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Interactive comment on "Impact of ship emissions on the microphysical, optical and radiative properties of marine stratus: a case study" *by* M. Schreier et al.

Anonymous Referee #1

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Impact of ship emissions on the microphysical, optical and radiative properties of marine stratus: a case study M. Schreier, A. A. Kokhanovsky, V. Eyring, L. Bugliaro, H. Mannstein, B. Mayer, H. Bovensmann, J. P. Burrows

It is common knowledge that emissions from ocean going ships can modify cloud microphysics to create ship tracks characterized by smaller but more numerous cloud droplets, greater optical thickness and often increased cloud liquid water if the clouds had been precipitating. It is also common knowledge that these modifications will act

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to increase cloud reflection of solar radiation to space while decreasing the amount of solar radiation reaching the surface. This paper re-iterates these findings. However, the paper does make two important contributions. (1) It demonstrates an automatic method for identifying ship tracks and (2) it begins to answer the question of whether or not ship tracks are sufficiently wide spread to make a significant perturbation to at least the regional radiation balance.

Because the development of the automatic method for identifying ship tracks is one of the key results of this paper, it should be given greater emphasis. In particular, there should be quantifiable validation of the method, or at least putting Figure 2 and Figure 10 together using the same map projection so we can see how well the method works. The authors point out that not all ship-track pixels are found by the algorithm. My personal estimate is that the algorithm misses almost a third of what I would label a ship track using my own eye. The authors argue that the algorithm finds the bulk of the radiative effect of the ship tracks, which is a legitimate argument, but this argument should be substantiated. As in all science it comes to the need for uncertainty analysis and error bars. How would the results change (% of pixels labels as ship tracks and perturbation to the radiation fields) if the thresholds on the algorithm were relaxed to let in more pixels?

The paper goes into detail concerning surface assumptions in the retrieval. I have a few comments here. First, 0.03 at 0.86 μm seems very high to me. Second, the question about ship wakes isn't about these wakes causing problems with the cloud retrieval, but more importantly with the ship track identification algorithm. Fig 7 is misleading. We really only care about (a) and (c) the change to the reflectances measured by satellite and used to identify the streaks in the clouds. How ocean wakes affect the microphysical retrieval is just one type of noise among many. The point could be much better made by showing that the spectral slopes caused by ship tracks in the clouds and ship wakes in the ocean are oppositely signed. Merge Figs. 7 and 8 together. Plot change in reflectance as function of wavelength, both in and out of ship tracks and wakes. Also there is no point to Fig 9 unless those streaks are positively identified as cloud features, which could be done by running the algorithm on them.

The authors find that the ship tracks perturb the radiative properties of the clouds enough and are sufficiently widespread to make a significant difference to the mean radiative balance of the entire scene, especially at the surface. This isn't simply a difference between pixels in ship tracks vs. pixels next to ship tracks, but the overall effect to the entire scene. That is a very interesting result. However, there are plenty of uncertainties in the calculation beginning with the division between ship tracks and no-ship-track-pixels. There ought to be a way of quantifying that uncertainty. In any event, there is no way these calculations are precise to the second decimal point, given the large standard deviations, and they should not be reported as such.

My final major comment is very basic. While I have nothing against different research groups applying their own algorithms to observed satellite reflectances, there exists a standard MODIS cloud product that includes the microphysical parameters used in this study. These parameters are inherently difficult to validate, but it seems that if two independent methods have been applied to the exact same radiances, it would be very interesting to compare the results. Such differences could be used to begin to quantify some of the uncertainty in the final radiative results. The data is easy to acquire and if at the same resolution, very easy to compare.

Minor comments:

1. p1029, 3.1 Ship track mask algorithm. Ship emissions can affect taller clouds, as long as those clouds begin in the boundary layer (see Rosenfeld's work). Granted the effect won't be classic ship tracks and are rightfully ignored in this paper, but the statement in this paragraph is too strong. 2. P1029, next sentence. Add the word "taller" or "higher". "To separate low cloud pixels from "higher" cloudy pixels.." 3. Are the authors retrieving cloud properties at 500 m or 1 km. I don't remember it being stated. 4. Fig. 10 is the natural result of Section 3.1 and should be referenced from

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this section. Section 3.3 should focus on problems surface features have on the ship track identification, not the cloud property retrieval and should thus following Section 3.1. Section 3.2 should follow the present Section 3.3. 5. P. 1031 Section 3.2. Assuming a surface reflectance of 0.03 for the 0.85 μm channel seems very high. At least reference the choice of this value or test the assumption. 6. P1031 Section 3.2. “1.6 μm was selected because the smaller absorption of liquid water enables more accurate results for the retrievals.” Needs a reference. Then why use 2.1 μm to identify the ship tracks? I would think that if 1.6 μm were more sensitive then it would be better for identification also. Choice of wavelength has a lot to do with the depth of penetration of the radiation into the cloud and the effective level of the r_eff retrieval. [Platnick 2000, JGR, 105, D18, 22919-22935] Also there is a another paper too that examines this issue [Chang and Li, 2002, JGR, 107] 7. There is an overall lack of reference of work done by Platnick, Michael King and Fu-long Chang who have spent a great deal of time developing two separate independent retrieval algorithms for MODIS data. 8. P1034. End of Section 3.3. What’s the difference between “all larger than 20” and “20 to 30”? 9. P1034. What is the uncertainty introduced by choice of homogeneous clouds with bases at 500 m and tops at 1000m? 10. P1037. The failure of liquid water to change may simply mean that in this particular scene the clouds are not drizzling. It is only one scene on one day. 11. Fig. 14. It is interesting that with such strong microphysical response the ship track response in the radiative fields doesn’t jump out immediately. The point made about the dominance of the solar zenith angle is important. 12. Fig 15. Doesn’t do anything for me. Because of the cut of these images there is no reference to the larger area. I don’t think this point needs belaboring. These clouds aren’t drizzling. If they were precipitating you might see a change in liquid water. 13. The next step in this line of work would be to take a proven ship track identification algorithm with KNOWN uncertainties and apply it globally. Coupled with the radiative flux calculations in and out of ship tracks, and the solar zenith angle, some one could then estimate the global effect of ship tracks on the global radiative balance. We’ve all seen ship tracks. The question that needs answering is whether ship tracks are just isolated interesting anomalies, or do they make a real difference in global or regional climate. The paper should discuss this question in its conclusions. 14. The abstract should emphasize that this paper will demonstrate an automatic algorithm for identifying these ship tracks and then the overall radiative effect these ship tracks have on the entire scene. Numbers should not be reported to the accuracy of two decimal points.

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