Review of "The Impact of Aerosols on the Stratiform Clouds over southern West Africa: A Large-Eddy Simulation Study"

Summary

This is a modeling work that uses LES for a coastal stratocumulus case study from the DACCIWA campaign in southern West Africa. The main focus of the work is given to the different effects of aerosols, for which three different aerosol size distributions are considered, which are then transformed to a total of six cases by switching off the black carbon content. Results highlight how spatial organization aspects of the cloud break-up play a role in the aerosol effects. Their effort in modeling a real case is quite valuable, and it gives them good results when compared to in-site observations. Their sensitivity analyses point at the different effects of aerosols, some of them unexpected, adding novelty to the work. Over all, the work is very interesting, the methods are good, and the topic is highly relevant. However, there are some aspects of the manuscript that should be improved prior to publication.

Major comments

- There are multiple writing mistakes along the document, along with confusing statements. Please revise the manuscript carefully. Some suggestions are given below, but still, readability is essential for a paper.

- Cloud break-up is used to refer to a state where the cloud deck has a low cloud fraction, but there is no clear definition of it nor a discussion about it. Some sentences talk about earlier or faster break-ups but I'd suggest to treat the concept carefully to avoid confusions, specially since coastal clouds go through cloud dissipation and the process is a complex one already.

- The case studied was said to be a late dissipation one. They hypothesized that precipitation evaporation could explain this. No further analysis was done using LES data related to this issue, I think it should be diagnosed. I wonder if studying a more usual dissipation time case would give the same results. A more critical comment could be appreciated.

Minor comments

- I'd suggest to simplify the Meso-NH model description, focus on the setup and how the data was used to create initial and boundary conditions, and leave the model details on Appendix if desired. In my opinion, later experiments on aerosol contributions can also be described in the model section. This is personal preference, as I've seen both around.

- Also related to readability, the results section can be summarized greatly, focusing on the big takeouts instead of carefully describing every value presented in the figures. While a description of the time evolution of the different vertical profiles seems fitting for this type of work, I'd suggest to be concise, highlight the most significant processes or values, since everything else is available in the plots.

- Cloud formation is said to occur around hour 2, which is probably already part of the LES spin-up time. Could this be an issue?

- As results are presented, there is no critical comparison with the references given in the introduction for similar processes. It is important when summarizing to compare and also state what is novel.

- Time-series of cloud fraction and liquid water path, both said to be available from observations and the LES runs, could complement the analysis greatly. Please include them in one of your figures, and strengthen the physical description of the PBL processes as needed.

- The cloud presence probability, CPP, is not carefully defined, so I don't understand how to interpret the values.

Line by line comments

- L10 Is it necessary to remark that there is no precipitation like this in the abstract? Maybe combine with previous sentence "...effect, with all cases having negligible precipitation".

- L15 Why use cloud-void instead of cloud fraction or cloud cover? This is true for all the document

- L21 What do you mean by stabilize? A more steady evolution?

- L23 Break-up faster means an earlier breakup time?

- L64 Why would aerosol emissions impact the wind?

- L74 Are these 2 studies observational or model-based?

- L80 It might be good to summarize what the direct, semi-direct, and indirect effects are, maybe in the second paragraph of the Introduction.

- L74 This paragraph has a lot of info but it's hard to follow as there is no clear story in it. The last sentence helps, but maybe it'd be good to have a similar introductory sentence and then highlight the knowledge gaps as info is presented. Just a suggestion. Another idea is to remove all unnecessary mentioned results if they won't be used for comparison or contrast.

- Fig. 1 Maybe a proper reference is better than the link.

- L98 What local scale and fine resolution are you talking about?

- L116 Local time is also UTC for this location, right?

- L124 The info in this paragraph is a bit heterogeneous; some descriptions are very detailed and others not as much. Is the importance given to the details of the sky camera meaning that this data is more important than the rest? Also, a matter of preference, but it could be easier to follow with a consistent sentence structure like: first the instrument, then the data it generates (as done first with the ceilometer).

- L135 Aren't these fluxes included in the last sentence?

- L162 Turbulent mixing maintains cooling? You mean through downdrafts or are you referring to the cooling advection?

- L168 What is the scenario C?

- L170 What does break-up mean here?

- L192 Add reference instead of link.

- L243 This resolution is not particularly high for stratocumulus LES

- L247 Are these values used to prescribed turbulence related to the local observations in any way? Is it okay for the profile to not change over time when modeling a coastal case?

- L249 if the model was tuned for the site observations, it'd be good to include that in an appendix. Otherwise, what kind of parameters is this surface model taking in for this case?

- L251 Are these 2 s chosen for numerically advancing the LES? If so it's more than adequate for diurnal variations, and probably needed not for that reason but for keeping a good CFL number. It's not clear as is written.

- L254 Do you mean using those observations as the initial condition? What is the nudging timescale for the tendency profiles?

- L258 How did you combine all that data to produce vertical profiles?

- Fig. 3 Improve the description: mass composition of what? Percentage text in a) is overlapping. Is the dot needed in the units of the b) y axis label (and all other labels)?

- Table 1 I'd suggest putting the symbol for each parameter after mentioning them in the description.

- Fig. 4 and other figures are vertically shrinked. "Vertical colored bars" are actually dots. Do simulated values represent the horizontally averaged CBH? Why are they reported hourly when the LES has a smaller step size? What is the meaning of this probability?

- L273 Do you say "formation" because the initial state for the LES is cloud-free? If so, initial conditions should be stated carefully.

- L274 Is the mean CBH estimated as the horizontal average of points where the first cloudy grid point is located?

- L280 You can be more specific than "some period"

- L284 Could the difference also be due to prescribing a weak subsidence profile or due to enhancing entrainment by not having a very fine vertical resolution?

- L289 This aids the previous paragraph in saying that for 10:00-14:00 UTC, observed CBH is below the 0 level probability. I'd move this and start a new paragraph with the spatial results.

- L289 What does a CPP of 50% mean? Is it the geometric midpoint?

- L294 By visible camera do you mean sky images in the visible range?

- L295 "distinct cloud rolls" instead of "clear cloud rolls", so that clear is not confused with clear sky. It can also be noted that this feature is not observed in the sky image

- L296 What is the CPP at the mid distance? At the mean in-cloud height? I still don't fully get the meaning of CPP values, so I don't understand what is useful of this description

- L301 Rather than demonstrating the break-up, it evidences the already broken field. This comment is related to what is the definition of break-up.

- L303 Still, the camera at Savè shows a big portion of the sky completely clear. The LES does not reach that type of organization.

- L317 Do you mean that the difference is due to the tuning being done for more persistent cloud decks?

- L319 Why would that difference be reduced in the convective phase?

- L354 along what altitude?

- Fig. 7 θ_e has not been defined, and its units are just K, not °K. Put w_s in equation mode. Why the discontinuous lines in f)? Why the choice of plotting T, RH, and θ_e instead of just θ_e and q_t?

- L376 Does stable mean constant cloud thickness here? Be careful not to be confused with thermal stability.

- L383 is this a fixed threshold to find the inversion height?

- L416 Does more unstable mean signs of decoupling?

- L417 What does "end of cloud break-up" mean? That the clouds cleared up or that it's fully covered again?

- Fig 9. Why report at 17 h and not 18 h to follow the 2 hours spacing? w_s to formula. Why does TKE, RH and θ_e increase above the PBL at 17 h?

- L435 What biases are you talking about?

- L440 Do these cases represent extreme situations in the set of observations?

- L456 What is cloud extent? Cloud thickness?

- L464 What does "this way" mean? I'm guessing not by the model activation but the text is confusing.

- L460 Here and in other places, comparing numbers in a more descriptive way can help the reader. For example, "N_c^{POL} reaches half of the droplet concentration of the REF case (333 vs 653 droplets per cm^3), with a slightly higher radius (6.45 vs 5.1 μm)."

- Fig 10 Why are there 2 cloud layers at hour 6? It might be useful to also have a plot of the standard deviation of surface SW irradiance to accompany the last panel.

- L473 I'd suggest to check if the difference in LWC is related to changes in cloud cover. Also, since the changes in CTH and CBH are equivalent to just a few grid points, dive into that discussion as well, what was the expected outcome? Are there both positive and negative cloud thickness feedbacks that may be canceling each other?

- Fig 11 It is hard to distinguish the clear portions in the last panel. Maybe you can set the zero values as NaN for plotting them in white, and mention that in the caption. I don't know if it's related to the wind at the time but POL seems to have less elongated structures at 14 UTC. What is ADEON?

- L491 When saying "major" reason, what is the other reason why the trend would be different from what you expected?

- L492,L500 The solar zenith angle should be lower near noon, right? Do you mean solar elevation angle?

- L498 I don't understand this sentence well. When you say "direct solar flux is relatively low" you don't mean the time of the day, right? Then you talk about cloud reflectance, which I'm guessing you interpret through LWP or LWC, saying it is a secondary factor. Does this mean that for clouds without full cloud cover (which would be the primary factor), then changes in reflectivity are also promoting the unexpected result for the POL case?

- L500 By "this", do you mean the reduced PBL heating due to a higher reflected SW at cloud top?

- L504 Though the images do suggest that some layers may dissipate earlier, it'd be better to include time-series plots of LWP and cloud fraction, maybe as panels b and c in Fig. 4.

- L505 The last sentence is confusing. It seems to relate a low number of variable pixels with variations in surface SW irradiance.

- Table 3 Is this LWP or LWC (units of LWP are typically g/m^2)? Why don't you put the % symbol instead of writing percentage again? Last column title shouldn't be PRP, right?

- L511 Do you think that a different type of variation could cause the more expected result?

- L523 You should explain the REF_NOBC case here (I'm guessing it has no BC, but were all the other aerosols kept?)

- L534 You could also include this mentioned difference in liquid water content in Fig. 12, because it's not shown.

- Fig. 12 It might be useful to include cloud thickness in panel a too. Why are the first hours skipped? If break-up time is important, it could be marked in these plots.

- L541 I don't completely understand the last sentences. If the CTH is kept nearly constant, dissipation could still occur due to other factors, are all of them unchanged? This could be diagnosed using your difference approach on a sort of budget terms (see van der Dussen 10.1175/JAS-D-13-0114.1 and Ghonima 10.1175/JAS-D-15-0228.1 works on LWP and cloud thickness budget equations, I'm not sure if there's work relating them to aerosol effects).

- L550 This being said, maybe the analysis could benefit from comparing not only the domain averaged SW fluxes but by separating the domain in cloud-void and cloudy portions, in order to quantify how much the low cloud fraction effect weights.

- L535 This decrease in TKE is very interesting. I'd interpret it as limiting entrainment.

- L554 How do you know that clouds break up slower? If you mean a state with greater or lower cloud cover, I think that's different from a break-up speed. Still, a cloud cover vs time plot could hint towards that.

- L555 Note that clouds are also larger for the ADEOFF cases at 16 UTC, this is relevant for cloud organization and solar variability.

- L559 This is a bit confusing. Are these the effect of having BC or of not having it?

Typos/Writing suggestions

- L45 models

- L61 growth?

- L81 break-up or breakup? (both seen)

- L107 the radiative budget

- L116 hours, "This site" instead of "It"

- L118 "(up to 1500 m above ground level)" instead of "reaching…". You could skip "a.g.l" since it's the only time it's used in the paper.

- L124 This is just personal preference but why not just say "At Savé" instead of supersite of Savé everytime?

- L133 "Radiation fluxes" or irradiance instead of "radiations"

- L141 remove "analyzed"

- L146 Also measured

- L147 Wind speed and direction

- L147 The last sentence is very lacking given all the details above, and reads too casual. Suggestion: "A gas concentration analyzer was used to measure CO2, CH4, and CO content."

- L150-151 reads weird, maybe it's better a sentence of its own to talk about the NLLJ

- L157 Why ABL now? You had used PBL before. Pick one

- L153 were located

- L159 add comma after coast

- L165 identified three evolution scenarios

- L168 evolve

- L171 The co-located radar...

- L180 sulfates

- L231 grid point

- L234 layers... separated in up to...

- L238 of the observed

- L255 radiosondes instead of radiosounding profiles

- L258 resulting instead of resulted?

- Table 1 described instead of describes?

- L266 Maybe "nitrates" to be consistent with the plural

- L266 has been

- Fig. 4 "represent" instead of "represents"

- L273 formation of the observed LLSCs

- L282 the simulated mean CBH approaches again the ceilometer readings

- L291 "column, calculated ...pixels, ..."

- L291 Say that LWP is shown in Fig. 5.

- L292 nearly equal to

- L293,L295 observations

- L295 Is is 6:00 or 06:00 as in Fig. 2? Be consistent

- L298 "less homogeneous" instead of "more inhomogeneous"

- L298 "sky camera" instead of "cloud camera"

- L299 "clear" instead of "no-cloud", "the middle row"

- L300 "continues", "the convection phase"

- L303 the LWP map (Fig 5b)

- L302 "cloud thinning" instead of "decreasing cloud thickness", "the cloud deck"

- L305 "at the surface", ", averaged.. domain,"

- L309 follows the observations well

- L312 cloud deck

- L313 in this case, I support "break up" since it's used as a verb

- L314 observations

- L316 "very close at around", "break up"

- L317 during the DACCIWA

- L318 detected by the Savè

- L320 "of the modeled", "reproduced those measured by the instrument well". Remove "as shown in. . ." since you already mentioned which Fig.

- Fig. 6 I'd suggest replacing the dots as spaces in the label units as it was done in the caption.

- L333 fluxes

- L336, L362 microphysics

- L337 evolution

- L344 radiosonde

- L346 "increasing" instead of "that increase"

- L347 decreased

- L351 "greater than" instead of "more than", "cloud formation"

- L353 "which yields a well-mixed sub-cloud layer"

- L363 "droplets per cm^3", droplets in text mode

- L370 "The more numerous the cloud droplets are ..."

- L371 If saying "in the figure", say which one

- L379 "as shown in", "ground temperature"

- L381 " between ground and CTH": isn't that the whole PBL?

- L384 it rises

- L386 increases

- L392 You should define SWHR at the first mention in L371

- L397 "stronger solar irradiance" instead of "more solar radiations"

- L411 $W\ m^{-2}$

- L419 convection phase?

- L428 dissipate

- Table 2 Maybe you can merge some cells for a better table. The second value of sigma is very high, what are its units, or is it normalized? Maybe shortening CLEAN to CLN can help later for naming the other variables.

- L459 lifetime

- L464 Do you mean "reversed by"? Confusing sentence.

- L466 break up

- L467 radii

- L471 is visible

- L481 "those" instead of "that"

- L485 "Fig. 10c" instead of "the bottom panel of Fig.10"

- L487 runs are also

- L489 until the

- L492 before noon

- L495 For a cloud with a large quantity

- L495 Exceed what?

- L498 seems to become

- L521 "in the same way as". Also, you may want to split this sentence for clarity.

- L524 "These scenarios retake...", "in terms of", "replaces the BC mass..."

- L525 an equivalent

- L526 there are

- L530 demonstrate

- L531 by a substantial

- L532 Do you mean "(SWHR difference)"?

- L536 reduced SW reflection

- L549 solar irradiance

- L554 "break up" (used as verb), "due to being thicker"

- L555 weaker SW irradiance

- L559 Be more specific: cloud layer or cloud top?

- L564 semidirect or semi-direct?

- L566 has been

- L580 entrained

- L582 Is this sentence incomplete?

- L584 break up

- L590 "because" instead of "by"

- L591 What is that "this"?

- L592 break up