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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 #1

Received and published: 14 November 2014

This paper pioneers using highly resolved LES simulations of ship tracks including a simple aerosol microphysics parameterisation in comparison to aircraft observations of cloud micro- and macrophysical properties as well as boundary layer (BL) profiles. A different behavior and relative strength (and sign) of the second indirect aerosol effect is simulated in this study for two types of ship tracks, which is supported by findings of previous studies. Particularly interesting is their approach of quantifying the contributions of micro- and macrophysical changes to the overall change in cloud albedo. The paper is well written and of great interest to the scientific community interested in aerosol-cloud-precipitation interactions and their representation in models.

General Comments:

1) It is stated that the initial conditions are chosen such that the BL characteristics are in adequate agreement with the observation available 8h into the simulation. Here I would like to be given more detail. In particular it would be interesting to know how strongly the BL characteristics and the roll structures are influenced regarding slight changes in the initial conditions, and how strongly such changes impact your ship track. For instance, as discussed in the paper, the roll structure strongly confines the track if the emissions are set along the roll axes. In particular could the low bias in track width and the smaller simulated roll width be related, and perhaps contribute to the high bias of Nd within the track? Considering the length of the paper, one could consider to present a discussion of the sensitivity to the initial conditions in an appendix.

2) The aerosol background concentrations and hence background Nd are continuously decreasing with time, as the only source of aerosol, the surface flux, decreases with time. Can you make any statements about the realism of this feature and what causes it? I presume it is linked to the roll circulation, which also reduces in strength as the simulation continues. Could there be issues here, as you consider only one mode of rather large particles? Thereby ignoring any source of particles in the activation range by condensational growth from the Aitken mode as well as new-particle nucleation?

3) The discussion of the SensHiAer simulation, although stepping away from the observation, adds scientifically to the paper, as a different ship track behavior is seen in terms of secondary aerosol-cloud interactions. However, the description of the involved processes is not clear yet. Differences in the background state, which behaves differently in terms of LWP and precipitation evolution (Fig. 15), remain largely unexplained. Furthermore, the hypothesized mechanism of the ship track LWP increases one hour after emission is not clear.

Technical Comments:

1) The symbolism of Na, Nad, Nd is not clearly enough stated at beginning of paper

and sometimes mixed up: - P24424: Nd is used in caption, but Na is used in figure. - P24395L13: Na used without definition, which follows later in P24399L25. - In the text Na=Nad+Nd+Nr should always be referred to as total aerosol number concentration and Nad as dry (or maybe unactivated) aerosol number concentration for clarity.

2) I follow the reasoning for using mg-1 as units of number concentration, but this should be done consistently throughout the paper. If not possible with the observations, I suggest to keep everything in cm-3. Otherwise statements like P24401L8-10 become cumbersome for the reader.

P24388L10: change “of cloud” into “of the cloud”.

P24389L10: Include Christensen and Stephens (2012: Microphysical and macrophysical responses of marine stratocumulus polluted by underlying ships: 2. Impacts of haze on precipitating clouds) in references.

P24393L17: Change “liquid ice static energy” to “liquid static energy”.

P24397L25 and in equation below: Two different values of S are given. Why?

P24398L6-7: Statement unclear.

P24398L23: Specify what statistics? Cloud, thermodynamical, dynamical... And change “BaseCtrl, BaseTrack, and SensPerp run suggest” to “BaseCtrl run, and background of BaseTrack and SensPerp”

P24399L23: Mark cross section in Fig.4. If there is a particular reason for choosing 6.4km as cross section location, it should be stated.

P24402L17 & P24403L5ff: Fig. 7 suggests that precipitation increases in the track as soon as LWP is increasing. Only when looking at Fig. 15, which is discussed much later, it becomes obvious that drizzle really remains suppressed with respect to the background as LWP increases.

P24401L27: I see precipitation change only after 09:30 in Fig.7, which does not add

up with 20min given in text.

P24404L25: Tendency of autoconversion is very small. Can that really be taken as evidence?

P24405L10: Specify that entrainment in track is 3rd largest term. In background its autoconversion.

P24407L18: “scaleupdrafts” to “scale updrafts”

P24411L15-16: Reformulate. Precipitation is continuously increasing from 9am onwards. It does not start 5h after emission.

P24416L0-1: Although I agree with your message, I would refrain from speaking about convergence, as the simulations are too short to see real convergence of the curves in Fig.15. For instance panels a1,a3 and b3 of Fig. 15 are clearly not converging in this time period.

P24417L13-16: Consider breaking up sentence into 2 for readability.

P24424: Please complete figure caption. ql is not defined and T in caption should be T_abs as in Figure. As mentioned above, there is an inconsistency in notation between Na and Nd.

P24425: In caption write T_abs instead of T.

P24426: Caption states hour 8, header of Fig. says hour 6. Please change accordingly.

P24429: In Fig. Na should be <Na> consistent with caption, where it should be mentioned that <Na> is MBL-depth averaged Na. Also contour spacing of <Na> is not clear.

P24430: In particular dashed stream lines are hard to identify in bottom panel. Please make it clearer using either larger panels or thicker lines.

P24433: A_TOA and A_Cld are not defined in caption.

P24434: State scaling of rain mixing ratio in caption.

P24436: Why are not the same times shown as for Fig.6? It would allow for direct comparison.

P24437: panel rows (a), (b), (c) and (d) are swapped between Fig and caption.

P24432 and P24439: Replace cyan with different color, as very close to blue when printed.

P24439: Consider defining RRTM in caption or putting in a reference to the text, where it is defined.

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