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Interactive comment on "Real-case simulations of aerosol-cloud interactions in ship tracks over the Bay of Biscay" *by* A. Possner et al.

Anonymous Referee #2

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Title: Real-case simulations of aerosol-cloud interactions in ship tracks over the Bay of Biscay Authors: Possner, Zubler, Lohmann and Schaer ACPD 14, 26721-26764

Recommendation: Minor Revisions

Summary:

A real case involving ship tracks near Europe is simulated in a regional model at kilometer scale using a sophisticated bulk treatment of aerosols and cloud microphysics. Since no observations of the ship emissions from that case were available, ship emissions from another case study were used and scaled up by a factor of ten to produce cloud effects similar to those observed. The microphysical and macrophysical impacts of the ship emissions on the cloud are described in detail.

Assessment: Minor revisions

The experiments are well-designed, and the paper is well-written and presents its evidence clearly. I believe that it should be acceptable for publication if the authors address the concerns raised below.

Major comment:

1. This concern may reflect my particular biases and interests, but I was curious if the authors could quantify more clearly the macrophysical impacts described in section 3.4. My thought is that perhaps a table could compare the values of various quantities averaged over the plume points and points with significant cloud response in the ship10 simulation (as defined on p. 26730) and the same regions in the clean simulation. The numbers from the clean simulations would provide a baseline, and the differences between the two regions in the clean simulation might give some indication of the natural variability in the background state. My suggestion for possible quantities of interest are:

- surface precipitation rate

- liquid water path

- total water path (\int qv+qc dz up to some height which lies above the inversion in both simulations)

- average bl temperature (computed similarly with either T or liquid water temperature or the similar versions of potential temperature)

- BL-integrated radiative cooling, if available.

- surface sensible and latent heat fluxes

- BL-integrated Na and Nc

- average inversion height and cloud base height

- optical depth and/or SWCF

This list is probably excessive, but I thought that some quantification of these changes might give insight into the mechanism underlying the macrophysical cloud changes. If the authors choose to add such a table, only a subset of these would be necessary, I think.

The analysis in section 3.4 suggests that most of the LWP changes are due to the decrease in precipitation, but there's also some discussion of increased mixing. Since the background BL is not well-mixed, would it be possible to increase LWP simply by making the profile better mixed with identical BL-integrated total water and liquid-water temperature? The explanation in the paper about mixing liquid water down below cloud base is referring to this mechanism in part, though it also mentions increased cloud liquid due to weakened precipitation.

Minor comments (28/14 means line 14 on p. 26728):

28/14: Does "global emissions" refer to "global shipping emissions"? Please clarify if necessary.

28/25: For clarity, I would suggest starting this paragraph with "In the present simulations, ..." The similar phrase on 29/8 could be deleted,

31/eqn 1: Please specify the dependent variable for tau, e.g. \tau(x,y,\lambda_i) = \int_{SFC}^{TOA} ...

31/14-17: Could this approximation be responsible for some of the model-MODIS disagreement in figure 11?

31/23: Please use consistent units for the subsidence rate here.

32/19-20: What does "near the upper troposphere" mean? I would suggest using "lower free troposphere", above the boundary layer but below about 650 hPa, or "mid-troposphere", roughly 400-600 hPa.

33/18: Duplicate cm-3 seems to be a typo.

33/19: I would suggest changing "merely" to "only" if that doesn't change the meaning.

34: Can the authors speculate as to why the ship emissions need to be scaled up by a factor of ten as compared to Hobbs et al (2000) to roughly match the microphysical and optical properties of the observed shiptracks. Is it the emissions, the homogeneous distribution of the emissions over four kilometer-scale grid cells, or some microphysical process that takes over while the plume is processed? My thought for future work is that a Lagrangian treatment of the plume might provide better estimates of subgrid variability (which might be able to be plugged into a PDF-based cloud scheme) and less numerical diffusion. However, this thought is less than half-baked at present, as I'm not sure how to handle the turbulent mixing of the plume in that framework. Further, treating the aerosol microphysics (coagulation, sedimentation, etc.) along many Lagrangian trajectories might get expensive.

36/3: Why does theta increase above the inversion? Is it related to the increased subsidence with time?

36/29-37/2: This sentence can be removed. There is no need to apologize for making scaling arguments about turbulent flows. Much can be learned in this way.

39/10: Since SW CRE is negative, speaking of "increased" SW CRE is a bit confusing. I would suggest using "stronger" or "strengthened" instead.

39/15: Add "the changes in" before "microphysical properties ..."

39/18: I think that "were" fits better in this sentence than "where".

pp. 26740-41: See major comment 1. above.

41/17-18: I have trouble imagining a situation where the top of the sub-cloud layer is not near saturation. Perhaps, beneath a near-surface inversion underlying arctic stratus... Unless the authors have a particular scenario in mind, the paragraph would be fine without this sentence, I think.

43/26: This sentence is a bit awkward. If all simulations with ship exhaust (even ship) had a doubling of tau, then I would suggest: "Furthermore, all simulations with ship exhaust displayed at least a doubling of tau with respect to the background." If this wasn't true of ship, then remove "or did not".

45/2-4: In the first paragraph of section 3.4, increases in qc are attributed to reduced precipitation, while there is also a suggestion of subcloud moistening by precipitation evaporation. While a better-mixed boundary layer is likely playing a role, my impression is that cloud base changes are driven by some combination of increased mixing, increased BL radiative cooling and decreased precipitation. This might be clarified by the table suggested above.

58/fig 5: Might a panel d showing profiles of total water (qv+qc) be helpful in showing the increased mixing of the boundary layer moisture as the ship tracks develop?

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 26721, 2014.