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Atmospheric Chemistry and Physics Discussions

# *Interactive comment on* "Top-down and Bottom-up aerosol-cloud-closure: towards understanding sources of uncertainty in deriving cloud radiative flux" *by* Kevin J. Sanchez et al.

**Anonymous Referee #2**

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Summary: This manuscript presents an observational analysis to understand sources of uncertainty in deriving cloud radiative flux. The observations are from a number of platforms, including ground based, UAV, and satellite measurements. They used a 1-D microphysical model in conjunction with observations to derive microphysical and optical properties of observed clouds. The differences were found in radiative fluxes between the simulated and the observed. They concluded that the cloud-top entrainment is an important source of uncertainty for the cloud radiative flux calculation; it is particularly true for decoupled cloud boundary layers because ground-based measurements are no longer enough to obtain reliable data in the decoupled cloud layer. Authors' overall analysis technique is good and their conclusion is important and in-



teresting. My main criticism is that some discussions and figures are not clear and confusing. I recommend publication after following comments are addressed.

I am wondering about the significance of showing the cloud-top extinction in Table 2 and 3. Even though the cloud-top radiative flux differences (Delta FR) in the two decoupled cases are larger than those in the coupled cases, delta sigma_ext values are similar for all the cases as shown in Table 3. The cloud-top value delta sigma_ext doesn't seem to mean a lot in terms of cloud optical property. Because the cloud-top radiative flux (RF) depends on the optical depth as shown in (2), it is probably more appropriate to show cloud optical depth (tau).

Page 2, line 71: "Such decoupled layers often contain two distinct cloud layers, . . . a lower layer within the well-mixed surface layer and a higher decoupled residual layer between the free atmosphere and surface layer". I don't think the surface layer can be well mixed because turbulent eddies there are too small near the surface to produce strong mixing. You probably meant surface based mixed layer. That is, a mixed layer that is connected to, but deeper than the surface layer. Why do you call a decoupled layer "residual layer"? Is there turbulence source in the decoupled layer? Does it have clouds?

Page 3, line 75: "the surface mixed layer". Surface based mixed layer?

Page 3, line 77 and line 80: " . . . involve cloud heating and surface cooling" and " i.e., evaporative cooling at the surface" I am not sure what is meat by the "surface cooling" or "evaporative cooling". Note that the surface evaporative cooling by surface moisture flux only cools the ocean surface, not the sub-cloud layer. I do not think the "surface evaporative cooling" directly contributes to the decoupling. Could you give a bit more explanation on this? An increase in the moisture flux with increasing SST enhances the cloud layer buoyancy flux, which intensifies the cloud-top entrainment to mix warmer and drier air into clouds, leading to negative buoyancy flux below cloud base.

Page 8, line 281-282 about Figure 8. Could you put the flight code (D05Sc, C11Sc, and C21Cu) inside the plot boxes? That would be easy to see. The caption of Figure 8 mentions the difference between UAV-observed (green measurements) and ACPM-simulated (black line) to calculate delta sigma_ext. But it looks like you also calculate the cloud free values too. Although the (a)-(f) are labeled in each plot, they are not used in the caption.

Page 10, line 354-357: "The UAV observations show both C11Sc have sub-adiabatic lapse rate measurements, compared to simulated moist-adiabatic lapse rates within the cloud (Table 2)…. The sub-adiabatic lapse rate is attributed to cloud-top entrainment …. at cloud-top (e.g., Figure 7a)" Where is the comparison between the observed and simulated lapse rate? I only see the simulated values in Table 2. Could you draw a line in Figure 7a to show the adiabatic lapse rate? It is hard to see the lapse rate is sub-adiabatic.

Page 11-12, 391-399: "For both C11Sc and D05SC,…... exhibit an approximately linear, proportional relationship (Figure10; Eq. 4.) … ". This paragraph is a bit confusing. What flights do those curves come from in Fig. 10? Could you state clearly which part you were referring to that is linear? In Fig. 10, the cloudy part (green curve) is not linear because qv is not conserved variable for condensation/evaporation process.

What is meant by "entrained air"? Does it consist of both free air and turbulent air or only free atmosphere and non-mixed air? Does it contain any cloud droplets? If not, why is it (red curve) not linear, particularly for the top panel plot?

What is the flight code (or number) for these two plots in Fig. 10? Please identify the blue dashed line in the text when discussing the entrainment conditions. There is no (a) and (b) in Fig 10. "Measurements above cloud-top (RH < 95%) with qv > 5.1 g kg-1 and qv > 6.5 g kg-1 are used to represent the properties of the entrained air". How do you choose this criterion for the entrained air? You should specify clearly the properties of the non-mixed sources of air: what are the values of theta_e and q_v of the air source? The orange circles include too many possibilities of these values.



Line 391: "Figure 11 shows the relative humidity and theta_e profiles used in Figure 10. …". The discussion following this sentence seems to be related to Figure 10. There is no discussion on Figure 11. Fig. 11 caption says " …used in Figure 9". It should be Figure 10?

Page 12, line 401-405. "Figure 12 shows …approaches zero". There is not much discussion on Fig. 12. What does Figure 12 suggest? What is the definition of Delta theta_ent ? Which curve best represents observation? Does the figure mean that sigma_ext is sensitive or not sensitive to the entrained air properties?

Page 12, line 407-419. Does Table 3 include the entrainment sensitivity results from Figure 12?

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