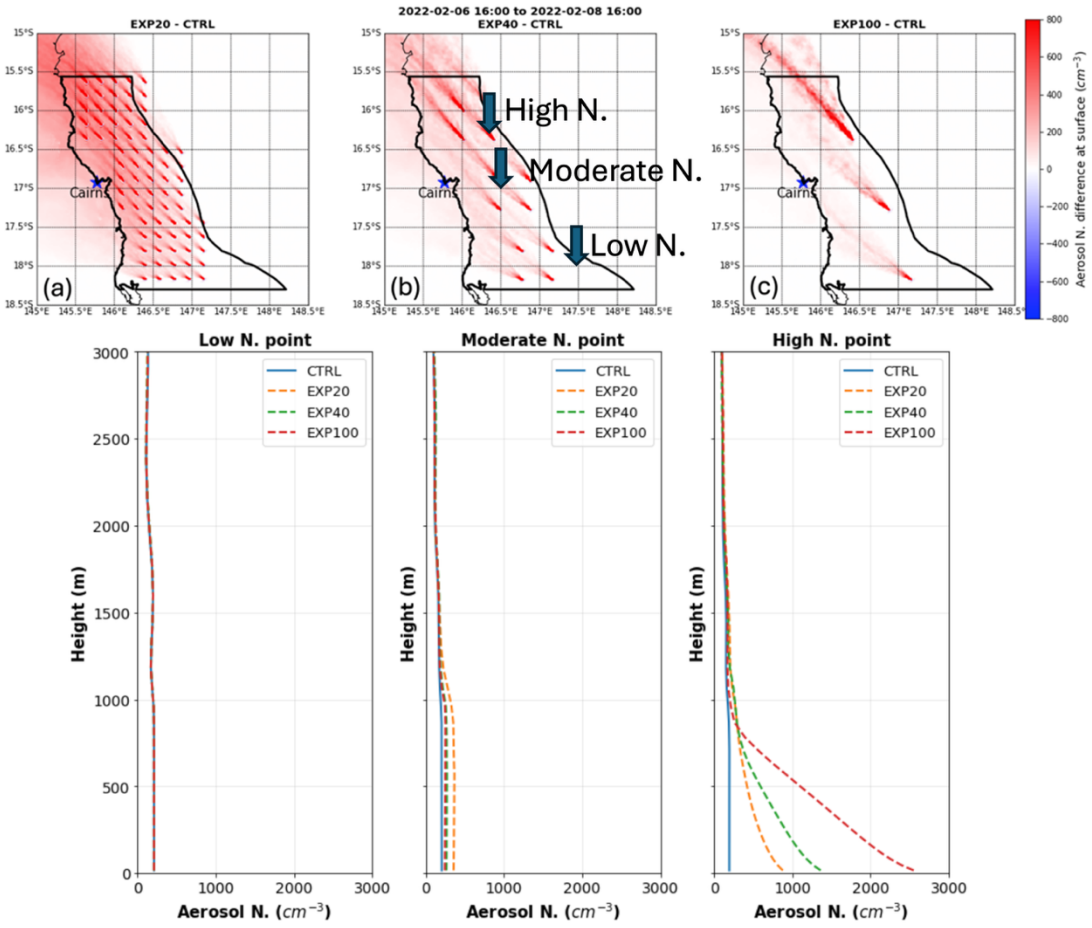

Figure R1: Aerosol number concentration profiles for columns with low, moderate, and high concentrations. The time period of this analysis is from 1600UTC 06 Feb 2022 to 1600UTC 08 Feb 2022.

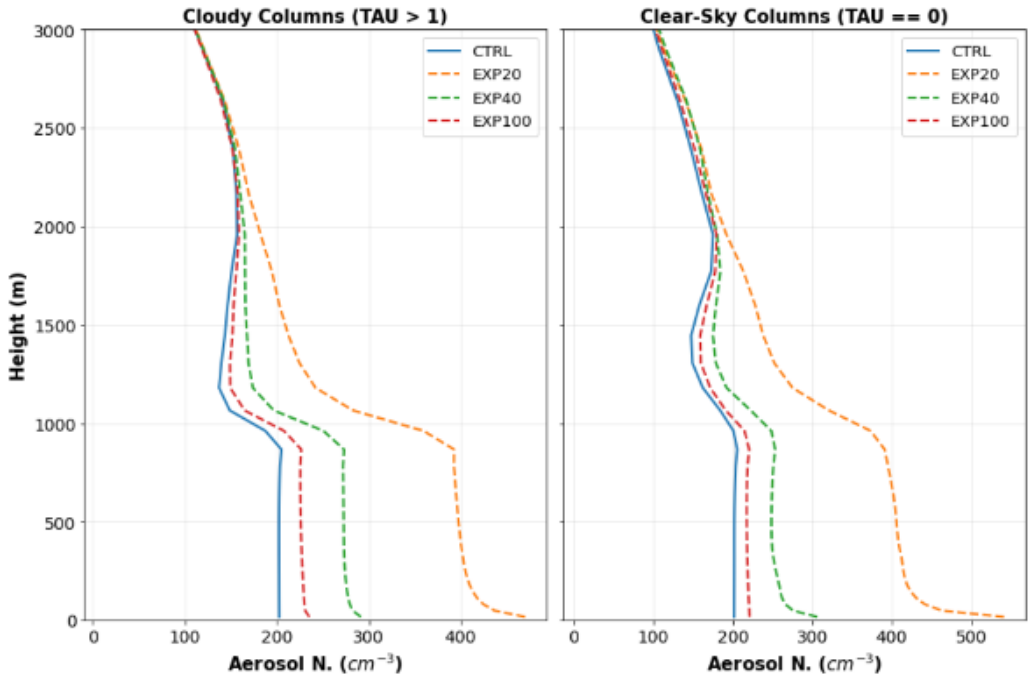

Figure R2: Domain-averaged vertical profiles of aerosol number concentration for cloudy and clear-sky columns. Cloudy columns are defined as those with optical depth (TAU) > 1, while clear-sky columns are defined as those with TAU = 0.

CRE: Check the sign here -- CRE should be strongly negative for shallow clouds. Although shortwave CRE is zero at night, net CRE would be slightly positive due to the longwave effect. If this is SW-only, it should be noted on the plot. Also note that the CRE results would be more relevant averaged over the whole domain, not just cloudy points, as the cloud fraction is a major factor as well.

Thank you for this comment. The CRE analysed here is the shortwave cloud radiative effect (SW CRE), rather than the net CRE. The calculated SW CRE is negative, as expected for shallow clouds due to their shortwave cooling effect. In the original figure, we plotted the absolute magnitude of the negative SW CRE to facilitate comparison of the cooling strength among CTRL, EXP20, EXP40, and EXP100. We have revised the figure caption and label to explicitly indicate that the quantity shown is the magnitude of SW CRE, |SW CRE|, rather than net CRE.

We also agree that averaging over the whole domain provides a more representative measure of the overall radiative impact because it incorporates changes in cloud fraction. We therefore conducted the analysis using domain-mean SW CRE, including both cloudy and clear-sky grid points (Figure R3 and R4). The relative behaviour and differences among the experiments remain consistent with the cloudy-pixel analysis. However, the magnitude decreases from approximately 200 W m^{-2} for the cloudy-point average to approximately 50 W m^{-2} for the domain average. This reduction is expected because a substantial fraction of the domain consists of clear-sky grid points, where SW CRE is close to zero. We have added this domain-average analysis to supplementary (as Figure S6 and S7) and keep Figure 7 and 8 showing cloudy pixels analysis for consistency and clarified the distinction between cloudy-pixel and domain-mean CRE in the revised manuscript.

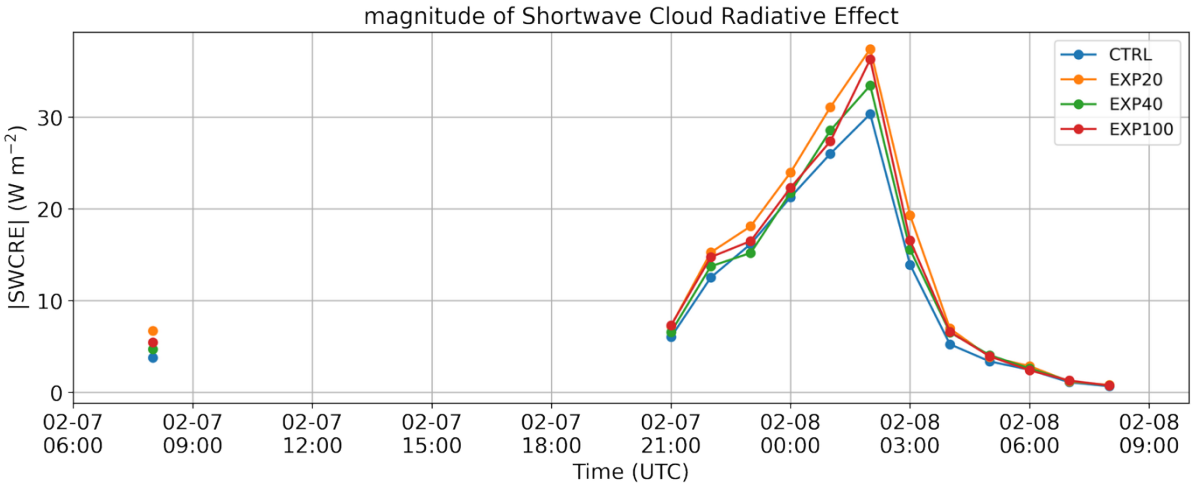

Figure R3: Time series of domain-averaged magnitude of shortwave cloud radiative effect over the Carins Region.

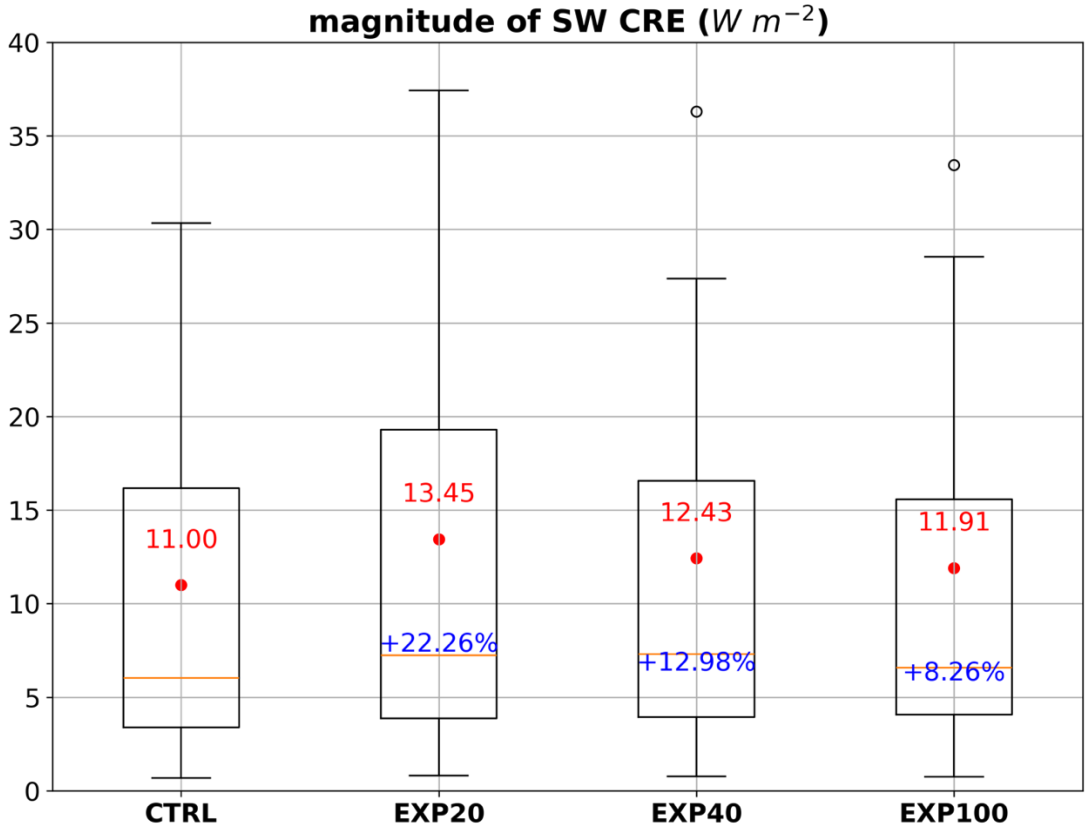

Figure R4: Boxplots of magnitude of SW CRE over the Cairns Region from CTRL and sensitivity experiments. Statistics are calculated for the period from 08:00 UTC on 7 Feb to 08:00 UTC on 8 Feb 2022.