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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Large-eddy simulation of ship tracks in the collapsed marine boundary layer: a case study from the Monterey Area Ship Track experiment" *by* A. H. Berner et al.

Anonymous Referee #2

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This large-eddy simulation (LES) study examines the impact of ship emissions on cloud properties in a shallow drizzling boundary layer under high winds over the northeast Pacific. Model simulations, conducted using the System for Atmospheric Modeling (SAM) equipped with a double-moment cloud microphysics scheme (coupled with a simple bulk aerosol scheme), are initialized and compared with aircraft observations collected during a field campaign. While model results compare well to important observed features of the ambient boundary layer (including the striking mesoscale organization of cloud rolls), cloud droplet number and albedo enhancement within the segment of ship track, there are some discrepancies in more detailed comparisons between the

simulation and observations. The cloud albedo response to ship emissions is further decomposed to the first and second aerosol indirect effects. The model experiment design is novel. While some results are consistent with those in previous studies, new scientific findings are significant and of interest to the community. The paper is well written, simulations are thoroughly analyzed, and the figures have very good quality. I recommend for publication after the following comments are satisfactorily addressed and the manuscript is to be revised accordingly.

General comments:

It is very interesting to see the simulated mesoscale organization of cloud rolls, for which the formation mechanism is definitely worth exploring. I am sure that the authors must have looked into this, but not much is discussed in the paper. What are the key environmental conditions (e.g., shallow boundary layer, strong winds, large-scale forcing, etc.) for the LES model to produce such cloud rolls? As also noted in the paper, the presence of such roll structures can have a profound influence on turbulent mixing and cloud microphysical processes in the marine boundary layer, compared to the relatively more common open or closed cell structures. Thus the impact of ship emissions on clouds could be quite different as well. Wang and Feingold (2009b) showed the suppression of cloud formation surrounding the ship track in their drizzling open cell case, which limited the increase of domain average albedo caused by the ship emissions. This suppression effect does not show up in the simulations of this paper. Is this due to some unique mesoscale circulation or cloud dynamics for the cloud rolls? It would be nice to discuss more on this in section 6 in the context of aerosol impact on cloud regime shift.

Specific comments and technical edits:

1) P24390, L5-10: it does not seem appropriate to use "positive or negative first/second indirect effect" to describe the increase or decrease of LWP. Reduction of LWP has nothing to do with the conventional aerosol indirect effects. Suggest remove "positive"

and change “negative” to something like “opposite to”. Same for a few other places throughout the paper.

2) P24392, L10: measured by which instrument onboard C-130?

3) P24392, L14-17: what’s the size range for aerosol particles above cloud? Seems that they are not represented in the bulk aerosol scheme. Also, Nd and Nad (Na in the plot) should be clearly described in the figure caption. Any measurements of interstitial aerosols in the MBL? What is the reason to set initial MBL aerosol concentration substantially smaller than the measured cloud droplet number concentration?

4) P24394, L1: change “precipitation” to “raindrop”. Having Lookup table for cloud droplet sedimentation as well?

5) P24394, L11 and L15: no need to use “dry” to describe aerosols, which usually take up water to various extents.

6) P24394, L20: not quite clear why such a high model top (29km) is needed for the radiation schemes when using diurnally averaged radiative forcing in the simulations. I assume that the sounding does not cover to that height. What profiles are used then?

7) L24396, L4-5: Could the “large scale updraft” be verified from reanalysis? I am wondering how strong a large-scale lifting can really affect droplet nucleation.

8) L24396, L25: please describe how the divergence was converted to subsidence and used in the model.

9) P24397, L11: which scheme is used to parameterize surface salt fluxes? Only the accumulation mode is accounted for?

10) P24397, L15: “m” is missing in the units of radius.

11) P24397, L28: please verify if S = 2.3e16 or 1.5e16. The former is inconsistent with the value given in L15, and does not seem to give s=15000 per mg.

12) P24398: would be nice to have all simulations summarized in a table.

13) P24399, L11: no need to have “Cloud” here

14) P24399, L25: “unactivated, interstitial” is redundant and a little confusing. Suggest remove “unactivated”

15) P24400, L11: It seems that the albedo here is not just for the visible wavelengths. How accurate are the equations (2 and 3) and associated parameters for the entire SW spectrum? Does the underlying ocean surface have zero albedo?

16) P24400, L25-26: unclear about “the scale” in Figure 6.

17) P24402, L22-27: Is there a physical explanation why the results are different from those seen in previous studies?

18) P24406, L14-15: why lower cloud cover results in a low bias in Nd? Isn’t the Nd averaged in clouds?

19) P24408, L24: the “360 minutes” after track injection (hour 8) does not match the “hour 15” in the figure.

20) P24415, L7: typo for “occur”

21) P24417, L7: scavenging “of” interstitial aerosol?

22) P24425, Figure 3: What does the “large scale” mean here? Why don’t use simulated vertical velocities instead of LWP for the conditional sampling?

23) P24426, Figure 4: “hour 6” or “hour 8” in the title of the albedo panel? Strictly speaking, the plots must be from the run BaseSpinup rather than BaseTrack (said in the caption) as ship track does not appear in the albedo plot yet.

24) P24427, Figure 5: also for run BaseSpinup? Please describe the white (cloud) contours in the figure caption. Why they look so different in the two panels?

25) P24431, Figure 9: why domain-average Nd is shown rather than cloud-average?

26) P24432, Figure 10: suggest change “sinks” in the titles to “budget” since sources are plotted too. Are these terms averaged within the boundary layer?

27) P24434, Figure 12 caption: change “times” to “hour” and add the experiment name.

28) P24437, Figure 15: remove units in the third row, as the quantity is not number concentration anymore.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 24387, 2014.