

Review of “Impact of the Variability in Vertical Separation between Biomass-Burning Aerosols and Marine Stratocumulus on Cloud Microphysical Properties over the Southeast Atlantic” by Gupta et al

This paper presents new and interesting measurements of aerosols and clouds from the ORACLES field study in this special issue. The measurements appear to be of a high quality and are presented well (in terms of the graphs)- the author has taken a large dataset and condensed it down into some useful figures. The first half of the paper is excellent- I have little of substance to say on the introduction and experimental sections. Then I reached the results sections 3&4, where the reader is presented with a monumental wall of text, which ends up being quite difficult to read. I was waiting for a discussion to help me make sense of it all, how it relates to the indirect and semi-direct effects, and which aspects are the most important, and then the discussion never came! If the intention is simply to provide numbers to put in a model, then I think you should rebrand this as a measurement report. If the intention is to give some original scientific insight using your results, then you should do this by adding a discussion section.

Major comments

Please add some sort of graphical or tabular summary of your results/conclusions. A bit like Table 5, but with words to help the reader.

L408 – 413 “The differences between contact and separated profiles in low- N_a ...” and “Consequently, the differences between contact and separated profiles in high- N_a ...”
These two statements are your actual science conclusions. Everything prior to this is largely a stamp collecting exercise. As in, we know from previous literature and your introduction that when pollution plumes mix into the cloud layer, the clouds become more polluted, and most of your paper is about putting some numbers on that. These two statements where you are summarising what you have inferred from these numbers about what are the main processes and drivers, those are actual conclusions. The first part of your discussion should focus on how you have come to these conclusions. The second should relate your results back to what you discussed in the introduction. The radiative effects depend on COT and microphysical properties at cloud top. You could discuss how the clean clouds with low below-cloud N_a are more susceptible to addition of extra aerosol than the clouds with a boundary layer that is already polluted (Twomey, 1991). And throughout your discussion, include some comparisons to relevant literature- look at other papers in the special issue, as well as other studies (certainly VOCALS, possibly DACCIWA and others).

Figure 9: This is actually a really key figure. It shows that the cloud depth is pretty much constant for all clouds sampled. If that wasn't the case then you couldn't do your normalised height plots, and you would have concerns that the semi-direct effects could dominate. Please add in somewhere about how much you think the semi-direct effects might have affected your results

Minor comments

L102 the end of the introduction is quite abrupt- it would be good to have a couple of sentences outlining what you do in this paper, such as what the different sections of the results are. In this study we present results from ORACLES. First we show a case study from one flight, then we look at a statistical analysis of several flights together.

2 Instrumentation section- there's some strange details in here. For example, I think I understand what you mean by the PCASP gain stage correction but I don't see how it's relevant if all you're doing is taking the total concentration. You mention lots of different cloud probes, hotwire probes etc., but then you only use the CAS and the 2DS for the cloud measurements. Also why do you mention the gas analyser first, when the aerosol and cloud are the focus of your measurements?

L114 Using the PCASP for total aerosol concentration- do you have an idea of the size distribution and what fraction of aerosol might be below the lower cutoff diameter of the PCASP?

L125 Whichever cloud probes you end up using, please briefly state how the size was calibrated, and give an estimate of the uncertainty in size and concentration

151 Is the CAS better than the CDP? I would normally think the CDP is better, but that's just using our instruments, yours may be different

Sections 3&4 Please divide each of these up into several subsections to break it up, and to guide the reader by summarising what you are talking about in each section

Figure 3: I suggest you make these just profiles, the time information isn't particularly useful. Also mark on cloud base and top heights with dashed lines

L119 the part about the big decrease in N_c between 0 – 0.25 in Z_n . This seems to only be one bin, so is it just a blip? It's difficult to tell how much data you have in any of these bins

L230 what part of the profile are these ratios from? The average?

L257 It is strange to mention these 4 regimes here and then not explain what they are.

L281 These violin plots- are they figure 10? If so then reference it here.

L296 "Buoyancy and humidity..." This is so weird and out of place. It would work much better if you start a new subsection with the next paragraph, and put it somewhere in that subsection.

L300-365 I have little to comment other than this is so densely written, it is very difficult to pick anything out as a reader. What I did was I looked at your plots, and I asked why Figure 12 only has profiles of N_c and not of Re and LWC as well?

The thresholds of 300 vs 350 thing, I think that makes it more confusing. You seem to come out with similar conclusions regardless of which number you use, right? So I think just pick one. On a different year or different time of the year, the particle concentrations might be different anyway so the number you pick is somewhat arbitrary. This is especially true when you have Appendix A which is all about your choice of threshold anyway.

Figure 12 At cloud base the Contact, high N_a numbers are significantly higher than the separated, high N_a numbers. How much of the differences you see are due to differences in below-cloud N_a versus mixing in from above? You would expect the cloud base N_c to be driven by the below-cloud N_a . Is the below-cloud N_a similar for both sets of cases? And how much does this affect the other differences between the contact and separated profiles?

Table 1: Please remove any instruments you haven't used in your analysis

Table 3: In the caption, state that the insitu measurements only cover up to the max altitude on the profile, whereas the AOD cover the whole of the above-cloud column

Table 5: What does "---" mean? No data? Or not statistically significant? Or something else?

Figures 6 & 10 Make sure the Y axes go from 0 to 1. Also figure 10 please plot these side by side

Technical corrections

L43 Hartmann et al- do you have a more recent reference?

L68 absorption increasing buoyancy- isn't this the semi-direct effect?

L68 It's a bit unclear what the next sentence is trying to say- are you trying to say that as particle-laden air is entrained into the cloud, this increases N_c but also can decrease LWC, depending on the humidity of the air that is mixing in?

L83 You haven't yet defined ORACLES in the main text

L182 "bulk LWC > 10g m⁻³" please check/correct

L203 " $N_a < 500\text{cm}^{-3}$ " Please check/correct, should it be >500?

L226 "drizzle concentration decreased near cloud base which led to the decrease in median R_e " Does it not increase near cloud base?

L244 Do you mean higher below-cloud N_a , rather than above? In general you need to be careful talking about above-cloud N_a , because your AOD measurements suggest all profiles had high above-cloud N_a if you go high enough

L250 "Higher N_c in the cloud layer..." This is a confusing sentence. How about "As the high- N_a air from the free troposphere entrains through the inversion, N_c in the top of the cloud layer increased. This change provides evidence for the aerosol indirect effect". Having said that...does it provide evidence of the indirect effect? The indirect effect being the radiative part, not just the microphysics.

L273 What is P1? Profile 1 obviously....but you have not explained your naming convention.

Reference

Twomey, S. (1991). Aerosols, clouds and radiation. *Atmospheric Environment Part A, General Topics*, 25(11), 2435–2442. [https://doi.org/10.1016/0960-1686\(91\)90159-5](https://doi.org/10.1016/0960-1686(91)90159-5)

Finally, thank you it has been interesting to read. I've not seen someone dig into such fine detail in something as basic as profiles before!