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Comment on acp-2022-351

Anonymous Referee #1

Referee comment on "Microphysical, macrophysical, and radiative responses of subtropical marine clouds to aerosol injections" by Je-Yun Chun et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-351-RC1, 2022

Review comments on “Microphysical, Macrophysical and radiative responses of subtropical marine clouds to aerosol injections” by Chun et al.,

General comments:

In this manuscript, the authors investigated the processes controlling the microphysical, macrophysical, and radiative response of clouds to aerosol injections from ship tracks through 5 simulations with various aerosols and free tropospheric moisture. Two novel methods are presented in the analysis. The first one decomposes the response of LWP to aerosols into the contribution from boundary layer processes, MBL decoupling processes, the response of cloud fraction, and the response of adiabaticity to aerosol injection. The second one decomposes the response of CRE to aerosol injection to the contribution from the response of droplet number concentration, LWP, and cloud fraction to aerosols. Both methods facilitate better analysis to improve the understanding of aerosol-cloud interaction processes associated with marine clouds. Overall, I think this manuscript meets the requirement of ACP and I recommend publishing it after addressing the following comments.

Major comments:

- The three polluted cases use a smaller domain than the “pristine” and “middle” cases. The authors explain in lines 146-149 that the wider domain for the pristine and middle case is for mesoscale circulation, which is more significant in the precipitation cases. By comparing the roll cloud size between the middle and polluted case, it looks similar if the "mesoscale circulation" refers to the mesoscale circulation which maintains the formation of roll structure. So, I am not quite convinced that a different domain size is necessary. I recommend using 96 km X 9.6 km for all the simulations so that many analyses using domain and run averaged values can be more robust.

- Section 3.2.4 shows the budget analysis of the impacts of 5 different processes on the cloud number concentration. But the method to decompose the droplet number concentration is omitted. Given the importance of the information, I recommend including the method in detail either in the main context or in the appendix.
- Line 215-216: "the low A may be attributed to the low qc,inv caused by the high sedimentation velocity of large cloud droplets…." How about the role of cloud thickness in low A?

Minor comments:

- Line 109: above? Below?
- Lines 138-139: how do you adjust the free-tropospheric aerosol and divergence?
- Line 152: any reference for the number 10.5 m s-1?
- Line 177: "this reduces the primary source of turbulence in the marine low clouds (TABLE 2)". Which variable from table 2 do you use to analyze turbulence? I don't find TKE or other variables that represent turbulence.
- Equation 1: please include the mathematical equation for entrainment efficiency A to show how A relates to cloud liquid water amount.
- Lines 267-270: reduction in re leads to the changes in dA/A for all the cases. Are the processes associated with this relationship the same for all the cases?
- Lines 280-281: explain why stronger entrainment tends to sharpen the inversion. Entrainment leads to the mixing between the air above and below the inversion, which is supposed to smooth the boundary at the inversion level.
- Line 303-305: I assume this is referred from Figure 8, which has not been explained yet. Add "(Figure 8)" to help the readers to digest.
- Is it better to exchange the order of section 3.2.3 and section 3.2.2 for the purpose of organizing the paper? The contribution from decoupling is introduced in 3.2.3 but already discussed in 3.2.2.
- Line 594: clarify how to calculate fad the adiabaticity.
- Line 650: cloud optical thickness? Albedo?