

***Interactive comment on* “Breakup of nocturnal low-level stratiform clouds during southern West African Monsoon Season” by Maurin Zouzoua et al.**

Anonymous Referee #1

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Review of “Breakup of nocturnal low-level stratiform clouds during southern West African Monsoon Season”

Authors: Zouzoua et al.

General Comments

This is a very interesting study discussing nocturnal stratiform cloud breakup and mechanisms describing this breakup. A large suite of observations documents several case studies of nocturnal low-level stratiform cloud breakup. This study also evaluates relevant observationally derived quantities describing LWP tendency against numerical simulation results. Finally, this paper describes the nature of coupling (decoupling) for

all available case studies. I learned quite a bit reading this work, noting especially that the intricate detail and analysis are the key strengths of this paper. The results in Section 5 are especially clear and perhaps the biggest strength of this paper. The scientific merit of the work alone merits publication. I do have some concerns, however, with the writing style of this manuscript and found myself at times overwhelmed by too many acronyms, abbreviations and equations in the text, thus needing to refer to multiple copies of this manuscript in order to track down and trace relevant details to pertinent results. I think this is partly because the authors have taken on an extremely difficult task by delving into the many aspects of stratiform cloud breakup. I recommend that the authors take greater care in re-organizing and re-writing portions of the text for clarity (specific comments are below), though I will leave it to their discretion since (again) the scientific quality of this work is excellent. Finally, I believe the authors do a great job of analyzing the available data and frame their results in a very appropriate context.

I refer to specific pages as “P” and lines as “L”. For example, “P10, L11” refers to page 10, line 11.

Specific Comments

General comment: I got confused at times, even after reading this twice, keeping track of the large number of acronyms made throughout this text. I see and acknowledge their importance for keeping the paper at an appropriate length, however, I think the authors should take care to re-state some acronyms through the text to clarify what is being discussed.

Section 1: Since this paper describes in great detail many processes responsible for nocturnal cloud maintenance and subsequent breakup, this section (and paper in general) would benefit greatly with some discussion about the land-surface types of the 3 supersites. The a priori knowledge of the typical land surface over this part of the continent may be unknown to several readers, and is especially worth noting since boundary layer heights depend somewhat on the land-surface.

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P2, First Paragraph: In this section, you state “However, the diurnal cycle of those clouds is still poorly represented in numerical models” and cite Hannak et al. (2017). This is definitely a strong motivation, but I do not think this point is expanded upon enough in this paragraph. Furthermore, I had some trouble reading through this paragraph as this text seemed disjointed and unclear as to the main motivation. I recommend re-writing this paragraph focusing on the importance of stratiform cloud cover in a global context (e.g. earth’s radiation budget, difficulty representing these clouds in climate models; I included a reference that may be of interest and relevant here) and expand upon the processes that make this difficult. Move Fig. 1, the discussion of Fig. 1, and the discussion about “scarce weather monitoring over West Africa” to elsewhere in the text.

Section 2 (beginning on P4): This is overall an excellent review of the relevant processes examined in this paper.

P3, L9: I recommend adding a short description of what a “supersite” is.

P4, L23: “... due to the cooling...” at what level of the atmosphere does this cooling occur? Also, change “their formation” to “cloud formation”.

Section 4: I really liked this section and found the intricate level of analysis excellent, though I have to admit – again – I needed to read this multiple times to understand it due mostly to the authors’ writing style.

Section 4: I will leave it up to the authors to proceed with this next comment as they see fit. Have you looked into the role of nocturnal cloud thickness as a possible reason why coupling sometimes does (or does not) occur (e.g. Fig. 5)? This is an interesting hypothesis that can (I think) be easily tested using your data. I would expect thicker cloud cover to inhibit surface warming enough to delay or possibly prohibit coupling if other meteorological factors cannot enable the transition. Likewise, could entrainment or precipitation – two sink terms for nocturnal cloud fraction under most conditions – correlate to a delayed coupling? These are questions bred from pure scientific curiosity

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based on the results you have shared.

P4, L20: This is an unusual title for a section in a manuscript. Did you mean “State of Art”? Maybe call this section “Review”?

P5, paragraph beginning at L19: There are several recent studies from the Cloud System Evolution over the Trades (CSET) experiment that, I believe, can really strengthen this paragraph and provide additional interesting results to compare & contrast your own results with. I believe intertwining principle results from these works will make your paper more interesting and accessible to research groups studying stratiform cloud breakup elsewhere across the globe, especially since the topic of stratocumulus-to-cumulus (or stratiform cloud breakup) has received increasing attention over the past several years.

Overview of CSET: Mohrmann, J., and Coauthors, 2019: Lagrangian Evolution of the Northeast Pacific Marine Boundary Layer Structure and Cloud during CSET. *Mon. Wea. Rev.*, 147, 4681–4700, <https://doi.org/10.1175/MWR-D-19-0053.1>.

Lagrangian case studies during CSET: Sarkar, M., P. Zuidema, B. Albrecht, V. Ghate, J. Jensen, J. Mohrmann, and R. Wood, 2020: Observations Pertaining to Precipitation within the Northeast Pacific Stratocumulus-to-Cumulus Transition. *Mon. Wea. Rev.*, 148, 1251–1273, <https://doi.org/10.1175/MWR-D-19-0235.1>.

Observational perspective of stratiform cloud breakup: Schwartz, M. C., and Coauthors, 2019: Merged Cloud and Precipitation Dataset from the HIAPER GV for the Cloud System Evolution in the Trades (CSET) Campaign. *J. Atmos. Oceanic Technol.*, 36, 921–940, <https://doi.org/10.1175/JTECH-D-18-0111.1>.

Many of the references cited within this paper may also be relevant and of interest. Finally, this work is related but more peripheral to the main context of your paper, but I think it might be worth reviewing the following study by Schneider et al. which discusses how stratocumulus cloud breakup (over the subtropics) might affect future

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climate: Schneider, T., Kaul, C.M. & Pressel, K.G. Possible climate transitions from breakup of stratocumulus decks under greenhouse warming. *Nat. Geosci.* 12, 163–167 (2019). <https://doi.org/10.1038/s41561-019-0310-1>. It is interesting to think about how the LLSC breakup paradigm over SWA might change in future climate.

End of P5: Again, this is an overall well-written section. This section seems to come to an abrupt end, however, with no suggestions or links as to how the described relevant dynamical processes relate to the observation studies presented in the remainder of the work.

Section 3.1 Header: I recommend renaming this section as “Instrumentation” instead of “Observational Data Used”

P7, L2: Are missing CTH data from the ceilometer the result of attenuation from optically thick daytime cumulus cloud, or were there frequent instrument malfunctions? This would be useful to know.

Section 3.1: What measurements did the radiosondes collect? And what versions/types of radiosondes were used? This section in general is also lacking descriptions of measurement uncertainties for each instrument. For example, how accurate are the cloud base and cloud top height estimates from the ceilometer? What uncertainty is expected with radiosonde temperature and humidity measurements? I noted some statements of measurement uncertainty and accuracy elsewhere in the text, but these need to be stated here. Finally, presuming meteorological conditions are estimated from the radiosondes, I would put paragraph 2 after the current 3rd paragraph since its unclear at that point in the paper how the authors estimate SHF, LHF, etc.

P11, L11: “Therefore, it has a spatio-temporal variability” this is true but is out of place at this point in the text.

P20, L7: What do you mean by “help us to depart the cases”? Do you mean “differentiate” instead of “depart”? This is confusing and needs clarified since this is obviously

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a key science question motivating subsection 4.2.

P20, L12: “Indeed, the crossing of the cloud wets the probe” this sounds very flowery. I recommend rewriting this entire sentence. Suggestion: “Liquid water buildup on the radiosonde’s sensors possibly renders some measurements suspect, especially near cloud top.”

P20, L23: Again, it is critical to know what the instrument uncertainties (or accuracy) are, such that these over/underestimations have context. This will elucidate the magnitude and seriousness of liquid water condensation on the sensors and subsequent computations using these measurements.

P28, L18-19: “... for which the hydrometeors radar reflectivity from the cloud radar reveals light precipitations above the LLSC layer” The way this sentence is written implies that precipitation is occurring above the cloud layer, which is physically not possible. Did you mean to say that there is precipitation occurring inside the cloud layer? I have a stylistic comment here too: its fine to simply say “collocated cloud radar data revealed precipitation inside the LLSC layer” or something to that effect. “hydrometeors radar reflectivity” is confusing and does not make much sense.

P29, L17: “30% lower” what exactly is 30% lower? the cloud base height? Also, the beginning of this sentence should be “The latter...”

P31, L26: “This could favour the convection in the cloud...” just state “This favors convection which...”

P34, L11: “more significantly impact” is this because the coupled cases generally result in longer lasting cloud cover and therefore decrease the total amount of solar insolation received at the surface? I would be much more specific here since and this statement as written is pretty bold yet a bit hand-wavy.

Figure captions (general comment): It would be helpful to the reader to re-state or spell out acronyms. I found it tough at times to try to dig variable abbreviations from the text

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while also trying to follow and learn from the figures.

Technical (Minor) Comments

Title: change “during southern West African” to “during the southern West African”

P1, L17: Change “Savè supersite, in Benin” to “Savè, Benin”

P4, L31: “the maximum of wind speed” → “the maximum wind speed” P2, L13-15: The two sentences here, beginning with “Figure 1 gives...”, are interesting details but, in my opinion, would be more effective if discussed in Section 2.

P3, L11: “at Savè supersite” → “at the Savè supersite”.

P5, L21: Eliminate the work “essentially”.

P6, L17: “because of a good data coverage” → “because of good data coverage”

P6, L13: Recommend rewriting this sentence to “Data acquired at the Savè supersite offer nearly continuous information on atmospheric conditions.” Sky coverage (clear or cloudy skies) is implied when you mention atmospheric conditions.

P7, L3: comma use, remove the second commas after each “and”.

P7, L8: “the radiosoundings” → radiosondes.

P7, L14: “data were smoothed by averaging with final vertical resolution...” → “data were averaged to a final vertical resolution...”

P9, L19-20: Recommended rewording “...of horizontally-homogeneous stratocumulus cloud cover maintained by vertical mixing, which is driven by convective turbulence and cloud-top radiative cooling (references)”. The current version of this sentence reads awkwardly.

P11, L18: Change this sentence to “For simplicity and due to a lack of precise estimate, we assume...”

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P11, L28: “In sum, ...” → “In summary, ...”

P15, L18: “This supposes that, the potential...” → “This evidence suggests potential early morning coupling...”

P27, L4: “...presented in Fig. 8, and summarizing the...” → “...presented in Fig. 8 which summarize...”. Also please remove the word “Eventually” from the beginning of this sentence.

P27, L6: “... is larger than 95% whatever the case, and...” I am extremely confused by “whatever the case” means here.

P27, L13: remove the word “firstly”

P28, L22: “here after” → “hereafter”

Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-602>, 2020.

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