Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2018-269-RC1, 2018

Atmospheric Chemistry and Physics Discussions
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Interactive comment on "The role of droplet sedimentation in the evolution of low level clouds over Southern West Africa" *by* Christopher Dearden et al.

Anonymous Referee #1

Received and published: 11 May 2018

Review of "The role of droplet sedimentation in the evolution of low level clouds over southern West Africa", submitted to ACP by Dearden et al. Paper number ACP-2018-269

This paper describes simulations of low clouds that form and deepen over the diurnal cycle during the monsoon season in West Africa. Enabling/disabling sedimentation of cloud droplets has a substantial impact on the evolution of the cloudy boundary layer.

Assessment:

This well-written paper does a good job of describing the sensitivity of low cloud to the changes through the diurnal cycle and to the various sensitivity studies with the model. Isolating cloud droplet sedimentation as key to the differences is a nice accomplishment. However, I have some concerns (outlined in more detail below) that the presence/absence of cloud droplet sedimentation during the spin-up of turbulence and convection at the start of the simulation may have a larger-than-expected impact on the simulations. As a result, I would ask the authors to branch a pair (or a full set) of simulations with/without sedimentation from a spun-up initial condition. I expect that the impact of sedimentation will be more modest in this case but still non-negligible and that the revised paper will be suitable for publication in ACP.

I also make some suggestions regarding the consolidation of figures, as I find seventeen figures to be a lot for a paper of this length, and I sometimes think that it's helpful to look at the relationship of related fields or simulations in multi-panel figures. As this is a stylistic concern, the authors may ignore these suggestions if they wish.

Recommendation: Major revisions.

Major comment:

1. A close reading of Bretherton et al (2007, section 3, paragraph 7) reveals that each of their simulations proceeded identically without sedimentation for two hours before sedimentation was enabled in two of the three simulations. My impression is that the initial absence of turbulence and convection in the boundary layer allows the presence/absence of sedimentation to have an outsize effect when there is no compensating water flux into the inversion. With a cloud droplet sedimentation speed of 5 mm/s (which seems about right for qc=0.5g/kg and Nd=500/cm3), the cloud layer would subside by one grid level (10m) over 2000 seconds, or about a half hour. If it takes the turbulence about a half hour to spin up at the start of the simulation, this sedimentation might account for a significant part of the difference in inversion height between CASIM_NO_PROC and SIMPLE_CLOUD at 0530, which I estimate as 20m. Isolating the effect of sedimentation by turning on/off sedimentation in an already turbulent boundary layer would eliminate this uncertainty and strengthen the study in my

view.

For the present paper, I would suggest using the CASIM_NO_PROC simulation as the control for the first two hours since it does a good job of maintaining the observed LWP and then branching all the simulations from that point. If it's easier, use CASIM_NO_SED in place of SIMPLE_CLOUD since the restart file may not want the microphysics scheme to be switched. If the comparisons of early morning cloud and boundary layer properties should stay at 0530 hours, perhaps the start of the spin-up simulation should be pushed back to 0130 hours.

Perhaps, this won't have a huge effect, but it's worth checking.

1a. The results of Ackerman et al (2004) suggest that the effect of sedimentation may be more notable in boundary layers with dry air above the PBL. Toll et al (2017, GRL, https://doi.org/10.1002/2017GL075280) note an LWP decrease in ship and volcano tracks in non-precipitating clouds with dry air aloft (bottom of their figure 2) that could be related to the droplet sedimentation effect. It would be interesting to see that same effect here in a boundary layer with a very weak moisture jump across the inversion. The effect on entrainment could be compared to the parameterization in section 6 of Bretherton et al.

2. Comparing cloud base observations with simulations: Instead of plotting the time series of a single model column for comparison with the observed cloud base height, I would suggest plotting three quantities than span the range of cloud base heights in the model:

+ the inversion height (roughly the top of the stratocumulus cloud),

+ the median cloud base height of cloudy column (roughly stratocumulus cloud base),

+ the lowest cloud base (where cloud fraction first reaches 1% or so) or the LCL of the subcloud layer. This roughly gives the cumulus cloud base in a decoupled boundary layer.

The observed cloud base height will nicely follow these lines, I think, with the lowest model cloud base capturing the low observed cloud base heights after 1000 hours. The presence of fog makes the computation of the lowest cloud base/LCL a bit more complicated, but I would suggest lowest non-fog cloud base. Note that the divergence of the median cloud base height from the lowest cloud base/LCL is a good indicator of decoupling.

Minor comments (5/26 means page 5, line 26):

5/1: What time is sunrise? I'm not sure it's crucial, but I felt myself wondering as I read the manuscript.

8/20: Suggested re-wording: "... by virtue of the effect of increased droplet size and excessive sedimentation velocity on entrainment."

9/30: Suggested re-wording: "... and _possibly_ the circulation of the West African monsoon."

Figures: These are stylistic suggestions, but I feel that grouping these many figures into fewer multi-panel figures could help the reader interrogate their meaning more easily. Feel free to ignore this advice if you wish.

+ Fig 0: An additional figure with a map-like image would be helpful for the reader who hasn't thought so carefully about clouds over Africa. How about a visible geostationary satellite image from 11Z showing the breakup of the cloud along with the locations of the coast, Sav\'e, Lome and the transect?

+ Fig 2: A bigger colorscale would be helpful

+ Figs 3-4: Could figures 3 and 4 be stacked? It would be cool to see Fig 3 extended over the full 24 hours and see the re-formaton of the jet in the evening. This would also let the reader clearly see the result of the strong afternoon surface buoyancy flux on the wind field.

+ Figs 5-6: Could these be stacked?

- Fig 5: I think it would be helpful to NaN (make blank) the regions where qc==0.

- Fig 6: Note major comment 2 above. If the cloud-free regions are white in figure 5, these lines could even be superimposed on figure 5, though that might be too much.

+ Figs 7,13: Could these be stacked with an additional panel for the 1100 UTC version of SIMPLE_CLOUD? Could the lowest cloud base, median cloud base and inversion height be marked as dashed lines.

+ Fig 8: If the authors think it's helpful, could the observations from figure 1 be added as dashed lines?

+ Figs 9, 10, 16: Could these be stacked as a three-panel figure? I felt the need to flip back and forth to compare the different versions of this figure.

+ Figs 12, 15: Could the lines in figure 15 be added as dashed lines in figure 12 if that's not too distracting?

Table 1: Could the cloud droplet number concentration be added to the table? For the run with predicted droplet concentration, a range of values could be given that could be different between the two times if appropriate.

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